112-019-7D36
MOTC-IOT-111-H2CA001f

Comparison Studies of Laboratory Tests on Eleven Armor Types

交通部運輸研究所

中華民國 112 年 3 月

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著 者：李勇榮

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出版機關：交通部運輸研究所

地　　址：105004 臺北市松山區敦化北路 240 號

網　　址：www.iot.gov.tw (中文版＞數位典藏＞本所出版品)

電　　話：(04)2658-7200

出版年月：中華民國 112 年 3 月

印 刷 者：

版(刷)次冊數：初版一刷 47 冊

本書同時登載於交通部運輸研究所網站

定　　價：300 元

展 售 處：

交通部運輸研究所運輸資訊組•電話：(02)2349-6789

國家書店松江門市:104472 臺北市中山區松江路 209 號•電話：(02)2518-0207

五南文化廣場：400002 臺中市中區中山路 6 號•電話：(04)2226-0330

GPN：1011200158　　ISBN 978-986-531-482-8(平裝)

著作財產權人：中華民國(代表機關：交通部運輸研究所)

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Comparison Studies of Laboratory Tests on Eleven Armor Types

交通部運輸研究所

GPN：1011200158

定價 300 元

交通部運輸研究所自行研究計畫出版品摘要表

<table>
<tr><td colspan="4">出版品名稱： Comparison Studies of Laboratory Tests on Eleven Armor Types</td></tr>
<tr><td>國際標準書號（或叢刊號）
ISBN 978-986-531-482-8(平裝)</td><td>政府出版品統一編號
1011200158</td><td>運輸研究所出版品編號
112-019-7D36</td><td>計畫編號
MOTC-IOT-111
-H2CA001f</td></tr>
<tr><td colspan="3">主辦單位：港灣技術研究中心
主管：蔡立宏
計劃主持人：李勇榮
研究人員：李勇榮
聯絡電話：(04)2658-7183
傳真號碼：(04)2656-0661</td><td>研究期間
自 111 年 01 月
至 111 年 12 月</td></tr>
<tr><td colspan="4">關鍵詞：Eleven armor types, Wave reflection, Wave run-up and run-down, Armor stability, Real time laboratory system, Optimized and unified approaches</td></tr>
<tr><td colspan="4">摘要：

本研究將 11 種類型消波塊置於 2 種不同坡度的防波堤，進行性能比較之試驗。本研究針對消波塊之波浪反射、波浪溯升降，及穩定性三大方面進行測試。由於過往類似實驗眾多，且設置和分析方法皆有差異，導致結果極其分散，沒有定論，難以比較。

為了解決這些問題，目前的研究執行以下操作：(1) 確認影響消波塊之相關因素，並了解是否有相關模型試驗。 (2) 開發一個數據採集、監測、校準和分析的實驗室系統，以提供準確、方便、自動化的試驗流程。 (3) 基於試驗水槽中 波浪的特性和數據分析的理論方面，提出入、反射波分離方式，以優化試驗數據之方法 。(4)不同比較對象的 ANOVA 的統計量是單獨和相互的，須檢查以證實研究的目的。

有了上述程序，所有數據能產生一個共同且不變的標準，以及完全相同的處理方式，數據利用率達到 100%使產生的結果更具決定性，並顯示出明顯更好的趨勢。雖然對於穩定性係數的部分，無論是在準則中還是在損壞判斷方面，仍然存在主觀性問題，但整體結果仍然是一致且有意義。</td></tr>
<tr><td>出版日期</td><td>頁數</td><td>定價</td><td>本 出 版 品 取 得 方 式</td></tr>
<tr><td>112 年 3 月</td><td>368</td><td>300</td><td>凡屬機密性出版品均不對外公開。普通性出版品，公營、公益機關團體及學校可函洽本所免費贈閱；私人及私營機關團體可按定價價購。</td></tr>
<tr><td colspan="4">備註：本研究之結論與建議不代表交通部之意見。</td></tr>
</table>

PUBLICATION ABSTRACTS OF RESEARCH PROJECTS
INSTITUTE OF TRANSPORTATION
MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

TITLE: Comparison Studies of Laboratory Tests on Eleven Armor Types			
ISBN(OR ISSN) 978-986-531-482-8(pbk)	GOVERNMENT PUBLICATIONS NUMBER 1011200158	IOT SERIAL NUMBER 112-019-7D36	PROJECT NUMBER MOTC-IOT-111-H2CA001f

DIVISION: HARBOR & MARINE TECHNOLOGY CENTER
DIVISION DIRECTOR: Li-Hung Tsai
PRINCIPAL INVESTIGATOR: Yueon-Ron Lee
PROJECT STAFF: Yueon-Ron Lee
PHONE: 886-4-26587183
FAX: 886-4-26560661

PROJECT PERIOD
FROM Jan. 2022
TO Dec. 2022

KEY WORDS: Eleven armor types, Wave reflection, Wave run-up and run-down, Armor stability, Real time laboratory system, Optimized and unified approaches

ABSTRACT:

Eleven types of armors were laboratory tested and their performances concerning the random placements of armors for two different surface slopes of rubble mound breakwater were compared. The three major categories of performance comparison are wave reflection, wave run-up and run-down, and armor stability. Due to the vast differences both in the setups of experiments and in the methodologies of data acquisition and analyses, the multitude of existing literatures yielded extremely scattering results, which are generally quite inconclusive and inconsistent, as well as incomparable. To cope with these problems the present research carries out the following: (1) Factors that affect armor behaviors are detailed and those that are modeled or not are indicated; (2) A real time laboratory system for data acquisition, monitoring, calibration, and analyses is developed, and the integrated program aims to provide accurate, convenient, and automated on-site processes; (3) Based upon the intrinsic properties of waves in flume and theoretical aspects of proper analyses, various optimizations and a unified approach for both the implementation of tests and the processing of data are deliberated, especially, the employment of the wave separation technique. (4) Various statistics of one-way and two-way ANOVA for the different comparison subjects are individually and mutually checked to substantiate the physics and the purposes of the comparisons. With these due cares, all the digitally acquired data have been subjected to a common and non-varying standard, as well as exactly the same treatments. The data utilization achieves a rate of 100\% and neither omission nor selection of data, or any sort of intervention, has ever been done. Compared to earlier literatures, the yielded outcomes here are far more conclusive and show clearly better trends, and the various phenomena exhibit properties of upright coherence with easy explanations and logical conformities. For the stability coefficients, there still exists the main subjective problem regarding the judgements of damage both in the criteria and in the measurements. But overall, the basic wave data are excellent and the results of the three performance subjects are well consistent and meaningfully linked. That is to say, the comparisons here are definite and conclusive to a certain degree.

DATE OF PUBLICATION	NUMBER OF PAGES	PRICE
Mar 2023	368	300

The views expressed in this publication are not necessarily those of the Ministry of Transportation and Communications.

Comparison Studies of Laboratory Tests on Eleven Armor Types

Yueon-Ron Lee

Institute of Harbor and Marine Technology

ronlee@ms4.hinet.net

Revision: January 30, 2023
Printed: January 30, 2023
Originally published in 1991 (in Chinese)

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ABSTRACT

Eleven types of armors were laboratory tested and their performances concerning the random placements of armors for two different surface slopes of rubble mound breakwater were compared. The three major categories of performance comparison are wave reflection, wave run-up and run-down, and armor stability. Due to the vast differences both in the setups of experiments and in the methodologies of data acquisition and analyses, the multitude of existing literatures yielded extremely scattering results, which are generally quite inconclusive and inconsistent, as well as incomparable. To cope with these problems the present research carries out the following: (1) Factors that affect armor behaviors are detailed and those that are modeled or not are indicated; (2) A real time laboratory system for data acquisition, monitoring, calibration, and analyses is developed. And the integrated program aims to provide accurate, convenient, and automated on-site processes; (3) Based upon the intrinsic properties of waves in flume and theoretical aspects of proper analyses, various optimizations and a unified approach for both the implementation of tests and the processing of data are deliberated, especially, the employment of the wave separation technique. (4) Various statistics of one-way and two-way ANOVA for the different comparison subjects are individually and mutually checked to substantiate the physics and the purposes of the comparisons. With these cares, all the digitally acquired data have been subjected to a common and non-varying standard, as well as exactly the same treatments. The data utilization achieves a rate of 100% and neither omission nor selection of data, or any sort of intervention, has ever been done. Compared to prior studies, the yielded outcomes here are far more conclusive and show clearly better trends, and the various physical features exhibit properties of upright coherence with easy explanations and logical conformities. Even though, for the stability coefficients, there still exists the main subjective problem regarding the judgements of damage both in the criteria and in the measurements; but overall, the basic wave data are excellent and the results of the three performance subjects are well consistent and meaningfully linked. That is to say, the comparisons here are definite and conclusive to a certain degree.

Chapter 1

Introduction

1.1 Background

Aiming at the functional enhancements of the protective natural blocks or quarry stones, man-made concrete armor units or non-blocks have been in existence for over many decades (for example, tetrapod, 1950). So far there are no less then seventy or eighty types of armors around the world, and in Taiwan there are about ten to twenty armor types that are most commonly seen. As for the armors' uses in ocean or river there exist different preferences and different view points. And, with the evolving of our societies and the changes of our ideas concerning the relation between human and nature, there exist various controversies on their uses in our environments; however, the studies and the comparisons of their performances should be of objective and scientific issues.

Graded natural stones, when used for revetment protection against waves, is only suitable for small waves (generally, less than 1.5 meters height). In most occasions, it is both more economical and much feasible to work with blocks of the same size and of a particular shape. For wave-related usages the main concerns in engineering practices are: the functionality, the feasibility, the economics, the durability, etc. In aspect of functionality, the main factors to be considered are: stability, wave dissipation, wave run-up run-down, spill-over, landscape, environmental influences, etc. In aspect of feasibility, the factors are: templates fabrication, concrete pouring, storage and transportation, placement dif-

ficulties both above and under the water, failure or breakage or damage during various engineering phases, etc. In aspect of economics, one needs to consider: the type of structure to be protected, the degree of protection, the number of block needed, the placement pattern, the possibility of partial failure, the maintenance or damage repair, the engineering alternatives, etc. In aspect of durability, it is basically the combined result of all the above factors.

In fact, so far, existing studies on armor-related topics have been invariably based upon rules of thumb that are either accumulated through practices or self-proposed ideas without rigorous investigations. On the one hand, few theories have been established such that they can be satisfactorily verified and precisely followed; on the other hand, current technologies are still unable to provide robust measurements and analyses both in the field and in the laboratory. Therefore, most individual researches have been highly subjectively influenced by human factors, and their outcomes are generally probabilistic, as well as only suitable for specific circumstances. This situation is particularly evident when concerning the topic on armor stability. Just take for examples some of the very important, as well as quite objective, issues: the cracks related to material, the stress distribution of the armor, reinforcement egresses, mechanical features among armors, failurement and repairment, etc. Moreover, there exist no comprehensive and systematical investigations or examinations in regards of experimental modelings, data collections, method of analyses, engineering relevances, construction complexity, economical assessments, etc. Obtainable information tends to be rather specific or individually oriented not only for its subject of interest but also for its way of attack.

Overall, the challenges the present study faces are enormous; there are no unified approaches and standards. And, among the available literatures, the inconsistencies exist in almost all aspects and the associate scattering are huge either in and out. In short, sound and fair assessments and judgements are nearly impossible to make — there exist not only objective inadequacies scientifically but also subjective progressions unscientifically.

1.2 Scope and purpose

Facing with the multitude of problems stated above and premising with the mass of complexity to be briefed in the next chapter, the present study aims to provide, more or less, fairer and sounder comparisons of the performances of eleven different armor types somewhat commonly seen in Taiwan. The fundamental thinking here is: with more thoughtful considerations and refined planning, both all the test implementations and all the data analyses shall be conducted under a unified scheme that employs exactly the same stipulations. And hopefully, together with the right methodology in wave data processing, which is mostly absent (or unclear) in the available literatures, the measures will be able to get rid of experimental discrepancies, minimize data scattering, and solidify physical trends. What will be covered in the performance comparisons are: the wave reflectivity, the relative wave run-up and run-down, and the armor stability under the setting of random placement. And both regular and irregular waves will be adopted; but with more emphases on the part of regular waves, especially with regard to the wave run-up rundown and the armor stability.

In the beginning, past researches will be reviewed and various influencing factors be listed, so as to gain the basic understanding on the complexity and the main concerns of the present topics, as well as on the modeling layouts. And these also manifest upon the modeling scope of the tests and upon the inevitable limitations of experiments.

Followingly, the scheme of data acquisition and analyses, as well as a right tool for incident and reflected wave separation, will be detailed. And all such implementations are associated with the development of a real time laboratory system that is basically fully automated for both data acquisition and various on-site processing. And the coding of the lab system aims to achieve a process that has minimum human intervention from its start till its end. Basically one key stroke will complete all digitally related works of a test — from the start of wave making to the results of proper analyses. The integrated front-end and back-end functions include, multi-channel calibration, real time monitoring

and auditing, multiplex A/D/A conversions, basic statistical analysis, filtering, spectral analysis, incident and reflected wave separation, computation of reflectivity, etc. This lab system fundamentally establish the rightfulness of all the data, and subsequently facilitate the meaningfulness of all the analyses. Overall, the credibility of this study is due to the development of the lab system, which, on the one hand, massively reduces manpower and resources, on the other hand, greatly enhances the definiteness of the analyses.

Even though much complexity still remains and important issues are still lingering, what could be done should be attempted to the possible extent in the author's capacity and inspiration. Hopefully, the outcomes here could show significant improvements when compared to the past and the performance comparisons among the eleven armor types be made possible. ❖

Chapter 2

The Planning of the Comparison Study

2.1 Introduction

To make laboratory comparisons meaningful and fair, the preliminary work is the determination of a common modeling detail and a consistent test condition. Moreover, both theoretical and practical aspects need to be considered. For example, the cladding layer of the armoring blocks of a rubble-mound breakwater is only a part of the overall structure, and the behaviors or the functioning of the breakwater as a whole, as well as those of the constituent structural elements, are not simply determined by the armoring blocks alone. As a whole, many different factors play important roles, such as, the surrounding topography, the toe berm, the cushion on the bed, the layers underneath the cladding, the associated gradations, the core structure and its material, the configuration of the breakwater, etc. Henceforth, the problems related to the movements of armors, the wave damping effect, the protection from wave run-up run-down, the stability of various layers, the overall durability of the breakwater, etc., are somewhat specific and should be studied case by case. Another specific problem concerns the emplacement of the armors, and it is about the practicality of an experimental modeling. In laboratorial situations, the armoring blocks can be arranged in a regular or in some particular patterns; but in the field, the placement of the armors both under and above the water is invariably a difficult task. Similarly, in addition to the modeling of the armors themselves, many relevant elements

need to be considered or properly simulated so as not to deviate from the reality that people want. Without these considerations, the comparability of test results is likely to be distorted from what we want and the usefulness or representativeness of the study will surely be dampened.

Armoring blocks are often seen in shore or inland rivers. They are there to protect breakwaters, jetties, seawalls, embankments or various structures. And their primary function is the control of waves or flows. A particular usage of armors may have its specific structural configurations and design considerations. In particular, the degrees of protection may vary and the thickness and extensiveness of shrouding may also be different. In order to have the credibility in simulations, as well as to gain its significant relevance in practical engineering, the breakwater configuration in this study adopts the setting as given in "The Coastal Protection Manual" published by the Coastal Engineering Research Center of the Waterways Experiment Station of the U.S. Army Corp of Engineers. Additionally, reference materials are studied and some of their associated circumstances will be discussed.

In this chapter, the three comparison subjects will be detailed in the following order: the stability of the armor layer, the relative wave run-up and run-down, and the wave reflectivity; but their individual results will be presented in the reverse order in a later chapter. The initial arrangement is based upon the order of the complexity of individual subject and the reverse arrangement is based upon the concreteness of individual outcome. And this is due to the fact that all three comparison subjects are fundamentally dependent on the results of the wave data. Without concrete wave data there will be no meaningful comparisons for all. Therefore, the heaps of influencing factors in this study will be given first, and the layout of experiment and the relevant parameters stated accordingly. As to the wave data or the reflection coefficients, they are essentially related to the pursuit of the true contents of waves in an experimental flume. Generally speaking, both the relative wave run-up run-down and the stability coefficients involve the visual observations of a substantial human factor, but the reflection coefficients basically do not involve any

human factor. In particular, the judgements of armor stability encompasses the complexity that is subjected not only to the non-existence of damage standard (or criteria) but also to the lack of measurement techniques. Nevertheless, with a consistent way in handling and an "objective" spirit in observations, hopefully, we will still be able to provide the meaningful analyses, as well as the comparable data, which are established upon the "most exact" "incident" wave heights.

2.2 Armor stability

Basically, almost all the formulas used to determine the size or weight of the armor unit are related to the Hudson formula (Hudson, 1959 [15]). This formula was originally derived from a series of experiments at the U.S. Army Waterways Experiment Station on natural blocks with regard to the surface protection of slope of rock-fill breakwater. It has since been widely used in various specially-shaped blocks or armors. The Hudson stability formula is:

$$W_c = \frac{\gamma_c {H_D}^3}{K_D\,(S_c - 1)\cot\theta,} \tag{2.1}$$

in which

W_c	:	the weight of an armor,
γ_c	:	the unit volume weight of the armor (surface dry but water saturation),
H_D	:	design wave height at the breakwater,
S_c	:	specific weight of the armor relative to water (sea or fresh water),
θ	:	the slope of the breakwater in reference to the horizontal level,
K_D	:	stability coefficient.

It can be seen from the formula that all the relevant influencing factors (except the four parameters that appear in the formula and listed below), either significantly or not, that determine the size of the armor are lumped into one dimensionless variable, i.e., the K_D coefficient. The four parameters explicitly specified in the formula are: the slope of the breakwater, the design wave height, the specific weight of the armor and the specific

weight of the water. And strictly speaking, only two parameters are prominent since the specific weights of the armor and the water are basically fixed. As a result, the heavy cloud of uncertainty has been looming over a single K_D factor. In the following, these influencing factors of uncertainty or the unspecified variables contained in the K_D will be grouped into one of the following four categories: (A) the armor, (B) the wave, (C) the structural elements of the breakwater, (D) other individual factors. Figure 2.1 (K_DFactors) gives a concise list of the multitude of factors. At the end of this section, we will come to realize that the relevant concerns are too many and that few factors could possibly be simulated in experiments. Nevertheless, on the one hand, we will gain the understanding of the unavoidable incertitude of this study; on the other hand, we will be able to acquaint with practical considerations needed in engineering.

2.2.1 (A) Factors related to the armor

1. **Shape of armor**

   Shape is the most direct and distinguishable representation of an armor; and it is probably the most easily, as well as the ultimate, modeled factor in experiments. That is to say, all other factors could hardly be reflected in the simulation. The shape manifests the properties of a protective work, such as: the porosity, the interlocking, the mobility, the possible arrangements, the interaction with the waves and the surroundings, etc. It is therefore intuitively expected that different shapes yield different performances for the three comparison subjects. In fact, it is quite fair to say, at this beginning, that the shape factor could basically be the sole factor that can be exclusively and significantly highlighted in the present tests. And it is noted that some armors with similar overall shapes but slightly different details may bear the same name as used by their proprietors.

2. **Material and structural strength**

   The material and structural properties of an armor unit concern about its internal

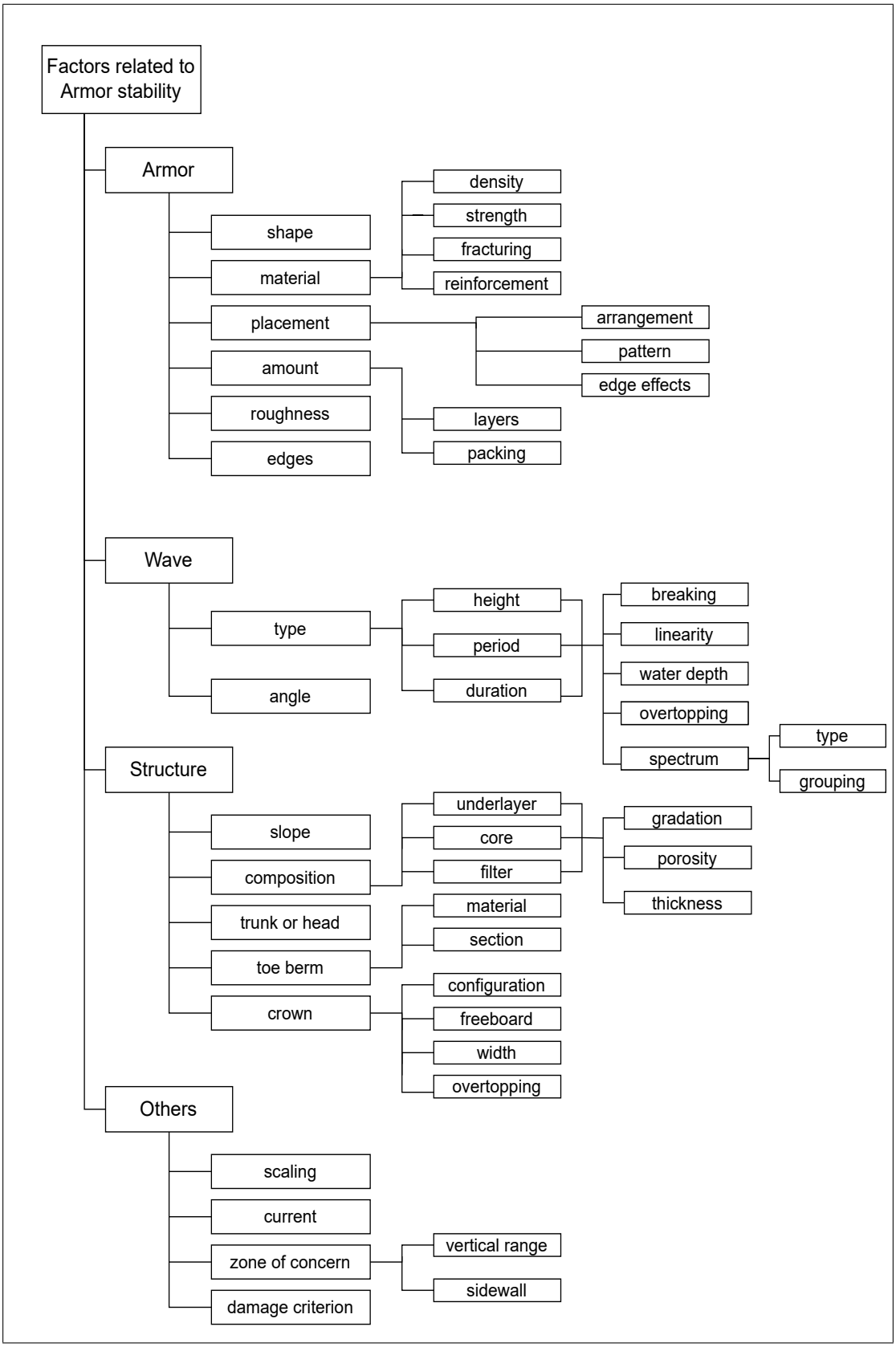


Fig 2.1 (K_DFactors). The influencing factors of the stability coefficient.

stresses, Young's modulus or modulus of elasticity, cracks, fracture resistance, Poisson's ratio, etc. Before we discuss the simulation limitations of this factor, we first list various scale relationships between the model and the prototype under the law of Froude's number as shown in table 2.1 (M/P ratios). From the various relational expressions in the table, it is not difficult to understand that it is extremely difficult to simulate the rupture or strength of the armor itself. On the one hand, as described in the note of the table, the preliminary condition among the three different densities of the armor model, the prototype and the water have been fixed and limited to the same material density between model and prototype; on the other hand, due to the fact that the mechanical properties of the model and the prototype are quite different, all these simulative relationships, or even just few of them, can not be fulfilled in a simultaneous way. Therefore, the simulation of this material factor, that is, to create a model armor unit that has a relatively weak strength when compared to that in the field, is one of the most difficult problems to overcome in experiments. Although there were attempts (Timco and Mansard, 1982 [27]), they were far from ideal. Moreover, in field situations, when the size or weight of the armor is very large, the critical mechanical strength is an additional serious concern and the stress distributions within the armor need to be investigated. In fact a general mechanical property of any object is: the larger the size of an object the weaker is its relative strength to its exterior impact forces. Some field experiences have shown that, for overly large armors (the heaviest armor used today has reached about a range of 50 to 100 tons), the armor failure is due to the insufficient strength within itself rather than the incident waves that may be greater than the design wave height (Mettan and Berry, 1982 [19]). Furthermore, for big armors, the thermochemical phenomenon of the concrete during the hardening process of manufacturing often causes cracks, and thereafter affects their strength and longevities. A related issue concerning the structural strength of the armor is whether it is beneficial to add steel bars. And the issue also introduces various additional problems such as cracks, corrosion, casting

work, transportation damage, etc. Many disputes and uncertainties exist.

Overall, it is basically not possible to simulate the material behaviors of the armors, and no such attempt is made in this study. And based on this concern. as well as the considerations regarding the size of the tank and the property of the wave generator (and with reference to existing literatures), it is decided that the armor unit models be casted with aluminum alloy and the weight be 150 grams for all the armor types. The aluminum alloy is used since it is difficult in practice to cast with concrete due to the sizes of the unit models are not large and the maximum dimension is about 6 to 7 cm. But the specific weight of the alloy is controlled to be close to that of the concrete, i.e., 2.3. In cases of excess weight under the specified model dimensions, the excess weight is removed by proper drilling that aims to maintain the position of the center of gravity. The shapes and sizes of the chosen eleven types of armors for the comparisons are shown in figure 2.2 (Armor-1) $\sim$ 2.12 (Armor-11). Note that the specific weight of the armor material has a significant effectuation on the stability coefficient. As an example: in reference to the same Hudson coefficient, a block with a weight of 40 tons and a specific weight of 2.3 can be replaced by a 20.8 ton block with specific weight of 2.7. And the calculation is (let the specific gravity of seawater be 1.02):

$$40.0\frac{2.7}{2.3}\left[\frac{(2.7/1.02)-1}{(2.3/1.02)-1}\right]^3 = 20.8.$$

3. **Number of stacking layers and packing density**

In general, the number of layers of the retaining armors for breakwaters should be no less than two. And to maximize the wave-damping effect and to enhance the interlocking among armor blocks, both the porosity and the packing density must be appropriately considered. However, it should also be mentioned that, if the protective layer has either a high porosity or a high degree of interlocking in its design, the margin of safety will be reduced, since a small damage may induce a serious breakdown or a catastrophic chain reaction. The packing density of the

General scale item	Scale between model and prototype
Length	$l_{\mathrm{M}} = l_{\mathrm{P}} \frac{1}{\lambda}$
time	$t_{\mathrm{M}} = t_{\mathrm{P}} \frac{1}{\sqrt{\lambda}}$
Velocity	$v_{\mathrm{M}} = v_{\mathrm{P}} \frac{1}{\sqrt{\lambda}}$
Acceleration	$a_{\mathrm{M}} = a_{\mathrm{P}}$
Mass	$m_{\mathrm{M}} = m_{\mathrm{P}} \frac{1}{\lambda^3} \rho_r$ ‡
Force	$F_{\mathrm{M}} = F_{\mathrm{P}} \frac{1}{\lambda^3} \rho_r$
Pressure	$p_{\mathrm{M}} = p_{\mathrm{P}} \frac{1}{\lambda} \rho_r$
Momentum	$M_{\mathrm{M}} = M_{\mathrm{P}} \frac{1}{\sqrt{\lambda^7}} \rho_r$
Energy	$E_{\mathrm{M}} = E_{\mathrm{P}} \frac{1}{\lambda^4} \rho_r$
Power	$N_{\mathrm{M}} = N_{\mathrm{P}} \frac{1}{\sqrt{\lambda^7}} \rho_r$

‡ $\rho_r = \frac{\rho_{\mathrm{M}}}{\rho_{\mathrm{P}}}$, Since the simulation involves two ρ_r (i.e., for the armor and the fluid) In reality, ρ_{M} and ρ_{P} need to be equal.

Material scale item	Scale between model and prototype
Density	$\rho_{\mathrm{M}} = \rho_{\mathrm{P}}$ ‡
Stress	$\sigma_{\mathrm{M}} = \sigma_{\mathrm{P}} \frac{1}{\lambda}$
Young's modulus	$Y_{\mathrm{M}} = Y_{\mathrm{P}} \frac{1}{\lambda}$
Crack resistance	$K_{\mathrm{M}} = K_{\mathrm{P}} \frac{1}{\sqrt{\lambda^7}}$
Poisson ratio	$\mu_{\mathrm{M}} = \mu_{\mathrm{P}}$
Friction coefficient	$f_{\mathrm{M}} = f_{\mathrm{P}}$

‡ $\rho_r = \frac{\rho_{\mathrm{M}}}{\rho_{\mathrm{P}}}$, Since the simulation involves two ρ_r (i.e., for the armor and the fluid) In reality, ρ_{M} and ρ_{P} need to be equal.

Tab 2.1 (M/P ratios). Scale relationships between model (M) and prototype (P) for various physical simulations under the Froude's law.

armor is calculated in the following way. Let the number of layers be n, the stacking thickness be t_n, and the net volume of a single armor be V_c, then

$$t_n = nk_\Delta {V_c}^{1/3} = nk_\Delta \left(\frac{W_c}{\gamma_c}\right)^{1/3}, \tag{2.2}$$

in which k_Δ is the layer coefficient. And let the porosity of the stacking armors be $P\%$, then the number of armors required per unit area N_n is

$$N_n = \frac{t_n}{V_c}\left(1 - \frac{P}{100}\right) = nk_\Delta \left(1 - \frac{P}{100}\right)\left(\frac{\gamma_c}{W_c}\right)^{2/3}. \tag{2.3}$$

Alternatively, the number of armors required per unit volume, N, is given by

$$N = \left(1 - \frac{P}{100}\right)\frac{1}{V_c} = \left(1 - \frac{P}{100}\right)\frac{\gamma_c}{W_c}. \tag{2.4}$$

The above P and k_Δ need to be statistically determined by experiments. Generally, the porosity of the packing layer is between 55% to 60% and the k_Δ value is close to 1. In the present tests the range of distribution of k_Δ is $0.90 \sim 1.31$.

As mentioned earlier, many uncertainties and ambiguities exist among the multitude of existing publications concerning the present study, and the relevant yields in many aspects are mostly extremely inconsistent and sometimes conflicting. Take the packing density as an example (other discrepancies will also be mentioned subsequently), according to Zwanborn's (1978 [31]) experiments with three different packing densities of dolos, they showed that the packing density is not quite related to the stability; however, according to the experiments by Carver and Davidson (1978 [6]) on the same targeted armor of dolos, they depicted that a higher density provides a better stability.

Here for all our tests, the number of stacking layers is chosen to be 2. And the armor density per unit area is calculated according to the porosity value suggested in the references or as provided by the proprietary right owners of the armor types.

If inconsistent values were observed, they were determined through proper judgement or through the conversion of relevant data. For all the chosen armor types the required number of armors per unit area is among 480-648 per square meter.

4. **Pattern of armor layout and placement method**

The placement pattern of the armors on the slope may be of randomness or of a special arrangement or of a mix. A specific armor type may have its own suitable configurations and applications. However, a regular placement pattern may not provide a more stable protection than that of random tossing. For example, Carver and Davidson (1978 [6]) studied the placement patterns of dolos and pointed out that some special arrangements were less stable than the random placement. And a few studies also suggested that it might be beneficial for some of the bottom rows to be arranged in a certain pattern for the reduction of the edge phenomenon.

The placements of armors at sea are technically difficult intrinsically. Coupled with adverse conditions of wind, wave and current the quality control of the placement is always a serious concern, especially in deep water. Moreover, in the field, it is unlikely to replicate the layout pattern and the degree of interlocking that can easily be achieved in experiments. In addition, for a specially arranged pattern, the whole layout is prone to a complete disintegration or cascading collapse when local damages or armor displacements occur. Therefore the random placement provides not only a lower risk factor but also repairableness and easy maintenance. Accordingly, the Shore Protection Manual recommends that the random placement K_D should be taken as the design reference.

In this study the way of placing the armors on the breakwater slopes are all of random tossing. It is noted that the choice of these 11 specially-shaped armor types is somewhat based upon intuitiveness, either by their frequent adoptions in the fields in Taiwan or by their appearances in reference materials, and no prejudgements were made on their suitability for random placement. The procedure of tossing the

armors in the tests is: hand lift the armor to a height of about one to two times of its size above the location where it situates, let go, and progress from bottom to top. For the purpose of objectivity and consistency, all such works and relevant observations were carried out by the author alone.

5. **Surface roughness and effects of edge, arris and corner**

   The surface roughness and the edges, arrises and corners of the armors affect the interlocking, movement, sliding, and all sorts of behaviors of not only the armors but also their underlayer. Moreover, edges and corners may also affect structural mechanics and stress distribution related to contact area, impact point, stress concentration, and so on. In principal, the similarity in roughness can be done by comparing the angle of repose for the model and for the prototype, but researches on these are rare and largely ignored. Such situation is also the case in this study. It is noted that, sometimes under the same identification name, a particular armor type may refers to its variations with different details in these aspects. . For such cases, only one variation that is best available in study material is picked and their exact scales are given in the size and shape figures.

2.2.2 (B) Factors related to waves

1. **Types of wave action**

   The water depth at the breakwater, the sea bed condition and the topography are important engineering considerations. These factors deeply affect the properties of waves and the action patterns. The relevant considerations here are like: linearity or nonlinearity, shallow or deep water, breaking or non-breaking, wave irregularity, etc. According to a few references, it is generally accepted that the pattern of wave action on the armoring cover may be associated with one of the following three categories. The first is of a fully breaking wave. For this, the sloping face is hit by a jet-like water column, and the wave form is similar to the plunging breaker

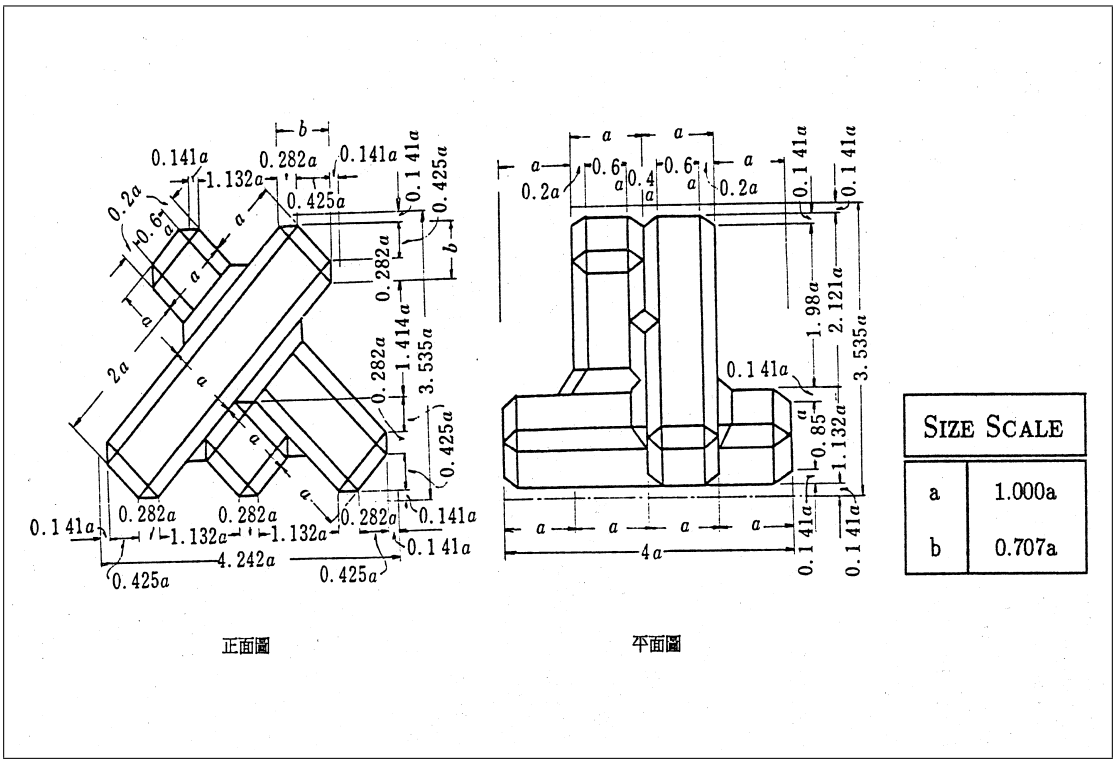


Fig 2.2 (Armor-1). The shape and size of the tri**B**ar.

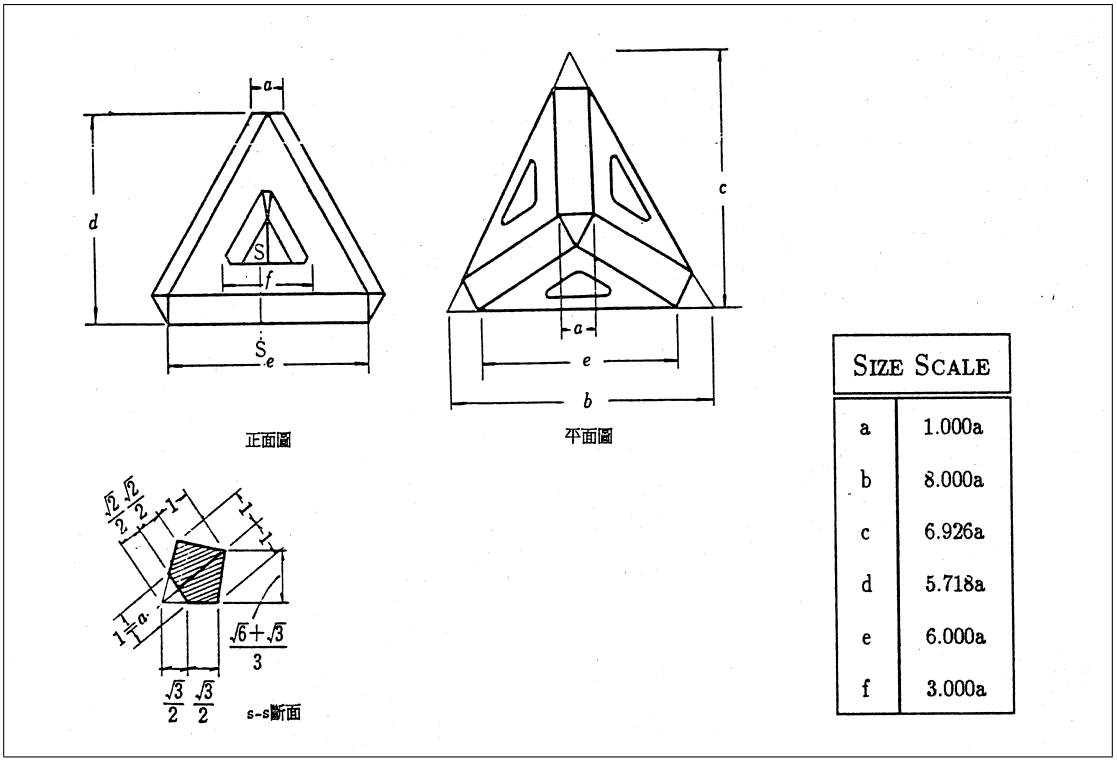
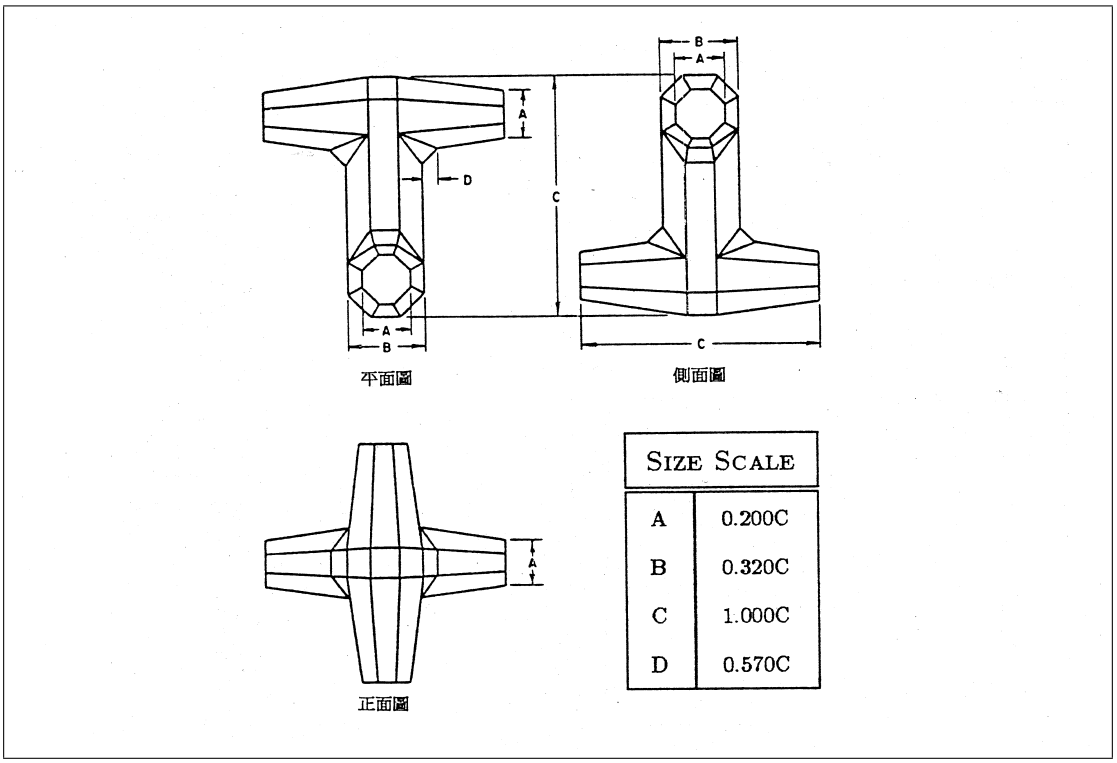
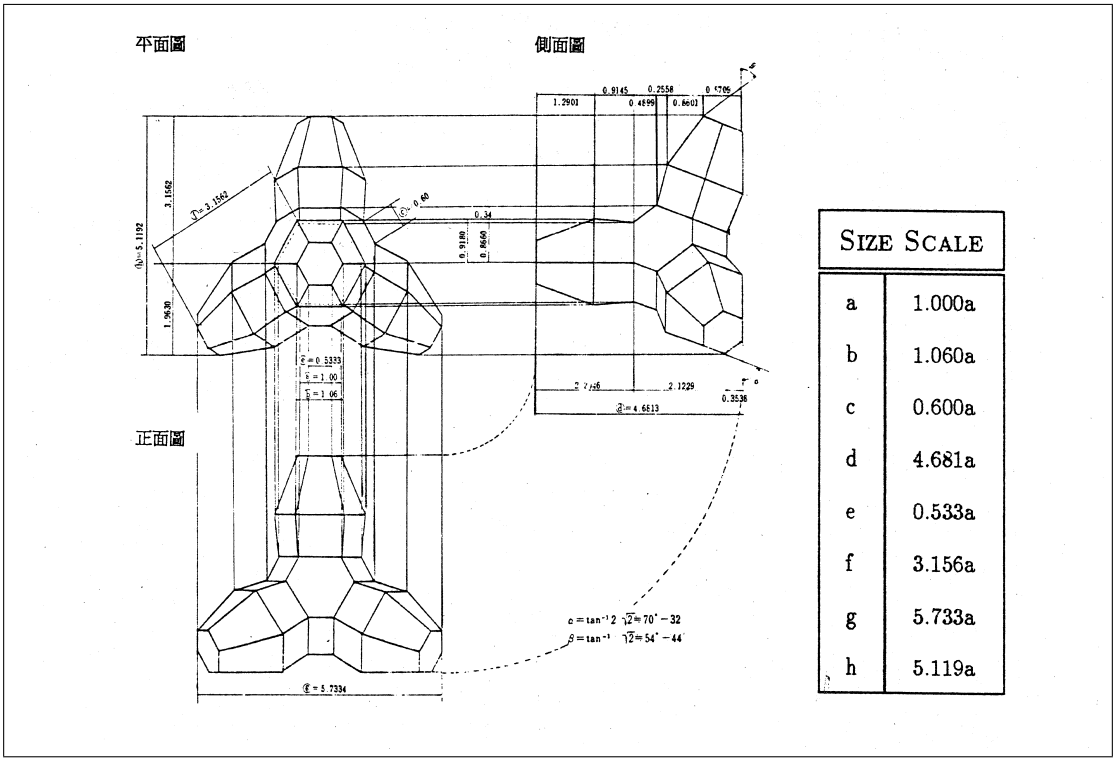


Fig 2.3 (Armor-2). The shape and size of the tetrahedro**N**.



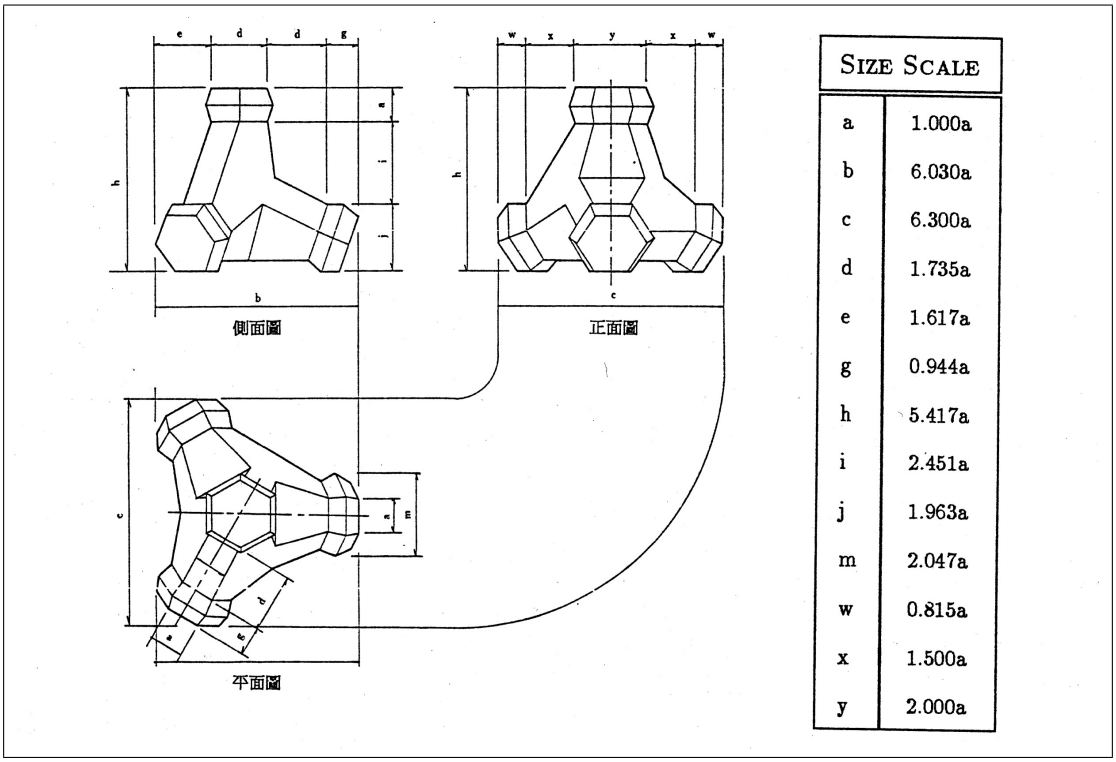
SIZE SCALE	
A	0.200C
B	0.320C
C	1.000C
D	0.570C

Fig 2.4 (Armor-3). The shape and size of the **D**olos.



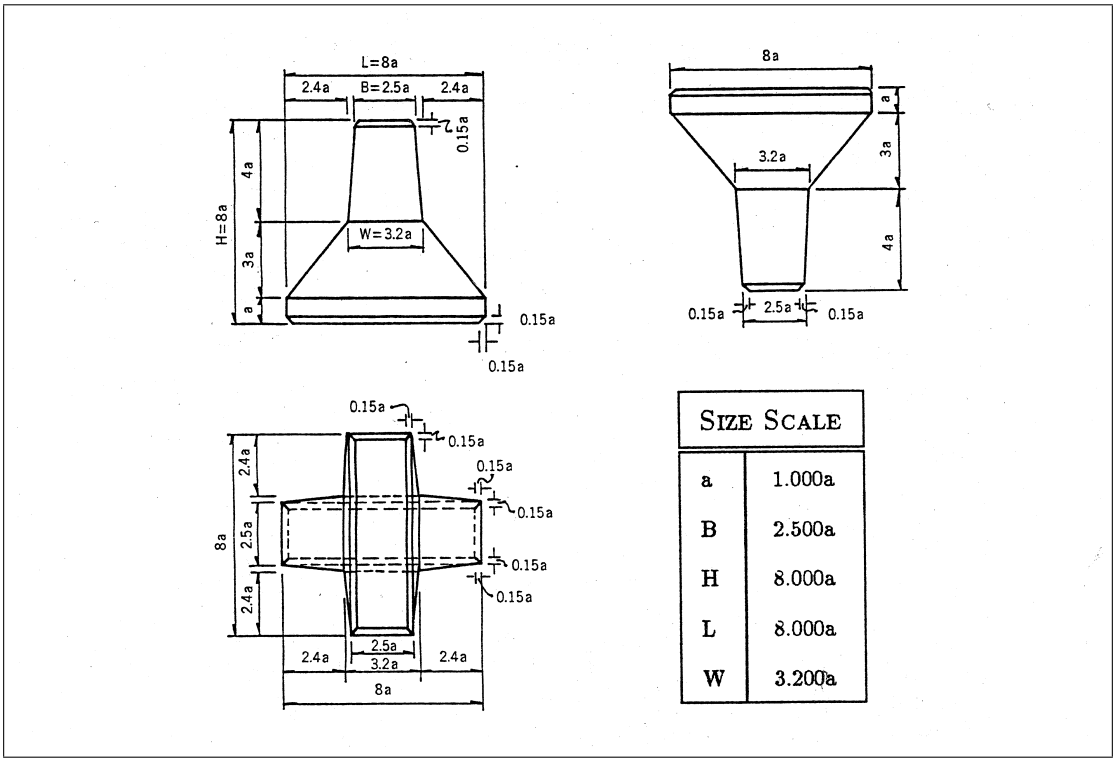
SIZE SCALE	
a	1.000a
b	1.060a
c	0.600a
d	4.681a
e	0.533a
f	3.156a
g	5.733a
h	5.119a

Fig 2.5 (Armor-4). The shape and size of the **S**hake.



SIZE SCALE	
a	1.000a
b	6.030a
c	6.300a
d	1.735a
e	1.617a
g	0.944a
h	5.417a
i	2.451a
j	1.963a
m	2.047a
w	0.815a
x	1.500a
y	2.000a

Fig 2.6 (Armor-5). The shape and size of the **L**inko.



SIZE SCALE	
a	1.000a
B	2.500a
H	8.000a
L	8.000a
W	3.200a

Fig 2.7 (Armor-6). The shape and size of the **A**nchor.

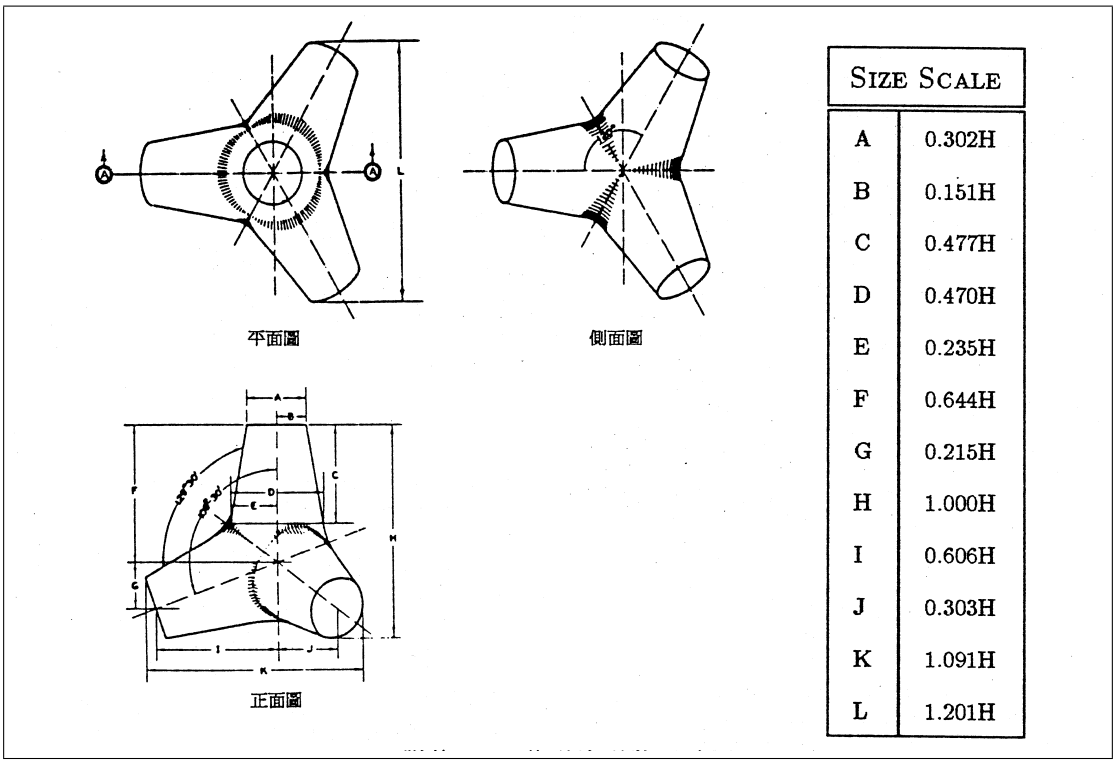


Fig 2.8 (Armor-7). The shape and size of the **T**etrapod.

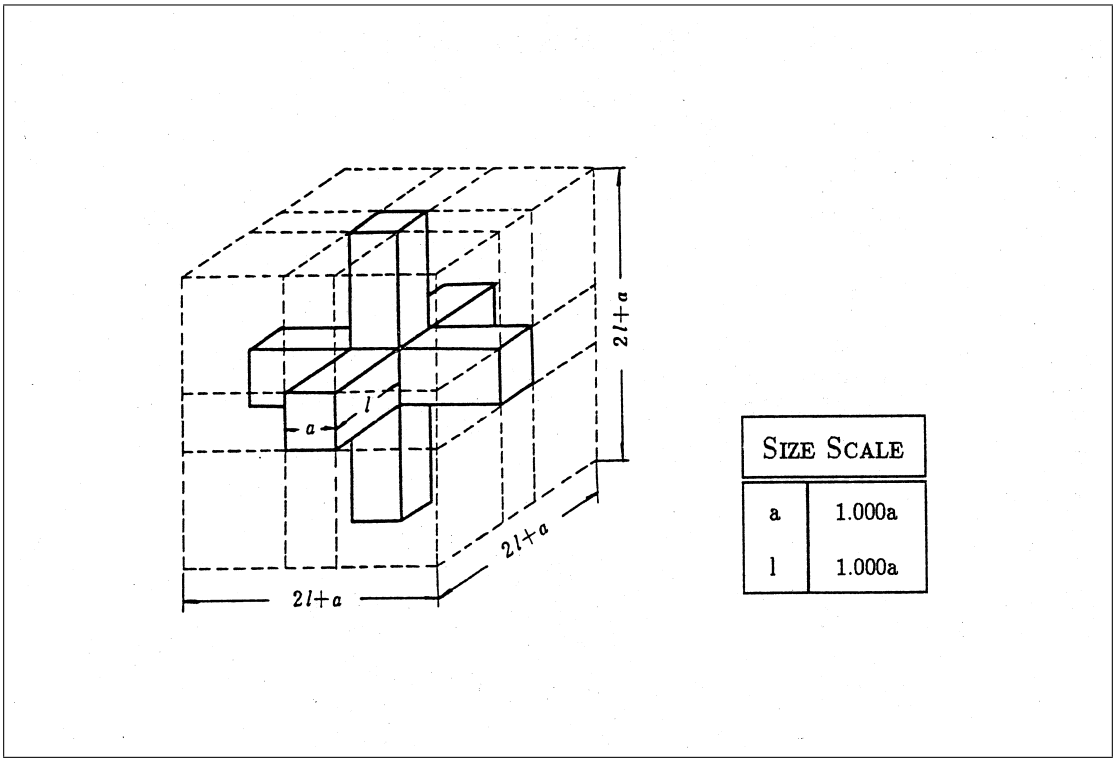


Fig 2.9 (Armor-8). The shape and size of the **H**exapod.

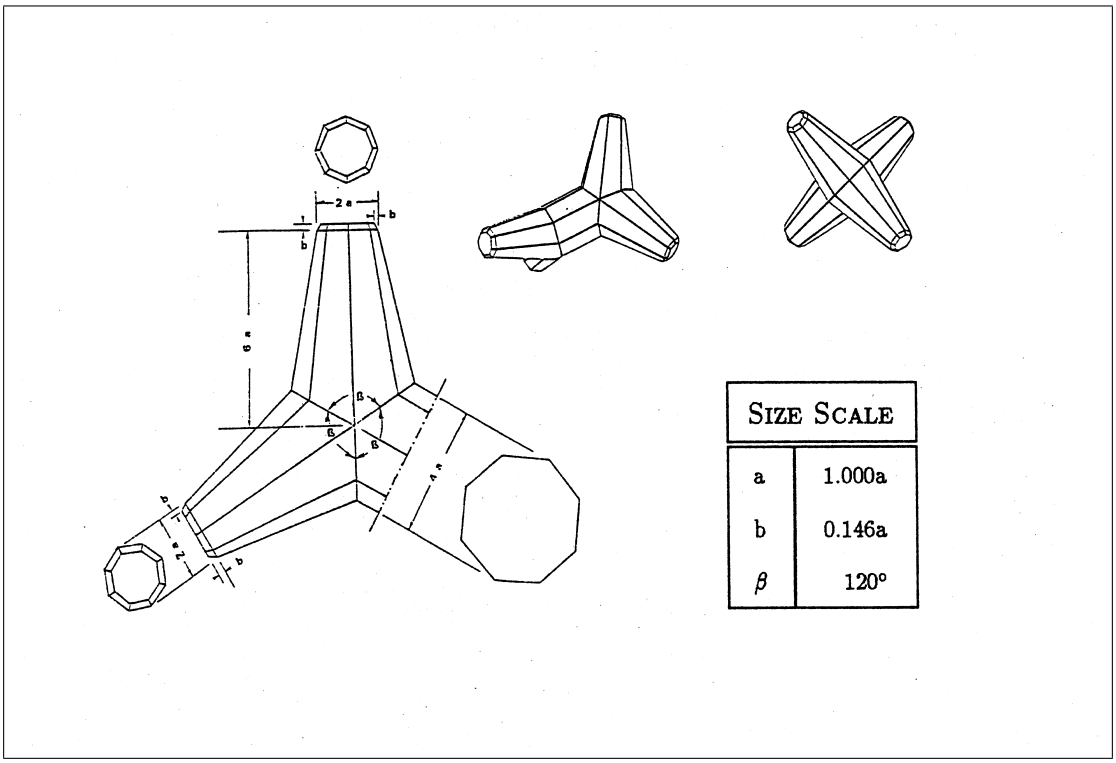


Fig 2.10 (Armor-9). The shape and size of the double-**Y**.

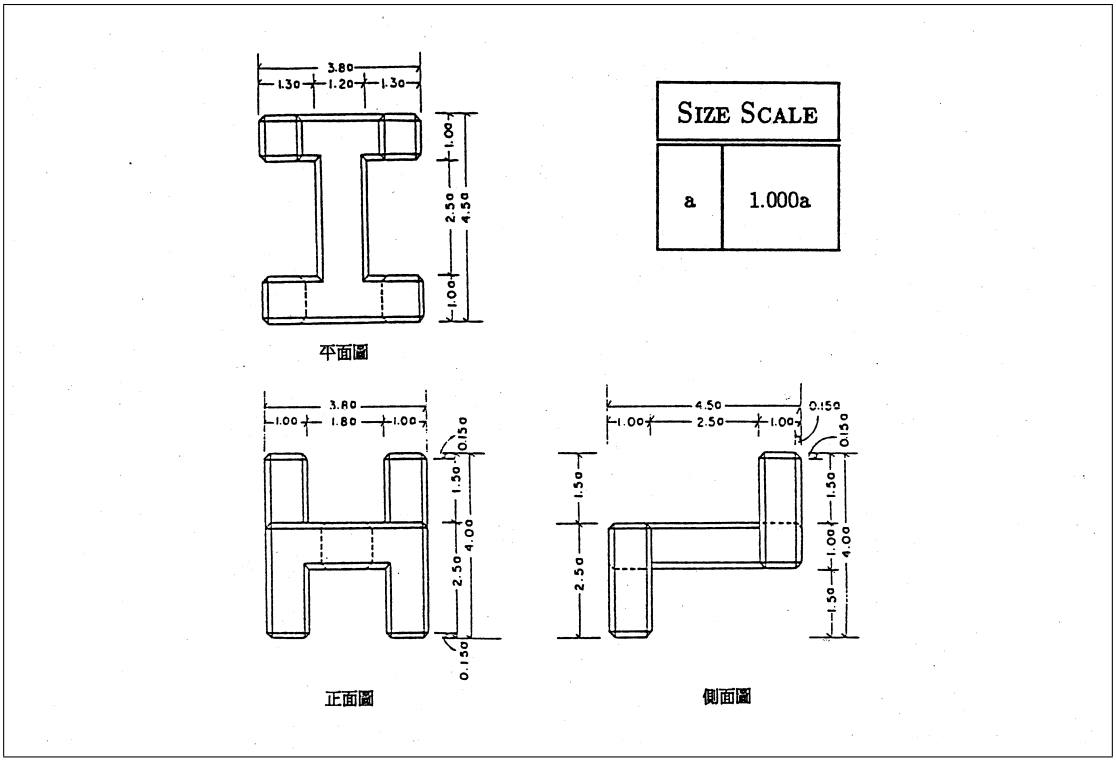
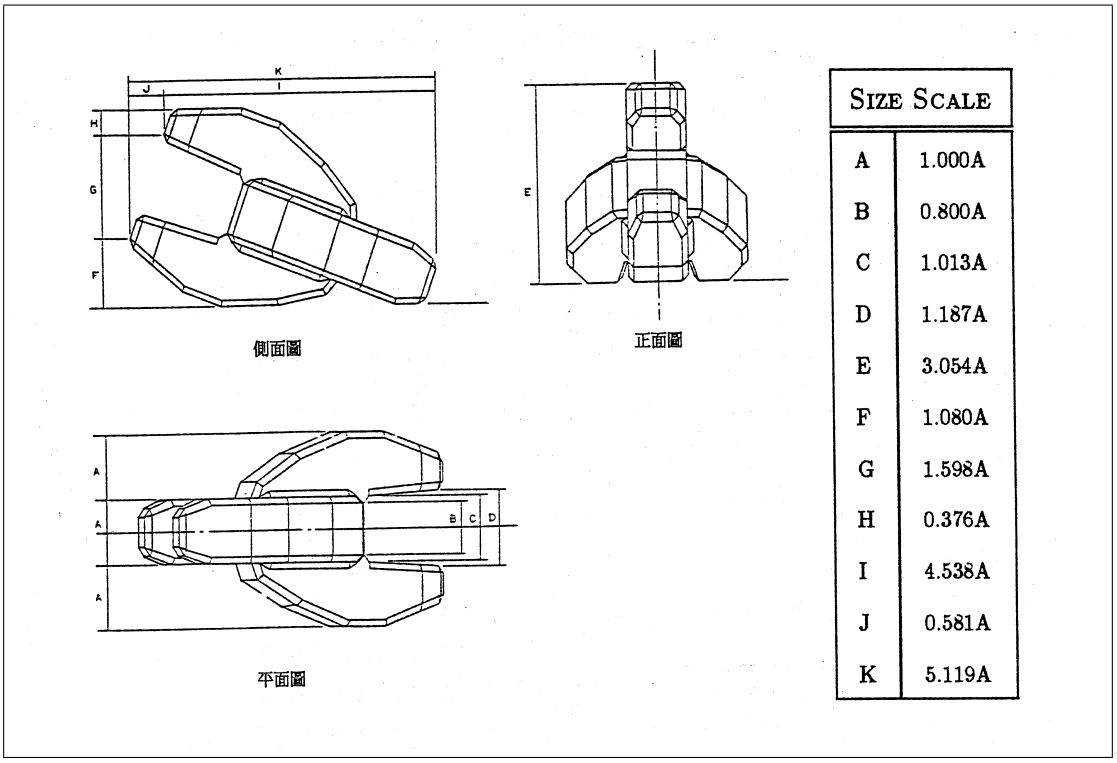


Fig 2.11 (Armor-10). The shape and size of the double-**U**.



SIZE SCALE	
A	1.000A
B	0.800A
C	1.013A
D	1.187A
E	3.054A
F	1.080A
G	1.598A
H	0.376A
I	4.538A
J	0.581A
K	5.119A

Fig 2.12 (Armor-11). The shape and size of the ten-En.

with its impact angle roughly perpendicular to the slope surface. The second is of a partially breaking wave. For this, the impact is like the motion of a water column and it may be intermittent and less severe. The third is of an unbroken wave. For this, the water motion reciprocates up and down the slope. Of the three categories, the first is the most destructive.

Some studies also indicated a specific situation like the following. If there is a horizontal bed in front of the breakwater, the ultimate breaking wave height is somewhat corresponding to that of the extreme amplitude of a partially standing wave. In such a situation, the superimposed wave height of incoming and reflected waves is approximately equal to the water depth, and the position of the breaking is not fixed, so the chance of damage is somewhat probabilistic. However, if there is a sea-bed slope in front of the breakwater, The wave shallows and the wave height grows gradually so as to form a wave height larger than the water depth and the wave breaks at the breakwater and causes a significant impact.

The aforementioned situations are basically externally induced wave evolutions, still, there are inherent characteristics of wave (such as the period, the height and the sharpness) that have direct influences on impacts. Many studies have hinted that the effect of wave period is quite obvious when the armor cover is in a state of progressive damage or in an advanced stage of damage. But here it is pointed out there are some ambiguities or concerns about the modeling of these situations in experiments, such as the problems related to their conditions of "sustained damage" or "percentile damage" as will be discussed in section 4.4. And some researches also pointed out that such damage is especially apparent when the breaking of long period wave somewhat coordinates or resonates with the pace of wave run-up and run-down, especially when the incoming wave coincides with the run-down retreat at its lowest point. In such a condition, the impact and suction forces take place simultaneously and the most dangerous coordinated actions occur (Bruun and Gunbak, 1976 [4]). According to most of the available reports with such experiments, the wave periods adopted are generally within 1.2 to 2.0 second.

Additionally, concerning the repeated back and forth reflections in the laboratory, some researches hinted the possibility of making waves intermittently like a series of bursts. But the intermittency is only possible for regular waves and not for irregular waves.

Moreover, a few researches emphasized that the damage or displacement of the covering armors is often progressive, and the durations of wave action in their tests were thus set to those lengthes at which the covering layer reached a further stable situation or when the armors stopped their further motions. However, it too should be pointed out that the significance of these tests could only be gained when the true incident waves had been tackled in their data acquisitions and analyses.

For the present study, we have the three comparison subjects to work on and the above breaking situations will not be the focus (and basically not relevant and did

not happen). And in the experiments, both regular and irregular waves will be tested and the wave parameters encompass four wave periods (or significant wave periods) and various wave heights (or significant wave heights) as to be detailed in the next chapter.

Figures 2.13 (Layout) and 2.14 (BW Profile) show the cross section of the breakwater and the tank layout. Their relevant metrics are determined based on the following considerations: the tank size, the capability of the wave maker, the sizes or weights of model armors, the simulation of the wave action pattern, the possible difficulties in observations and labors, etc. The model armors' weight is chosen to be not too heavy so as to allow easy observations of damages and not too small so as to avoid distortion from scale effects. Major layout metrics are: the water depth in front of the breakwater is 30 cm, the slope of the sea bed near the breakwater site is 1:20, the distance of the far-field wave gauges are about 25 meters from the breakwater, the distance of the near-field wave gauges are about 3.5 meters from the breakwater, and the chosen slopes of the breakwater are 1:1.5 and 1:1.2. The 1:1.2 slope is a steeper than the maximum practical slope, but it is chosen intentionally for comfortable jurisdictions on damages, as well as for possibly clearer comparisons.

2. **Wave incidence angle**

   Intuitively, waves that approach perpendicularly to the breakwater inflict the most direct impacts since waves that approach obliquely endure a relatively mild slope on the breakwater surface and a partial refraction may also evolve. Therefore, one is likely to think that the case of oblique incidence is less prone to damage, but it is not always the case. The 1:2.0 slope tests on dolos by Whillock (1977 [29]) pointed out that the stability of the armors decreases from a perpendicular incidence angle (0°) to an angle of about 45° (his earlier report gave it as 60°), and thereafter increases rapidly. For these obliquely incident waves, a lateral flow is created and the damage phenomenon may be linked to the enhanced water flow due to the coupling effects

of wave run-up. Under such condition the high drag force may be the culprit. And for usages in rivers, the primary concern is the drag force.

An armor may be directionally uneven in its shape and size, and such directionality may be more obvious when the armors are placed on the slope surface or arranged in a particular pattern, therefore, when there are oblique waves, special considerations and additional experiments are often needed. For our experiments in flume there is no involvement of the oblique incidence.

3. **Irregular waves**

Most of the available experimental studies on armors have been associated with regular waves; cases of irregular waves are rare and limited. In cases of irregular waves, additional problems that arise include: the type of spectrum, the effects of wave groupness, no easy separation of incoming and reflected waves, the choice of a statistical characteristic wave height that has the most significant implication of the design wave (currently, various choices from $H_{1/3}$ to $H_{1/20}$ exist), etc. The wave grouping effect means that high amplitude wave heights consecutively occur one after another in a wave train and thus cause more serious damage. And the grouping phenomenon involves both the wave height spectrum and the phase spectrum. That is to say, even with the same power content, the time history of the wave train may vary and affect the damage phenomena, and this factor is not easily simulated. Furthermore, without separating the incident and reflected waves, the data analyses will yield meaningless results. In the present study, all the analyses are based upon the substantive, as well as the most realistic, incident waves calculated through the spectral wave separation method (Goda and Suzuki, 1976) to be detailed in section 2.4. And since all the comparisons fundamentally depend on the true incident waves, the wave separation process establishes the foundation for all meaningful comparisons. Together with thoughtful planning and precise implementation, it is hoped that the randomness that appeared in existing literature could

be greatly eliminated and various propensities yielded here could behavior in reasonable and linkable manners. Noted that, for the irregular waves, there will only be the comparison on the reflection coefficient; and for the regular waves, all three comparison subjects will be covered.

By the way, after finishing the placement of the armors on the slope, a wave train of small height will be initiated before the formal test routine, and this is to simulate a pre-consolidation action and to avoid possible bias.

2.2.3 (C) Factors related to the breakwater structure

The three main constituent parts of a rubble mount breakwater are the armor covering, the underlayer of the armors and the inner core. These parts and possibly the relevant structural configuration, interact with each others. In this study, we adopt the typical three-part rubble-mound breakwater as proposed by the "Shore Protection Manual" since this entity has been investigated most and has the practicality in engineering and also the better understanding in its hydraulics and functionalities. Stray test conditions or unrealistic modelings are vexations and should be fundamentally nullified. Figure 2.14(BW Profile) shows the cross section of the breakwater. Here we list two major influencing factors related to this.

1. **The underlayer of the armors and the core of the breakwater**

   The natural rocks or blocks used in the underlayers and the core of the breakwater must be able to interlock properly among themselves and between their adjacent layers. And they must also be able to prevent any loss of material during their service life. A proper distribution of porosity and water permeability of these elements may have a positive contribution to the overall stability of the breakwater since there will be reduction of lifting force during the impact, as well as the possible reduction of drag forces by the currents. So, if the breakwater body is completely impermeable or the main structure is supported by a concrete wall, or there is an

impermeable slope under the armors, their test results will likely be different from those studied here. According to the experiments of Timco and Mansard (1984 [28]), if the core of the breakwater is impermeable, the damage will occur quite easily.

According to the CERC specification, the thickness of the underlying stone layer must be at least two layers thick, and the size of the stones must be between $W_c/5 \sim W_c/20$. Depending on the value of K_D, a proper size adjustment may be taken. For a higher K_D value, one may choose larger stones, like $W_c/5$; conversely, a small K_D may choose small ones, like $W_c/10$. And according to the experiments of Carver and Davidson (1978 [6]), for stone sizes within the above range, the stability shows little variation or basically remains the same. As for the core of the breakwater, the size of the stones should be $W_c/4000 \sim W_c/200$. And according to Timco (1984 [28]), as long as the model scale is appropriate, the influence of the permeability is not obvious, but, when the model scale is too small, damage is likely to happen for small permeability. The empirically oriented visual stone size or apparent size (or the sieve size) D for the underlayer and the core of the breakwater is given as the following formula:

$$D = 1.15\frac{W_r}{\gamma_r}, \tag{2.5}$$

in which W_r is the weight of stone and γ_r is the specific gravity of stone (about 2.65). For our tests, the weight of the underlayer stones is chosen as $W_c/5$ and the weight for the core also meets the above requirements. And smashed or crushed stones are used for these.

2. **toe berm**

   The toe berm is to avoid the edge phenomenon of both the armor layer and the underlayer since blocks or armors at the bottom of the breakwater are less interlocked and have a reduced stability, especially, when they are located within the range of obvious wave action.

The size of the toe berm stones and their covering range quite often are determined by experiments. The general reference values are: weight of the stones between $W_c/5 \sim W_c/10$, minimum berm width 3 stones, and minimum berm height 2 stones. In our model setup, a sudden drop of the fixed concrete sea bed at the site of the breakwater is adopted. Initially, its purpose is to provide the possibility of the simulation either for a destructible toe berm or a stable one. But, for the present setups and wave conditions, the toe berm is basically out of the range of major wave impacts, and literally, noticeable initial movements near the toe berm did not happen. The relevant detail is shown in the cross section figure and there is no further investigation on this.

2.2.4 (D) Factors otherwise

1. **Scale**

   The scale relationships for the tests are mainly determined by the Froude's law but the Reynolds' number must also be checked. When the Reynolds' number is too small, the relative magnitude between the impact forces and the drag forces may be distorted. That is to say, a too small scale will pervert the experiments. Sollitt and DeBok (1976 [25]) pointed out that a too small Reynolds' number yields a too conservative design of the armor layer for the prototypes. In the meantime, the height of the breakwater is likely to be underestimated since a tiny scale introduces not only high drag forces but also the impermeability effects. Here the impermeability enhances the up-lifting forces of the impact reactions of the incoming waves and thus decreases the stability of the armors. Moreover, a high drag force reduces the travel distance of run-up in the tests.

   The Reynolds' number R_N for the present modeling is generally given as

$$R_N = \frac{\sqrt{gH_D}k_\Delta(W_c/\gamma_c)^{1/3}}{\nu}, \tag{2.6}$$

where ν is the kinematic viscosity of water. For temperature of $20°C$ the ν is about $0.10\,\mathrm{cm}^2/\mathrm{sec}$; for $0°C$ it is about $0.18\,\mathrm{cm}^2/\mathrm{sec}$. The minimum value to avoid the scale effect, as suggested by Hudson (1975 [16]), is $R > 3 \times 10^4$. While according to Thomsen et al. (1972 [26]) and Sollitt and DeBok (1976 [25]), it is suggested that $R > 3 \times 10^5$. Figure 2.15 $(N_D \sim R_N)$ shows the scale effect of Reynolds' number on the non-dimensional stability number as used by them (in the figure, its formula is different from the above equation by a k_Δ, but in general k_Δ is close to 1). It can be seen that the stability number N_D needs to be corrected when the value of R is less than what they suggest.

In fact, for some modeling tests like here on armors, the scaling concern is basically not about a predetermined scale value or a certain fixed armor size (i.e., the λ value in table 2.1 (M/P ratios)). What is important is the practical situations both in the model and in the corresponding prototype, that is to say, the proper simulation of physics is the key point. Simply put, it doesn't make much sense to predetermine the scale (or λ), but rather, when the weight or size is chosen, one can reference upon the test parameters and find the possible corresponding prototype range. Conversely, once the prototype parameters are known one may check the authentic or meaningful range of the modeling scales. The above statement indicates that the test results here can be applied to different prototype situations if relevant field conditions (such as waves) are justifiable. In the tests here we do not provide a scale value, rather, we simply specify the weight of the model armors (or the sizes, but the weight is an easier and more direct choice since each armor type has its own length dimensions) and check the corresponding Reynolds' number. The weight of the unit armor adopted here is 150 g for all the armor types. Roughly speaking, this weight tends to be near the low end of armor modeling, but its Reynolds' number meets the requirement and it has the feasibility in molding and casting.

2. **Damage criteria**

The design wave height H_D that appears in Hudson's stability coefficient formula (equation 2.1) inherently involves one's understanding of a certain (or chosen) standard of damage. Such a concern is basically related to the definition of "the damage". And bearing on this is "the percentage of damage". But the percentage count is still related to the degree of activity and the statistical covering area. It is therefore required first to define an active zone of damage for meaningful statistics. Moreover, the damage may be related to the rocking, the moving, the displacement, or the removal, etc. According to Jackson's definition, as given in the Shore Protection Manual (1985 [10]), the statistical zone covers a range from the middle line of the top of the breakwater to the water depth equal to the design wave height. Another zone definition suggested by Zawnborn (1978 [31]) is $\pm 1.5 H_D$ vertically above and below the water surface. Additional concern in experiments is the influence of the side wall of the tank, since there is no interlocking on the wall.

Observations from past studies indicate that perceivable damages happen in the region $\pm H_D$ above and below the water surface, with the most serious damages occur near the water surface. Furthermore, in reference to the Shore Protection Manual, the so-called stability coefficient K_D refers to the design wave height that is corresponding to the condition of the no-damage criteria, and what is even more perplexing is that the so-called no-damage criteria is a specification that covers a rate range of the armor destruction percentage (referring to shaking and moving) varying between $0 \sim 5\%$ (i.e., less than 5% rocking or displaced). Again, this may also be the cause of the scattering among the results of existing researches.

3. **Trunk or tip position**

   In general, at the tip or end of a breakwater the wave and current conditions are likely to be complicated and the armor covering is prone to damages due to severely harsh circumstances. Moreover, at the tip, the mutual positions and the interlocking among the armors may be different from those located in the trunk section. In such

a case, special considerations and additional tests may be needed. For our tests in flume, this factor is excluded.

The above itemized list of influencing factors somewhat explain the multitude of difficulties faced with the determination of the stability coefficient K_D. Figure 2.1 (K_DFactors) gives the concise list.

Next let us recite a somewhat traditional method for the determination of stability coefficient that is related to the stability number N_D. And the method is to test the armors under different surface slopes of the breakwater and the N_D is calculated as

$$N_D = \left(\frac{\gamma_c}{W_c}\right)^{1/3} \frac{H_D}{S_c - 1}. \tag{2.7}$$

When all these data of N_D and slopes $\cot\theta$ are put into the dual logarithmic coordinates, a straight line is then drawn underneath all the points, such that $N_D = (K_D \cot\theta)^{1/3}$ represents the line. And the value of K_D can then be determined by the intercept of the line. Here it is mentioned that the straight line with the power of $1/3$ is often not the most approximate straight line. But, according to the Hudson formula, K_D and θ have been separated (or appear separately), and therefore the two should be independent with each other when determining the suitable weight of the armor. For this, there is controversy deserved to be investigated.

Overall, it is not difficult to understand the complexity and subjectiveness involved when determining the stability coefficient of an armor covering, let alone making any comparison among existing studies. Fundamentally, we are faced with the lack of measurement techniques, no satisfactory way of testing, no standard criterion, no commonly accepted rule in making damage judgement, etc. In short, a well received study on this is basically unavailable. Therefore, some people fall back to an intuitive way for making the comparison, and it is named as “the modes of failure (or failure zones)” method. Though somewhat more subjective and intuitive, the method is relatively straightforward in classifying the stability performance of an armor type, and it directly attributes the movement

or damage phenomenon to the wave height based on its relative magnitude to the design wave height (Paul and Baird, 1971 [22]; Bronson et al., 1974 [3]; Ouellet, 1976 [21]). They even regard that the relationship between wave height and damage mode is more meaningful or useful than the relationship between K_D and damage rate. Table 2.2 (D-Modes) lists the modes of failure and the corresponding ranges of wave height, and there are 5 categories in its classification.

Destruction Mode for the Armor Stability

Category	Phenomenon	Corresponding Wave Height ‡
Level 1	No action of armors	$0 \sim 0.5H_D$
Level 2	Partial action without displacement	$0.5H_D \sim 0.9H_D$
Level 3	A few units dislocated but still stable	$0.9H_D \sim 1.5H_D$
Level 4	Continuous displacement with eventual destruction of covering slope	$1.5H_D \sim 1.8H_D$
Level 5	Instant or rapid complete destruction	$1.8H_D \sim$

‡: The corresponding wave height is a relative value with reference to the non-destructive design wave height H_D.

Tab 2.2 (D-Modes). The modes of failure and the classifications of armor movements.

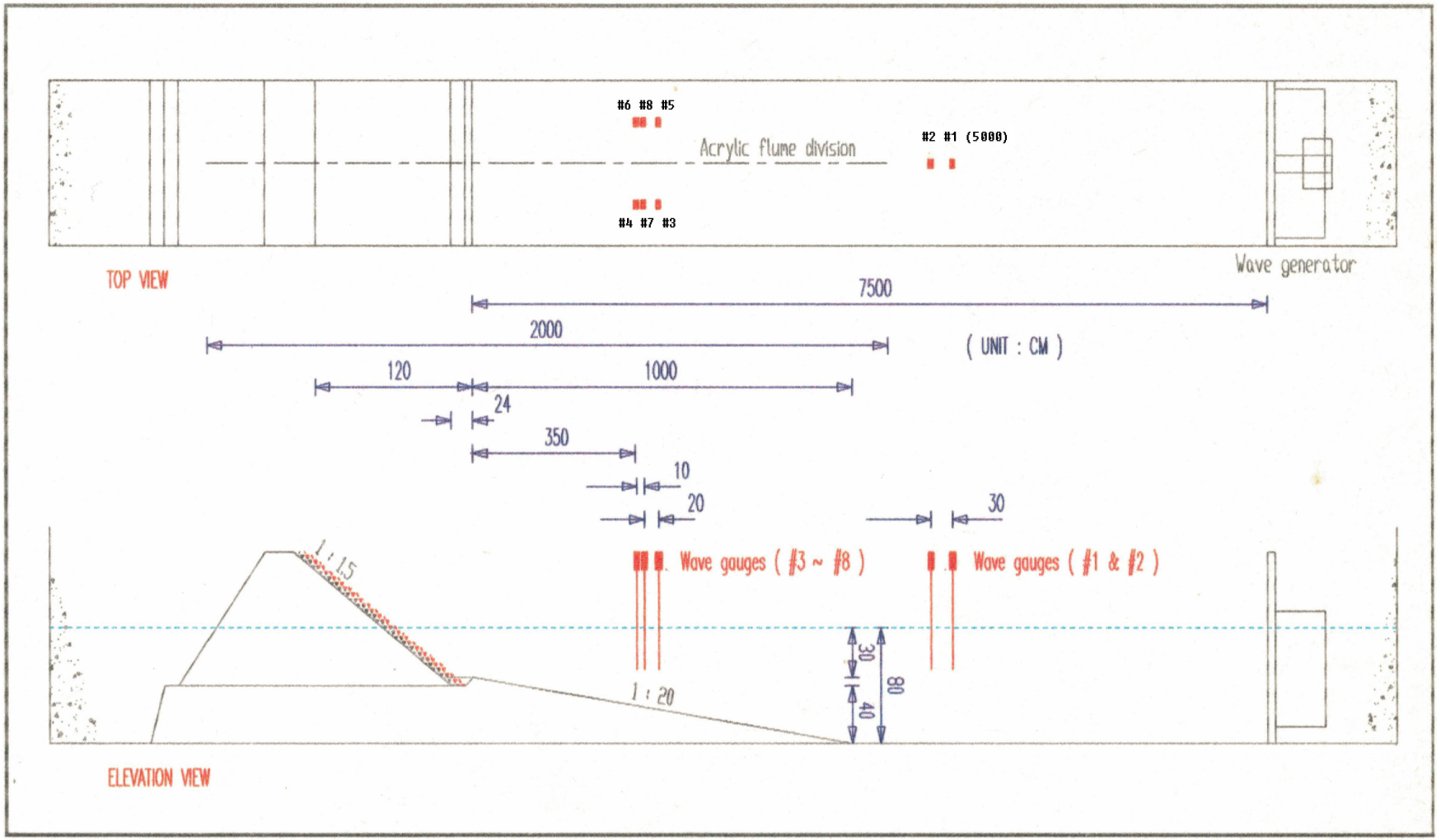


Fig 2.13 (Layout). Layout of the test flume.

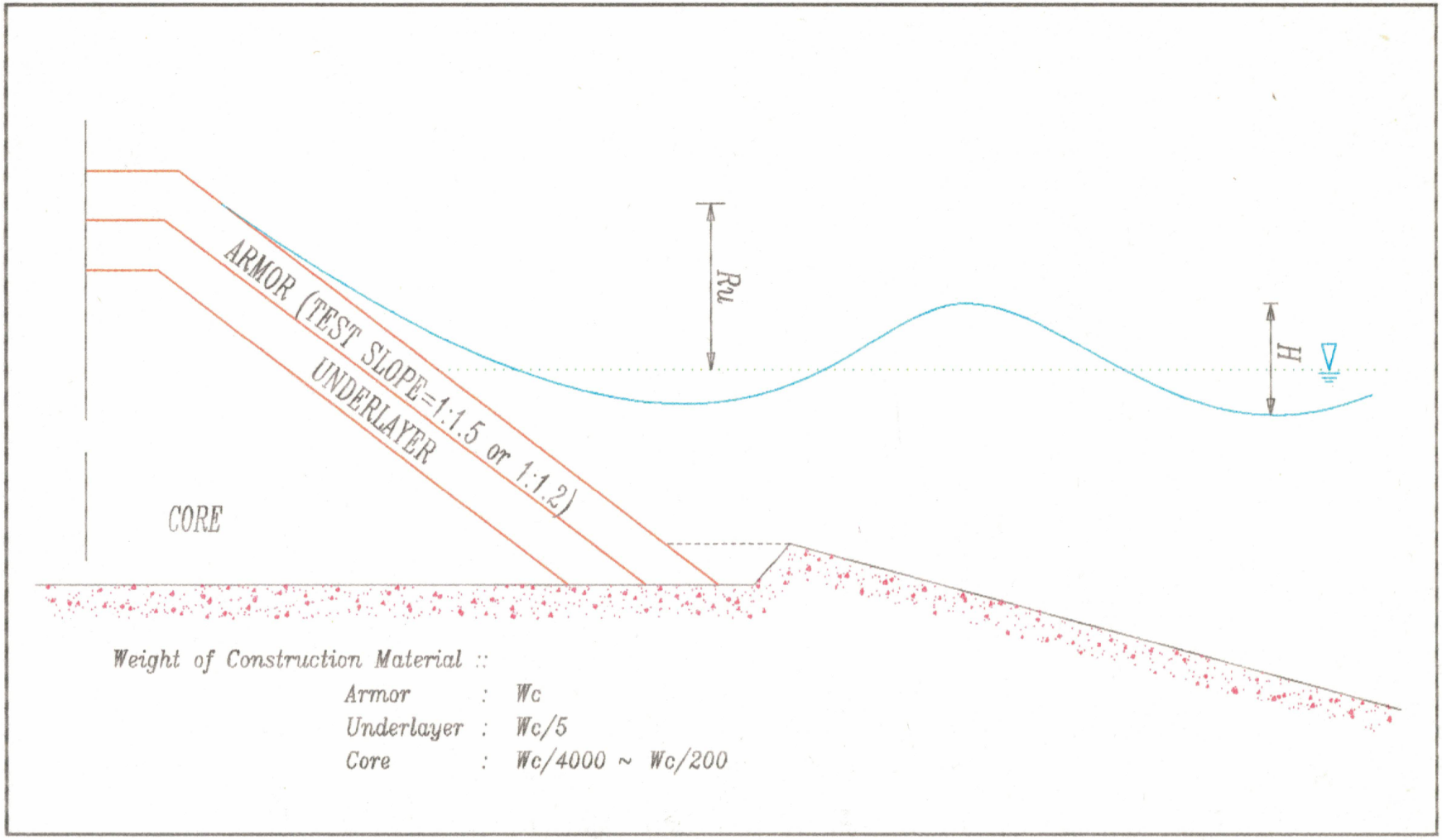


Fig 2.14 (BW Profile). Cross section of the breakwater.

2.3 Wave run-up and run-down

The vertical height from the still water level to the top of the breakwater is the freeboard. And the freeboard is mainly determined by the wave run-up or by the functioning purpose of the breakwater. Most of the influencing factors listed in the prior section also play a role on wave run-up and run-down. Major factors among them are: the properties of the incident waves, the topography of the sea bed, the water depth at toe, the environment of the breakwater and its relevant structures, the characteristic of the armor layer (such as shape, roughness, packing, porosity, arrangement pattern), etc.

Due to the many factors involved, the proportional contribution from the armor itself to wave run-up and run-down can hardly be isolated or separated from other influences, and each situation may need its own case study. Again, the performance comparisons in this aspect are basically unavailable from existing studies which are associated with different authors and different settings. Ideally, the comparison can only be achieved under the same test condition and implemented by the same examiner. Although the results here should also be attributed with the situation of a peculiar setting, but with the same test layouts under the same well controlled implementation, hopefully, one might be able to grasp the comparative features of wave run-up run-down for all the armors, and possibly, gain their relations with the performances in other comparison subjects. Note that, if there is an over-topping of waves or the armors are under the action of reverse incident waves (such as the condition of a submerged dyke), the performances of the armors need to be studied separately. Another practical design consideration is to avoid the in-tune or co-resonance between the occurrence of collapsing-plunging breaking of waves and the wave run-up run-down. This is to ward off the possibility of a combined impingement related to enhanced impact forces and strong water flows. But in the tests here there is no anticipation of overtopping and breaking.

The relative wave run-up and run-down are generally defined as $\frac{R_u}{H_o}$ and $\frac{R_d}{H_o}$, respectively, in which R_u and R_d are the vertical distances between the still water level and the

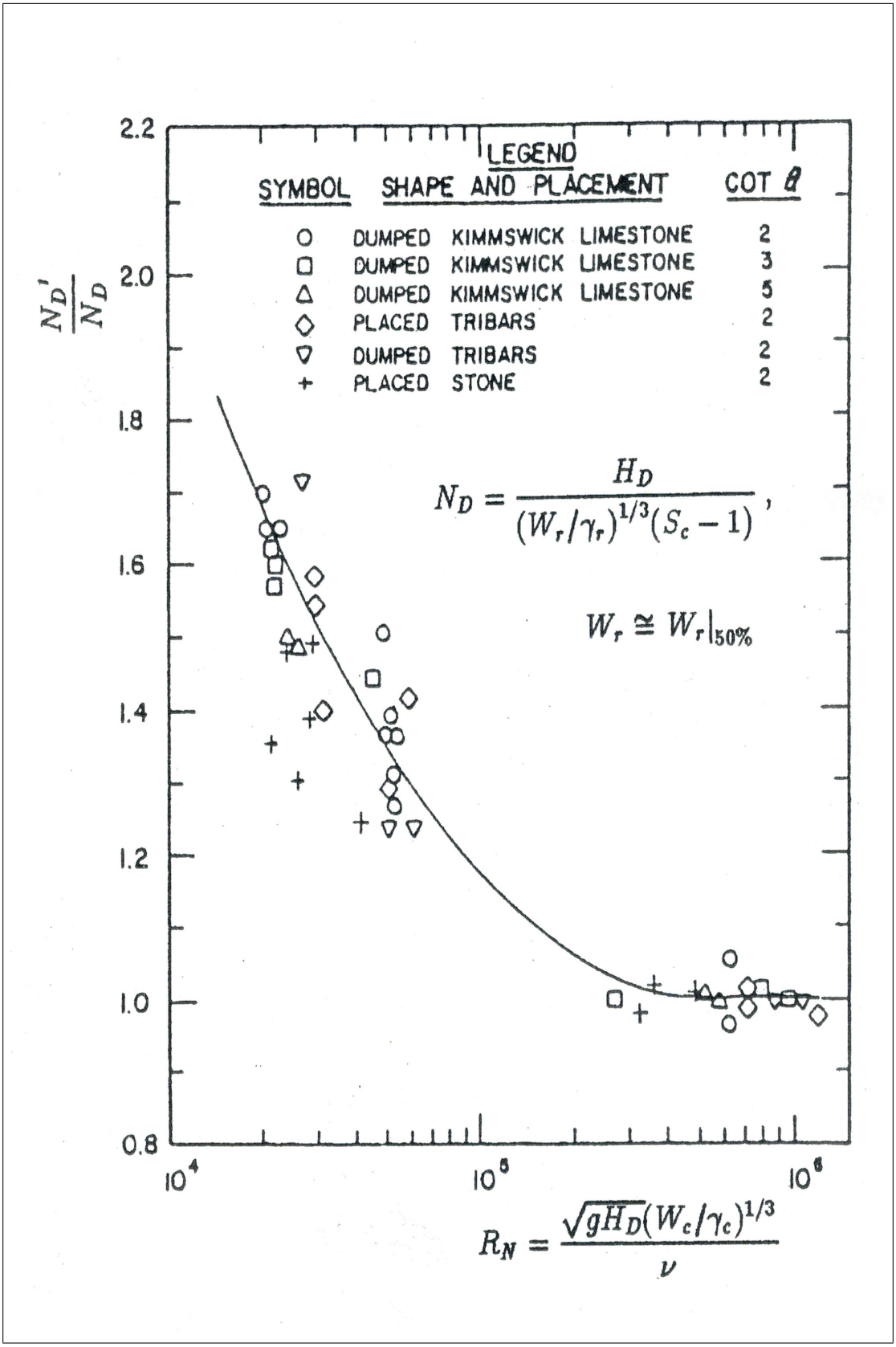


Fig 2.15 ($N_D \sim R_N$). The relation between the Reynolds' number and the stability number N_D (Thomsen et al. (1972 [26]) 、Sollitt and DeBok (1976 [25])).

highest and lowest water levels of the waves, respectively, on the breakwater slope, and the reference wave height H_o refers to the incident wave height at the far-field (sometimes the reference wave height is taken as the wave height at the breakwater location prior to the existence of the breakwater). In reference to the Shore Protection Manual, the maximum value of the run-up distribution curve is about 1.1 for a permeable rubble mount breakwater with a slope of $\tan\theta = \frac{1}{2}$ and with a on-site water depth of 3 times the deep water wave height. In our tests the two adopted slopes are steeper than the $1:2$, therefore, it is anticipated that no overtopping will be observed for all the tests. And based on the following considerations the wave run-up run-down will all be visually observed through the glass walls and all the observations will be done by the author. (a) There is the unevenness of the armors on the slope. Besides, the run-up and run-down are defined in the gravitational direction. (b) There is no control of the gap between the gauge and the armors when the gauge is placed along the slope covering. Furthermore, since the angle of intersection between the run-up (or run-down) water and the measuring device is extremely small (the two lines are almost parallel), there is a serious concern of error. (c) Splashes may occur and correct measurements may be difficult. (d) Placing the gauge upon the armor surface inevitably affects the movement of armors and the phenomena of damage. (e) The lengthes of the wave gauges in our inventory are shorter than that required. Accordingly, no attempt of gauge modification is made.

Also note that, at that 1990 era, no camcorder was available for us and video in digital format did not exist in the mind.

2.4 Wave reflection coefficient

The reflection coefficient manifests the effectiveness of energy damping of waves by the armors and it pertains to the maneuvering of ships, the calmness of an enclosure, the transport of sediments, the change of seabed topography, etc. Among the influencing factors mentioned in the section on stability many also play a role in the reflectivity performance

of the armors. Externally, the main factors are the intrinsic nature of the wave, the configuration of the structure, the underlayer, the terrain and topography, etc. Internally, they are the specific elements of the individual armor and the placement pattern, such as shape, porosity, permeability, roughness, interlocking pattern, etc. For tests in laboratory, the scale effect may also be a consideration since, when the scale is too small, the viscous energy dissipation may be larger and the hysteresis effects reduce the reflectivity.

Although these many factors still exist, the reckoning of performance comparison for the subject of reflectivity shall be of the least concern among the three comparison subjects; since, not only there is the non-subjective and completely scientific method based on the theory of wave separation, but also there are thoughtfully optimized and fully computerized implementations both in tests and analyses. We will come to realize that the degree of confidence (or the representativeness) on the results of the reflection coefficient is far superior than those on the stability coefficients and on the wave run-up run-down. Still, it must also be emphasized that the results of the stability coefficients and the relative run-up run-down are fundamentally dependent on the exactness of the incident wave statistics, and that exactness can only be obtained by the proper wave separation processing.

An earlier method to calculate the reflection coefficient is the spatial waveform envelope method by Healy (1952 [14]), in which one needs to find the maximum and minimum amplitudes of the envelope of the waveform. For the method, the difficulties and disadvantages that can hardly be overcome are: (a) The positions where the maximum and minimum envelope amplitudes occur quite often drastically vary with different incident waves, and the incurred test procedures are extremely cumbersome and laborious. (b) Even the initial conditions of the incident waves are the same, the relevant measurement positions are likely to change for dissimilar structures or different terrains. (c) The minimum amplitude is quite sensitive to the deviation of the position of measurement, and large errors befall when these values are small. (d) The method is applicable for regular waves only.

Here in our tests both regular and irregular waves are adopted and there are the same lots of wave conditions for each armor type and the two breakwater slopes. Without an automatized approach both in experiments and analyses, it will certainly be an unthinkable task. And the difficulties of the task is overcome through the adoption of the wave separation method as given by Goda and Suzuki (1976 [13]) and of course through the unified and optimized implementations of experiments and analyses. For the Goda and Suzuki method, there is no troublesome arising from different test parameters and varying layouts. The wave gauge positions can be kept at fixed locations for all the tests and no human factors and no unscientific aspects are involved in all the data acquisitions and processing. Furthermore, the length of data points for analysis may cover the whole meaningful data sequence, and there is no concern about the selection or segmentation of data. The method fundamentally gets rid of all the cumbersome associated with the old method in the following regards. Firstly, there is no need of determining beforehand the wavelength of the incident wave, which is possibly varying along its traveling course. Secondly, there is no worry in situating the gauges at tests. Thirdly, there is no need for on-site inspections of waves. Here it is also noted that in some studies the reflectivity calculations might also referred to the method of Goda and Suzuki, but they did not adopted the spectral approach, hence they still encountered some of the difficulties stated above and they did not fit for irregular waves.

Overall, with a fully automatized approach in tests and with a rigorous theoretical foundation for wave data, what is guaranteed is the correctness of the most fundamental and critical element of this study, i.e., the "meaningful and genuine" incident wave data needed for the objectivity and significance in all the three comparisons. Most importantly, enormous time is saved and tremendous manpower is spared.

Following is a brief description of Goda and Suzuki's wave separation method and the relevant formulation is prepared for the coding of the calculation of wave reflection coefficient through the Fourier series approach.

Let the sequence of data points at equal time interval (or the data points sampled at a

fixed rate) be

$$F = (f_0, f_1, f_2, \cdots, f_n, \cdots, f_{N-1}) \qquad n = 0, 1, 2, \cdots, N-1. \tag{2.8}$$

Here f_n may be real or complex. According to the discrete Fourier transform, the element in the series of F is

$$f_n = \frac{1}{N} \sum_{m=0}^{N-1} \left[f_m{}' \exp\left(mn \frac{2\pi}{N} i \right) \right]. \tag{2.9}$$

in which i is the exponential sign of a complex number or the Euler formula, i.e.,

$$\exp(x, i) = e^{ix} = \cos x + i \sin x, \tag{2.10}$$

and the $f_m{}'$ is the element of the series of the Fourier transform F' of F, i.e.,

$$F' = \left(f_0{}', f_1{}', f_2{}', \cdots, f_m{}', \cdots, f_{N-1}{}' \right) \qquad m = 0, 1, 2, \cdots, N-1, \tag{2.11}$$

$$f_m{}' = \sum_{n=0}^{N-1} \left[f_n \exp\left(mn \frac{-2\pi}{N} i \right) \right]. \tag{2.12}$$

The only difference between equations 2.9 and 2.12 is the plus and minus sign in the exponential forms. Let

$$f_{N-m}{}' = f_{-m}{}' \qquad -m = -\frac{N}{2} + 1, -\frac{N}{2} + 2, \cdots, -1. \tag{2.13}$$

And it can be shown that

$$f_n = \frac{1}{N} \left\{ \sum_{m=1}^{\frac{N}{2}-1} \left[\left(f_m{}' + f_{-m}{}' \right) \cos \frac{mn2\pi}{N} + i \left(f_m{}' - f_{-m}{}' \right) \sin \frac{mn2\pi}{N} \right] + f_0{}' + f_{\frac{N}{2}}{}' (-1)^n \right\}. \tag{2.14}$$

If F is real then F' is a complex series with its real part (Re) belonging to an even function

and its imaginary part (Im) belonging to an odd function. Now we have

$$f_n = \frac{1}{N}\left\{ 2\sum_{m=1}^{\frac{N}{2}-1} f_m{}'\Big|_{\mathrm{Re}} \cos\frac{mn2\pi}{N} - 2\sum_{m=1}^{\frac{N}{2}-1} f_m{}'\Big|_{\mathrm{Im}} \sin\frac{mn2\pi}{N} + \left[f_0{}' + f_{\frac{N}{2}}{}'(-1)^n \right]\Big|_{\mathrm{Re}} \right\}. \tag{2.15}$$

The above is the basic formulation of the discrete Fourier transform to be applied to Goda and Suzuki's method of wave separation as described below.

First, let consider the case of regular wave, for this, the period of the incoming and reflected waves remains unchanged and their wave number and wave frequency are $k = 2\pi/L$ and $\sigma = 2\pi/T$, respectively. And let the water levels, amplitudes, and phase angles of the incident and reflected waves, respectively, be denoted as η_i, a_i, ϵ_i and η_r, a_r, ϵ_r. One has

$$\eta_i = a_i \cos(kx - \sigma t + \epsilon_i), \tag{2.16}$$

$$\eta_r = a_r \cos(kx + \sigma t + \epsilon_r). \tag{2.17}$$

Suppose that the water levels at two adjacent locations $x = x_1$ and $x = x_2 = x_1 + \Delta l$ are individually the superposition of the incident and reflected waves. One has

$$\eta_1 = (\eta_i + \eta_r)|_{x=x_1} = A_1 \cos\sigma t + B_1 \sin\sigma t, \tag{2.18}$$

$$\eta_2 = (\eta_i + \eta_r)|_{x=x_1+\Delta l} = A_2 \cos\sigma t + B_2 \sin\sigma t, \tag{2.19}$$

in which

$$A_1 = a_i \cos\phi_i + a_r \cos\phi_r, \tag{2.20}$$

$$B_1 = a_i \sin\phi_i - a_r \sin\phi_r, \tag{2.21}$$

$$A_2 = a_i \cos(k\Delta l + \phi_i) + a_r \cos(k\Delta l + \phi_r), \tag{2.22}$$

$$B_2 = a_i \sin(k\Delta l + \phi_i) - a_r \sin(k\Delta l + \phi_r), \tag{2.23}$$

$$\phi_i = kx_1 + \epsilon_i, \tag{2.24}$$

$$\phi_r = kx_1 + \epsilon_r. \tag{2.25}$$

Taking the trigonometric expansion of sin and cos for A_2 and B_2 (equations 2.22 and 2.23), one has

$$\begin{aligned} A_2 &= (a_i \cos\phi_i + a_r \cos\phi_r)\cos k\Delta l - \\ &\quad (a_i \sin\phi_i + a_r \sin\phi_r)\sin k\Delta l \\ &= A_1 \cos k\Delta l - B_1 \sin k\Delta l + 2a_r \sin\phi_r \sin k\Delta l, \end{aligned} \tag{2.26}$$

$$\begin{aligned} B_2 &= (a_i \cos\phi_i - a_r \cos\phi_r)\sin k\Delta l + \\ &\quad (a_i \sin\phi_i - a_r \sin\phi_r)\cos k\Delta l \\ &= A_1 \sin k\Delta l + B_1 \cos k\Delta l - 2a_r \cos\phi_r \sin k\Delta l. \end{aligned} \tag{2.27}$$

The two equations above yield

$$\begin{aligned} a_r = \frac{1}{2|\sin k\Delta l|} \Big[&(A_2 - A_1 \cos k\Delta l + B_1 \sin k\Delta l)^2 + \\ &(B_2 - A_1 \sin k\Delta l - B_1 \cos k\Delta l)^2 \Big]^{1/2}. \end{aligned} \tag{2.28}$$

Again, the trigonometric expansions of equations 2.22 and 2.23 can be formulated as the following two equations which only contain a_i. That is

$$A_2 = A_1 \cos k\Delta l + B_1 \sin k\Delta l - 2a_i \sin\phi_i \sin k\Delta l, \tag{2.29}$$

$$B_2 = -A_1 \sin k\Delta l + B_1 \cos k\Delta l + 2a_i \cos\phi_i \sin k\Delta l. \tag{2.30}$$

Hence

$$a_i = \frac{1}{2|\sin k\Delta l|}\Big[(A_2 - A_1\cos k\Delta l - B_1\sin k\Delta l)^2 + (B_2 + A_1\sin k\Delta l - B_1\cos k\Delta l)^2\Big]^{1/2}. \tag{2.31}$$

Now the reflection coefficient is

$$K_r = \frac{a_r}{a_i} = \left[\frac{(A_2 - A_1\cos k\Delta l + B_1\sin k\Delta l)^2 +}{(A_2 - A_1\cos k\Delta l - B_1\sin k\Delta l)^2 +} \frac{(B_2 - A_1\sin k\Delta l - B_1\cos k\Delta l)^2}{(B_2 + A_1\sin k\Delta l - B_1\cos k\Delta l)^2}\right]^{1/2}. \tag{2.32}$$

Theoretically, as long as 2.16 and 2.17 are independent, that is, $\Delta l \neq 0$, or $k\Delta l \neq \pi, 2\pi, \cdots$, the Δl can be any value. However, this situation can only be best fulfilled when the data is completely correct or free of measurement errors. Practically, small $\sin k\Delta l$ should be avoided since it will either reduce the numerical accuracy or amplify the errors related to concerns of various measurement precisions, A simple explanation follows. Although, when seeking K_r, explicitly, the denominator $\sin k\Delta l$ appears both in a_i and in a_r, and therefore they seem to cancel with each other in the final form of K_r. However, implicitly, since the A_1, B_1, A_2, and B_2 are still dictated by a_i and a_r, so the hidden effects of $\sin k\Delta l$ cannot be ignored. For small $\sin k\Delta l$, a small distraction or inaccuracy in measurement is likely to induce sensitive and serious errors. Here the concept is actually the same as that related to trigonometric measurements in engineering. In trigonometric measurements, it is best to avoid a triangle shape that is very narrow or in elongated shape, and it is desirable for the three sides to be about the same magnitude. An even simpler alternative explanation similar to the point above is like the following. Under the influence of errors (either numerically or measurement related), when one wants to find the angle between the two lines of a relatively elongated right triangle from the lengthes of its three sides, it is better to use $\cos^{-1}$ instead of $\sin^{-1}$. According to Goda and Suzuki's

experimentations with regular waves, the suggested range of Δl is

$$0.05L < \Delta l < 0.45L. \tag{2.33}$$

The above formulation for K_r is based on regular wave. For spectral wave, the wave form is regarded as a synthesis of linear superposition of a series of regular waves with various amplitudes, frequencies and phases. If the number of points of the recorded data is N, then the number of Fourier component waves is $N/2$ (say, N is even) since the periods are pairwise symmetric (see the formula 2.14). Assuming that each component wave satisfy the the following dispersion relation:

$$\sigma_n^2 = g k_n \tanh k_n d, \tag{2.34}$$

in which d is the water depth at the measurement point, one can therefore find the A_1, B_1, A_2, B_2 for each wave component in accordance with equations 2.18, 2.19 and 2.15, and then calculate each a_i and a_r. Now the reflection coefficient of the irregular wave is

$$K_r = \sqrt{\frac{E_r}{E_i}} = \left[\frac{\int S_r(f) df}{\int S_i(f) df} \right]^{1/2}, \tag{2.35}$$

where E_i, E_r, S_i, and S_r are the energy and the power spectrum of the incoming and reflected waves, respectively. Similarly, those waves that generate significant errors due to their sensitivity to the $\sin k\Delta l$ should be excluded from the range of integration. In other words, in the layout of wave gauges one needs to decide a proper Δl that is suitable for all the main wave components. Conversely, if the Δl (or the distance of the two wave gauges) is chosen, the suitable upper and lower limits of frequency (f_{min} and f_{max}) for the integration can be decided in accord with the the range formula 2.33 and the dispersion

relation 2.34. Here comes

$$K_r = \left[\frac{\int_{f_{min}}^{f_{max}} S_r(f)df}{\int_{f_{min}}^{f_{max}} S_i(f)df} \right]^{1/2}. \tag{2.36}$$

For the current test layouts with both regular and irregular waves, the appropriate Δl is about 30 to 40 cm. And the distance can be adjusted according to the water depth and the size of the wave tank.

In cases of irregular waves, near the structure, there may be phase disturbances (or phase noise) in the incident and reflected wave components. And according to the spectral data of Ishida (1972 [17]) and the experiments by Goda and Suzuki (1976 [13]), the locations of the wave gauges need to be placed more than one wavelength (such as the wave length of the significant wave) away from the structure.

Some studies adopted the simplified estimations of the representative (or significant) wave heights of the incident and reflected waves, H_i and H_r, based upon the corresponding representative wave heights of the synthesized wave forms at two wave gauges (e.g., taking the average value). That is

$$H_i = \frac{1}{\sqrt{1 + {K_r}^2}} H_s, \tag{2.37}$$

$$H_r = \frac{K_r}{\sqrt{1 + {K_r}^2}} H_s \tag{2.38}$$

The hypothesis for the above two formulas are: (a) The combined energy of all component waves is the energy of the composite wave. (b) Regardless of the wave direction of individual wave, the relationship between wave height and wave energy for any representative wave of the composite wave satisfies the general wave energy relationship, i.e., the wave height being the square root of the wave energy.

The description right above is an simplified method for the approximate estimations

of incident and reflective wave heights and the reflection coefficient. But in the present study, regardless of regular or irregular waves, all the incident and reflected wave statistics (either at the far-field deep water site or at the near-field breakwater side) are derived from the spectral separation method, and there is no involvement of the two simplified formula.

Basically, the main process of the Goda and Suzuki formulation involves the deduction of the phase angles ϕ_i and ϕ_r for each component wave of the FFT and this is done by simultaneously solving equations 2.20 $\sim$ 2.23 with the surface displacement equations 2.18 and 2.19, and then applying the IFFT.

The complete codes (written in the ASYST programming language) for real time implementation are provided in the appendix. Numerical verifications on spectral wave separation are given in figures 2.16 (SepSimF-1) and 2.17 (SepSimF-2) and in tables 2.3 (SepSimT-1) and 2.4 (SepSimT-2). Figure 2.16 (SepSimF-1) shows the time history of the water surface displacements of the combined wave at two adjacent stations (station 1 and 2). Figure 2.17 (SepSimF-2) shows the comparison between the original incident waveform (bottom) and the reconstructed waveform (top). The two waveforms match quite closely. Tables 2.3 (SepSimT-1) and 2.4 (SepSimT-2) show their numerical details.

Additional verifications for cases of simulated regular waves are provided in tables 2.5 (SepSimT-3) $\sim$ 2.8 (SepSimT-6), which include cases of total, partial, and no reflection, as well as the effect of the convolutional low-pass filtering.

The above figures and tables, together with all the results form the experiments to be given later on, show that the spectral separation method yields far precise and realistic outcomes than those of the simplified method related to equations 2.37 and 2.38.

The wave gauge groups are shown in the layout figure 2.13 (Layout). In the layout, the water tank is divided into two channels with 5 wave gauges in each channel and among them two of the gauges at deep water site are being shared, therefore a total of 8 wave gauges are employed.

Lastly, it is emphasized again that meaningful comparisons can only be accomplished through the fulfillment of the fundamental requirement — the exactness of the substantive

incident and reflected waves; and the wave separation is a must-have. For all our analyses and comparisons, the data will all be based upon the statistics of the separated waves. And we will come to realize the astonishing contrasts between the data with and without such a processing, such as those shown in some of the lab printout tables 4.15 (StaRpt-R-1) ∼ 4.18 (StaRpt-I-1), and tables 4.19 (StaRpt-I-2) and 4.20 (StaRpt-I-3), as to be elaborated in the chapter on data analyses and the comparisons. ❖

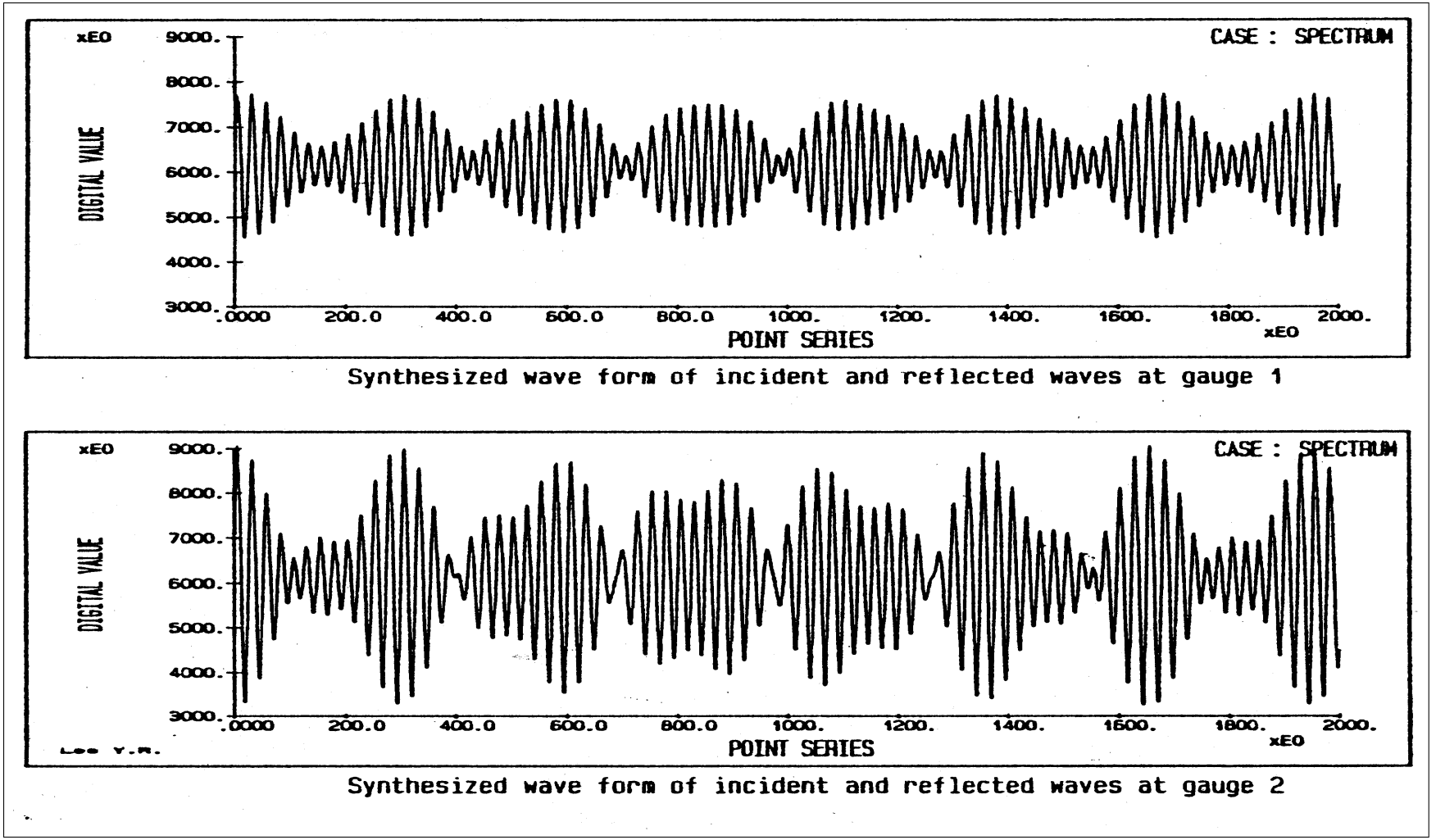


Fig 2.16 (SepSimF-1). The numerical simulation verification of the spectral wave separation of incident and reflected waves. The top and bottom subfigures are the waveforms of the superposition of the incident and reflected waves at two nearby locations.

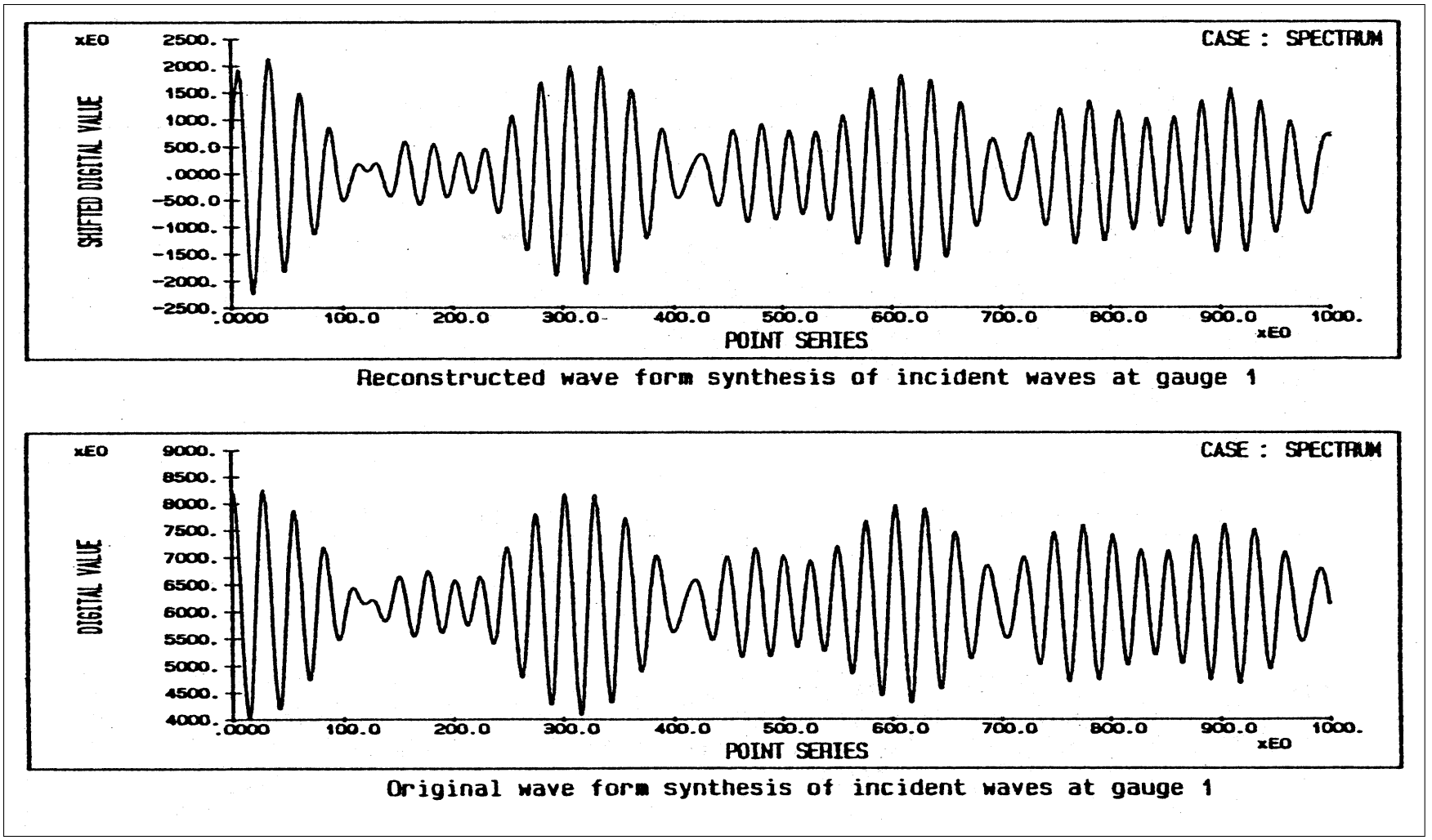


Fig 2.17 (SepSimF-2). The numerical simulation verification of the spectral wave separation of incident and reflected waves. The original incident wave is shown in the bottom subfigure and the reconstructed incident wave is shown in the top.

```
..
Case          :   c:\lyl\asy\expdat\Spectrum.dat
Date          :   08/06/90
Time          :   17:33:55.55                                   Sampling   frequency  :   25  Hz
Specifics     :   Spectrum test ¦  with reflection              Sampling time length  :   80 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.   79  77.64  77.64  75.81    75.53  70.19  65.59  48.45  52.30     1.04  1.04  1.04  1.00  1.00
  2.   76 141.55 139.26 139.26   134.32 119.25 108.31  77.31  85.31     1.06  1.06  1.06  1.04  1.05
  3.  883  21.92  21.46  21.36    19.06  17.86  16.75  12.51  13.46      .08   .08   .08   .09   .09
  4.  883  27.05  26.90  26.54    23.19  21.77  20.46  15.32  16.43      .08   .08   .08   .09   .09
  5.  882  27.76  27.47  27.32    23.79  22.45  21.20  15.90  17.02      .08   .08   .08   .09   .09
  6.  882  27.44  27.20  27.12    22.90  21.59  20.44  15.29  16.39      .08   .08   .08   .09   .09
  7.  882  25.05  24.85  24.34    21.07  19.86  18.83  14.12  15.10      .08   .08   .08   .09   .09
  8.  881  21.02  21.00  20.90    17.60  16.55  15.68  11.79  12.59      .08   .08   .08   .09   .09
.................................................
FFT parameters          :
              Kr        :      .6410     r.ch1  :         1     r.ch2  :         2
              del.L     :    19.4965     depth  : 2000.0000     w.l.n  :   43.0107
              L.min     :    43.3255     T.min  :      .5270     M.max  :        78
              L.max     :   389.9296     T.max  :    1.5811     M.min  :        26
              i.smt     :         0     f.cut  :      .5000     aR.sq  : .0162628E  13
              fft.point :      1024     b.pnt  :         1     aI.sq  : .0395760E  13
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   36 107.02  98.63  95.23    96.93  83.13  74.29  54.89  59.81     1.09  1.09  1.08  1.10  1.11
  1.   36  64.08  58.72  57.97    59.63  53.04  48.27  35.57  38.62     1.10  1.10  1.10  1.10  1.11
..
```

Tab 2.3 (SepSimT-1). A verification case of numerical simulation for the wave separation program (spectral wave with reflection).

```
..
Case          :   c:\lyl\asy\expdat\Spec-2.dat
Date          :   08/06/90
Time          :   17:33:55.55                                  Sampling   frequency  :   25  Hz
Specifics     :   Spectrum test ¦  no reflection               Sampling time length  :   80 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.   74 103.64 103.64  99.90    99.84  86.39  77.76  55.02  61.19     1.08  1.09  1.09  1.07  1.08
  2.   74 104.03 104.03 100.20    99.66  86.26  77.98  55.03  61.23     1.08  1.08  1.08  1.07  1.08

.....................................
FFT parameters           :
               Kr        :     .0400     r.ch1  :         1     r.ch2  :         2
               del.L     :   19.4965     depth  : 2000.0000     w.l.n  :   43.0107
               L.min     :   43.3255     T.min  :     .5270     M.max  :        78
               L.max     :  389.9296     T.max  :    1.5811     M.min  :        26
               Sum.aR.sq : .06357E  10
               Sum.aI.sq : .03970E  13                          b.pnt  :         1
               fft.point :      1024     i.smt  :         0     f.cut  :     .5000

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   37 106.92  97.42  92.97    96.59  82.52  74.65  54.31  59.44     1.09  1.09  1.08  1.07  1.08
  1.   41   9.06   4.51   3.25     5.00   3.27   2.91   2.16   2.53     1.00   .99   .99   .99  1.02
..
```

Tab 2.4 (SepSimT-2). A verification case of numerical simulation for the wave separation program (spectral wave without reflection).

```
Case          :   c:\lyl\asy\expdat\Re-tst-1.dat
Date          :   09/03/90
Time          :   22:01:01.33                                   Sampling   frequency  :   25  Hz
Specifics     :   perfect reflection - raw - referential limits Sampling time length  :   80 Sec

 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.    79  34.47  34.47  34.47    34.47  34.47  34.47  34.47  34.47     1.00  1.00  1.00  1.00  1.00
  2.    79  48.73  48.73  48.73    48.73  48.73  48.73  48.73  48.73     1.00  1.00  1.00  1.00  1.00
  3.   590  82.76  60.69  60.28    20.31  12.00  10.68   8.70  11.61      .13   .10   .11   .13   .15
  4.   703  52.86  52.51  51.66    12.83  10.36   9.75   7.97   8.95      .13   .10   .10   .11   .16
  5.   636  47.39  46.70  42.82    11.27   9.68   9.26   7.92   8.47      .09   .09   .10   .12   .13
  6.   721  42.31  40.67  39.55    10.40   9.08   8.66   7.09   7.62      .09   .08   .09   .11   .12
  7.   633  37.18  34.28  34.06     9.61   8.40   8.06   6.92   7.31      .09   .09   .10   .12   .13
  8.   552  32.18  32.15  31.96     8.31   7.08   6.81   6.05   6.40      .10   .11   .12   .14   .16
.....................................................................
FFT parameters          :
               Kr       :    1.0000     r.ch1  :         1     r.ch2  :         2
               del.L    :   19.4965     depth  : 2000.0000     H.eng  :   24.4510
               L.min    :   43.3255     T.min  :      .5270    M.max  :        79
               L.max    :  389.9296     T.max  :    1.5811     M.min  :        26
               i.smt    :          0    f.cut  :      .5000    aR.sq  : .0657290E  12
               fft.point :      1024    b.pnt  :         1     aI.sq  : .0657344E  12
Reconstructed incident and reflected waves :
 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.    40  24.48  24.46  24.43    24.45  24.42  24.41  24.35  24.35     1.00  1.00  1.00  1.00  1.00
  1.    40  24.61  24.54  24.48    24.53  24.44  24.42  24.39  24.39     1.00  1.00  1.00  1.00  1.00
..
```

Tab 2.5 (SepSimT-3). A verification case of numerical simulation for the wave separation program (regular wave with total reflection).

```
Case          :   c:\lyl\asy\expdat\Re-tst-2.dat
Date          :   09/03/90
Time          :   22:10:51.13                                  Sampling   frequency  :   25  Hz
Specifics     :   partial standing - windowed - normal limits  Sampling time length  :   80 Sec

 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.    79  27.68  27.68  27.68    27.68  27.68  27.68  27.68  27.68     1.00  1.00  1.00  1.00  1.00
  2.    79  37.98  37.98  37.98    37.98  37.98  37.98  37.98  37.98     1.00  1.00  1.00  1.00  1.00
  3.     1   ------- Too small number of waves ------
  4.     1   ------- Too small number of waves ------
  5.     1   ------- Too small number of waves ------
  6.     2   ------- Too small number of waves ------
  7.     1   ------- Too small number of waves ------
  8.     1   ------- Too small number of waves ------
.............................................................
FFT parameters           :
               Kr        :      .6137     r.ch1  :          1     r.ch2  :          2
               del.L     :   19.4965     depth  : 2000.0000     H.eng  :   23.6209
               L.min     :   43.3255     T.min  :      .5270     M.max  :         79
               L.max     :  389.9296     T.max  :    1.5811     M.min  :         26
               i.smt     :         1     f.cut  :      .5000     aR.sq  : .0231022E  12
               fft.point :      1024     b.pnt  :          1     aI.sq  : .0613468E  12
Reconstructed incident and reflected waves :
 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.    40  23.07  23.03  23.02    23.04  23.00  22.98  22.92  22.92     1.00  1.00  1.00  1.00  1.00
  1.    40  14.31  14.18  14.16    14.19  14.12  14.10  14.08  14.08     1.00  1.00  1.00  1.00  1.00
..
```

Tab 2.6 (SepSimT-4). A verification case of numerical simulation for the wave separation program (regular wave with partial reflection of $a_r/a_i = 150/250$).

```
Case          :   c:\lyl\asy\expdat\Re-tst-3.dat
Date          :   09/03/90
Time          :   22:17:20.42                                  Sampling   frequency  :   25  Hz
Specifics     :   no reflection - raw - referential limits     Sampling time length  :   80 Sec

 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.    79  24.37  24.37  24.37    24.37  24.37  24.37  24.37  24.37     1.00  1.00  1.00  1.00  1.00
  2.    79  24.37  24.37  24.37    24.37  24.37  24.37  24.37  24.37     1.00  1.00  1.00  1.00  1.00
  3.   590  82.76  60.69  60.28    20.31  12.00  10.68   8.70  11.61      .13   .10   .11   .13   .15
  4.   703  52.86  52.51  51.66    12.83  10.36   9.75   7.97   8.95      .13   .10   .10   .11   .16
  5.   636  47.39  46.70  42.82    11.27   9.68   9.26   7.92   8.47      .09   .09   .10   .12   .13
  6.   721  42.31  40.67  39.55    10.40   9.08   8.66   7.09   7.62      .09   .08   .09   .11   .12
  7.   633  37.18  34.28  34.06     9.61   8.40   8.06   6.92   7.31      .09   .09   .10   .12   .13
  8.   552  32.18  32.15  31.96     8.31   7.08   6.81   6.05   6.40      .10   .11   .12   .14   .16
.............................................................
FFT parameters          :
               Kr       :     .0300     r.ch1  :         1     r.ch2  :         2
               del.L    :   19.4965     depth  : 2000.0000     H.eng  :   23.9539
               L.min    :   43.3255     T.min  :     .5270     M.max  :        74
               L.max    :  389.9296     T.max  :    1.5811     M.min  :        31
               i.smt    :          0     f.cut  :     .5000     aR.sq  : .0566662E   9
               fft.point :      1024     b.pnt  :         1     aI.sq  : .0630890E  12
Reconstructed incident and reflected waves :
 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.    40  24.27  24.19  24.08    24.14  24.03  24.00  23.91  23.91     1.00  1.00  1.00  1.00  1.00
  1.    40   1.43   1.09    .76     1.01    .79    .75    .69    .70     1.03  1.01  1.01  1.00  1.00
..
```

Tab 2.7 (SepSimT-5). A verification case of numerical simulation for the wave separation program (regular wave without reflection).

```
Case          :   c:\lyl\asy\expdat\Re-tst-4.dat
Date          :   09/03/90
Time          :   22:25:50.42                                  Sampling   frequency  :   25  Hz
Specifics     :   no reflection - windowed - normal limits     Sampling time length  :   80 Sec

 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.    79  23.73  23.73  23.73    23.73  23.73  23.73  23.73  23.73     1.00  1.00  1.00  1.00  1.00
  2.    79  23.74  23.74  23.74    23.74  23.74  23.74  23.74  23.74     1.00  1.00  1.00  1.00  1.00
  3.     1   ------- Too small number of waves ------
  4.     1   ------- Too small number of waves ------
  5.     1   ------- Too small number of waves ------
  6.     2   ------- Too small number of waves ------
  7.     1   ------- Too small number of waves ------
  8.     1   ------- Too small number of waves ------
.............................................................
FFT parameters          :
               Kr       :      .0319     r.ch1  :         1     r.ch2  :         2
               del.L    :    19.4965     depth  : 2000.0000     H.eng  :   23.3430
               L.min    :    43.3255     T.min  :      .5270     M.max  :        79
               L.max    :   389.9296     T.max  :    1.5811     M.min  :        26
               i.smt    :         1     f.cut  :      .5000     aR.sq  : .0609134E   9
               fft.point :      1024     b.pnt  :         1     aI.sq  : .0599118E  12
Reconstructed incident and reflected waves :
 Ch    #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.    40  23.15  22.91  22.91    22.94  22.82  22.79  22.72  22.72     1.00  1.00  1.00  1.00  1.00
  1.    41   1.73    .87    .86     1.07    .79    .75    .67    .69     1.07  1.02  1.02   .98   .99
..
```

Tab 2.8 (SepSimT-6). A verification case of numerical simulation for the wave separation program (regular wave without reflection and the effect of convolution or low pass filtering).

Chapter 3

The Optimization of Experiments and Data Processing

3.1 Test facility and equipments

This study is a 2-year basic research project sponsored by the Taiwan Provincial Government (1989.07 ~ 1991.06) and the experiments were carried out at the Institute of Harbor and Marine Technology of the Department of Communications of the Taiwan Provincial Government （臺灣省政府交通處港灣技術研究所）. The facility and equipments used are as follows:

1. **Wave flume**

   The wave flume is a water tank with the capability of wind, wave, and current generations. Its net length, width and height are 100, 1.5 and 2.0 meters, respectively, and at each side of the tank there are two long glass sections for observations. For our tests, the part of the tank near the breakwater is divided into two channels by an acrylic plate of 19 m length, 1 cm thickness and a height about the top of the breakwater (figure 2.13 (Layout)). The distance between the breakwater and the wave generator is about 76 m.

2. **Wave maker**

   The wave maker is a brand new purchase of our institute and this study is its first use.

It is a horizontally moving piston type generator and made by the Danish Hydraulic Institute (DHI Wave Controller Model 403/AAS). Its accompanying wave synthesis software can create various wave spectrums and the whole system can be fully controlled by a personal computer once the buttons on the control box panel are properly set in accordance with the desired waves. Its operation is basically a call of a digital file that was generated beforehand and stored in the PC. According to the original specification of the wave maker, the wave controller has a function of automatic cancelation (or real-time signal compensation) of the incoming reflected waves through the detection of the water levels at the 4 sensors installed on the wave making board driven by the piston. However, after several test runs, it is concluded that this uninterrupted long duration wave-making function is completely not feasible. For the present layout of experiment, the generated waveforms were completely distorted from the desired ones, and the mechanical movements of the machine were strikingly weird and even unimaginable (making strange and terrible sounds, and when these happened they were immediately halted). For this reason, the wave action times for all our tests are not set to a long duration. And the situation of repeated reflections will be avoided as much as possible or completely avoided (depending on wave gauge positions and wave types), especially for the regular wave cases.

3. **Wave gauges**

The wave gauges are KENEX model CH-406X. They were also newly purchased and their first uses. The gauges are of capacitance type with the capacitance-to-voltage conversion carried out in a small box attached to the gauge end, such that the influence of the circuit and cable can be minimized. The stabilities of these gauges were quite good and their calibration coefficients showed little variations during the whole course of experiments. Together with the development of the laboratory real-time system and the optimization of the experiment and the analyses, the completion of the experiment task was smoothly achieved in about two months.

4. **A/D card**

   Advantech ISA interface PCL-718 A/D/A multitasking card. The card has a resolution of 12 bits and its gain can be adjusted for proper precision.

3.2 The development of the laboratory real-time system

Test settings in most hydraulic experiments quite often involves many layouts, multitudes of parameters, lots of conditions, and loads of data; and the optimization of the work flow is a key element of a successful and fruitful research. Such a work flow concerns the systematic workability and integrated usability of many functions, such as instrument calibrations, data collections, on-the-scene monitoring, quality inspections, in-situ prejudgments, realtime and posterior analyses, etc. Therefore, the utilization of a well integrated laboratory system will greatly affects the correctness and the representativeness of the final outcomes not only directly and indirectly but also subjectively and objectively; most importantly, it saves time and efforts. Simply stated, the system must be humanly oriented with its excellency meeting various outstanding characteristics, such as easy operation, flexible manipulation, multi-functional integration, real-time processing, required precision, minimum or even zero human intervention or interruption, and so on. To react to these desires, a great amount of work was paid to the development of the integrated laboratory real-time system using the ASYST programming language. The main functions of the system are:

- Multiplexed analog/digital (A/D) data collection and D/A simulation.
- A multi-channel digital meter for simultaneous calibrations of multiple instruments and wave gauges.
- Both realtime and post-realtime inspections and presentments of all sorts of information.
- On-site statistics, analyses, charts making, figures drawing, etc.

With the advancement of personal computer in that era (mainly DOS based 286 PC at that time), these functions were fully made possible by a single PC and the stack-style programming language ASYST, which is capable of hardware control and software mathematics. Some of the relevant details are described below.

1. **Menu-driven module architecture**

   Figure 3.1 (AsystRT-1) showcases the functions of the integrated laboratory system. Based on the menu-driven modular architecture, individual program can perform its specific task or be easily incorporated into an automatic work flow without any intervention. Basically, a minimized number of initial keyboard strokes or even a single key stroke will complete the whole work flow of a test case — from data sampling to the results of preliminary or advanced analyses. In most cases the needed key stroke was basically the return key only. In fact we didn't encounter or notice any mistakes during and after the whole experiments, and no repeated works had ever been needed.

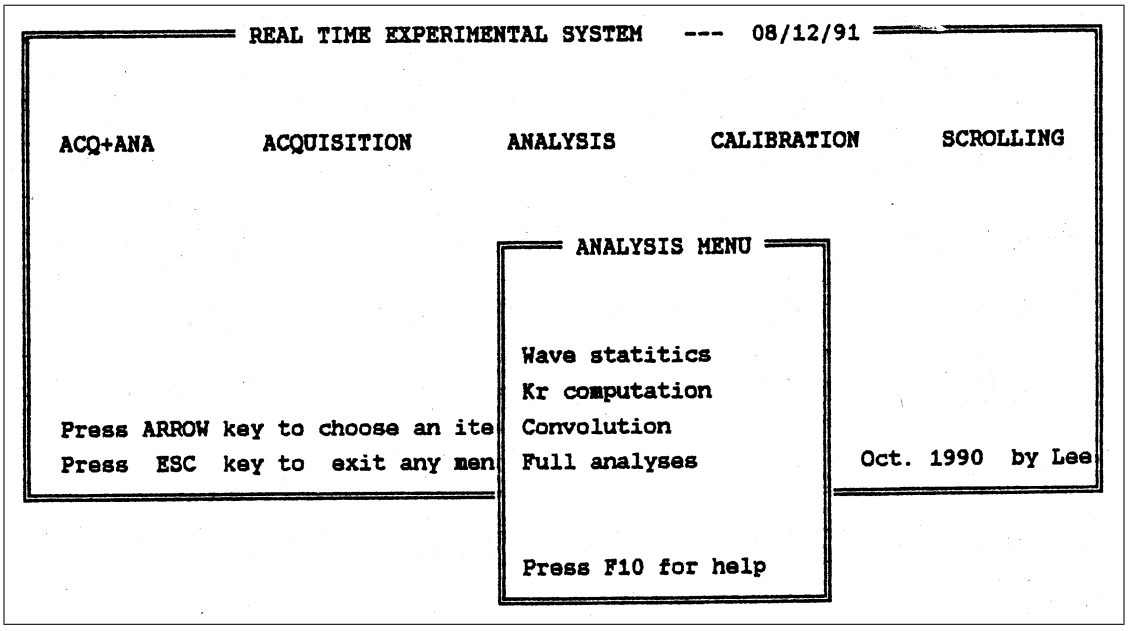


Fig 3.1 (AsystRT-1). The modular menu-driven real-time lab system

2. **Humanization**

   The quest of humanization mainly concerns the automation, friendliness and error-

free implementation of the whole experiment. In addition to the consideration of the general or flexible usage under different situations of experiments, the implementation of each program pays attention to its comprehensiveness, selectiveness and interconnectedness. Moreover, all individual programs are written with a mind to minimize any man-made mistake and to avoid unnecessary procedural interruptions. Specifically, for all the formal test routines, any manual input, key strokes, or key-ins have been removed to the utmost extend. Without this feature, erroneous or inconsistent parameters or settings may be entered and not noticed on the spot. For example, by proper file naming of test cases, when a file is called, the programs automatically determine all their relevant parameters, such as the wave type, number of channels, sampling rate, sampling duration, time delay of sampling startup (relative to the startup time of the wave maker), points of analysis startup and ending for each individual wave gauge, various parameters related to A/D conversion and different analyses, etc. And basically, a single key stroke completes a case run during the whole formal routine experiment. If some additional reference works is ever needed, the operational steps are basically also reduced to just a series of "pressing the return or arrow key". In addition, automatic record keeping is also considered, such as the registration of date, time, attribute, category, special notes, etc. Some of these details may seem trivial but they help greatly in the reduction of cumbersome routine works and in the avoidance of human negligence or mistakes that might not be noticed during or after a test. And they also make easier the management of files and the systematic processing and analysis of data. Such humanization, together with workability and functionality, guarantees the basic requirements in standardization and overall consistency in comparisons.

3. **Multitasking**

   The A/D data acquisition is capable of foreground, background and multitasking operations. The usage of a single PC can thus be maximized by simultaneous implementations of multiple functions. During the A/D acquisition in the background

the PC can function as a monitor or as an oscilloscope in the foreground. And to assure the sampling concurrency for different channels, the multitasking is also properly employed such that the time lag between consecutive A/D channels is minimized. This is due to the data acquisition for each channel is done in a sequential manner (i.e., one at a time) and there is a concern of out of synchronization when the sampling frequency is low. Note also that the capability of multi-tasking needs to be matched with the processing power of the hardware, such as CPU speed, data transfer rate of the disk, the size of the base memory, etc. In cases of a very high sampling rate, the DMA (Direct Memory Access) method may be needed, in which the data acquisition process bypasses the CPU of the computer. Additionally, when recording vast amount of data, the DMA method can also be used to store directly the A/D data into the hard disk. Generally speaking, the DMA method has more constraints on foreground and background operations. For the present software and hardware configuration, the total data volume of the multiplexed A/D is 64KB (ie 32K data points), and the overall (or all channels combined) sampling rate can reach about 800 Hz. Screen shots of the data acquisition (in which the key pressing steps are not simplified) are shown in figure 3.2 (SepSimF-2).

Listed in the following are the names of the modular programs for the real time laboratory system, including both hardware control and on-site data analyses. And their complete contents are provided in Appendix 1. Note again that the programming language is ASYST. Also note that these programs are the evolving ones and they are somewhat different from those appeared in the original report published in 1991. This is due to the corruption of floppy disks that happened during the following three years when the author was studying abroad. But a full and complete original copy printed in papers still survived.

- `Lee.men`
- `Acq.men`

- Mon.men
- Cal.men
- LSta-0.txt
- LSta-mai.asy
- LRef-0.txt
- LRef-Mai.txt
- LWHP-0.txt
- LWHP-Mai.txt
- LPlt-0.txt
- LPlt-Mai.txt
- pre-file.nam
- bell.txt
- def-winn.nam
- def-acqn.nam
- def-acqs.spe
- def-anan.nam
- def-ana1.1sp
- lacq-spe.men

4. **Efficient and convenient calibrations**

   The calibrations of the wave gauges make use of the previous multitasking capability, and the monitor of the PC acts like a multichannel digital meter. For the Avantech PCL-718 A/D interface card, a total of 16 channels can be calibrated and displayed at the same time; and the unit of calibration can be programmed as bit value (A/D resolution value), voltage, or centimeter. Note that the jumper setting (for gain multiplier) on the A/D interface card should be properly checked.

Previously, the ways of calibrations in our lab were done in manners that were rather cumbersome, cluttering and time-consuming. The current process involves no plugging-unplugging of cables, and needs no switching or knob selections on the instrument panel. The statuses of all the channels are monitored at a glance and the chance of accidentally altering the gain button is minimized; even if a button is accidentally touched, it can be reverted immediately. This makes possible the efficient, convenient and hassle-free preparation for the data acquisition. In addition, the status or the health of all the gauges can be checked at any time or during the experiments, and thus the accuracy of data and the confidence for subsequent analyses are fundamentally established. Figure 3.3 (SepSimF-3) shows some of the screen shots.

5. **Real-time processing and on-site inspections**

   Upon the end of a data acquisition or during the gap between two tests, relevant analyses can be automated and results be displayed or printed immediately. Such that the recorded data could be checked and scrutinized at any time. The apparent benefits are like immediate detection of abnormality, getting rid of unnecessary trials or repeated works, and cutting down the possibility of faults and errors. The on-site real-time processing includes: filtering or convolutional operation, conventional wave statistics, spectral results, reflection coefficients, separation of incident and reflective waves, etc. Together with the previous functions, the on-site auditing, on the one hand, minimizes the demand of manpower and material resources, on the other hand, maximizes the genuineness and correctness of all the data and the subsequent comparisons. Take for an example that one might encounter a situation where the data are found to be something wrong when the test layout has been changed, or even when all the experiments had been finished.

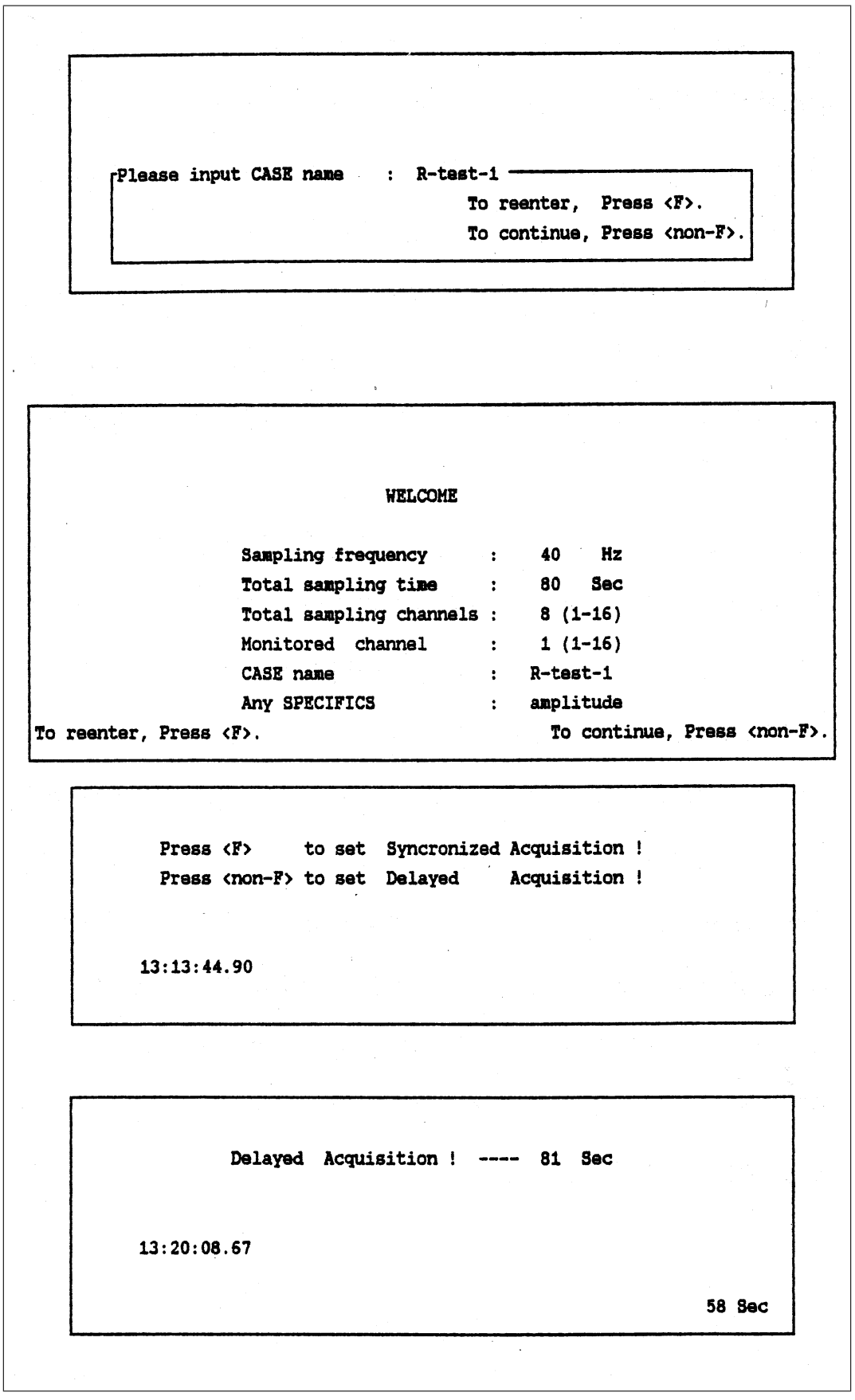


Fig 3.2 (SepSimF-2). A few screen shots of the multitasking A/D data acquisition.

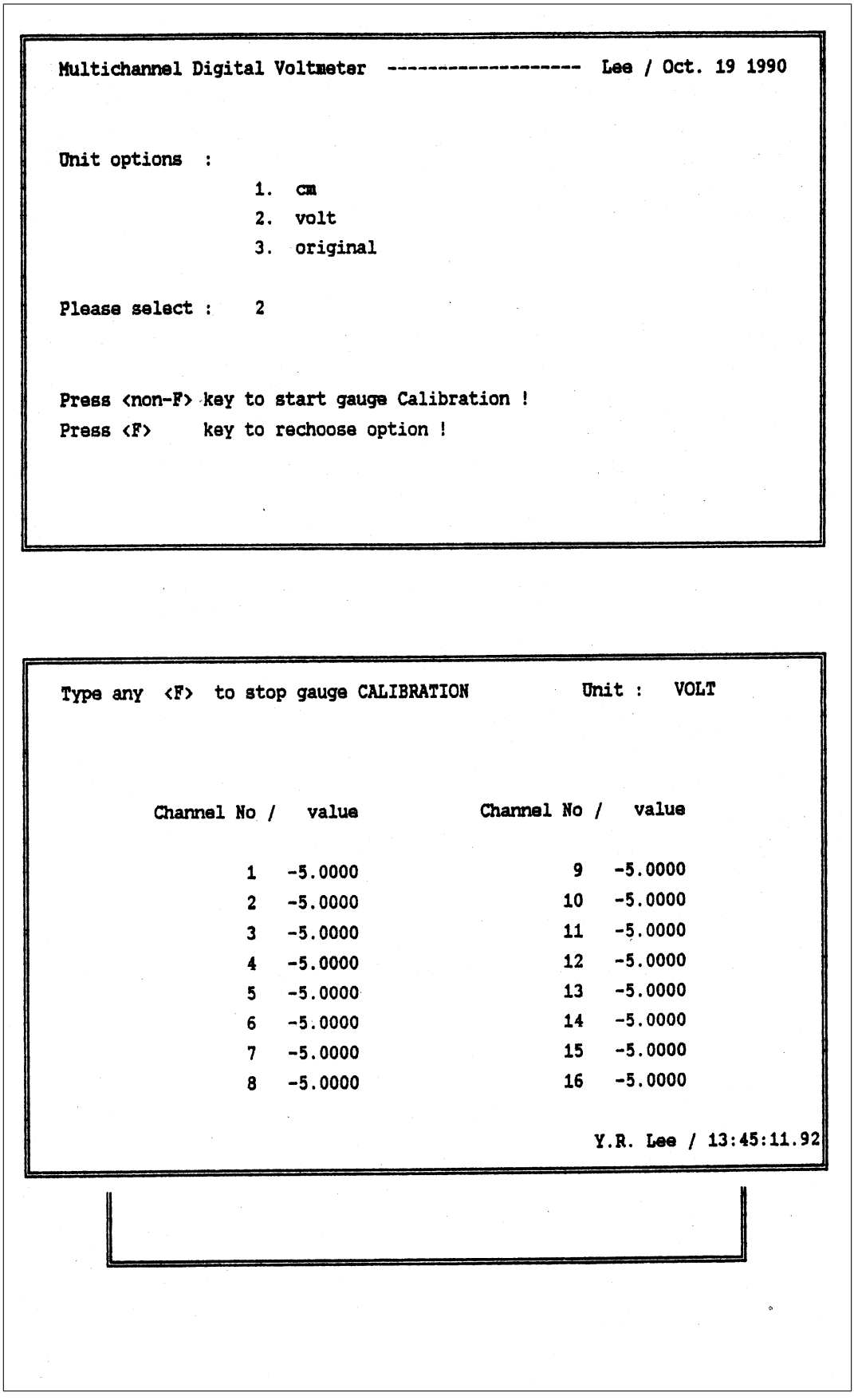


Fig 3.3 (SepSimF-3). The PC multichannel digital meter for simultaneous calibration.

3.3 The uniformization and the signification of test conditions and data analyses

Since here the ultimate aims are on “comparisons”, the basic requirement can only be fulfilled by following the same correct mean of approach and the non-selective way of data handling. But, “the same correct mean of approach” and “the non-selective way of data handling” are mutually dependent, and the persuasiveness or justification can only be achieved by not only a properly designed attack plan in experiments but also a sound methodology in analyses; and again a proper plan and a sound methodology are mutually in need. For this spirit, we are focusing on the “uniformization” and the “signification” of the study, both in experiments and analyses. Basically, the so-called “uniformization” means that each armor type is subjected to the same, and exactly the same, sequences of wave action, and all the relevant processing and analyses are subjected to the same, and again exactly the same, treatments (no human involvement ever occurs). And the so-called “signification” refers to the use of the purest contents of the waves and the adoption of the most appropriate method of analysis. That is to say, on the one hand, the recorded and the analyzed data should each spans the right duration and locates at the decent section where we have the best grasping of the waves’ characteristics and purity; on the other hand, the analytic method adopts a technique that is theoretically much more precise and practically far easier when compared to conventional approaches. And for the “precise” and “easier”, concisely, it means a completely automated wave separation process, which again involves no human factors. The contrivances for these are described in the following.

3.3.1 Uniformization

In section 3.1 a brief description of the functioning of the wave maker was mentioned. Since the waves are generated by digital files pre-created and stored in the PC hard drive, unless there is an unstable situation of the hardware (such as without proper warm-up,

and for out tests a small warm-up wave is applied in the beginning of an experimental batch), the waves generated should be consistent. With proper and accurate timing, all the armor types will be subjected to the same wave actions and the recorded data will also be spanning the same time location. For the experiments here, the choice of wave parameters mainly depend on the layouts of tests and the capability or functioning of the wave tank facility. Table 3.1 (Waves) shows the chosen action waves and their primary significant parameters. And the parameters in the table refer to the parameters used to generate the aforementioned digital files fed into the wave maker, and they are called instrument parameters here. These parameters may not completely be the same with those derived statistics from actual measurements with proper wave processing (such as those of the separated incident waves). But, in general, they are reasonably close, as will be shown in the next chapter (section 4.2 that details the numerical results of the separation of incident and reflected waves). And we emphasize again that, for all the different types of armors, from data acquisition to final results of wave data, we are not making any flexible handling or any differential treatment on waves and their relevant analyses — no alternate condition, no choice of data, and no existence of a possible second outcome. Both the instrument operations and the computations are completely automated without any human intervention — unified instrument control, unified conditions, unified parameters, and unified analyses. After all, the mean to achieve such standardization and uniformity can be imputed to the development of the laboratory real-time system mentioned the earlier section and to the incorporation of the "signification" of raw data and subsequent analyses to be described next.

3.3.2 Signification

In a laboratory setting, both its wave generator and the tank setup have their own properties. For example, the wave generator has its specific driving mechanism related to the pattern of driving paddle motion, output capacity, surrounding architecture of the machine, timelag between activation and stable action, etc. And the tank mainly concerns

ACTION WAVE CONDITIONS FOR SLOPE 1:1.5

Wave type	Period			
	T1.30	T1.60	T1.90	T2.20
RHO8	*	*	*	*
RH10	*	*	*	*
RH12	*	*	*	*
RH14	*	*	*	*
RH16	*	*	*	*
RH18	*	*	*	*
RH20		*	-*	
RH22		*	-*	
RH24		*	-*	
BH10	*	*	*	*
BH13	*	*	*	*
BH16	*	*	*	*
BH20	*	*	*	*

Note :: BH : Bretschneider spectrum, RH : Regular wave.

ACTION WAVE CONDITIONS FOR SLOPE 1:1.2

Wave type	Period			
	T1.30	T1.60	T1.90	T2.20
RHO6	*	*	*	*
RHO8	*	*	*	*
RH10	*	*	*	*
RH12	*	*	*	*
RH14	*	*	*	*
RH16	*	*	*	*
RH18	*	*	*	*
RH20		*	*	
RH22		*	*	
BH08	*	*	*	*
BH10	*	*	*	*
BH13	*	*	*	*
BH16	*	*	*	*
BH20	*	*	*	*

Note :: BH : Bretschneider spectrum, RH : Regular wave.

Tab 3.1 (Waves). Action waves and their instrument parameters.

the factors that are related to the propagation of waves and the possible flows. These factors include the water depth and the length of test channel, the bottom topography, the positions of observations, the materials used in the tank, etc. A basic understanding of the actual wave propagations is the preliminary work of the experiment. And such an understanding is the most fundamental element in the unformization and signification of the research.

Prior to the activation of the wave generator, the water is calm. And the activation creates an initial series of transient waves before the desired mature wave is formed. And ever since the startup of the piston stroke, the wave series travel bach and forth along the tank, hitting both the breakwater and the driving paddle repeatedly. Each cycle of wave is a complex process of continuous change that may involve internal evolution and external interactions. Now the simple fundamental point to grasp is when to start the capturing of data and what shall be the length of the recording. Simply put, what is fundamentally important is the determination of the data durations and sections that involve fewest confusions and generate highest significance for our purposes. Another point to consider is the amount of data required for proper and accurate analyses. Overall the sampled data must be both meaningful and sufficient. Of course, too much data is also an unnecessary burden and a waste in time and resources. With these in mind, the optimizations of the data acquisition are described as follows.

1. **Sampling rate**

   Factors that determine the sampling rates are: the target or purpose of the measurement, theoretical requirements, numerical errors, hardware related capability, sensor characteristics, etc. Proper cares need to be taken both in hardware and software aspects. And this is especially true for a DOS configuration PC in the 1990 era when there were serious concerns about the sizes of both memory and disk, as well as about the limitations of the data acquisition board and the processing power of PC. Quite often a comprise must be made between rate and duration. Our wave statistics here involves the zero-upcrossing statistics and the spectral FFT operations.

If the sampling rate is too low, the peak value from zero-upcrossing will be reduced and the spectral histogram will be rough, but if the rate is too high, possible noise or abnormal condition may occur due to A/D board limitations and storage concern may also arise. For our situations (or experiment settings of similar nature), the minimum 20 Hz sampling rate shall be reasonable and sufficient.

2. **Data acquisition scheme**

Before the formal test routine, the data acquisition schemes were investigated for all the different wave periods adopted in the present experiments. These are done by looking into the actual wave propagation characteristics in the wave flume, as well as by referencing the corresponding estimations from wave theory. Such data acquisition schemes concern the following parameters: the arrival time of initial disturbance, the transient duration of individual wave growth, the time of sampling activation relative to wave-maker startup, the duration of sampling, the initial data point of the analysis for individual gauge, the range of data to be analyzed for individual gauge, etc. Figures 3.4 (Surface-1) to 3.7 (Surface-4) are examples of actual observations of wave forms for some of the wave periods. These figures directly demonstrate the importance of the proper timing of the data acquisitions and analyses; moreover, they also hint the cause of the extremely scattering of the results of existing studies. From these figures, we can make assessment of the wave arrival time, the timing of the repeated wave reflections, and the transient wave growth phenomenon. Note that the zero coordinate in each figure is the synchronization point of wave generator activation and the execution startup of the A/D program (i.e., non-delayed acquisition). Some peculiar features may also be observed from these figures, such as: the extreme discrepancy among the simultaneous measurements of water surface displacements at different gauge locations (even for the adjacent ones), a case of the rise of mean water level (or set-up) at gauge 3 shown in figure 3.7 (Surface-4), the operational capability or characteristic of the wave maker. From these practically quite basic illustrations one realized unpredictable outcomes are

certainly going to happen in a poorly designed data acquisition scheme, let alone in the subsequent analyses.

Moreover, from these figures, we also know the absolute necessity of the wave separation. Without such an operation the analyses are destined to fail entirely and there will be no meaningful comparisons. And again, this is another culprit of the extreme scattering of the results among various existing studies related to water wave experiments, possibly not restricted to the subjects or experiments focused here. Table 3.2 (C_g) shows theoretical estimations (wave celerity and travel duration) of various arrival times at different gauge positions for the different wave periods based upon the linear wave theory. Without considering the transient duration of wave growth it is not possible to accurately estimate the timing of the scheme. But when the wave reaches its maturity, its traveling history is not far from the observation. Figure 3.8 (Acq Lap) shows, in accordance with the wave period, the curve of the arrival time of the first reflected wave (reflected from the wave maker) at gauge 3 located near the breakwater. Overall, figures like these that are based on actual observations are used to determine the various parameters of the data acquisition and analysis scheme. For our tests, two synchronized button presses are performed for the activation of wave generator at one end of the tank and for the start of the PC-controlled scheme at another end (i.e., the observational section) of the tank. And after a specified time lag the data acquisition starts automatically, and later, after a specified duration, stops automatically. There is absolutely no visual involvement and no key strokes or any human inputs in the process of data acquisition — everything is preset in the program and automated.

3. **Data segment Analysed**

   Depending on the location of the gauge, the optimal segment of data analysis may not be the same. Since a reflected wave arrives at different times for individual gauges, one needs to determine the initial point and the length with the most mean-

ingful analysis concerns. In addition, the number of data points must be sufficient for the desired purposes, such as: the separation of waves, the computation of wave statistics, spectral analyses, etc. And these optimizing factors are mainly dependent on the wave period and the wave type, that is to say, the parameter sets for both the data acquisition and the analyses are different under different wave conditions. For the values of these parameters, one may consult the real-time on-site printouts of the tests as given in section 4.2 (table 4.15 (StaRpt-R-1) ∼ 4.20 (StaRpt-I-3)). Note that each armor type is treated equally.

To sum up, with these measures and approaches, all the acquired raw data gain the full utilization. There are no missing, no eliminating and no duplicating on tests and data. And in the whole experiment process. no interference or disturbance, or whatsoever, had ever happened. ❖

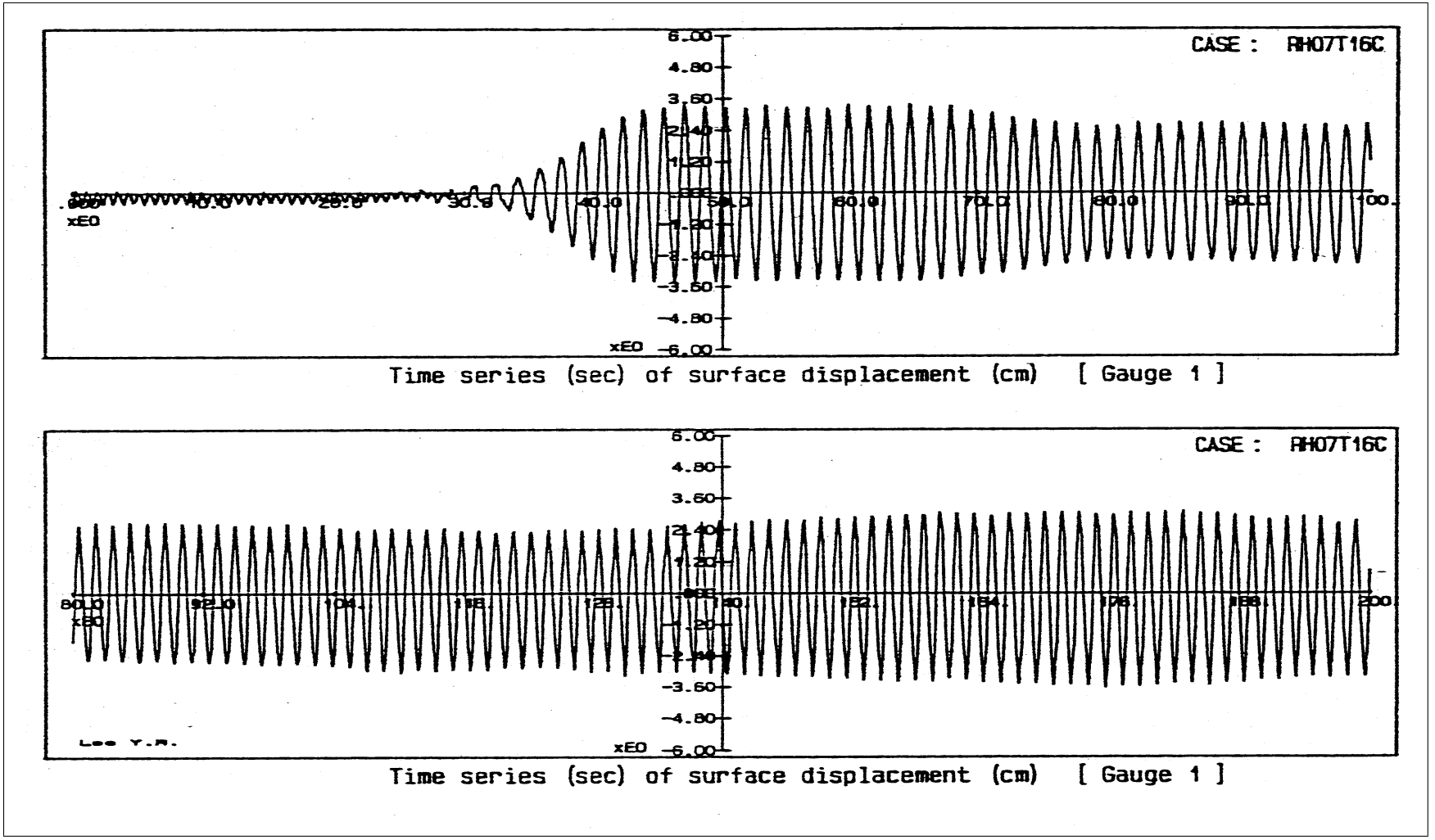


Fig 3.4 (Surface-1). A figure related to the preparatory work — the time history of the water surface displacement at gauge 1 (period 1.6 sec)

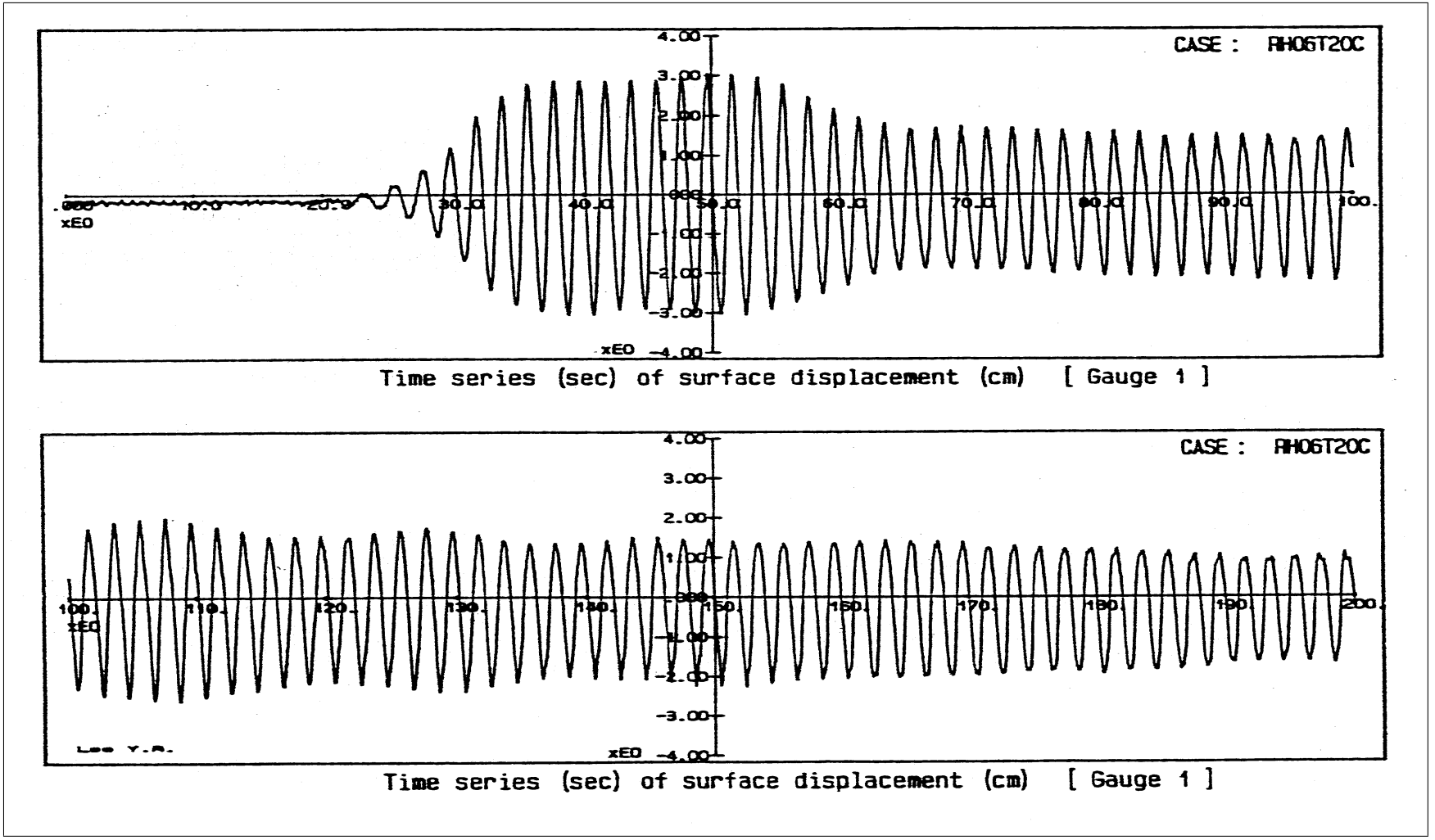


Fig 3.5 (Surface-2). A figure related to the preparatory work — the time history of the water surface displacement at gauge 1 (period 2.0 sec)

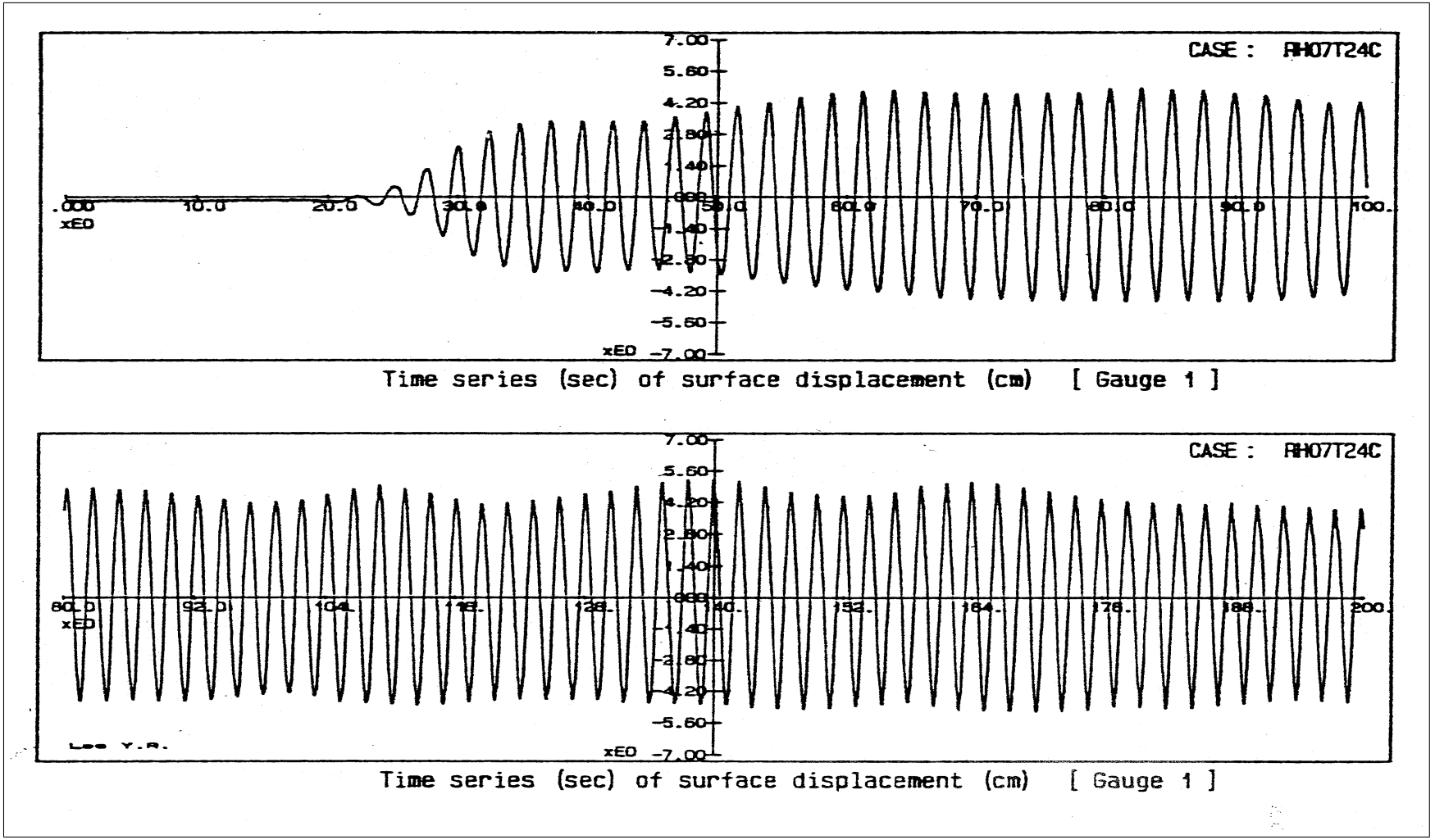


Fig 3.6 (Surface-3). A figure related to the preparatory work — the time history of the water surface displacement at gauge 1 (period 2.4 sec)

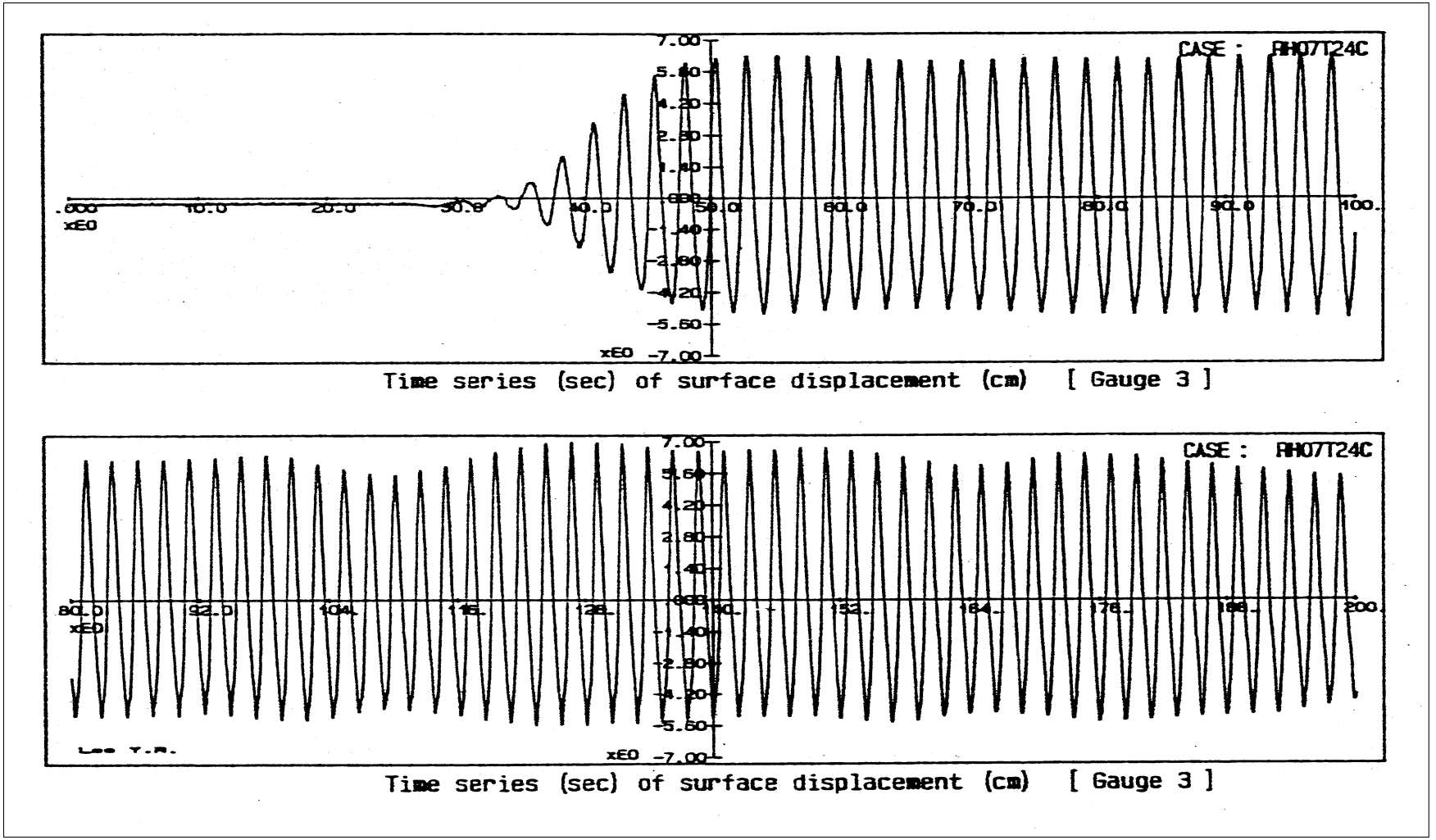


Fig 3.7 (Surface-4). A figure related to the preparatory work — the time history of the water surface displacement at gauge 3 (period 2.4 sec) (also shows set-up)

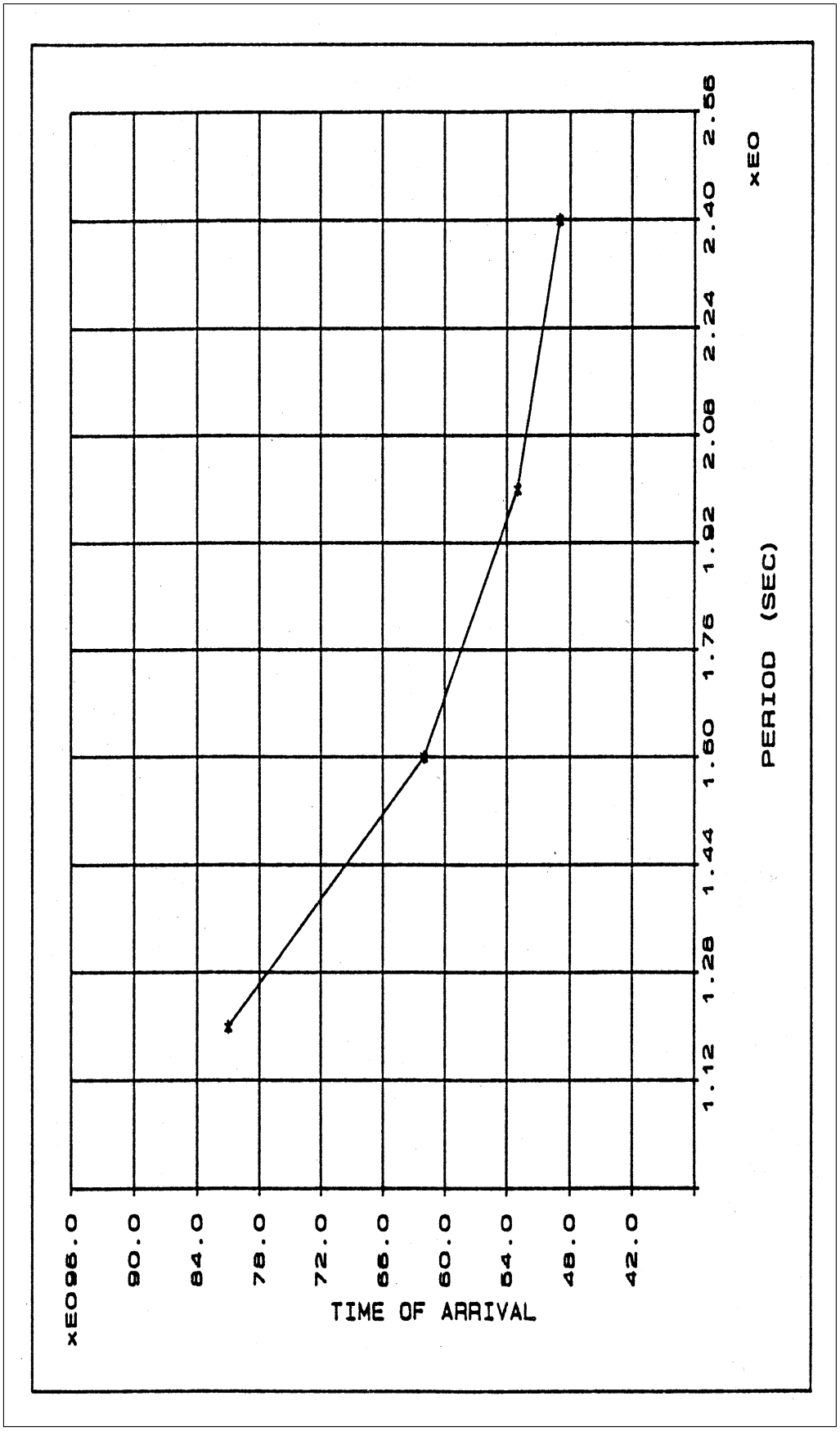


Fig 3.8 (Acq Lap). The actual arrival time of the first mature reflected wave in accordance with the wave period (for gauge 3)

TABLE OF WAVE CELERITY AND TIME OF ARRIVAL

ITEM	PERIOD (SEC)			
	1.30	1.60	1.90	2.20
DEEP WAVE LENGTH	264.0	399.4	563.1	755.0
[GAUGE-1]				
DEPTH (CM)	81.0	81.0	81.0	81.0
WAVE LENGTH (CM)	254.1	356.0	454.6	549.9
CELERITY (CM/SEC)	195.5	222.5	239.3	250.0
DEPTH (CM)	55.5	55.5	55.5	55.5
WAVE LENGTH (CM)	237.1	318.8	397.2	473.4
CELERITY (CM/SEC)	182.4	199.2	209.0	215.2
[GAUGE-3]				
DEPTH (CM)	48.0	48.0	48.0	48.0
WAVE LENGTH (CM)	228.5	303.2	375.1	445.2
CELERITY (CM/SEC)	175.8	189.5	197.4	202.0
ARRIVAL TIME (BASED ON LINEAR WAVE, WITHOUT ANY ADJUSTMENT)				
GAUGE-1	25.58	22.47	20.89	20.00
GAUGE-3	36.81	32.48	30.27	29.02
BREAKWATER	38.97	34.48	32.20	30.90
GAUGE-3	41.13	36.49	34.12	32.78
GAUGE-1	52.37	46.49	43.50	41.80
GAUGE-1	103.52	91.44	85.29	81.80
GAUGE-3	114.76	101.44	94.67	90.82
BREAKWATER	116.92	103.45	96.59	92.70

NOTE : Due to flume characters the actual time of arrival does not correspond to that listed in this table.

Tab 3.2 (C_g). The theoretical estimations of wave celerity and traveling time duration for different wave periods based upon linear wave theory.

Chapter 4

Data Analyses and the Comparisons

4.1 Introduction

Based on its simplicity in nature, its elemental relevance to whole study and its definiteness in outcomes, the individual comparison subject will be subsequently detailed in the following order: (1) reflection coefficient, (2) wave run-up and run-down, and (3) stability coefficient. Note again, the comparisons here are specifically targeting the condition of two-layer random placement of armors upon the rubble mount breakwater and a total of eleven types of armors are included. And the choices of these armor types are based upon either their frequent appearances or their most heard of in Taiwan. Table 4.1 (ArmorName) lists the armor names in English and Chinese, as well as the individual alphabet denotation as used in the various tables and figures.

It is noted that some armor types may have their individual variants with slightly different shapes and sizes but with the same naming. Those shapes and sizes used in this study are exactly shown in figure 2.2 (Armor-1) $\sim$ 2.12 (Armor-11). Among the eleven types, the **S**hake, the **L**inko, the **A**nchor, the double-**Y** and the ten-**E**n are molded according to the data provided by the right owners; the double-**U** is made according to the reference by Lin et al. (1987 [35]) since the information provided by the right owner is incomplete; the **H**exapod adopts an equal split type of $3 \times 3 \times 3$; the **T**etrapod has no trimming at the ends of its four pods; and the other armors are molded according to reference papers or reports.

Table 4.2 (ArmorParam) lists the experiment-related parameters for each armor type (slope 1:1.5), including layer coefficient, porosity, placement density, Reynolds' number, ratio of the amounts of armor units in the upper and lower layers, etc. In cases where the original data of these parameters are not sufficient or with inconsistency, proper judgements or conversions had been made or taken from the data of similar armor.

Here some background information of this study may deserve to be pointed out. The most fundamental point is that this two-year project was not initiated or originated from the author, rather it was an assigned task. If fact, all the assignment information the author got was simply the verbal words of its purpose, i.e., "performance comparisons of different armor types", and nothing else were given (not even any written words or documents). From what the author heard, the study was based upon the request of the then "The Provincial Assembly" of the then "The Provincial Government of Taiwan". And there were no specified armor types or how many types should be tested.

Moreover, in light of the multitude of existing studies related to the present researches — in which, the schemes were mostly muddy or unspecified, the methods were generally unclear or unspoken, and the yields were extremely dotting or scattering; — it too ought to be emphasized that, up until the overall systematic analyses for all the tests could be done, the author had been completely pessimistic about the forthcoming outcomes, let alone their meaningful comparisons; even though, at that time, the prudent, consistent, and substantive optimizations for both the data acquisition and the analyses had been figured out and the codes had been well tested. In brief, there had been the least expectations on the possible enhancements of data contents and on the clearer formations of any behavior trends, as well as on the establishment of comparative significance.

In fact, it ought to be confessed too that, ever since the task's inception, as well as after reading all sorts of reference papers and available reports, the author had reckoned that praying for ideal or good results is just an extravagant wish and any slightest improvement upon existing studies is simply not a realistic anticipation. Nevertheless, soon after the end of all the tests, the author was greatly gratified — surprisingly, when systematic analyses

of the whole data were carried out and all sorts of figures and tables were brought forth, it was found that the numerous scattering phenomena related to the prior literatures seemed to have been greatly improved and many substantial trends could easily be derived. Not only cause and effect of individual feature could be depicted but also the relevant physics among the three comparison subjects be drawn and linked. Hence, the desired purpose of comparisons were not in a state of chaoticness, and the report could promptly be finalized and published before the deadline soon to arrive.

Followings are the results and discussions for the three comparison subjects as separately listed in individual section.

1.	tri**B**ar	三　柱　塊
2.	tetrahedro**N** or t-hedro**N**	中空三角塊
3.	**D**olos	雙　T　塊
4.	**S**hake	協　克　塊
5.	**L**inko	林　克　塊
6.	**A**nchor	安　卡　塊
7.	**T**etrapod	菱　形　塊
8.	**H**exapod	六　腳　塊
9.	double-**Y**	雙　Y　塊
10.	double-**U**	雙　U　塊
11.	ten-**E**n	天　允　塊

Tab 4.1 (ArmorName). The English and Chinese names of the eleven armor types sequentially tested and their individual denotation alphabets as used in the various tables and figures.

ARMOR BLOCK PARAMETERS

ARMOR TYPE	Layer coefficient	Porosity	Number of block [Density,	Total,	Lower,	Upper]	Length of unit	Reynolds' number
			#/m**2	100%	55%	45%	cm(max)	approx.
1. Dolos	0.940	0.56	512	546	301	246	7.41	8.36E+04
2. Shake	1.094	0.56	594	634	349	285	6.34	8.33E+04
3. Linko	1.005	0.59	509	543	299	244	5.95	7.18E+04
4. Anchor	1.045	0.60	516	551	303	248	5.99	7.51E+04
5. Tetrapod	1.020	0.50	642	685	377	308	7.39	9.05E+04
6. Hexapod	1.280	0.59	648	692	380	311	6.31	9.70E+04
7. triBar	1.310	0.60	647	691	380	311	7.03	1.11E+05
8. tetrahedroN	1.016	0.55	564	602	331	271	6.50	7.93E+04
9. tenEn	1.061	0.57	562	600	330	270	5.37	6.84E+04
10. double-U	0.897	0.57	480	512	282	231	7.23	7.79E+04
11. double-Y	0.940	0.56	512	546	301	246	-	ERR

Note :
Slope = 1 on 1.5
Vertical height = 0.8 M
Reynolds' number is based on 15cm wave height and max. armor length

Tab 4.2 (ArmorParam). The test-related armor parameters for all the armor types, including layer coefficient, porosity, placement density, ratio of the amounts of armor units in the upper and lower layers, and Reynolds' number.

4.2 Reflection coefficient K_r

4.2.1 K_r values and the distributions and trends

Tables 4.3 (Kr-A-1) ∼ 4.8 (Kr-A-6) and 4.9 (Kr-B-1) ∼ 4.14 (Kr-B-6) are the reflection coefficients, including both regular and irregular (Bretschneider spectrum) waves, of the eleven armor types under the two breakwater slopes 1:1.5 and 1:1.2, respectively, In the tables the zero-up crossing significant wave periods ($H_{1/3}$) and wave heights ($T_{1/3}$) derived from the separated incident waves are also listed, and the wave statistics are associated with the two far-field wave gauges (No. 1 and 2). The "A" and "B" that appear in the case name "Layout" of the sheets (and all tables and figures thereafter) represent the individual slope of 1:1.5 and 1:1.2, respectively.

It can be seen from these tables that, for the regular waves, the periods of the separated incident waves are almost identical to the instrument wave period parameters of the digital signals as fed into the wave maker. As for the wave height with regard to the regular wave case, there is some difference between the height of the separated incident wave and that of the instrumental parameter. For small incident wave heights, the two are very close for all the wave periods. And for cases of larger wave heights and of the periods 1.6 or 1.9 second, the relative discrepancy is somewhat larger, with a difference of up to about 13%. Based upon the numerical experience of the simulation verifications on the spectral separation of incident and reflected waves, the numerical discrepancy or error is small and about 3% if proper data resolution is taken. It is therefore reasonable to attribute the differences to those factors related to the discrete nature of FFT operations and to the wave tank setup, such as the evolution during the traveling distance, the flume layout, the property of the wave generator, the interaction with the breakwater, etc.

As for the irregular waves, the periods of the separated incident waves are also very close to the machine parameters for the 1.6 and 1.9 second wave periods. But for the instrument parameters of 1.3 and 2.2 second, there are differences of $+0.1$ and -0.1 second respectively (i.e., the computed individual period is about 1.4 and 2.1 second

respectively). As to the significant wave heights $H_{1/3}$ of the separated incident waves, their values are somewhat different from the instrument parameters of the wave maker. The reasons may be complex and worth investigating, but the factors mentioned earlier could also be the causes.

Here it should be stressed that, without the separation of incident and reflected waves, the direct statistics from measurements of wave gauges are destined to be completely misleading and absolutely unusable. Henceforth, all the wave heights and periods in this study refer to those derived from the wave separations that are associated either with the far-field or with near-field wave gauges. Table 4.15 (StaRpt-R-1) $\sim$ 4.17 (StaRpt-R-3) and 4.18 (StaRpt-I-1) $\sim$ 4.20 (StaRpt-I-3) show examples of real-time laboratory outputs for both regular and irregular waves, respectively. From these tables we see the absolute necessity of the use of wave separation. Without such a processing we have those extremely weird and ad hoc situations such as "randomness in wave number" (table 4.18 (StaRpt-I-1)), "Too small number of waves" (tables 4.15 (StaRpt-R-1) and 4.16 (StaRpt-R-2)), and even the "No complete wave cycle" (table 4.17 (StaRpt-R-3)) — all the chaoticness beyond imagination. Note that, in the tables, gauges No. 3, 4 and 7, as well as No. 5, 6 and 8, are adjacent gauges, respectively, in the individual water channel. Gauges No. 1 and 2 are the shared far-field wave gauges. Quite apparently, it can be easily concluded that the features shown in these tables fundamentally explains, on the one hand, the main root cause of the scattering of the results of existing studies, on the other hand, the effectuation of the " uniformization and signification" of the present study.

Now, let examine the variation of the reflection coefficient K_r with the incident wave height at the far-field (H_o related) for each wave period T. Figures 4.1 (Kr-A&B-1) $\sim$ 4.11 (Kr-A&B-11) show those of the regular wave cases for all the armor types under the two slopes. In comparison with existing studies or available literatures, evidently, the scattering of data has been greatly reduced and the trends are far more identifiable.

Additionally, figures 4.12 (Kr-Skt-1) $\sim$ 4.23 (Kr-Skt-12) show the average values and the spreading of K_r for each of the four different significant wave periods for both the regular

and irregular waves (slope 1:1.5). It is quite clear that the general behaviors are good except the somewhat more scattering for a few armor types under the 1.3 second regular waves. It is also quite interesting to recognize that the K_r values with regard to the irregular wave cases are much less spreading than those of the regular waves. Further noted is that, for all the comparisons and discusses (including reflection coefficient, wave run-up run-down, and stability coefficient), the parameters cover all the four wave periods and the wave heights up to instrument parameter of 18 cm (table 3.1 (Waves)). Tests with larger wave heights were not included in the overall comparisons due to possible occurrences of splash or having been damaged to a certain extent. Apparently, in these conditions, the K_r and the wave run-up and run-down could not be faithfully observed. Generally speaking, it is observed that, for these larger wave heights beyond the above limit, the K_r will be reduced due to greater relative energy loss during the wave propagation and a possible change in slope. Based upon the above observations and discernments, one may infer that, for all the comparisons in this study, the yielded statistical values and results of analyses are in better accuracy for those relatively stable armors, and likely to be more spreading for those relatively unstable ones. In other words, the significance and representativeness of a deduction increase with higher armor stability. And a greater ambiguity is associated with lesser stable armors; but still we will come to realize that such ambiguity is not enough to interfere with the judgements of the comparisons.

4.2.2 K_r ANOVA

From the above tables and figures on K_r, it has been clearly shown that the reflection coefficient has a strong correlation with the wave period and the correlation with the wave height is weak or not obvious. Followings are some behavioral descriptions of the trends based upon the more rigorous statistical method of "analysis of variance (ANOVA)".

Tables 4.21 (KrA-A-1) ~ 4.31 (KrA-A-11) and 4.32 (KrA-B-1) ~ 4.42 (KrA-B-11) are the one-way ANOVA tables for all the armor types under the two surface slopes of 1:1.5 and 1:1.2, respectively. These one-way ANOVA analyses are for the two non-interaction factors of

wave period and wave height. Since each test (run) in the experiments has no repetition, that is the one-way ANOVA is the statistical case of "one element per cell" or the case of "single replicate", the non-additivity needs to be checked first for the two factors. In the tables, the statistical F-values (F-distribution) and the corresponding p-values (significance level or the indication of the probability confidence) clearly indicate the existence of non-interaction. Therefore, the single element one-way ANOVA analysis is applicable and should provide concrete information. Note that the F-value in an ANOVA is calculated as: the ratio of "the variation between sample means" to " the variation within the samples". The higher the F-value in an ANOVA, the higher the variation between sample means relative to the variation within the samples. The p-value is determined by the F statistic and it indicates the significance level of an ANOVA result. Practically, the p-value refers to "the probability to reject the null hypothesis" or refers to the situation where the significant level of probability corresponds to those distribution with "$>$ F-value." In general, the critical significance level is commonly taken as 0.05. If the p-value is less than this level, the statistics are significant, i.e., the null hypothesis can be rejected.

For all the 22 one-way ANOVA tables, the p-values for the wave period factor invariably reach the confidence level of a 100%. Moreover, their corresponding F-values are very large. And the extreme cases of the F-values for the two individual slopes are both associated with the double-**U** armor. There is a reason for this to be acquainted with later. However, all but two tables show the existence of null hypothesis for the wave height factor. Though these two exceptions exist, all the F-values for the wave height factor are relatively extremely small (when compared to those of the wave period). It is therefore concluded that there is an absolute role played by the wave period variable, and the wave height variable is far less important and almost negligible.

Additionally, let us check the coefficient of determination, R^2 or "R Squared", of each ANOVA table. For the milder slope of 1:1.5, all their values exceed the 95% level, and many even approach the 100%. For the steep slope of 1:1.2, their performance are not as good as those of the milder slope, but still they mostly are above the 95% level. The

coefficient of determination is basically the manifestation of the correlation coefficient. The implication here is that the behaviors of K_r can reasonably be prescribed by these tables and the responsible factors have been satisfactory included. That is to say, influences from other uncontrollable or unknown factors should be very small.

Now let us provide a further perspective from the influence of armor type, that is, the ANOVA related to three factors or the two-way ANOVA. And now we have an additional variable in a "cell" and this variable is to be chosen from the two factors: the armor type and the wave height (no need for the wave period factor). Note that, although theoretically, some of the conditional assumptions or requirements for the use of ANOVA may be difficult to make or meet, the implications of those statistics should still be quite fruitful.

First, let regard the armor type as an uncontrollable or unknown factor, and let the instrument parameters of wave period and wave height be the two factors of treatment. That is, the K_r data of all the armor types but of the same instrument parameters of wave period and wave height are placed in the same cell. We have the two-way ANOVA as shown in tables 4.43 (KrA-A-HT/A) and 4.45 (KrA-B-HT/A), respectively, for the two breakwater slopes.

Second, let regard the wave height as an uncontrollable or unknown factor, and let the armor type and the instrument parameter of wave period be the two factors of treatment. That is, the K_r data of all the different wave heights but of the same instrument wave period and the same armor type are placed in the same cell. Now the two-way ANOVA is shown in tables 4.44 (KrA-A-AT/H) and 4.46 (KrA-B-AT/H), respectively, for the two slopes.

All these tables further foster the absolute effects of wave period. Meanwhile, tables 4.43 (KrA-A-HT/A) and 4.46 (KrA-B-AT/H) indicate again the null effects of the wave height factor. And tables 4.44 (KrA-A-AT/H) and 4.46 (KrA-B-AT/H) show clearly the important role played by the armor type. Additionally, by examining the coefficients of determination for all the four tables, it is concluded that there are precise effects from the armor type, and that the combined effects of the two factors of armor type and wave period constitute the overall influence to an undoubtable extent with the R^2 greater than 95%, even approaching the

98% for the milder slope of 1:1.5. Furthermore, the R^2 values in tables 4.43 (KrA-A-HT/A) and 4.46 (KrA-B-AT/H) (less than about 91%) indicate that, without considering the factor of armor type, the statistics may not behave as well and the deviation may happen. Overall, the features illuminated by these two-way ANOVA tables are every informative and in very good agreement with those of the one-way ANOVA.

To sum up from these one-way and two-way ANOVA analyses, it can be concluded as follows. Under the same slope, the main determining factor for the reflection coefficients is the wave period and the influence of other factors, such as the armor type and the wave height, are much smaller. Moreover, effects from other unknown factors should be negligible and could be disregarded. Besides, the influence of armor type factor is significantly greater than that of the wave height factor (for at least the range of wave heights taken here).

As to the ANOVA analyses for the irregular wave cases, it is absolutely of no doubt that the above discernments and trends are even much more stronger and definite than for the regular wave cases; and this perceptiveness can simply be made by judging the K_r data for all the irregular wave cases as given earlier in the various K_r tables and figures (see for example the scatter plot figures 4.12 (Kr-Skt-1) $\sim$ 4.22 (Kr-Skt-11)).

Also note that, if needed, these ANOVA analyses in some situations do not directly adopted the wave height values of the instrument parameters; when necessary, interpolations were performed so as to enhance the consistency and the significance of the statistics.

Based upon the above observations and interpretations, it is quite reasonable to compare the K_r performances among different armor types for both the regular and the irregular waves, and such comparisons are done through averaging the K_r values of different wave heights for each individual wave period. Tables 4.47 (KrAve-A) and 4.48 (KrAve-B) list, respectively for the 1.5 and 1.2 slopes, the data of K_r and T for all the armor types under the actions of both regular and irregular waves. Figures 4.24 (KrAve-A-R) $\sim$ 4.27 (KrAve-B-I) show the distribution curves of K_r versus T for all the armor types and both the wave types. A few features of these distribution curves can be given:

- Regardless of regular or irregular waves, the value of K_r gets larger when the slope of the breakwater get steeper.And for all the armor types, the trends of variation or the relative changes in magnitude generally behave consistently either based upon the slopes (figures 4.24 (KrAve-A-R) and 4.26 (KrAve-B-R), as well as figures 4.25 (KrAve-A-I) and 4.27 (KrAve-B-I)), or based upon the wave types (figures 4.24 (KrAve-A-R) and 4.25 (KrAve-A-I), as well as figures 4.26 (KrAve-B-R) and 4.27 (KrAve-B-I)).

- The distribution curves of K_r versus T, either for the slope of 1:1.5 or 1:1.2, generally vary in a trend of positive curvature for the regular waves; while for the irregular waves, the curves invariably vary in a trend of negative curvature. The regression analyses for $K_r \sim T$ to be given soon after will further show the definite trends concisely. This particular feature is worth exploring, and it indicates that the mechanisms of the energy phenomena among the incident, reflected and component waves may be quite different for the regular and irregular wave conditions. One of the possible reasons is that, for the irregular cases, there may exist some repeated reflections which is associated with longer wave components, and for such waves the energy transfers among waves and the energy dissipation of waves are both relatively significant.

- The differences in K_r among most of the armor types are basically not very significant; good or bad, the difference is about 0.1. But still, a few armor types show observable better performance. On the whole, the double-**U**, tri**B**ar and tetrahedro**N** yield the lowest K_r values.

4.2.3 K_r regressions and their field applications

The reflection coefficient has its practical prototype uses in the field. And based upon the various elaborations given above, we gain the understanding that the overall K_r data fit for a meaningful regressive purpose. That is to say, the reflection coefficients thus obtained could be of service in engineering. Such regressions are done between the overall-

averaged reflection coefficients and the wave periods. In which the overall-averaged reflection coefficient is the mean of K_r over all the different wave heights and all the eleven armor types.

Using the numerical method of QR-Factorization of the orthogonal polynomial functions, the orthonormal polynomials of the wave period variable (t below) of various orders are obtained as the following. Since in the field the slope of the breakwater can not be steeper than 1:1.5 (hence this regression estimation is conservatively oriented), only those related to this slope are listed.

$$\begin{aligned} P_0(t) &= -0.1508 \\ P_1(t) &= -0.7866 + 0.4495t \\ P_2(t) &= +4.9414 - 5.8627t + 1.6751t^2 \\ P_3(t) &= +41.9216 - 74.9370t + 43.6986t^2 - 8.3236t^3 \end{aligned}$$

And the errors of the second-order and the third-order approximations are 0.079 and 0.050 respectively. These two errors are small and close, and since the drawn curve for the second order approximation provides a more reasonable prediction for a period beyond the scope of fitted range, the best quadratic polynomial approximation is thus provided as:

$$K_r(t) = 0.3324t^2 - 0.8869t + 0.8955. \tag{4.1}$$

Data related to the numerical regression are listed in table 4.49 (KrReg-A-R).

The above are for the regular waves; for the irregular waves the regression data are listed in table 4.50 (KrReg-A-I).

Figure 4.28 (KrReg-A-R) shows the individual regression curves for the regular waves under the two individual slopes, Their characteristic curvatures are +0.33242 and +0.25533, respectively, for the 1:1.5 and 1:1.2 slope. Figure 4.29 (KrReg-A-I) shows those regression curves for the irregular waves, and the characteristic curvatures are −0.24102 and

-0.31760 respectively for the 1:1.5 and 1:1.2 slope. The features of these curves concisely demonstrate some of the phenomena stated earlier.

In the regression, K_r is dimensionless and t is dimensional and there is no scale involvement. In practical applications, the way to determine a reference reflection coefficient for field uses is given in the following.

As explained in the earlier chapter on planning, for experiments like those in this study, there is no need for a predetermine model scale. That is to say, a precise model scale is not the main concern and what is most relevant is to check the Reynolds' number for not causing adverse effects. Therefore, as long as the value converted from the model to the prototype based upon the Froude's law is not outrageous (i.e., within a suitable range), the regression results can be applied, and vice versa. In fact, since the K_r is barely related to the factor of wave height, as well as not much affected by the armor type, it is therefore reasonable to assume that K_r is mainly affected by the size and the placement pattern of an armor type; correspondingly, the K_r is most likely related to the porosity factor. Now a simple way to find the K_r in applications is suggested as the following. The weight ratio between the prototype and the model (150 grams) can be most easily obtained, and by the Froude's law the scale is determined and the prototype wave period thus converted to the model one. With a model wave period the K_r regression can be applied. Note that a scale related to the length ratio is also possible, but the length measure is somewhat indirect and harder to choose for most of the armor types.

LAYOUT : 1-A (BN5) [Slope: 1 on 1.5]
Armor types : triBar(R) & tetrahedroN(L) Note : Ho~S , Hd~E
Table No. : 1 - A - 1 [Kr - Ho] Kr TABLE 06/12/91-21:50:19.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RHO8	1.294230	7.833190	0.257206	0.214390	1.595000	7.392591	0.330107	0.292195	1.894444	6.491298	0.385140	0.374669	2.256249	8.020213	0.529277	0.522150
RH10	1.303846	9.763978	0.291986	0.260145	1.597500	9.109750	0.338494	0.311129	1.894444	8.272395	0.374208	0.373601	2.212500	10.05357	0.540403	0.541513
RH12	1.303846	11.76577	0.286465	0.266439	1.600000	10.68750	0.348217	0.325170	1.894444	10.19917	0.369069	0.371308	2.237499	13.14761	0.539964	0.549259
RH14	1.276923	14.30147	0.352325	0.323062	1.595000	12.68577	0.345027	0.346819	1.894444	12.17256	0.355720	0.370337	2.259375	14.65132	0.553566	0.574381
RH16	1.290384	16.73536	0.383569	0.330922	1.597500	14.40397	0.362626	0.357774	1.888888	13.82786	0.339502	0.371764	2.200000	17.06270	0.534648	0.603789
RH18	1.288461	19.42958	0.402187	0.370427	1.600000	16.26821	0.370670	0.354352	1.891666	15.39965	0.332505	0.350199	2.189285	19.93451	0.529487	0.600520
RH20					1.600000	17.63179	0.365596	0.277022	1.880555	17.56552	0.333536	0.278125				
RH22					1.595000	19.79512	0.333050	0.215979	1.894444	20.03047	0.342306	0.285957				
RH24					1.595000	21.71136	0.267396	0.235122	1.891666	21.59777	0.321542	0.281220				
BH10	1.374285	8.761880	0.259890	0.243719	1.585263	8.703333	0.358853	0.338681	1.967499	8.761203	0.410518	0.397141	2.086896	8.259503	0.455810	0.441650
BH13	1.363720	11.03385	0.269082	0.213425	1.561025	11.09230	0.363297	0.312154	1.860000	10.96934	0.400404	0.370939	2.111724	10.86987	0.457202	0.431072
BH16	1.445999	12.83467	0.284287	0.231895	1.620000	13.38254	0.355494	0.313552	1.808235	13.13815	0.400270	0.370365	2.003999	12.86949	0.433447	0.416506
BH20	1.465999	14.94687	0.290325	0.244922	1.625882	15.86072	0.359840	0.325515	1.856470	16.05753	0.390772	0.365817	2.001250	14.92674	0.436503	0.403267
std (RH)	0.0093		0.0536	0.0521	0.0020		0.0138	0.0240	0.0021		0.0187	0.0084	0.0270		0.0083	0.0302
std (BH)	0.0442		0.0121	0.0127	0.0264		0.0028	0.0107	0.0582		0.0070	0.0123	0.0491		0.0108	0.0145
ave (RH)	1.293		0.329	0.294	1.598		0.349	0.331	1.893		0.359	0.369	2.226		0.538	0.565
ave (BH)	1.413		0.276	0.233	1.598		0.359	0.322	1.873		0.400	0.376	2.051		0.446	0.423

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.3 (Kr-A-1). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.5) (tri**B**ar and tetrahedro**N**).

LAYOUT : 2-A (DS5) [Slope: 1 on 1.5]
Armor types : Dolos (R) & Shake (L) Note : Ho~S , Hd~E
Table No. : 2 - A - 1 [Kr - Ho] Kr TABLE 06/12/91-22:45:55.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RHO8	1.299999	7.736350	0.233073	0.207612	1.592499	7.539447	0.367302	0.343670	1.897222	6.454843	0.421139	0.424678	2.209374	7.998416	0.566184	0.564716
RH10	1.301923	9.491713	0.251885	0.218913	1.595000	9.260855	0.371501	0.354862	1.894444	8.111087	0.403831	0.413362	2.234375	10.29706	0.574229	0.578342
RH12	1.296153	11.52914	0.239822	0.203607	1.600000	11.07063	0.381163	0.364614	1.891666	10.14140	0.397967	0.405869	2.212500	12.21508	0.570629	0.585415
RH14	1.296153	13.39732	0.239341	0.217796	1.597500	12.47655	0.385195	0.378146	1.893749	11.99522	0.381217	0.398095	2.243750	14.64297	0.578927	0.590561
RH16	1.296153	14.99388	0.234733	0.196648	1.600000	14.49151	0.403885	0.396027	1.897222	13.39772	0.359213	0.381497	2.240624	17.56952	0.584181	0.594413
RH18	1.309615	17.18408	0.223686	0.200205	1.600000	16.52248	0.409025	0.397258	1.888888	16.94078	0.352240	0.349707	2.262500	18.98113	0.563826	0.599742
RH20					1.602499	18.19946	0.420012	0.383756								
RH22					1.589999	21.27647	0.363568	0.277951								
RH24					1.595000	21.75474	0.328761	0.310829								
BH10	1.372093	8.908819	0.296738	0.272132	1.624864	8.812429	0.397271	0.382482	1.916249	8.799792	0.454546	0.450072	2.184827	8.779970	0.505578	0.493681
BH13	1.367441	11.17065	0.293603	0.276641	1.671111	11.54592	0.396264	0.384627	1.882352	11.10081	0.438922	0.442166	2.104516	10.80194	0.490374	0.485305
BH16	1.402999	12.81281	0.311803	0.315565	1.639999	13.48981	0.388397	0.385838	1.876250	13.38564	0.435667	0.448193	2.115999	13.25239	0.476114	0.488130
BH20	1.468999	14.70432	0.331391	0.319876	1.714444	15.81079	0.383997	0.390782	1.837647	15.99786	0.424940	0.435412	2.152258	16.48997	0.454452	0.481299
std (RH)	0.0048		0.0085	0.0084	0.0029		0.0155	0.0200	0.0030		0.0244	0.0244	0.0183		0.0070	0.0115
std (BH)	0.0405		0.0150	0.0218	0.0343		0.0055	0.0030	0.0279		0.0106	0.0057	0.0316		0.0188	0.0045
ave (RH)	1.300		0.237	0.207	1.598		0.386	0.372	1.894		0.386	0.396	2.234		0.573	0.586
ave (BH)	1.403		0.308	0.296	1.663		0.391	0.386	1.878		0.439	0.444	2.139		0.482	0.487

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.4 (Kr-A-2). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.5) (**D**olos and **S**hake).

LAYOUT : 3-A (LA5) [Slope: 1 on 1.5]
Armor types : Linko (R) & Anchor (L) Note : Ho~S , Hd~E
Table No. : 3 - A - 1 [Kr - Ho] Kr TABLE 06/12/91-23:38:15.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RHO8	1.296153	7.667766	0.273334	0.328599	1.592499	7.570640	0.371281	0.360514	1.883333	6.947706	0.420904	0.440113	2.243750	8.287925	0.566262	0.565180
RH10	1.319230	9.773086	0.271604	0.337901	1.597500	9.255384	0.385882	0.366347	1.880555	8.551914	0.416413	0.436697	2.234375	10.61952	0.584695	0.592732
RH12	1.296153	11.99964	0.269329	0.343407	1.595000	11.13744	0.395902	0.372917	1.894444	10.24335	0.402399	0.405440	2.221874	12.68988	0.596864	0.603048
RH14	1.309615	14.33524	0.282721	0.376889	1.604999	12.63598	0.415684	0.391025	1.894444	13.08623	0.395216	0.385566	2.203125	15.64593	0.617286	0.609935
RH16	1.311538	16.62708	0.317944	0.373651	1.597500	15.14457	0.425879	0.401715	1.891666	14.15921	0.363395	0.349584	2.1875	18.11737	0.610984	0.618649
RH18	1.323076	19.61754	0.357071	0.375156	1.592499	16.35735	0.409460	0.365900	1.900000	16.87976	0.360975	0.323005	2.200000	20.09879	0.600893	0.580358
RH20					1.597500	18.01089	0.407475	0.313009								
RH22					1.600000	19.76729	0.330550	0.239686								
RH24					1.587499	21.32206	0.296176	0.251064								
BH10	1.399090	8.754822	0.291949	0.292747	1.563243	8.996037	0.396428	0.391877	1.899393	8.753749	0.452749	0.448677	2.153333	8.591058	0.493810	0.499349
BH13	1.347272	10.86523	0.293046	0.292773	1.678918	11.28129	0.392153	0.391205	1.853749	11.30399	0.437572	0.439014	2.082580	10.96753	0.487454	0.495480
BH16	1.460999	12.84393	0.293792	0.234775	1.684571	13.61869	0.382221	0.333976	1.854545	13.22832	0.423220	0.384469	2.110666	13.03778	0.473597	0.451475
BH20	1.468999	14.75360	0.312577	0.253492	1.639999	16.17637	0.387711	0.352746	1.841290	16.66768	0.424420	0.399547	2.043529	15.35369	0.441558	0.428185
std (RH)	0.0103		0.0322	0.0198	0.0042		0.0185	0.0149	0.0067		0.0235	0.0430	0.0199		0.0169	0.0181
std (BH)	0.0495		0.0085	0.0252	0.0484		0.0053	0.0250	0.0221		0.0120	0.0267	0.0401		0.0202	0.0300
ave (RH)	1.309		0.295	0.356	1.597		0.401	0.376	1.891		0.393	0.390	2.215		0.596	0.595
ave (BH)	1.419		0.298	0.268	1.642		0.390	0.367	1.862		0.434	0.418	2.098		0.474	0.469

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.5 (Kr-A-3). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.5) (Linko and Anchor).

LAYOUT : 4-A (TH5) [Slope: 1 on 1.5]
Armor types : Tetrapod (R) & Hexapod (L) Note : Ho~S , Hd~E
Table No. : 4 - A - 1 [Kr - Ho] Kr TABLE 06/13/91-00:30:50.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RHO8	1.311538	7.774634	0.274082	0.262566	1.590000	7.229054	0.356367	0.327344	1.897222	6.567490	0.406165	0.388094	2.21875	8.463264	0.559896	0.544043
RH10	1.309615	10.07011	0.303883	0.320865	1.597500	9.121217	0.370013	0.341442	1.891666	8.342067	0.395533	0.389318	2.224999	10.85253	0.569251	0.551543
RH12	1.317307	11.88941	0.283475	0.318908	1.600000	10.81535	0.385052	0.350346	1.894444	9.975181	0.384178	0.389980	2.231250	12.78468	0.578082	0.561525
RH14	1.292307	13.52877	0.332816	0.355628	1.597500	12.37750	0.396950	0.360161	1.888888	12.22134	0.367228	0.381187	2.234375	14.78859	0.583475	0.571237
RH16	1.271153	17.30754	0.374201	0.369686	1.592499	14.34581	0.403591	0.380236	1.900000	13.24729	0.350065	0.365704	2.243750	17.25924	0.578004	0.577525
RH18	1.290384	19.94112	0.367228	0.382513	1.595000	16.14670	0.386784	0.377811	1.886111	16.81187	0.342080	0.351885	2.21875	19.41712	0.557996	0.606596
RH20					1.600000	17.89634	0.348748	0.383154								
RH22					1.595000	19.92038	0.274075	0.303279								
RH24					1.595000	22.47305	0.269659	0.297144								
BH10	1.366666	8.762548	0.281559	0.251725	1.589189	8.895013	0.391307	0.359832	1.879999	8.633097	0.439644	0.414462	2.121379	8.644033	0.492563	0.462918
BH13	1.373333	11.05087	0.290418	0.269417	1.612972	11.38216	0.381006	0.366228	1.870000	11.38086	0.439526	0.410475	2.094193	10.55830	0.479475	0.458572
BH16	1.422000	12.70284	0.265895	0.290569	1.624705	13.40411	0.345615	0.369461	1.886250	13.58565	0.400174	0.414463	2.070666	13.01201	0.446625	0.448737
BH20	1.457000	15.34825	0.282170	0.299806	1.618823	16.00352	0.355961	0.374258	1.837499	16.38118	0.400724	0.410443	2.069677	15.04064	0.433051	0.427519
std (RH)	0.0158		0.0387	0.0400	0.0034		0.0159	0.0189	0.0047		0.0232	0.0142	0.0089		0.0096	0.0203
std (BH)	0.0370		0.0089	0.0187	0.0135		0.0184	0.0052	0.0188		0.0196	0.0020	0.0211		0.0240	0.0137
ave (RH)	1.299		0.323	0.335	1.595		0.383	0.356	1.893		0.374	0.378	2.229		0.571	0.569
ave (BH)	1.405		0.280	0.278	1.611		0.368	0.367	1.868		0.420	0.412	2.089		0.463	0.449

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.6 (Kr-A-4). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.5) (**T**etrapod and **H**exapod).

LAYOUT : 5-A (YU5) [Slope: 1 on 1.5]
Armor types : double-Y (R) & double-U (L) Note : Ho~S , Hd~E
Table No. : 5 - A - 1 [Kr - Ho] Kr TABLE 06/13/91-01:23:22.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RHO8	1.303846	7.896674	0.317703	0.198558	1.595000	7.278096	0.372481	0.295237	1.897222	6.740957	0.423489	0.384877	2.237499	8.554899	0.566676	0.492837
RH10	1.299999	10.07393	0.343033	0.199778	1.590000	9.374087	0.368159	0.299307	1.891666	8.471698	0.404942	0.374792	2.237499	10.36301	0.559674	0.499458
RH12	1.311538	12.67054	0.309317	0.182871	1.595000	10.84628	0.379921	0.304131	1.897222	10.05001	0.389474	0.361711	2.221874	12.37828	0.562145	0.504549
RH14	1.298076	15.45939	0.340976	0.179664	1.587499	12.41146	0.383167	0.299866	1.897222	12.13563	0.375650	0.347224	2.209374	16.23706	0.562020	0.508765
RH16	1.282692	17.28844	0.393757	0.197000	1.597500	14.72554	0.380581	0.322266	1.902777	13.99677	0.348137	0.336654	2.200000	18.63206	0.565267	0.516060
RH18	1.299999	20.13900	0.442523	0.176913	1.597500	16.14841	0.384015	0.332996	1.891666	16.73542	0.353785	0.322482	2.196875	21.20615	0.559972	0.516058
RH20					1.600000	17.65381	0.318109	0.319599	1.894444	17.95722	0.337331	0.306809				
RH22					1.592499	19.41918	0.267190	0.263137	1.897222	20.50751	0.348624	0.306405				
RH24					1.610000	20.83882	0.285806	0.278490	1.900000	23.07798	0.381353	0.305268				
BH10	1.386046	8.772416	0.277677	0.239513	1.614054	8.763849	0.384185	0.339368	1.882424	8.466488	0.445023	0.404190	2.096551	8.241031	0.488649	0.439184
BH13	1.364761	11.06589	0.272520	0.247786	1.582702	10.98189	0.371332	0.334340	1.887500	11.03012	0.434636	0.394531	2.091034	10.23125	0.472354	0.420620
BH16	1.385365	13.08812	0.291177	0.262799	1.642105	12.81638	0.367896	0.339157	1.888484	13.30279	0.424991	0.386779	2.041379	12.82280	0.455350	0.410049
BH20	1.464390	15.21735	0.307492	0.280762	1.627428	15.42320	0.378238	0.349012	1.815757	16.09146	0.427897	0.385950	2.033750	15.37557	0.429586	0.386895
std (RH)	0.0086		0.0464	0.0095	0.0038		0.0058	0.0138	0.0038		0.0267	0.0215	0.0164		0.0026	0.0084
std (BH)	0.0381		0.0135	0.0157	0.0219		0.0063	0.0053	0.0306		0.0077	0.0073	0.0283		0.0219	0.0189
ave (RH)	1.299		0.358	0.189	1.594		0.378	0.309	1.896		0.383	0.355	2.217		0.563	0.506
ave (BH)	1.400		0.287	0.258	1.617		0.375	0.340	1.869		0.433	0.393	2.066		0.461	0.414

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.7 (Kr-A-5). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.5) (double-**Y** and double-**U**).

LAYOUT : 6-A (EU5) [Slope: 1 on 1.5]
Armor types : Ten-En (R) & double-U (L) Note : Ho~S , Hd~E
Table No. : 6 - A - 1 [Kr - Ho] Kr TABLE 06/13/91-02:18:51.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RHO8	1.303846	8.111522	0.220984	0.183637	1.600000	7.252129	0.315308	0.290377	1.902777	6.564159	0.378048	0.375989	2.234375	8.272403	0.532426	0.488619
RH10	1.299999	9.704081	0.268928	0.168076	1.600000	9.144964	0.324545	0.278268	1.897222	8.082653	0.372310	0.372570	2.234375	10.75159	0.533404	0.470838
RH12	1.305769	12.49263	0.271977	0.183297	1.597500	10.81842	0.336045	0.288191	1.894444	10.27666	0.364600	0.368791	2.206249	12.54261	0.550236	0.481507
RH14	1.311538	14.54633	0.309540	0.175710	1.600000	12.47940	0.350816	0.301281	1.897222	11.82589	0.362722	0.358691	2.234375	14.40973	0.554716	0.490299
RH16	1.315384	16.48378	0.325269	0.170248	1.597500	14.29499	0.344261	0.314822	1.891666	13.51115	0.340046	0.348482	2.231250	17.57623	0.576535	0.502621
RH18	1.296153	18.61866	0.393417	0.173793	1.597500	16.32963	0.345937	0.329271	1.900000	15.66524	0.318771	0.332075	2.237499	19.37028	0.549747	0.489381
RH20					1.595000	18.42246	0.302978	0.322784	1.894444	17.50379	0.321885	0.316648				
RH22					1.587499	19.72073	0.226861	0.278367	1.897222	20.14196	0.331891	0.322624				
RH24					1.612499	21.28365	0.248406	0.269673	1.888888	23.20252	0.351029	0.318007				
BH10	1.357209	8.913845	0.249175	0.237066	1.566486	8.728595	0.347916	0.331592	1.873749	8.765125	0.406990	0.403427	2.136551	8.277419	0.459481	0.444880
BH13	1.365714	11.14157	0.241923	0.245470	1.609230	11.05295	0.330273	0.340137	1.870967	11.03845	0.385066	0.394666	2.089999	10.89655	0.435032	0.425608
BH16	1.430999	13.07008	0.257063	0.262781	1.603333	13.05572	0.330521	0.340778	1.876363	13.27298	0.380687	0.383684	2.036128	12.52324	0.415145	0.401362
BH20	1.477999	15.07293	0.269057	0.274546	1.670857	15.39242	0.339072	0.347418	1.846060	16.14598	0.389754	0.377137	2.100645	15.35187	0.409526	0.390099
std (RH)	0.0065		0.0539	0.0059	0.0012		0.0126	0.0172	0.0036		0.0205	0.0153	0.0106		0.0148	0.0096
std (BH)	0.0495		0.0101	0.0146	0.0375		0.0073	0.0056	0.0121		0.0100	0.0101	0.0360		0.0196	0.0213
ave (RH)	1.305		0.298	0.176	1.599		0.336	0.300	1.897		0.356	0.359	2.230		0.550	0.487
ave (BH)	1.408		0.254	0.255	1.612		0.337	0.340	1.867		0.391	0.390	2.091		0.430	0.415

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.8 (Kr-A-6). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.5) (ten-**E**n and double-**U**).

LAYOUT : 1-B (NB2) [Slope: 1 on 1.2]
Armor types : triBar(R) & tetrahedroN(L) Note : Ho~S , Hd~E
Table No. : 1 - B - 1 [kr - Ho] Kr TABLE 06/13/91-03:14:19.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RH06	1.305769	5.841880	0.294492	0.292288	1.595000	5.509516	0.385124	0.394708	1.897222	5.036674	0.477644	0.466413	2.215625	6.501950	0.602153	0.588554
RH08	1.317307	7.831109	0.339418	0.326463	1.595000	7.292704	0.388287	0.392913	1.891666	6.631360	0.468169	0.457879	2.234375	8.189706	0.598896	0.593383
RH10	1.309615	10.24973	0.355231	0.339746	1.592499	9.231187	0.384116	0.385503	1.900000	8.163345	0.465691	0.454724	2.21875	10.21978	0.601202	0.592041
RH12	1.299999	12.68700	0.354373	0.411276	1.595000	11.09277	0.390073	0.392804	1.888888	9.935019	0.453858	0.444399	2.234375	12.37819	0.595981	0.593293
RH14	1.298076	14.53212	0.382660	0.380556	1.589999	13.00930	0.401091	0.329648	1.891666	11.79324	0.429127	0.400969	2.228125	14.83799	0.593904	0.569391
RH16	1.296153	17.10281	0.406615	0.381124	1.595000	14.85422	0.417021	0.341525	1.894444	13.71924	0.410399	0.391855	2.231250	17.07885	0.598032	0.574858
RH18	1.290384	19.43737	0.413863	0.394764	1.595000	16.31541	0.436821	0.356681	1.891666	15.31119	0.401881	0.364130	2.200000	19.40656	0.588020	0.573744
RH20					1.597500	17.86591	0.463742	0.338597	1.880555	17.16765	0.396844	0.336539				
RH22					1.600000	19.16054	0.470060	0.264573								
BH08	1.340444	7.327995	0.322674	0.323776	1.602162	7.159982	0.432755	0.425562	1.957575	7.104005	0.480021	0.474952	2.157241	6.958849	0.527001	0.517470
BH10	1.347272	9.031567	0.319280	0.236226	1.584210	8.773456	0.429454	0.343398	1.906666	8.814856	0.476531	0.400995	2.105333	8.513501	0.520298	0.451676
BH13	1.357142	11.52436	0.326665	0.241610	1.603157	11.14884	0.423890	0.348605	1.897500	11.10158	0.460164	0.392137	2.078620	10.68719	0.492659	0.440302
BH16	1.431219	12.99943	0.333159	0.251835	1.654444	13.57425	0.424554	0.358387	1.853749	13.24791	0.449710	0.387277	2.047499	12.87465	0.472519	0.422154
BH20	1.477073	15.31385	0.341563	0.274679	1.669189	15.67172	0.426343	0.362918	1.912500	16.60315	0.445422	0.379230	1.965333	15.73550	0.465197	0.416155
std (RH)	0.0084		0.0383	0.0393	0.0018		0.0183	0.0254	0.0035		0.0278	0.0367	0.0117		0.0045	0.0097
std (BH)	0.0541		0.0079	0.0319	0.0330		0.0033	0.0297	0.0332		0.0139	0.0347	0.0639		0.0247	0.0362
ave (RH)	1.302		0.364	0.361	1.594		0.400	0.371	1.894		0.444	0.426	2.223		0.597	0.584
ave (BH)	1.391		0.329	0.266	1.623		0.427	0.368	1.906		0.462	0.407	2.071		0.496	0.450

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.9 (Kr-B-1). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.2) (tri**B**ar and tetrahedro**N**).

LAYOUT : 2-B (SD2) [Slope: 1 on 1.2]
Armor types : Dolos (R) & Shake (L) Note : Ho~S , Hd~E
Table No. : 2 - B - 1 [kr - Ho] Kr TABLE 06/13/91-04:17:27.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RH06	1.303846	5.768622	0.284233	0.320968	1.592499	5.535429	0.391859	0.428483	1.888888	5.070028	0.482248	0.532857	2.224999	6.102148	0.603696	0.618056
RH08	1.309615	8.025066	0.307401	0.325095	1.597500	7.734045	0.392232	0.413952	1.894444	6.553867	0.469451	0.501582	2.21875	8.011611	0.596183	0.607351
RH10	1.301923	9.929829	0.330144	0.320916	1.592499	9.450603	0.389931	0.400800	1.900000	8.260231	0.458011	0.485862	2.224999	9.986791	0.596447	0.607589
RH12	1.303846	11.81460	0.380437	0.336439	1.587499	11.18105	0.387744	0.391639	1.897222	9.778232	0.443603	0.477531	2.231250	12.49899	0.595287	0.598611
RH14	1.294230	13.91082	0.433412	0.378516	1.597500	13.06413	0.402896	0.396609	1.891666	12.01920	0.432579	0.467616	2.196875	14.93760	0.603638	0.608801
RH16	1.298076	16.89639	0.442836	0.387991	1.597500	14.94510	0.416188	0.420758	1.894444	14.00841	0.419037	0.450529	2.228125	16.81901	0.602877	0.612280
RH18	1.298076	19.03678	0.410880	0.357469	1.602499	16.20443	0.442430	0.460116	1.886111	16.09895	0.402638	0.425109	2.215625	19.02827	0.602687	0.603953
RH20					1.602499	18.97594	0.438408	0.443071	1.877777	18.16902	0.394883	0.416902				
RH22					1.600000	18.95672	0.403736	0.411707								
BH08	1.330909	6.907793	0.326659	0.352739	1.591111	7.220721	0.432149	0.447627	1.911515	7.032975	0.479033	0.495323	2.171428	6.780647	0.527453	0.531039
BH10	1.360000	8.925104	0.321091	0.349620	1.590270	8.971689	0.418811	0.448672	1.886060	8.842863	0.479944	0.504174	2.151999	8.449638	0.520773	0.534351
BH13	1.396279	11.18814	0.323685	0.353129	1.620000	11.37715	0.422131	0.449735	1.857499	11.03956	0.462367	0.481921	2.095999	10.83091	0.505292	0.501196
BH16	1.419512	13.10984	0.326465	0.344788	1.652972	13.59178	0.416432	0.432006	1.853333	13.11909	0.452158	0.464107	2.103999	13.36900	0.480004	0.476048
BH20	1.457999	15.24656	0.337132	0.361783	1.670857	16.06207	0.419757	0.423256	1.894117	16.51532	0.437409	0.440110	2.050666	15.92712	0.453249	0.458169
std (RH)	0.0047		0.0585	0.0260	0.0045		0.0184	0.0218	0.0044		0.0261	0.0323	0.0107		0.0036	0.0057
std (BH)	0.0445		0.0055	0.0056	0.0324		0.0055	0.0107	0.0221		0.0162	0.0229	0.0428		0.0274	0.0299
ave (RH)	1.301		0.370	0.347	1.595		0.403	0.416	1.893		0.444	0.477	2.220		0.600	0.608
ave (BH)	1.393		0.327	0.352	1.625		0.422	0.440	1.881		0.462	0.477	2.115		0.497	0.500

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.10 (Kr-B-2). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.2) (**D**olos and **S**hake).

LAYOUT : 3-B (AL2) [Slope: 1 on 1.2]
Armor types : Linko (R) & Anchor (L) Note : Ho~S , Hd~E
Table No. : 3 - B - 1 [kr - Ho] Kr TABLE 06/13/91-05:20:28.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Hol/3	Kr(R)	Kr(L)	T1/3	Hol/3	Kr(R)	Kr(L)	T1/3	Hol/3	Kr(R)	Kr(L)	T1/3	Hol/3	Kr(R)	Kr(L)
RH06	1.305769	6.058722	0.353598	0.312264	1.587499	5.573372	0.445482	0.433778	1.902777	4.980465	0.518719	0.508901	2.221874	6.027891	0.638420	0.624956
RH08	1.313461	8.000148	0.374367	0.321281	1.592499	7.629402	0.445574	0.429861	1.894444	6.586743	0.509640	0.505148	2.224999	8.092367	0.634986	0.626772
RH10	1.303846	10.11054	0.378271	0.296921	1.592499	9.325475	0.454432	0.427929	1.880555	8.162436	0.504878	0.496945	2.221874	10.33441	0.632514	0.633060
RH12	1.313461	11.76857	0.396770	0.295811	1.597500	11.27029	0.447698	0.421045	1.900000	9.943982	0.491704	0.491208	2.231250	12.87851	0.633780	0.632998
RH14	1.298076	14.24037	0.397851	0.316306	1.610000	13.13666	0.470663	0.434553	1.894444	11.89828	0.474111	0.484939	2.224999	14.66829	0.637489	0.642394
RH16	1.299999	16.22668	0.407665	0.365140	1.597500	15.05852	0.475419	0.451087	1.897222	13.37529	0.451096	0.468118	2.209374	16.60677	0.629060	0.623678
RH18	1.307692	18.75527	0.426803	0.367906	1.597500	16.05134	0.475088	0.459253	1.894444	16.25249	0.421956	0.428378	2.231250	18.33024	0.598826	0.593270
RH20					1.607500	17.91584	0.492090	0.451989	1.891666	18.13855	0.403096	0.389597				
RH22					1.602499	19.19704	0.477107	0.366179								
BH08	1.342222	7.284595	0.362704	0.354448	1.621621	7.264748	0.474831	0.473564	1.935294	7.137998	0.522299	0.514711	2.155999	6.984460	0.555151	0.543611
BH10	1.338181	8.933094	0.359157	0.320112	1.587368	8.790301	0.456982	0.416434	1.949411	8.837539	0.505650	0.472709	2.139999	8.784051	0.540732	0.512030
BH13	1.386976	11.29619	0.361033	0.316578	1.611578	11.22897	0.453635	0.415064	1.904242	11.03411	0.489935	0.461323	2.087742	10.63528	0.515053	0.492570
BH16	1.437073	13.06465	0.374321	0.327007	1.669189	13.30251	0.453017	0.422365	1.912727	13.15284	0.477184	0.449302	2.100645	13.09224	0.490802	0.471245
BH20	1.448571	14.99644	0.367101	0.340291					1.819393	16.34126	0.465195	0.441154	2.045161	16.57182	0.489877	0.465742
std (RH)	0.0056		0.0223	0.0276	0.0065		0.0130	0.0125	0.0065		0.0324	0.0257	0.0069		0.0128	0.0144
std (BH)	0.0461		0.0054	0.0140	0.0297		0.0089	0.0242	0.0453		0.0202	0.0258	0.0393		0.0262	0.0285
ave (RH)	1.306		0.391	0.325	1.596		0.459	0.437	1.895		0.482	0.483	2.224		0.629	0.625
ave (BH)	1.391		0.365	0.332	1.622		0.460	0.432	1.904		0.492	0.468	2.106		0.518	0.497

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.11 (Kr-B-3). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.2) (Linko and Anchor).

LAYOUT : 4-B (HT2) [Slope: 1 on 1.2]
Armor types : Tetrapod (R) & Hexapod (L) Note : Ho~S , Hd~E
Table No. : 4 - B - 1 [kr - Ho] Kr TABLE 06/13/91-06:22:09.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Hol/3	Kr(R)	Kr(L)	T1/3	Hol/3	Kr(R)	Kr(L)	T1/3	Hol/3	Kr(R)	Kr(L)	T1/3	Hol/3	Kr(R)	Kr(L)
RH06	1.298076	6.091511	0.301589	0.328322	1.592499	5.870591	0.415416	0.421120	1.891666	5.218745	0.494542	0.468254	2.224999	5.952314	0.620982	0.604755
RH08	1.299999	8.351797	0.317011	0.336968	1.600000	7.593208	0.412251	0.409486	1.894444	6.658014	0.484392	0.468349	2.228125	8.143772	0.618258	0.602186
RH10	1.309615	10.54810	0.352167	0.358860	1.595000	9.599664	0.425760	0.398802	1.897222	8.441328	0.474507	0.467914	2.228125	10.53833	0.624602	0.594613
RH12	1.305769	13.28162	0.381750	0.373657	1.597500	11.35313	0.431814	0.383172	1.891666	10.01519	0.464020	0.462507	2.209374	12.50804	0.624003	0.585010
RH14	1.294230	14.63770	0.369099	0.380570	1.597500	13.28408	0.448657	0.386350	1.894444	11.75522	0.453152	0.456711	2.193749	15.22858	0.626552	0.580431
RH16	1.296153	18.46031	0.388697	0.433627	1.597500	14.51950	0.477977	0.404311	1.888888	14.31169	0.430195	0.433834	2.228125	17.39409	0.634593	0.593922
RH18	1.303846	20.18473	0.398339	0.445948	1.595000	16.44135	0.487936	0.426299	1.883333	17.04328	0.413023	0.413941	2.193749	19.92196	0.617627	0.573640
RH20					1.592499	19.34908	0.440672	0.429245	1.883333	17.88167	0.381242	0.391286				
RH22					1.597500	20.03400	0.372380	0.420988								
BH08	1.320000	7.292575	0.352607	0.341096	1.614054	7.388078	0.451350	0.434163	1.879999	7.188287	0.512574	0.495923	2.099999	6.834682	0.546000	0.528987
BH10	1.367619	9.212791	0.332137	0.343449	1.589473	8.894146	0.434186	0.432292	1.84375	8.675684	0.489009	0.485525	2.115862	8.569547	0.532864	0.522338
BH13	1.394285	11.50973	0.332035	0.337078	1.664615	11.46754	0.438749	0.448106	1.877575	11.06223	0.467721	0.469151	2.122666	11.24894	0.501977	0.499769
BH16	1.419999	13.32427	0.340182	0.352835	1.678888	13.55456	0.424798	0.431622	1.851249	13.31670	0.460379	0.468656	2.034666	13.15312	0.481268	0.476981
BH20	1.447804	15.12249	0.356063	0.370722	1.635555	15.95785	0.422416	0.427351	1.819393	16.10384	0.451951	0.447997	2.083870	16.21520	0.464271	0.463863
std (RH)	0.0051		0.0341	0.0418	0.0023		0.0278	0.0151	0.0042		0.0271	0.0196	0.0149		0.0054	0.0106
std (BH)	0.0440		0.0101	0.0120	0.0326		0.0104	0.0071	0.0225		0.0219	0.0164	0.0314		0.0306	0.0251
ave (RH)	1.301		0.358	0.380	1.596		0.443	0.404	1.892		0.459	0.453	2.215		0.624	0.591
ave (BH)	1.390		0.343	0.349	1.637		0.434	0.435	1.854		0.476	0.473	2.091		0.505	0.498

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.12 (Kr-B-4). The K_r and the wave period $T_{1/3}$ and wave height $H_{o1/3}$ of the separated incident wave (slope: 1:1.2) (**T**etrapod and **H**exapod).

LAYOUT : 5-B (UY2) [Slope: 1 on 1.2]
Armor types : double-Y (R) & double-U (L) Note : Ho~S , Hd~E
Table No. : 5 - B - 1 [kr - Ho] Kr TABLE 06/13/91-07:25:09.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RH06	1.311538	6.147562	0.320334	0.238087	1.592499	5.570049	0.409597	0.364148	1.883333	5.162760	0.487466	0.452323	2.228124	6.319530	0.605805	0.562260
RH08	1.303846	8.091185	0.330027	0.237482	1.597500	7.819745	0.409273	0.357136	1.894444	6.580924	0.471801	0.443583	2.231250	8.413904	0.603296	0.550786
RH10	1.313461	10.43238	0.373860	0.254203	1.595000	9.662900	0.413360	0.357206	1.894444	8.331759	0.461134	0.432713	2.237499	10.43641	0.602311	0.547012
RH12	1.301923	12.66066	0.365085	0.237086	1.592499	11.13929	0.407918	0.340878	1.891666	10.27883	0.451842	0.419190	2.224999	13.14367	0.599732	0.534521
RH14	1.298076	14.68151	0.406421	0.220001	1.592499	13.05415	0.421540	0.343620	1.900000	12.02866	0.433833	0.412220	2.262500	14.37447	0.602215	0.533897
RH16	1.299999	18.33382	0.429400	0.225522	1.597500	14.38447	0.432873	0.352406	1.897222	14.24510	0.412644	0.395580	2.253124	17.08302	0.609881	0.526050
RH18	1.282692	20.13330	0.428841	0.240565	1.602499	16.17608	0.448749	0.365276	1.888888	16.08556	0.396555	0.375502	2.207142	19.19324	0.606614	0.508402
RH20					1.600000	17.85706	0.429826	0.380797	1.883333	17.55263	0.384491	0.357539				
RH22					1.600000	18.63900	0.376485	0.340559								
BH08	1.328181	7.319000	0.325799	0.293772	1.584864	7.281580	0.433873	0.398457	1.916470	7.015056	0.483242	0.462626	2.136000	7.057270	0.523964	0.501882
BH10	1.376744	9.105052	0.325280	0.302593	1.605263	8.879320	0.436401	0.401443	1.923750	9.065982	0.481952	0.461890	2.146666	8.520489	0.528172	0.505317
BH13	1.378604	11.30923	0.330566	0.311862	1.669473	11.39602	0.429917	0.396935	1.882499	11.21140	0.468323	0.448136	2.139310	11.25659	0.507524	0.476000
BH16	1.428292	13.04336	0.330236	0.317012	1.690810	13.55034	0.420255	0.397477	1.881212	13.65878	0.462105	0.447240	2.047741	13.24308	0.490227	0.473209
BH20	1.471794	15.58532	0.340114	0.327897	1.639999	15.87042	0.420695	0.394830	1.910303	16.12397	0.446939	0.426394	2.087500	16.42020	0.462699	0.443737
std (RH)	0.0094		0.0411	0.0102	0.0035		0.0142	0.0087	0.0051		0.0301	0.0250	0.0170		0.0031	0.0164
std (BH)	0.0491		0.0053	0.0117	0.0392		0.0067	0.0022	0.0177		0.0134	0.0132	0.0381		0.0240	0.0223
ave (RH)	1.302		0.379	0.236	1.596		0.420	0.354	1.893		0.445	0.419	2.235		0.604	0.538
ave (BH)	1.397		0.330	0.311	1.638		0.428	0.398	1.903		0.469	0.449	2.111		0.503	0.480

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.13 (Kr-B-5). The K_r and the wave period $T_{1/3}$ and wave height $H_{o\,1/3}$ of the separated incident wave (slope: 1:1.2) (double-**Y** and double-**U**).

LAYOUT : 6-B (IA2) [Slope: 1 on 1.2]
Armor types : ten-En (R) Note : Ho~S , Hd~E
Table No. : 6 - B - 1 [kr - Ho] Kr TABLE 06/13/91-08:28:12.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)	T1/3	Ho1/3	Kr(R)	Kr(L)
RH06	1.303846	6.153922	0.304450		1.597500	5.571199	0.404765		1.894444	5.029817	0.497882		2.215625	6.102622	0.608664	
RH08	1.307692	8.054056	0.313262		1.590000	7.376290	0.400173		1.891666	6.740662	0.490244		2.228124	7.986986	0.609406	
RH10	1.309615	10.01582	0.376622		1.595000	9.549870	0.393333		1.894444	8.146387	0.477045		2.237499	10.76208	0.605265	
RH12	1.299999	12.35962	0.399834		1.600000	11.35441	0.391807		1.897222	9.967349	0.468154		2.200000	12.61425	0.595774	
RH14	1.303846	13.99354	0.412685		1.600000	13.02791	0.390225		1.894444	11.71916	0.444782		2.206249	14.39657	0.587967	
RH16	1.299999	17.34313	0.415515		1.894444	13.32564	0.424000		1.894444	13.32564	0.424000		2.206249	16.41325	0.595438	
RH18	1.315384	18.51741	0.396253		1.602499	16.77679	0.425351		1.891666	15.19439	0.407305		2.259375	20.11139	0.585217	
RH20					1.604999	18.06635	0.423097		1.900000	17.53981	0.392391					
RH22					1.607500	19.53067	0.399878									
BH08	1.331304	7.195821	0.335025		1.622702	7.261884	0.448192		1.949999	7.184861	0.490348		2.171034	7.026235	0.531844	
BH10	1.353636	8.897407	0.308254		1.641081	8.785220	0.417053		1.858749	8.709047	0.448365		2.190666	8.502079	0.508271	
BH13	1.418095	11.18130	0.320036		1.605263	11.24063	0.405254		1.922500	11.17807	0.449425		2.095999	10.80545	0.490069	
BH16	1.406829	13.23277	0.311207		1.673142	13.66183	0.417901		1.855757	13.28125	0.441011		2.055483	12.84318	0.468074	
BH20	1.447000	15.15524	0.328749		1.683333	15.81031	0.403245		1.849696	16.02646	0.431944		2.030588	16.24630	0.449926	
std (RH)	0.0051		0.0430	ERR	0.1040		0.0137	ERR	0.0018		0.0316	ERR	0.0196		0.0090	ERR
std (BH)	0.0426		0.0102	ERR	0.0295		0.0161	ERR	0.0410		0.0201	ERR	0.0628		0.0289	ERR
ave (RH)	1.306		0.374	ERR	1.640		0.404	ERR	1.894		0.458	ERR	2.222		0.598	ERR
ave (BH)	1.391		0.321	ERR	1.645		0.418	ERR	1.887		0.452	ERR	2.109		0.490	ERR

Note :: (1) BH : Bretschneider spectrum, RH : Regular wave, (2) R : Right channel, L : Left channel, (3) Kr : Reflection coefficient,
(4) std : standard deviation, ave : average, (5) unit : H1/3 <cm>, T1/3 <sec>

Tab 4.14 (Kr-B-6). The K_r and the wave period $T_{1/3}$ and wave height $H_{o\,1/3}$ of the separated incident wave (slope: 1:1.2) (ten-**E**n and double-**U**).

```
..
Case          :   c:\lyl\asy\expdat\RH18T19T.dat   [slope = 1:1.5]
Date          :   01/18/91
Time          :   11:40:57.82                                  Sampling   frequency  :   40  Hz
Specifics     :   R-T-27 ¦ Tetrapod(3,4,7) & H-pod(5,6,8)      Sampling time length  :   80 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.   42  19.09  18.73  18.41    18.65  17.92  17.30  15.24  15.42     1.89  1.89  1.89  1.89  1.89
  2.   42  21.12  21.09  20.87    20.94  20.38  19.82  18.30  18.39     1.91  1.90  1.90  1.89  1.89
  3.   42  16.97  16.46  15.80    16.13  15.24  15.02  13.95  14.07     1.86  1.88  1.88  1.85  1.86
  4.    4   ------- Too small number of waves ------
  5.   41  14.36  14.09  13.53    13.87  13.28  13.10  12.49  12.51     1.89  1.90  1.89  1.90  1.90
  6.   41  14.23  14.09  13.92    14.01  13.56  13.36  12.74  12.77     1.89  1.90  1.90  1.89  1.89
  7.   48  13.87  13.79  13.70    13.56  13.11  12.88  10.83  11.20     1.88  1.89  1.86  1.62  1.68
  8.    5   ------- Too small number of waves ------
.....
FFT parameters          :
              Kr        :     .3421     r.ch1  :         3     r.ch2  :         4
              del.L     :   28.8000     depth  :   48.0000     w.l.n  :   63.8759
              L.min     :   64.0000     T.min  :     .6406     M.max  :        80
              L.max     :  576.0000     T.max  :    2.7724     M.min  :        18
              Sum.aR.sq : .01197E  12
              Sum.aI.sq : .01023E  13                          b.pnt  :         1
              fft.point :      2048     i.smt  :         0     f.cut  :     .3333
    )
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  3.   26  17.73  16.65  15.28    16.55  14.04  12.74  10.19  10.68     1.90  1.90  1.90  1.90  1.90
  3.   26   7.91   6.14   5.73     6.59   5.12   4.54   3.72   3.93     1.91  1.89  1.88  1.90  1.90
.........
FFT parameters          :
              Kr        :     .3519     r.ch1  :         5     r.ch2  :         6
              del.L     :   28.8000     depth  :   48.0000     w.l.n  :   63.8759
              L.min     :   64.0000     T.min  :     .6406     M.max  :        80
              L.max     :  576.0000     T.max  :    2.7724     M.min  :        18
              Sum.aR.sq : .01034E  12
              Sum.aI.sq : .08349E  12                          b.pnt  :         1
              fft.point :      2048     i.smt  :         0     f.cut  :     .3333
.................
FFT parameters          :
              Kr        :     .4072     r.ch1  :         1     r.ch2  :         2
              del.L     :   32.0000     depth  :   82.0000     w.l.n  :   70.7878
              L.min     :   71.1111     T.min  :     .6752     M.max  :        76
              L.max     :  640.0000     T.max  :    2.4806     M.min  :        21
              Sum.aR.sq : .01469E  12
              Sum.aI.sq : .08858E  12                          b.pnt  :       441
              fft.point :      2048     i.smt  :         0     f.cut  :     .3333

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   26  17.58  17.30  16.81    17.23  16.74  16.37  14.20  14.41     1.89  1.89  1.89  1.89  1.89
  1.   26   8.66   8.62   8.53     8.60   7.81   7.29   6.15   6.31     1.86  1.90  1.88  1.90  1.90
.....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Page 1    C:\ARMDAT\EXPPRN\RH18T19T.PRN   01/18/91   17:04:06.90
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Tab 4.15 (StaRpt-R-1). Note the implication of "Too small number of waves" and the wave separation — an on-site data-sheet printout (regular wave, T1.9, slope: 1:1.5, **T**etrapod and **H**exapod).

```
..
Case          :   c:\lyl\asy\expdat\RH10T16H.dat   [slope = 1:1.2]
Date          :   02/22/91
Time          :   01:38:13.28                                  Sampling   frequency  :   40  Hz
Specifics     :   R-H-10 ¦ Tetrapod(3,4,7) & H-pod(5,6,8)      Sampling time length  :   80 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.   49   9.62   9.59   9.35    9.23   8.41   8.21   7.76   7.79     1.60  1.60  1.60  1.60  1.60
  2.   49  11.47  11.47  11.45   11.45  11.19  10.93  10.48  10.49     1.60  1.60  1.60  1.60  1.60
  3.   49  10.67  10.62  10.55   10.57  10.36  10.30  10.12  10.12     1.60  1.60  1.60  1.60  1.60
  4.    1   -------- Too small number of waves -------
  5.    8  11.30  11.23  11.13   11.30  11.22  11.20  10.93  10.93    18.33 16.50 14.77  9.49 12.12
  6.    4   -------- Too small number of waves -------
  7.   49  11.84  11.82  11.79   11.78  11.71  11.68  11.54  11.54     1.59  1.59  1.60  1.60  1.60
  8.   49  12.11  12.01  11.99   11.99  11.85  11.79  11.64  11.64     1.59  1.60  1.60  1.60  1.60
.
FFT parameters          :
              Kr        :     .4258     r.ch1  :         3     r.ch2  :         4
              del.L     :   28.5000     depth  :   48.0000     i.smt  :         0
              fft.point :      2048     b.pnt  :         1     f.cut  :     .3333

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  3.   31   8.65   8.39   7.71    8.25   7.30   6.80   6.20   6.26     1.60  1.60  1.60  1.60  1.60
  3.   31   4.70   3.62   3.39    3.90   3.26   3.02   2.71   2.76     1.60  1.60  1.60  1.60  1.60
.............
FFT parameters          :
              Kr        :     .3988     r.ch1  :         5     r.ch2  :         6
              del.L     :   28.8000     depth  :   48.0000     i.smt  :         0
              fft.point :      2048     b.pnt  :         1     f.cut  :     .3333

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  5.   31   8.50   8.29   7.74    8.18   7.31   6.86   6.22   6.28     1.61  1.60  1.60  1.60  1.60
  5.   31   3.88   3.09   3.00    3.32   2.86   2.70   2.48   2.51     1.60  1.60  1.60  1.60  1.60
...............
FFT parameters          :
              Kr        :     .3084     r.ch1  :         1     r.ch2  :         2
              del.L     :   31.6000     depth  :   82.0000     i.smt  :         0
              fft.point :      2048     b.pnt  :       441     f.cut  :     .3333

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   31  10.66  10.01   9.64   10.10   9.60   9.45   9.09   9.10     1.60  1.60  1.60  1.60  1.60
  1.   31   3.62   3.55   3.43    3.53   3.20   3.08   2.81   2.83     1.57  1.58  1.59  1.60  1.60
..
.

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```

Tab 4.16 (StaRpt-R-2). Note the implication of "Too small number of waves" and the wave separation — an on-site data-sheet printout (regular wave, T1.6, slope: 1:1.2, **T**etrapod and **H**exapod).

```
..
Case          :   c:\lyl\asy\expdat\RH08T22B.dat   [slope = 1:1.5]
Date          :   01/22/91
Time          :   10:12:04.55                                  Sampling   frequency  :   40  Hz
Specifics     :   R-B-8 ¦ triBar(3,4,7) & t-hetroN(5,6,8)      Sampling time length  :   80 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.   35  10.01   9.99   9.62     9.78   9.27   9.07   8.63   8.65     2.18  2.19  2.19  2.19  2.20
  2.    0   -------- No complete wave cycle  ---------
  3.   35   9.25   9.06   9.03     9.08   8.71   8.54   8.20   8.21     2.19  2.19  2.19  2.19  2.19
  4.   35  12.45  12.30  12.13    12.15  11.48  11.23  10.85  10.87     2.19  2.20  2.19  2.19  2.19
  5.   35   9.45   9.30   9.23     9.30   8.84   8.64   8.25   8.27     2.18  2.19  2.19  2.19  2.19
  6.   35  12.99  12.70  12.57    12.61  11.86  11.60  11.11  11.13     2.18  2.19  2.19  2.19  2.19
  7.   35  10.74  10.62  10.50    10.55   9.98   9.74   9.36   9.37     2.19  2.19  2.19  2.19  2.19
  8.   35  10.40  10.38  10.38    10.35   9.83   9.61   9.23   9.24     2.19  2.19  2.19  2.19  2.19
.

FFT parameters          :
              Kr        :     .5293     r.ch1  :        3     r.ch2  :        4
              del.L     :   28.8000     depth  :  48.0000     i.smt  :        0
              fft.point :     2048      b.pnt  :        1     f.cut  :    .3333
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  3.   22   9.82   9.52   7.11     9.67   6.76   5.71   4.16   4.69     2.24  2.21  2.21  2.23  2.23
  3.   22   5.84   4.42   3.97     5.13   3.64   3.05   2.20   2.51     2.19  2.20  2.20  2.23  2.23
.................

FFT parameters          :
              Kr        :     .5222     r.ch1  :        5     r.ch2  :        6
              del.L     :   28.8000     depth  :  48.0000     i.smt  :        0
              fft.point :     2048      b.pnt  :        1     f.cut  :    .3333
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  5.   22  10.15   9.91   7.41    10.03   7.05   5.95   4.32   4.88     2.24  2.21  2.21  2.23  2.23
  5.   23   6.19   4.69   3.95     5.44   3.71   3.18   2.29   2.63     2.20  2.20  2.20  2.13  2.16
.................

FFT parameters          :
              Kr        :     .4608     r.ch1  :        1     r.ch2  :        2
              del.L     :   31.6000     depth  :  82.0000     i.smt  :        0
              fft.point :     2048      b.pnt  :      441     f.cut  :    .3333
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   23   8.58   8.25   8.03     8.42   8.02   7.92   7.38   7.45     2.24  2.26  2.23  2.15  2.17
  1.   23   4.72   4.60   4.21     4.66   4.06   3.92   3.58   3.62     2.25  2.21  2.20  2.18  2.18
..

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```

Tab 4.17 (StaRpt-R-3). Note the implication of "No complete wave cycle" and the wave separation — an on-site data-sheet printout (regular wave, T2.2, slope: 1:1.5, tri**B**ar and tetrahedro**N**).

```
..
Case          :   c:\lyl\asy\expdat\BH16T22D.dat   [slope = 1:1.5]
Date          :   01/12/91
Time          :   09:43:09.95                                  Sampling   frequency  :   25  Hz
Specifics     :   B-D-24 ¦ Dolos(3,4,7) & Shake(5,6,8)         Sampling time length  :  210 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.  101  24.32  21.75  20.75    18.91  15.42  14.02  10.16  11.19     2.15  2.34  2.27  2.07  2.17
  2.  109  25.59  22.97  22.61    19.28  15.71  14.04   9.66  11.00     2.24  2.23  2.23  1.92  2.03
  3.  103  24.10  23.95  23.93    23.10  18.47  16.12  11.29  12.82     2.33  2.32  2.27  2.03  2.13
  4.    7  31.54  31.47  26.93    31.54  31.51  28.71  21.98  23.89    56.32 63.54 43.17 28.09 36.85
  5.   15  26.03  25.10  23.32    25.56  24.09  22.93  16.66  18.52    12.54 17.80 17.83 13.18 16.78
  6.   99  27.22  27.00  25.29    23.89  18.45  16.19  11.52  13.00     2.14  2.34  2.33  2.11  2.20
......
FFT parameters          :
              Kr        :     .4712     r.ch1  :        3     r.ch2  :        4
              del.L     :   28.8000     depth  :  48.0000     w.l.n  :  63.8759
              L.min     :   64.0000     T.min  :     .6406    M.max  :      256
              L.max     :  576.0000     T.max  :    2.7724    M.min  :       59
              Sum.aR.sq : .03741E  12
              Sum.aI.sq : .01685E  13                        b.pnt  :        1
              fft.point :     4096      i.smt  :        0     f.cut  :     .5000

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  3.  100  19.83  16.74   7.99     8.79   5.27   4.41   2.90   3.97     2.24  2.12  2.04  1.62  1.73
  3.   96  14.47   7.18   6.60     4.81   2.88   2.42   1.60   2.34     2.36  2.32  2.17  1.68  1.84
........
FFT parameters          :
              Kr        :     .4843     r.ch1  :        5     r.ch2  :        6
              del.L     :   28.8000     depth  :  48.0000     w.l.n  :  63.8759
              L.min     :   64.0000     T.min  :     .6406    M.max  :      256
              L.max     :  576.0000     T.max  :    2.7724    M.min  :       59
              Sum.aR.sq : .03380E  12
              Sum.aI.sq : .01441E  13                        b.pnt  :        1
              fft.point :     4096      i.smt  :        0     f.cut  :     .5000
............
FFT parameters          :
              Kr        :     .3711     r.ch1  :        1     r.ch2  :        2
              del.L     :   32.0000     depth  :  82.0000     w.l.n  :  70.9044
              L.min     :   71.1111     T.min  :     .6752    M.max  :      243
              L.max     :  640.0000     T.max  :    2.4806    M.min  :       66
              Sum.aR.sq : .02107E  12
              Sum.aI.sq : .01530E  13                        b.pnt  :      401
              fft.point :     4096      i.smt  :        0     f.cut  :     .5000

Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   90  19.63  18.28  18.10    16.52  13.03  11.54   8.32   9.27     2.06  2.08  2.07  1.79  1.88
  1.  100   6.63   6.50   6.50     6.10   5.12   4.55   3.09   3.53     2.00  2.09  2.06  1.63  1.76
.....



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```

Tab 4.18 (StaRpt-I-1). Note the implication of "the random numbers of waves" and the wave separation — an on-site data-sheet printout (irregular wave, T1.6, slope: 1:1.5, **T**etrapod and **H**exapod).

```
..
Case         :   c:\lyl\asy\expdat\BH20T13H.dat   [slope = 1:1.2]
Date         :   02/22/91
Time         :   00:53:57.47                                  Sampling   frequency  :   25  Hz
Specifics    :   B-H-29 ¦ Tetrapod(3,4,7) & H-pod(5,6,8)      Sampling time length  :  210 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.  145  24.05  24.02  23.49    21.38  15.97  14.32  10.41  11.58     1.49  1.48  1.48  1.44  1.48
  2.  149  24.66  23.61  23.12    20.25  15.88  14.26  10.16  11.39     1.49  1.50  1.51  1.41  1.45
  3.  149  31.23  30.54  26.95    21.57  15.97  14.09  10.02  11.41     1.47  1.49  1.45  1.40  1.44
  4.  147  29.83  28.66  25.46    20.55  15.33  13.65  10.18  11.27     1.47  1.49  1.51  1.41  1.45
  5.  145  26.25  25.17  24.80    19.36  14.55  12.91   9.48  10.54     1.45  1.48  1.52  1.43  1.47
  6.  146  21.68  21.39  20.92    18.52  14.40  12.92   9.61  10.52     1.48  1.50  1.49  1.42  1.46
.................

FFT parameters          :
              Kr        :     .3561     r.ch1  :        3     r.ch2  :        4
              H.eng     :   10.5659     depth  :  48.0000     del.L  :   28.5000
              L.min     :   63.3333     T.min  :    .6373     M.max  :      257
              L.max     :  570.0000     T.max  :   2.7459     M.min  :       60
              i.smt     :        0     f.cut  :    .5000     aR.sq  : .0248994E  12
              fft.point :     4096     b.pnt  :       1     aI.sq  : .0196397E  13
.................

FFT parameters          :
              Kr        :     .3707     r.ch1  :        5     r.ch2  :        6
              H.eng     :    9.6532     depth  :  48.0000     del.L  :   28.8000
              L.min     :   64.0000     T.min  :    .6406     M.max  :      256
              L.max     :  576.0000     T.max  :   2.7724     M.min  :       59
              i.smt     :        0     f.cut  :    .5000     aR.sq  : .0225298E  12
              fft.point :     4096     b.pnt  :       1     aI.sq  : .0163930E  13
...............

FFT parameters          :
              Kr        :     .2966     r.ch1  :        1     r.ch2  :        2
              H.eng     :   10.8469     depth  :  82.0000     del.L  :   31.6000
              L.min     :   70.2222     T.min  :    .6710     M.max  :      244
              L.max     :  632.0000     T.max  :   2.4547     M.min  :       67
              i.smt     :        0     f.cut  :    .5000     aR.sq  : .0182097E  12
              fft.point :     4096     b.pnt  :       1     aI.sq  : .0206983E  13
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.  123  22.29  21.61  21.03    19.45  15.12  13.32   9.37  10.61     1.43  1.45  1.45  1.33  1.37
  1.  137   7.02   6.96   6.60     5.62   4.53   4.03   2.79   3.17     1.54  1.47  1.44  1.19  1.27
..
```

Tab 4.19 (StaRpt-I-2). An on-site data-sheet printout (irregular wave, T1.3, slope: 1:1.2, **T**etrapod and **H**exapod).

```
..
Case         :   c:\lyl\asy\expdat\BH20T22H.dat   [slope = 1:1.2]
Date         :   02/22/91
Time         :   01:20:47.88                                  Sampling   frequency  :   25  Hz
Specifics    :   B-H-32 ¦ Tetrapod(3,4,7) & H-pod(5,6,8)      Sampling time length  :  210 Sec

 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms

  1.  102  27.93  27.81  27.20    23.37  19.03  17.08  12.16  13.57     2.33  2.38  2.37  2.02  2.14
  2.  100  30.86  27.22  27.03    23.93  19.29  17.54  12.56  13.96     2.40  2.42  2.35  2.08  2.19
  3.  101  37.70  31.23  30.64    29.45  22.50  20.10  14.05  15.97     2.20  2.40  2.32  2.06  2.18
  4.  104  33.15  32.06  30.54    29.06  22.71  20.47  13.98  16.08     2.08  2.27  2.28  2.00  2.13
  5.   99  34.55  29.91  29.76    27.71  21.59  19.01  13.58  15.29     2.22  2.35  2.35  2.10  2.20
  6.  106  30.69  30.32  29.98    27.64  21.85  19.40  13.30  15.28     2.09  2.23  2.25  1.96  2.08
.................

FFT parameters          :
              Kr        :     .4643     r.ch1  :         3     r.ch2  :         4
              H.eng     :   12.1318     depth  :   48.0000     del.L  :   28.5000
              L.min     :   63.3333     T.min  :     .6373     M.max  :       257
              L.max     :  570.0000     T.max  :    2.7459     M.min  :        60
              i.smt     :         0     f.cut  :     .5000     aR.sq  : .0558103E  12
              fft.point :      4096     b.pnt  :         1     aI.sq  : .0258923E  13
.................

FFT parameters          :
              Kr        :     .4639     r.ch1  :         5     r.ch2  :         6
              H.eng     :   11.6609     depth  :   48.0000     del.L  :   28.8000
              L.min     :   64.0000     T.min  :     .6406     M.max  :       256
              L.max     :  576.0000     T.max  :    2.7724     M.min  :        59
              i.smt     :         0     f.cut  :     .5000     aR.sq  : .0514710E  12
              fft.point :      4096     b.pnt  :         1     aI.sq  : .0239212E  13
.................

FFT parameters          :
              Kr        :     .3681     r.ch1  :         1     r.ch2  :         2
              H.eng     :   11.2201     depth  :   82.0000     del.L  :   31.6000
              L.min     :   70.2222     T.min  :     .6710     M.max  :       244
              L.max     :  632.0000     T.max  :    2.4547     M.min  :        67
              i.smt     :         0     f.cut  :     .5000     aR.sq  : .0300037E  12
              fft.point :      4096     b.pnt  :       401     aI.sq  : .0221469E  13
Reconstructed incident and reflected waves :
 Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms    T1/10  T1/3  T1/2 T.ave T.rms
  1.   92  22.07  21.94  20.99    20.17  16.22  14.41   9.90  11.30     2.20  2.08  2.05  1.76  1.85
  1.   97   8.92   8.40   7.63     7.25   6.05   5.49   3.89   4.33     2.12  2.16  2.05  1.66  1.76
..
```

Tab 4.20 (StaRpt-I-3). An on-site data-sheet printout (irregular wave, T2.2, slope: 1:1.2, **T**etrapod and **H**exapod).

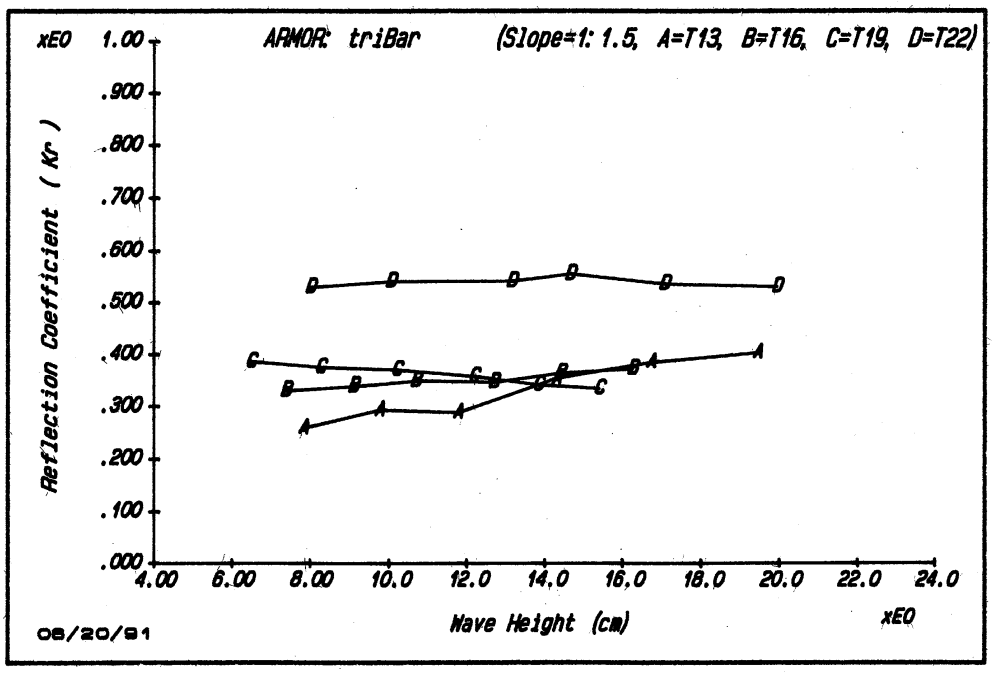

Fig : Kr -- A - 1

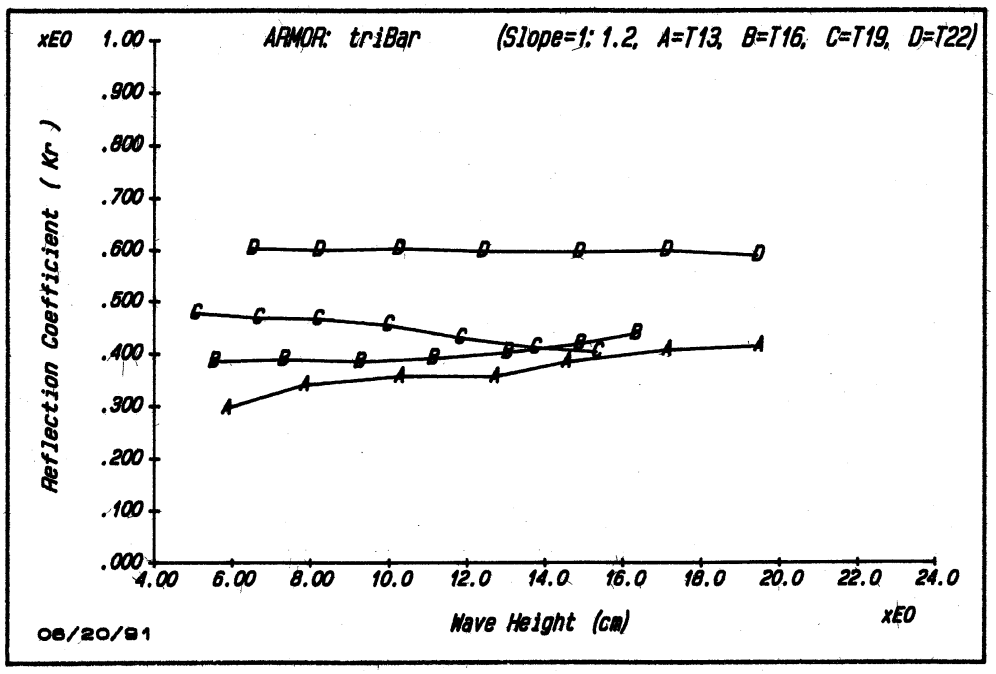

Fig : Kr -- B - 1

Fig 4.1 (Kr-A&B-1). The variation of the reflection coefficients with the wave height for each individual wave period (tri**B**ar).

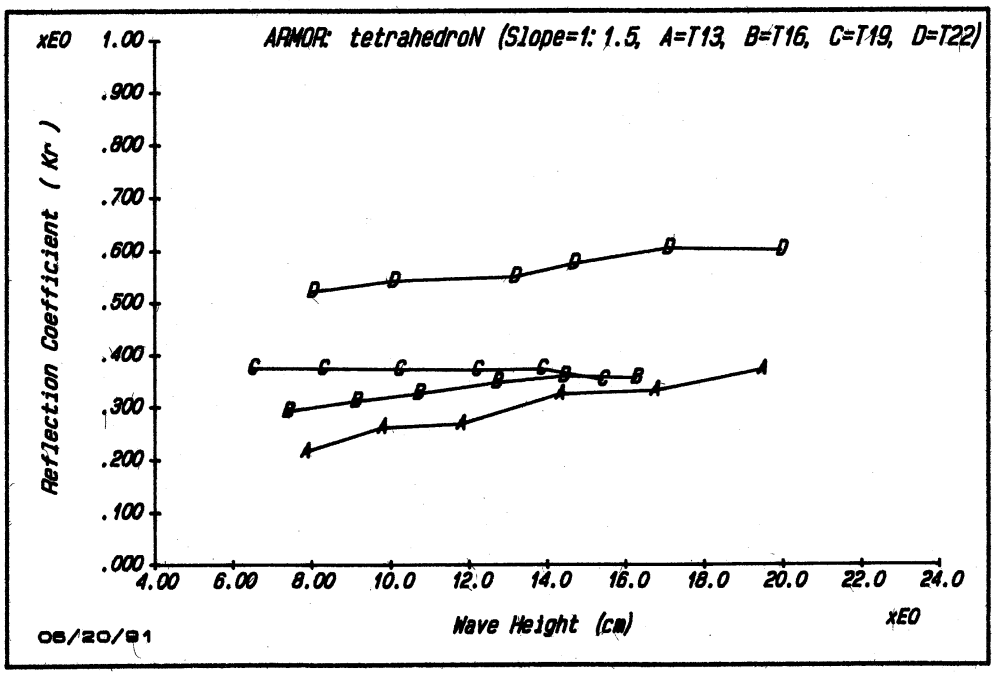

Fig ; Kr -- A - 2

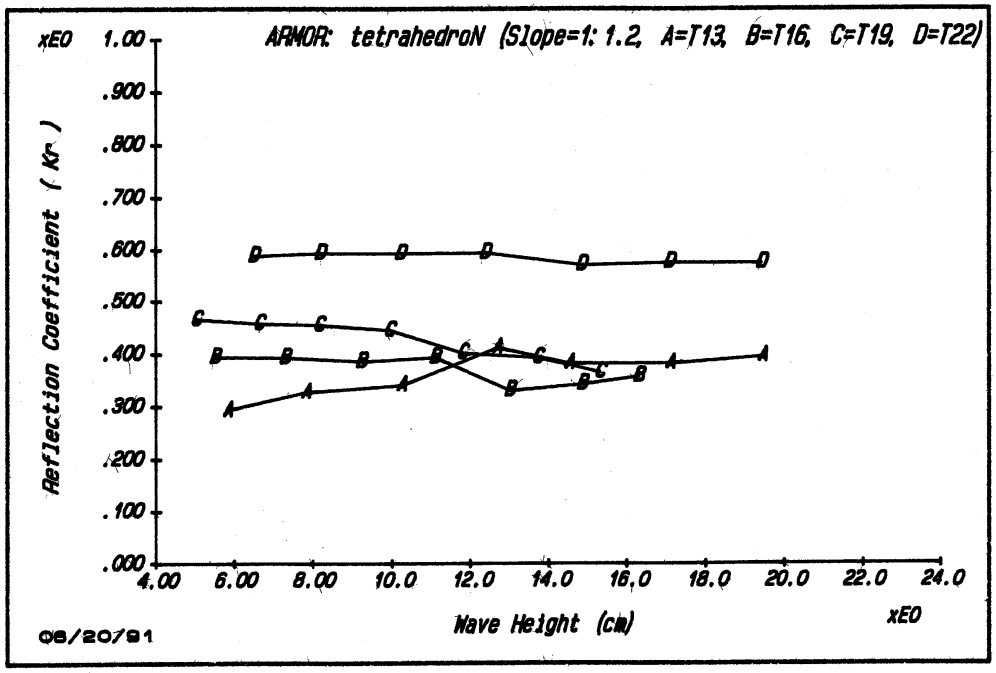

Fig ; Kr -- B - 2

Fig 4.2 (Kr-A&B-2). The variation of the reflection coefficients with the wave height for each individual wave period (tetrahedro**N**).

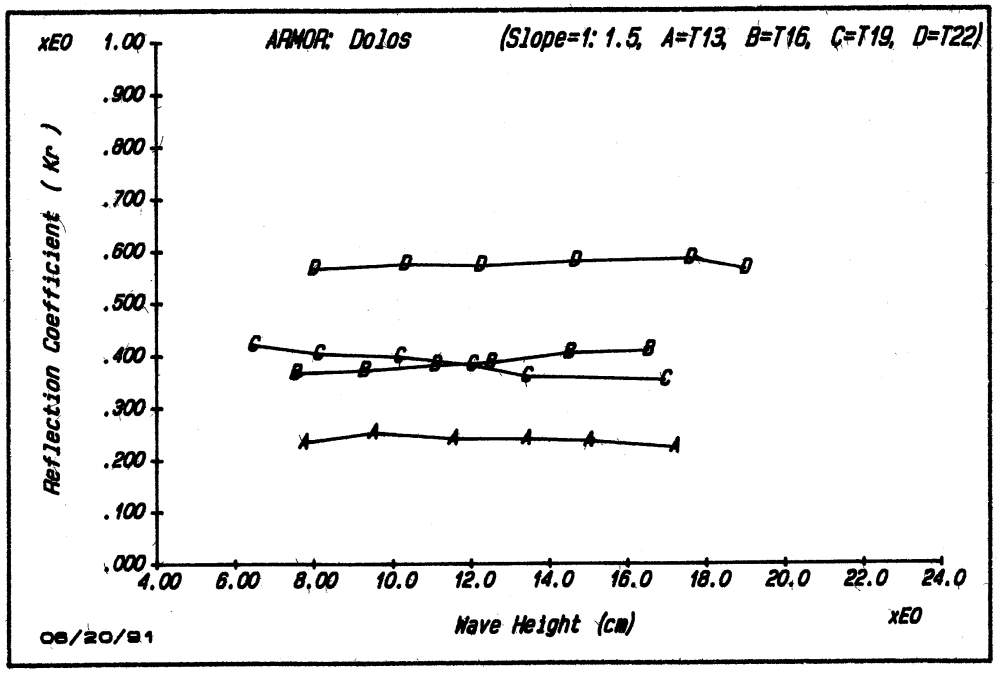

Fig : Kr -- A - 3

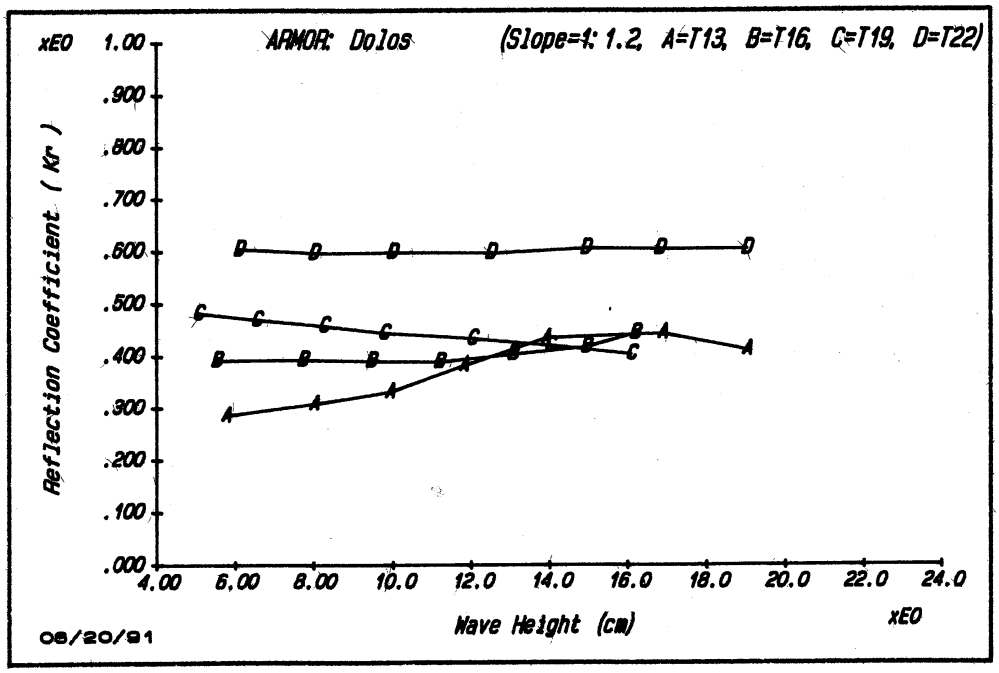

Fig ; Kr -- B - 3

Fig 4.3 (Kr-A&B-3). The variation of the reflection coefficients with the wave height for each individual wave period (**D**olos).

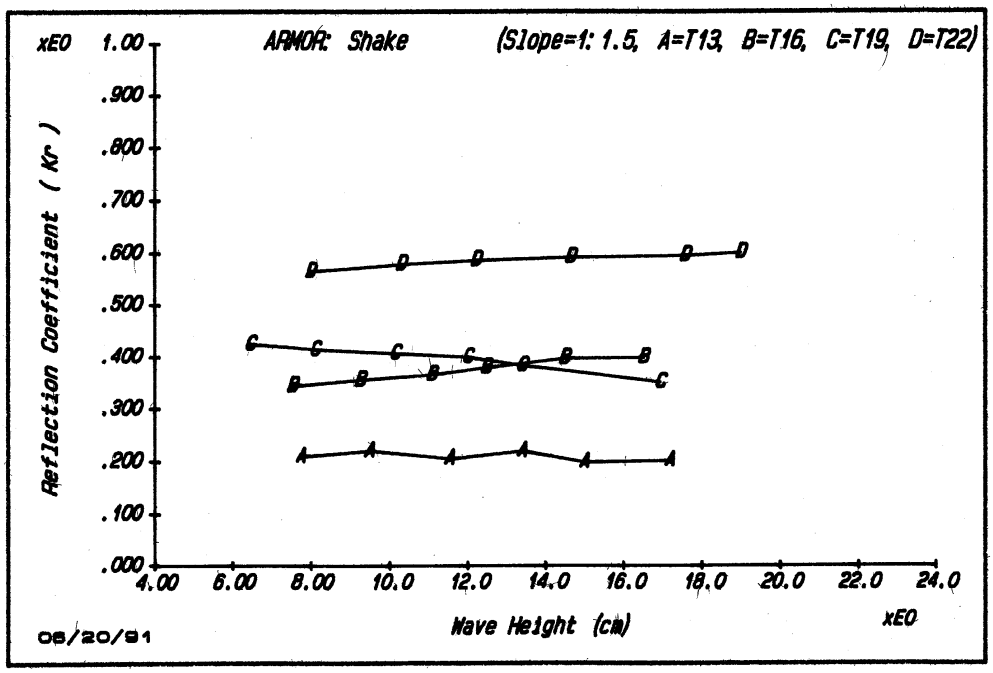

Fig : Kr -- A - 4

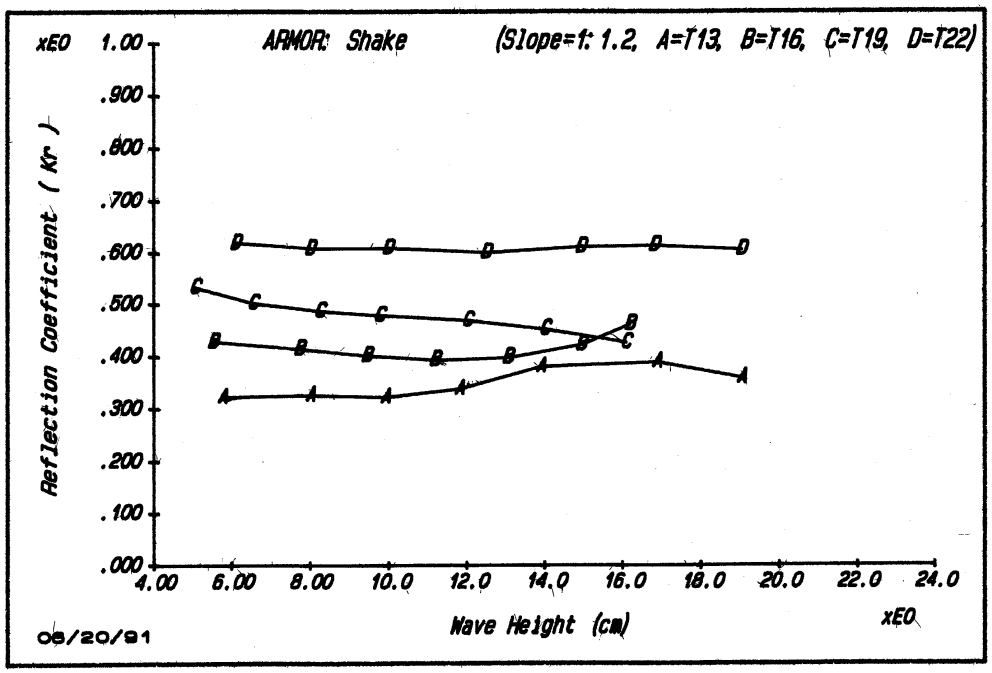

Fig : Kr -- B - 4

Fig 4.4 (Kr-A&B-4). The variation of the reflection coefficients with the wave height for each individual wave period (**D**olos).

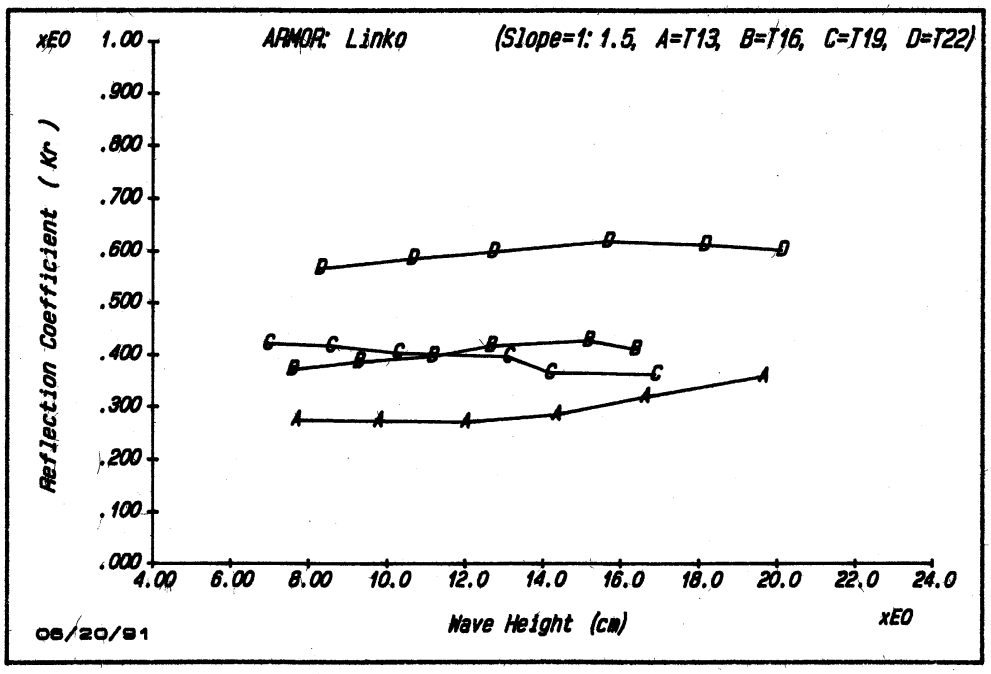

Fig : Kr -- A - 5

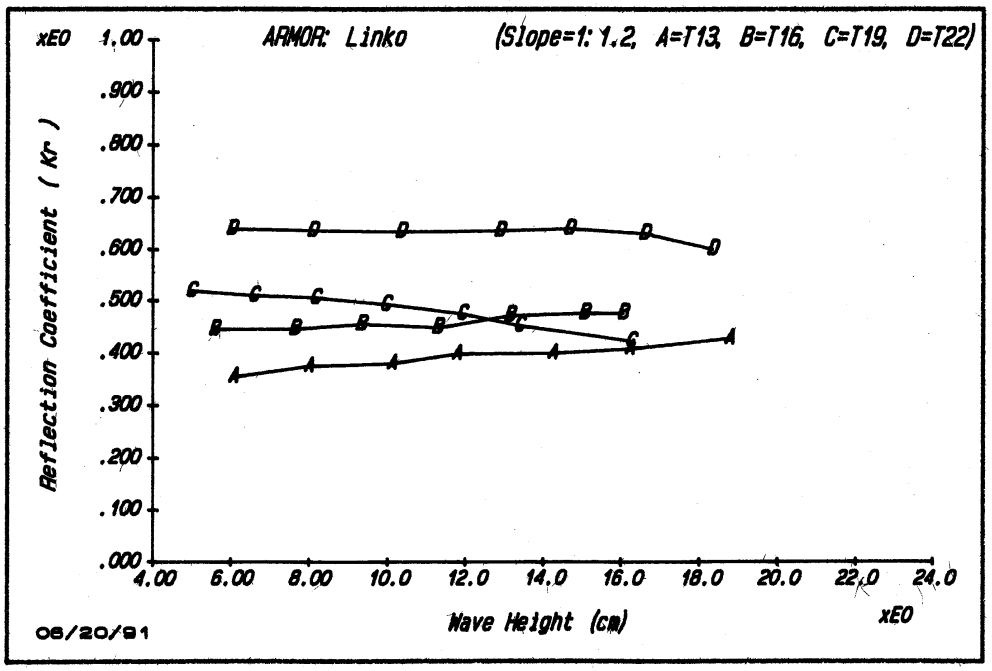

Fig : Kr -- B - 5

Fig 4.5 (Kr-A&B-5). The variation of the reflection coefficients with the wave height for each individual wave period (Linko).

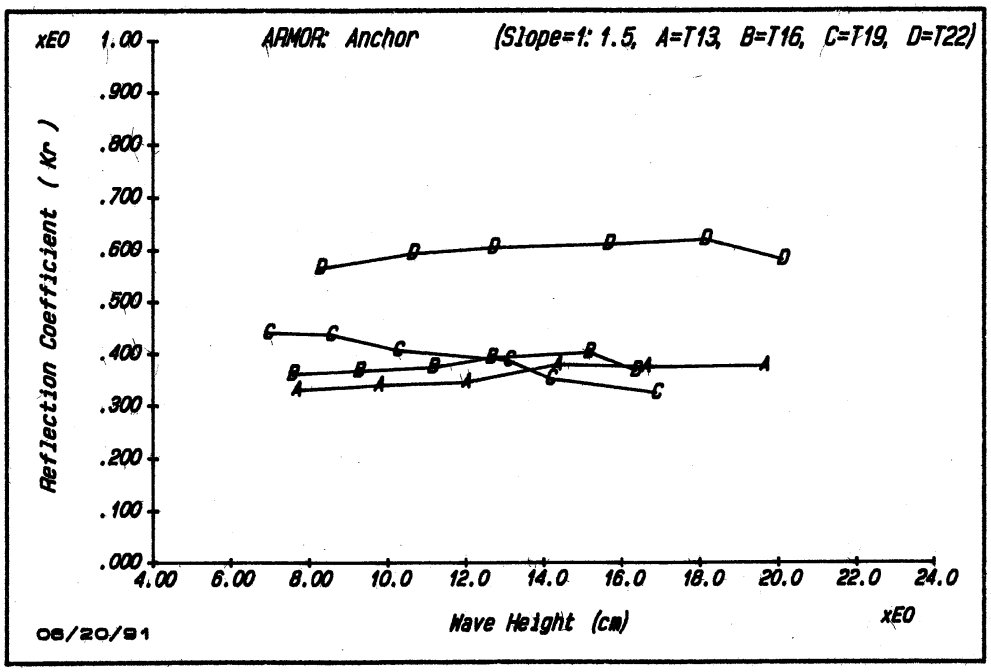

Fig ; Kr -- A - 6

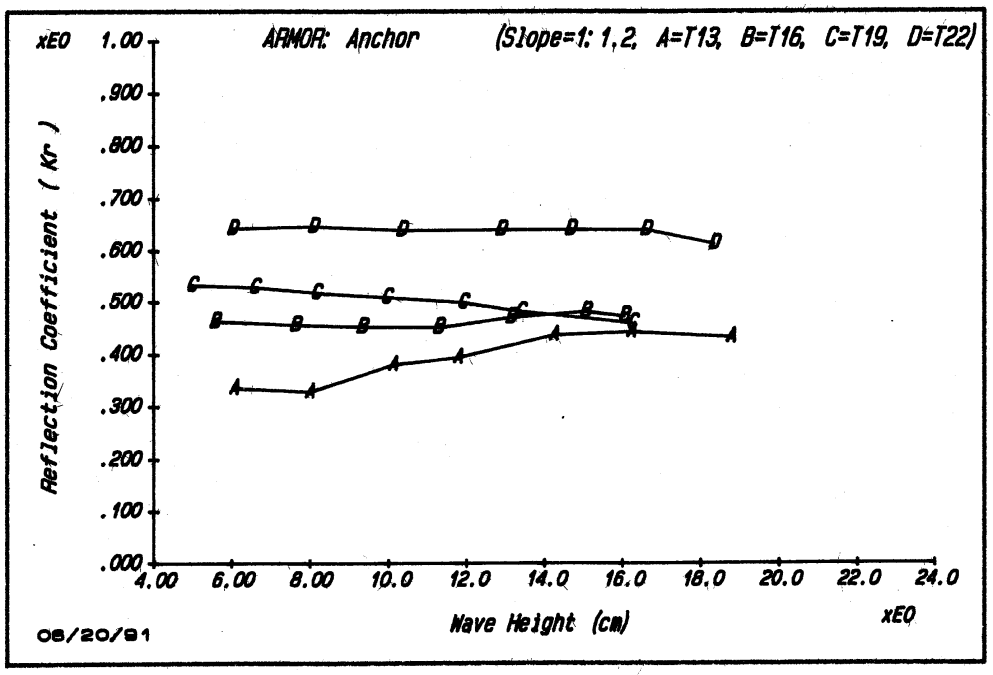

Fig : Kr -- B - 6

Fig 4.6 (Kr-A&B-6). The variation of the reflection coefficients with the wave height for each individual wave period (Anchor).

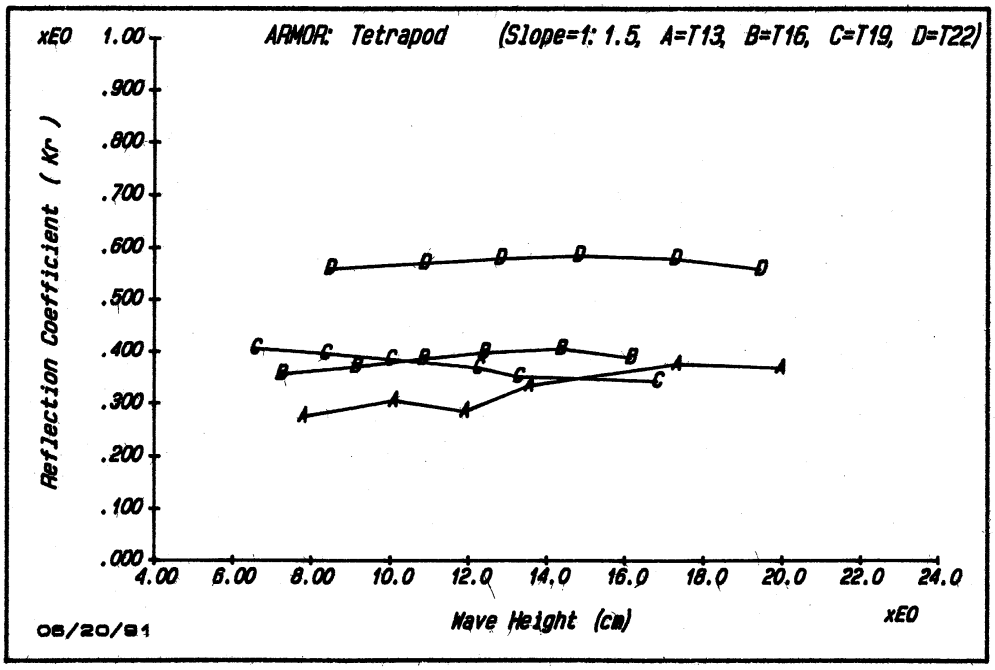

Fig : Kr -- A - 7

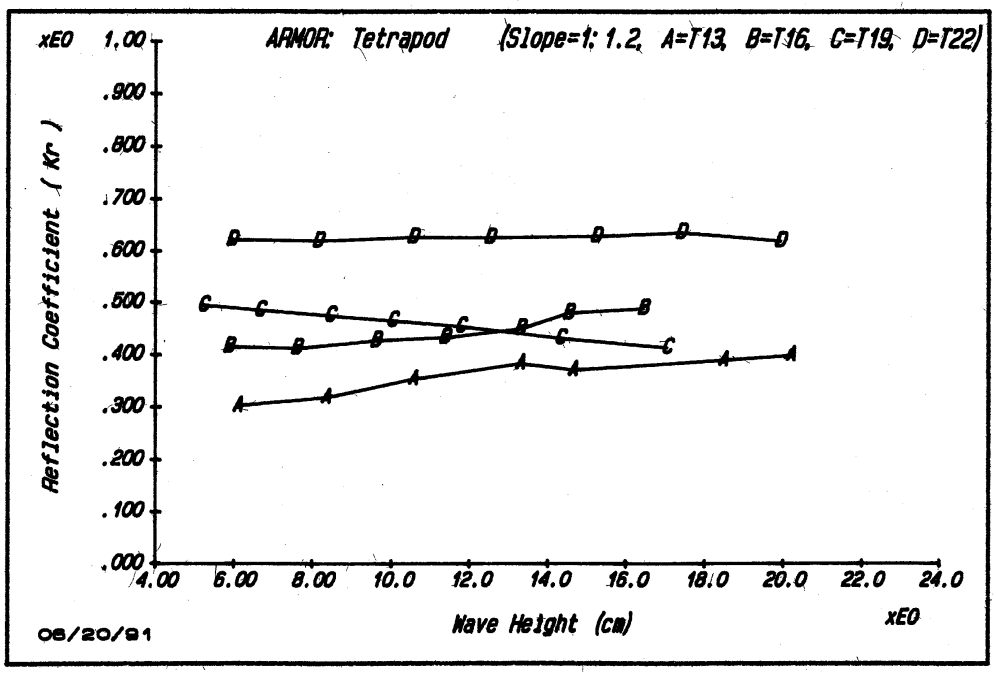

Fig : Kr -- B - 7

Fig 4.7 (Kr-A&B-7). The variation of the reflection coefficients with the wave height for each individual wave period (Tetrapod).

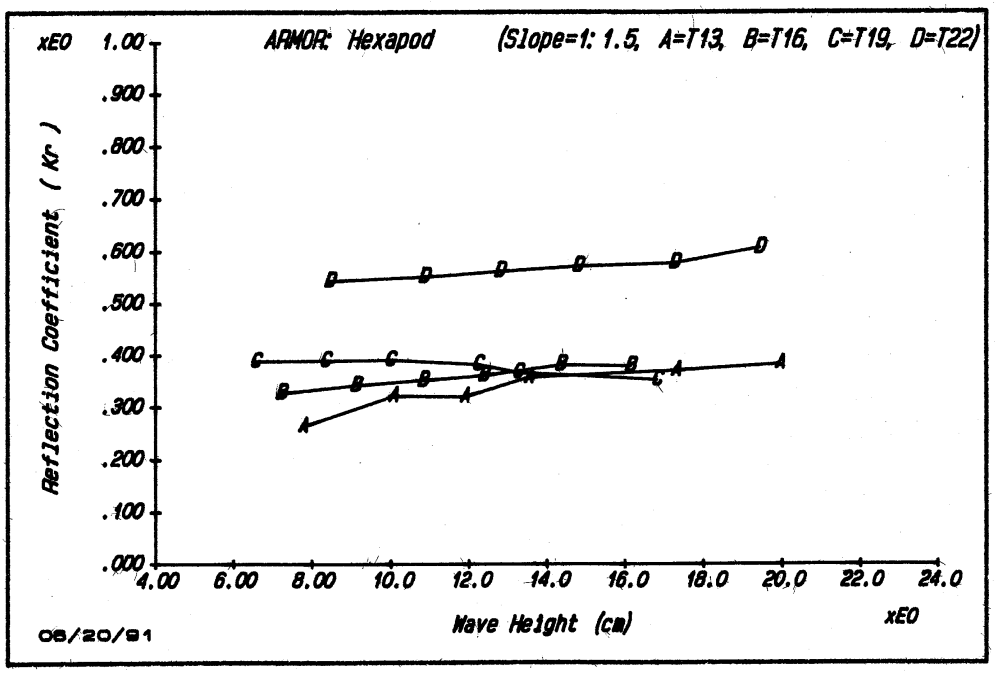

Fig : Kr -- A - B

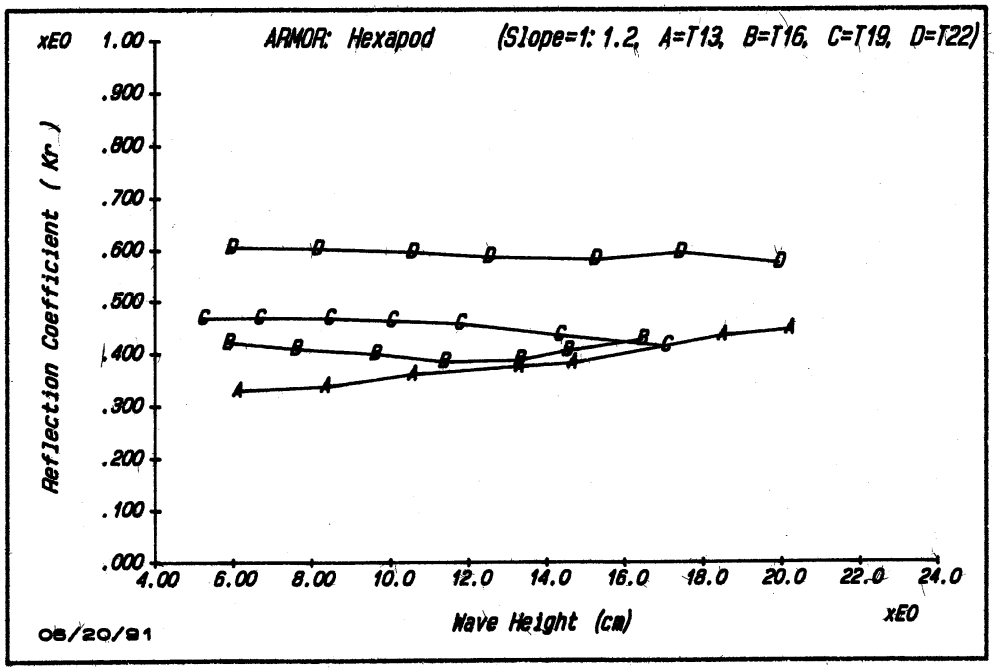

Fig : Kr -- B - B

Fig 4.8 (Kr-A&B-8). The variation of the reflection coefficients with the wave height for each individual wave period (**H**exapod).

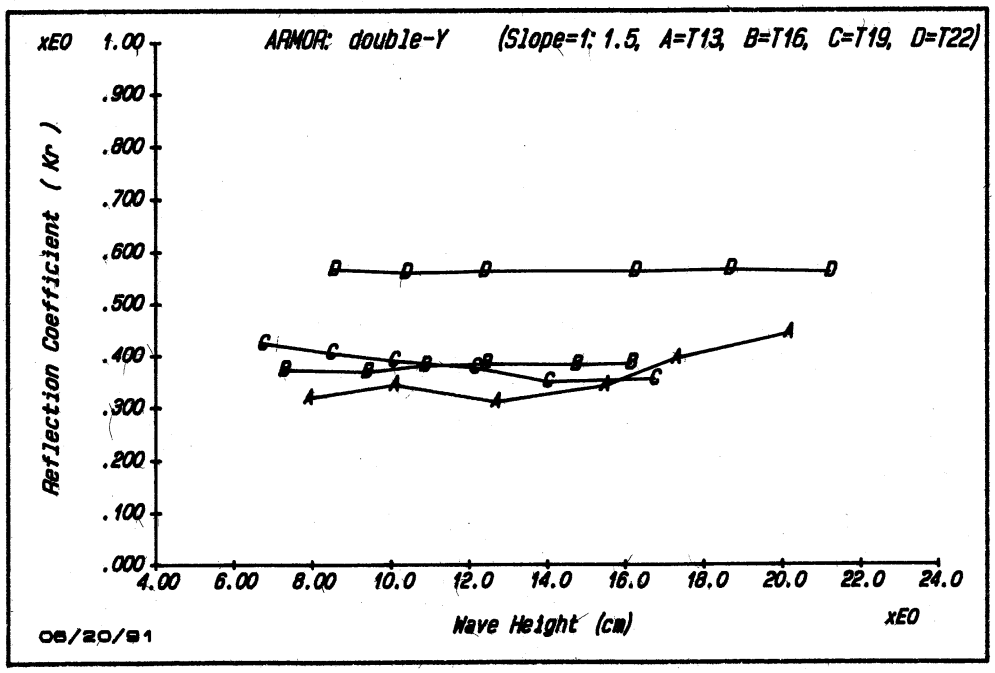

Fig : Kr -- A - 9

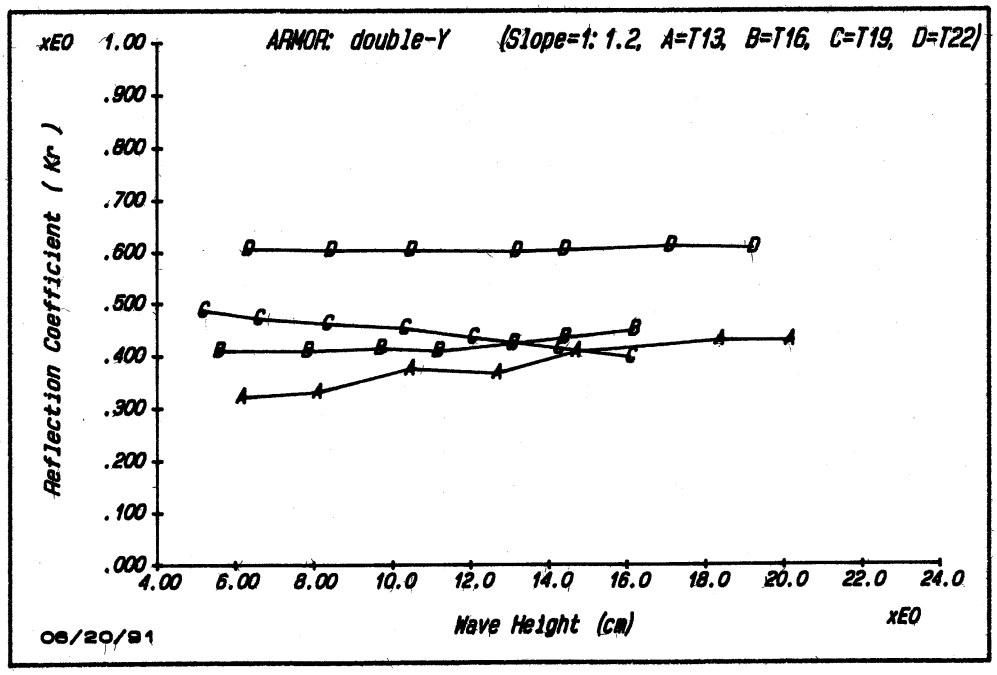

Fig : Kr -- B - 9

Fig 4.9 (Kr-A&B-9). The variation of the reflection coefficients with the wave height for each individual wave period (double-Y).

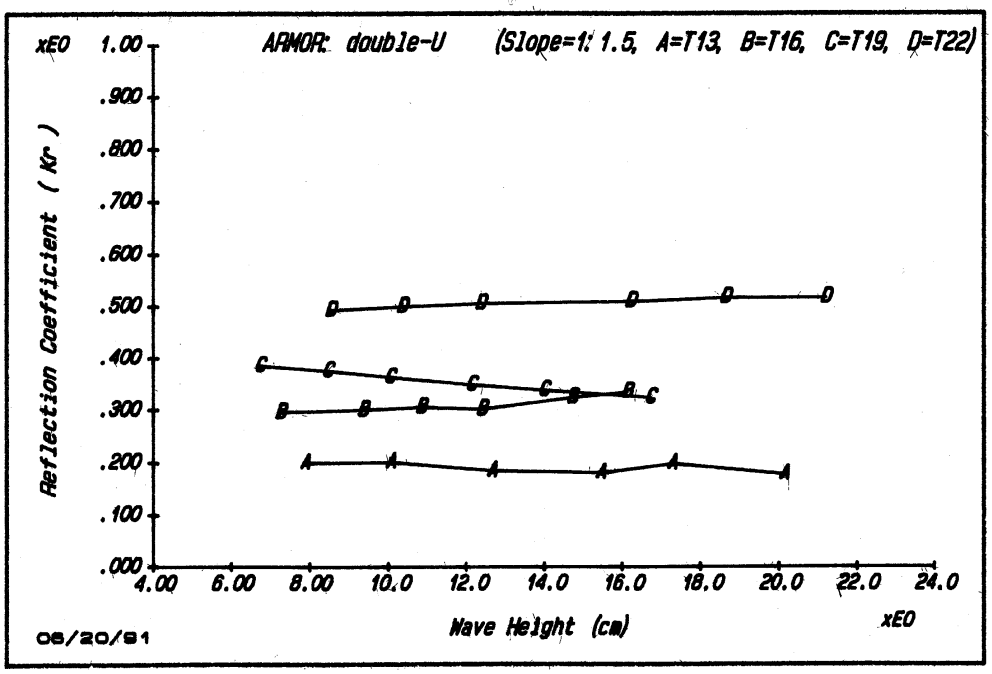

Fig : Kr -- A - 10

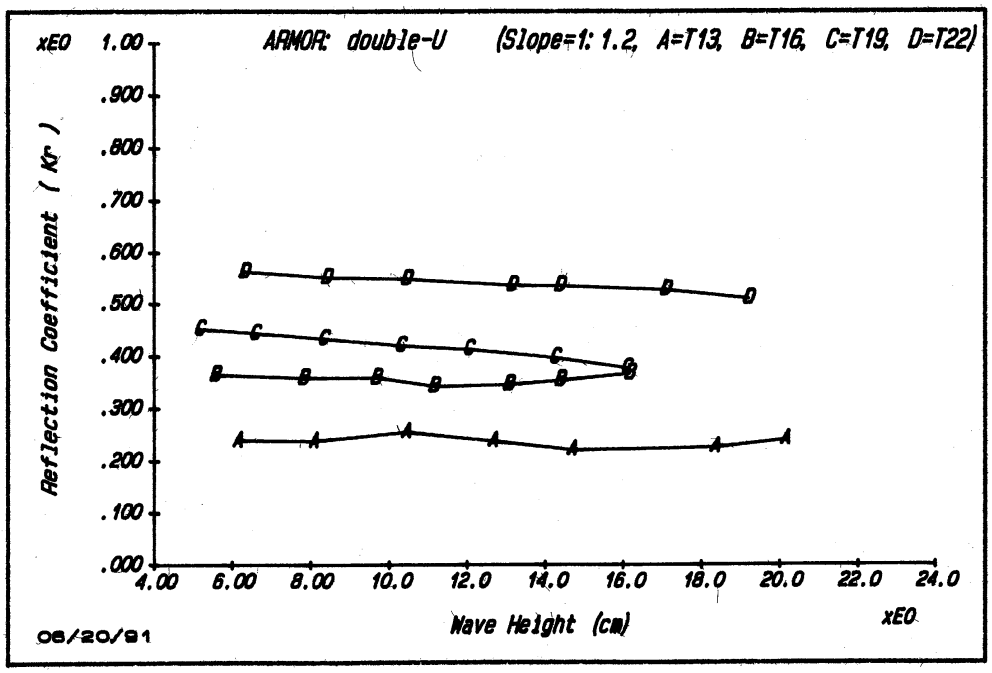

Fig : Kr -- B - 10

Fig 4.10 (Kr-A&B-10). The variation of the reflection coefficients with the wave height for each individual wave period (double-U).

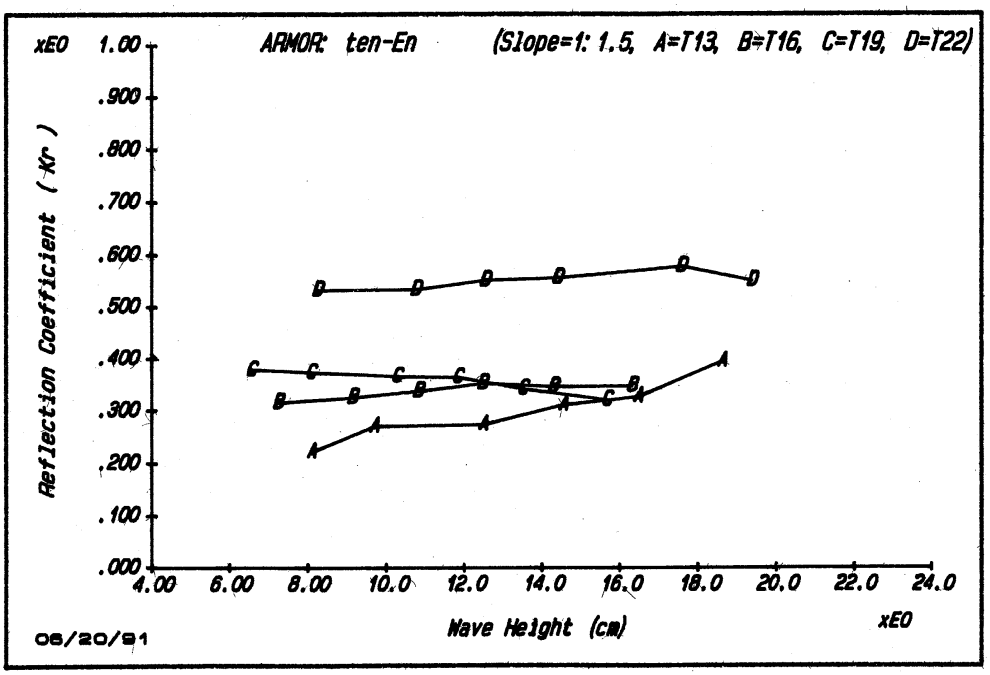

Fig : Kr -- A - 11

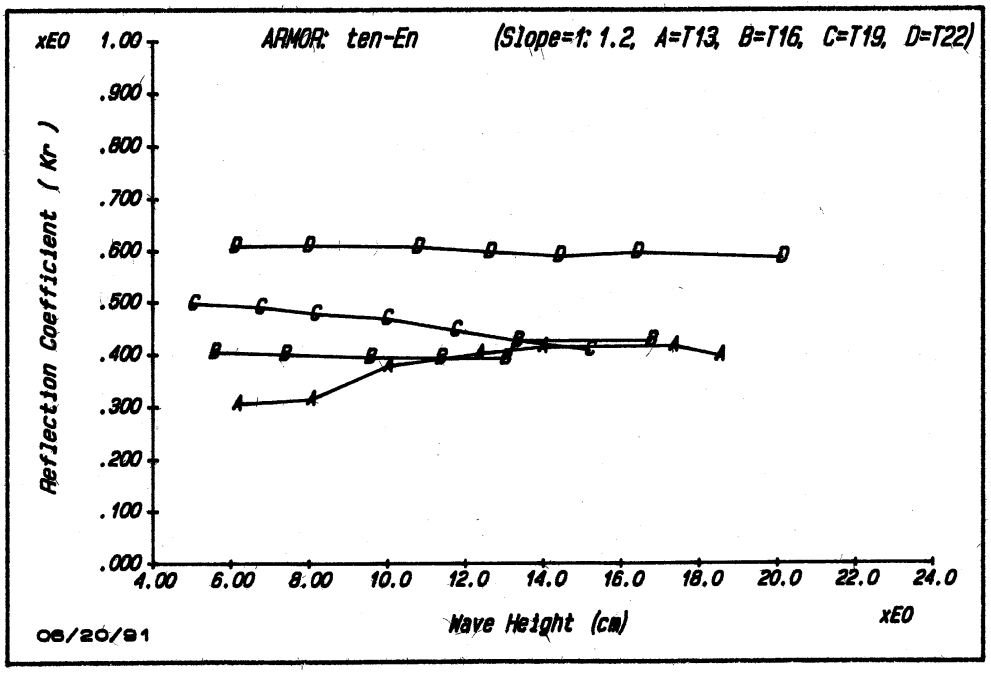

Fig : Kr -- B - 11

Fig 4.11 (Kr-A&B-11). The variation of the reflection coefficients with the wave height for each individual wave period (ten-En).

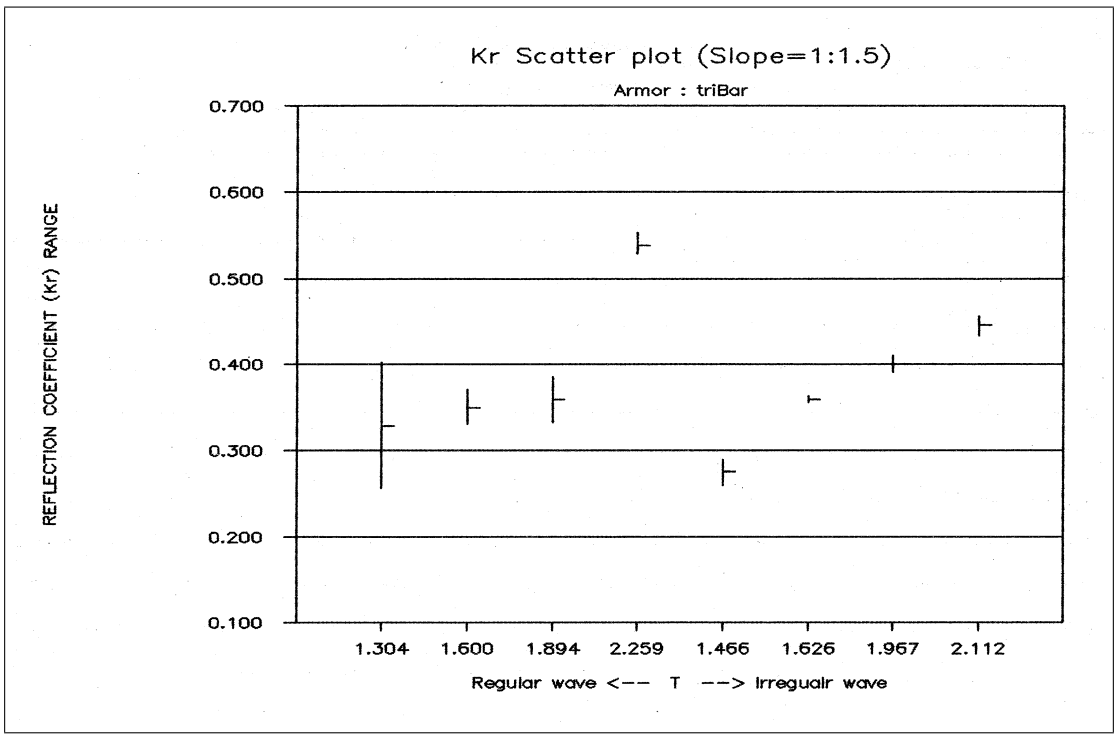

Fig 4.12 (Kr-Skt-1). The average and the range of variation of the reflection coefficients for each individual wave period. (tri**B**ar).

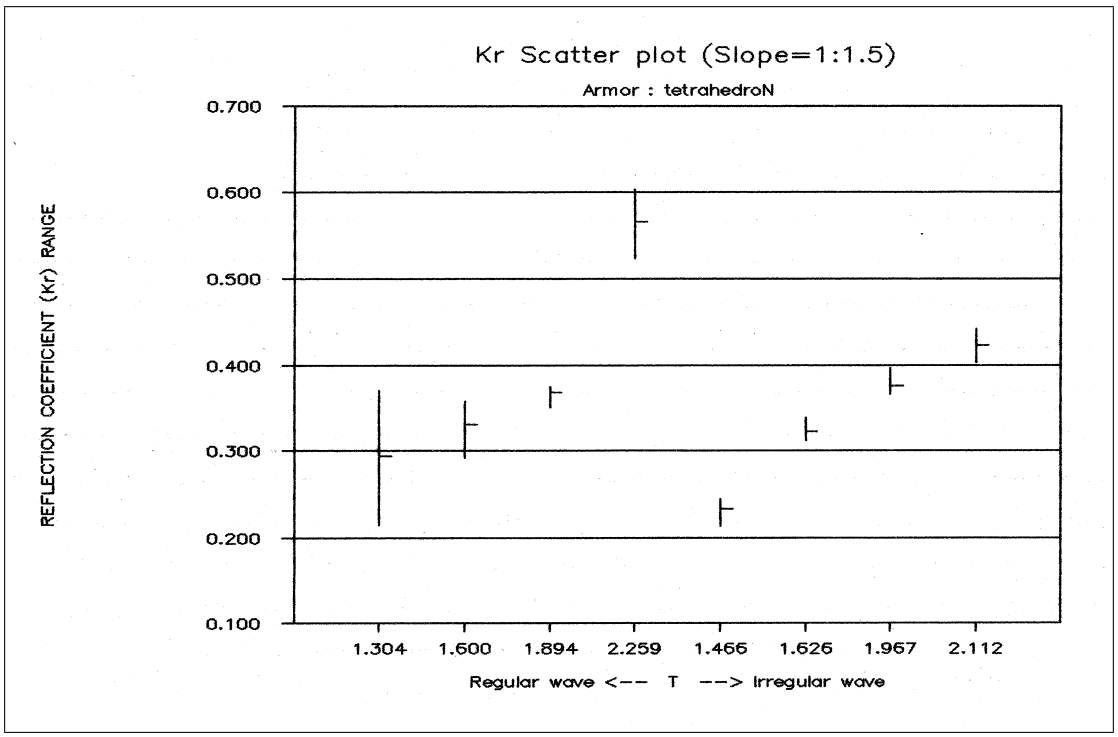

Fig 4.13 (Kr-Skt-2). The average and the range of variation of the reflection coefficients for each individual wave period. (tetrahedro**N**).

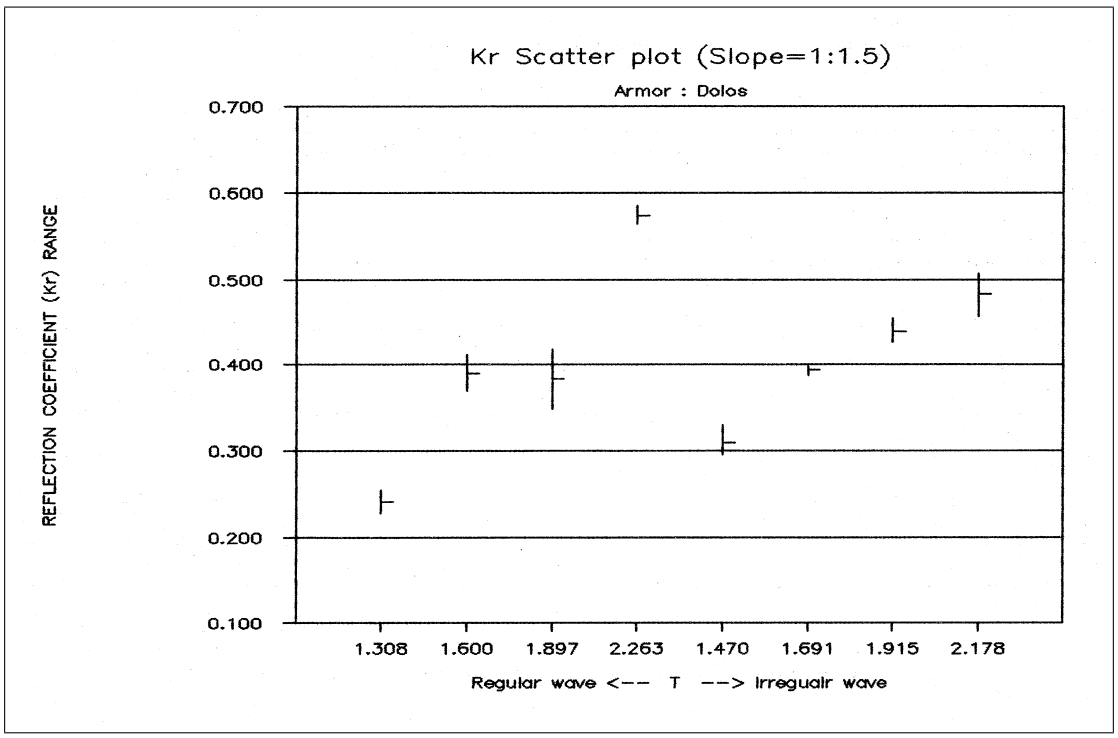

Fig 4.14 (Kr-Skt-3). The average and the range of variation of the reflection coefficients for each individual wave period. (**D**olos).

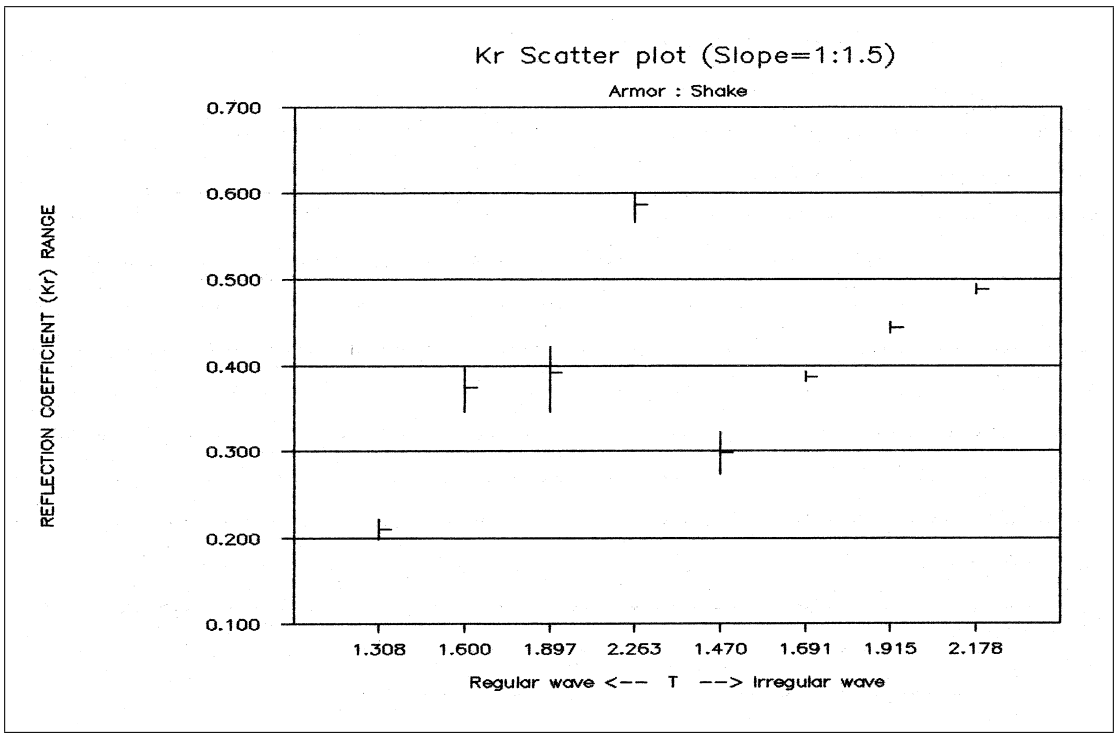

Fig 4.15 (Kr-Skt-4). The average and the range of variation of the reflection coefficients for each individual wave period. (**S**hake).

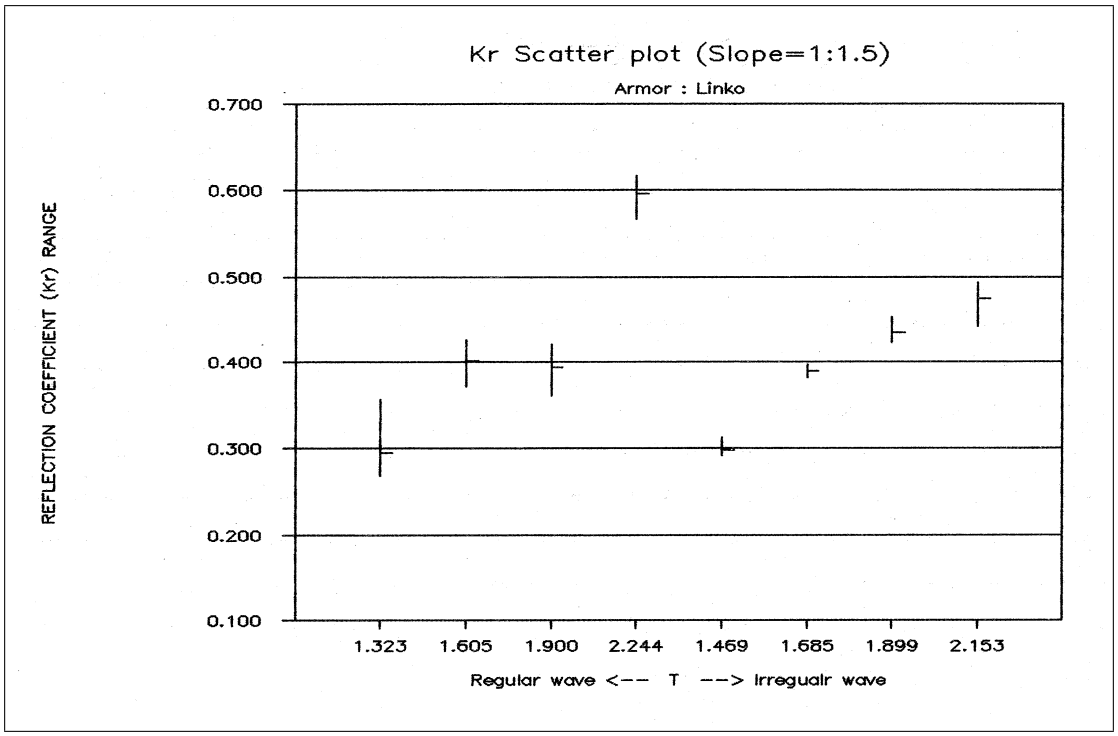

Fig 4.16 (Kr-Skt-5). The average and the range of variation of the reflection coefficients for each individual wave period. (**L**inko).

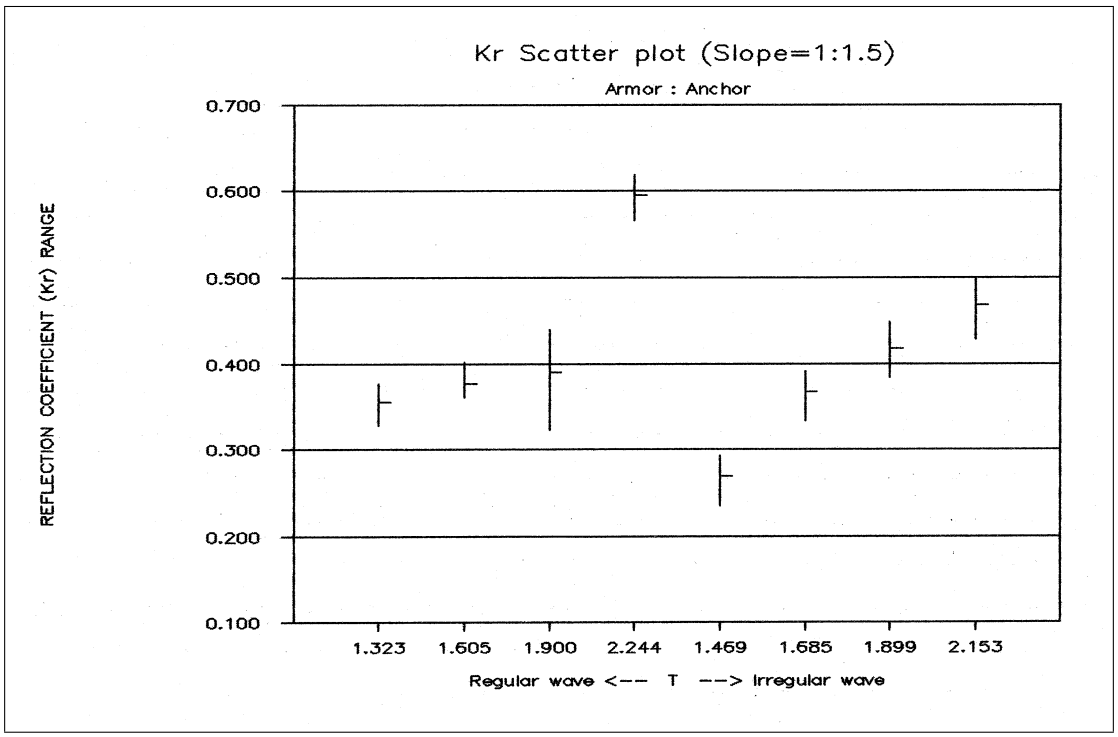

Fig 4.17 (Kr-Skt-6). The average and the range of variation of the reflection coefficients for each individual wave period. (**A**nchor).

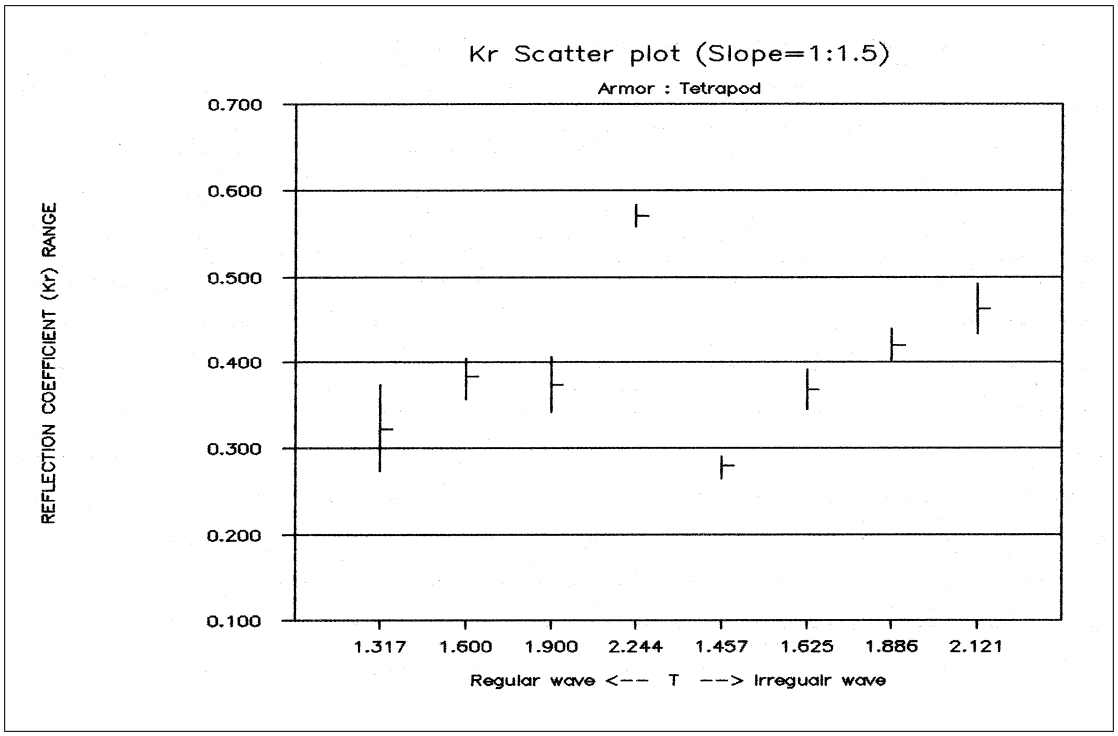

Fig 4.18 (Kr-Skt-7). The average and the range of variation of the reflection coefficients for each individual wave period. (**T**etrapod).

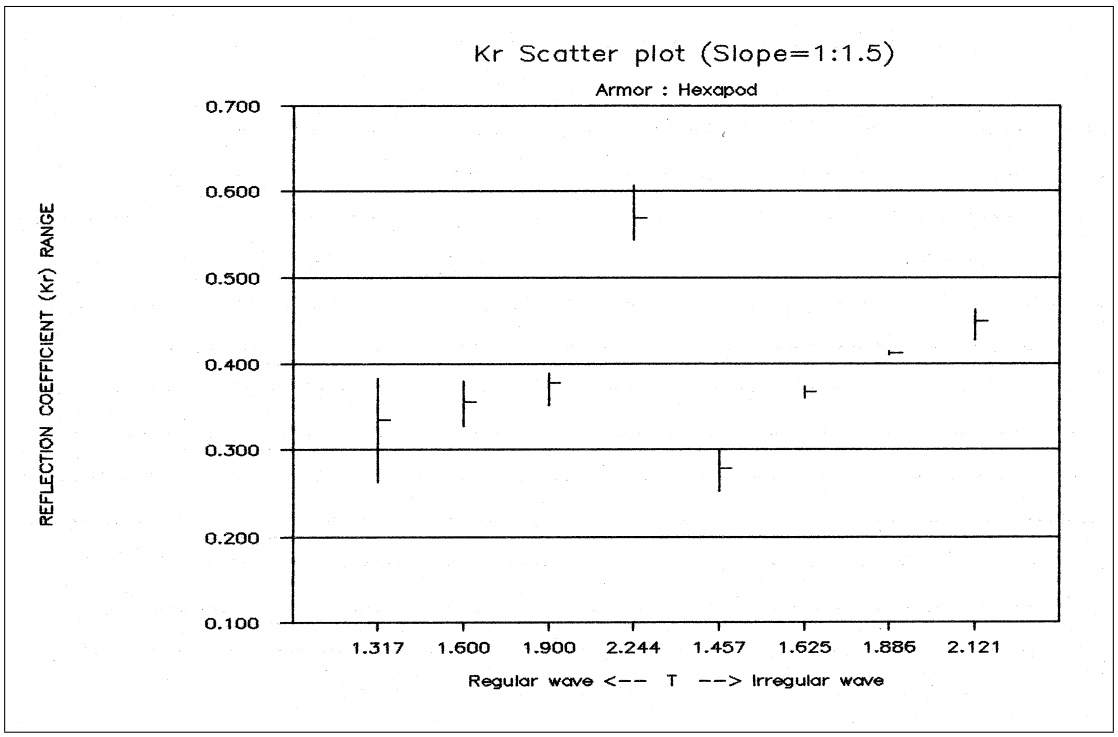

Fig 4.19 (Kr-Skt-8). The average and the range of variation of the reflection coefficients for each individual wave period. (**H**exapod).

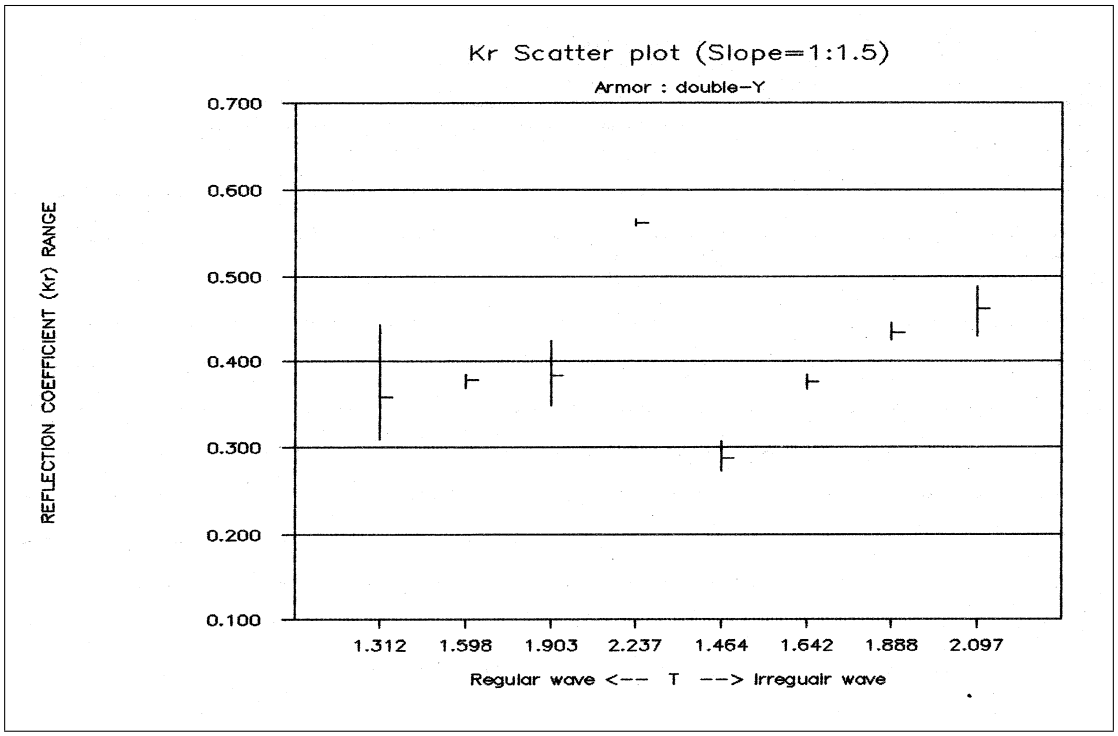

Fig 4.20 (Kr-Skt-9). The average and the range of variation of the reflection coefficients for each individual wave period. (double-**Y**).

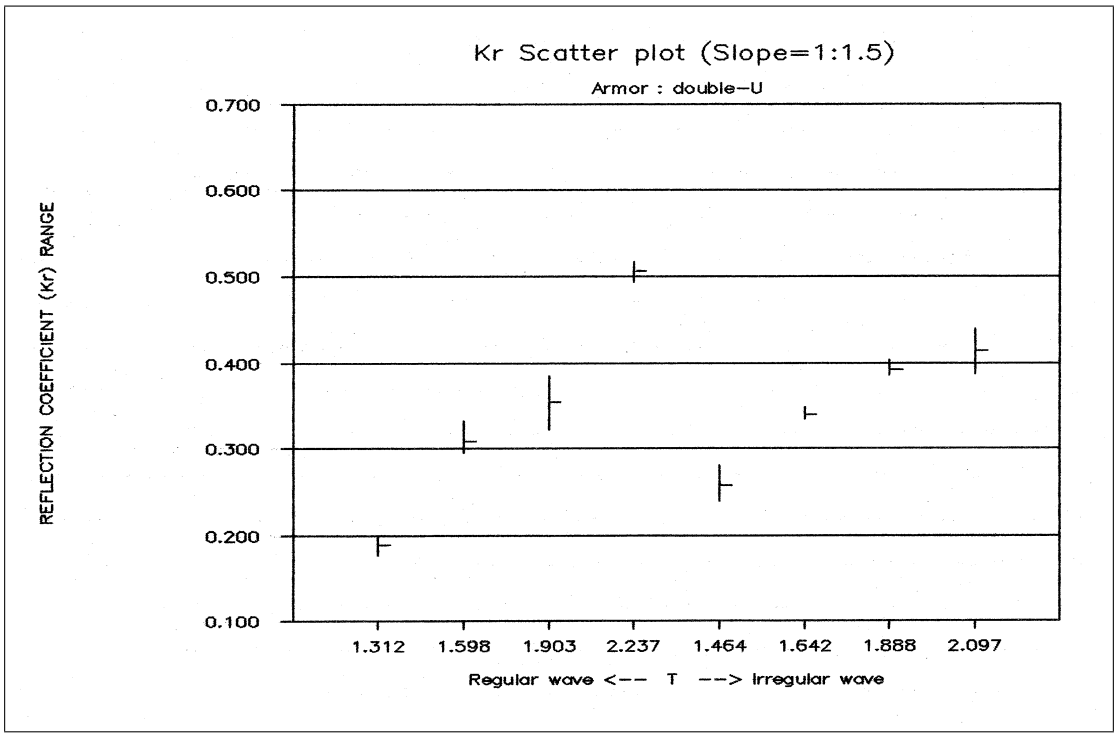

Fig 4.21 (Kr-Skt-10). The average and the range of variation of the reflection coefficients for each individual wave period. (double-**U**).

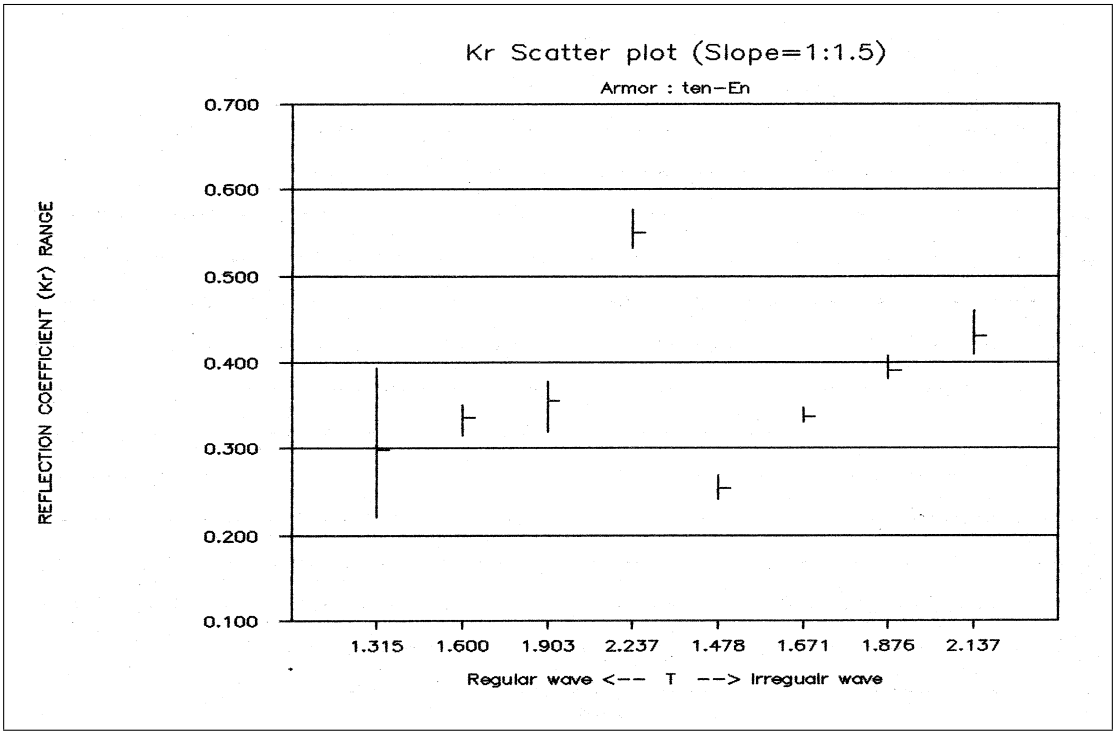

Fig 4.22 (Kr-Skt-11). The average and the range of variation of the reflection coefficients for each individual wave period. (ten-**E**n).

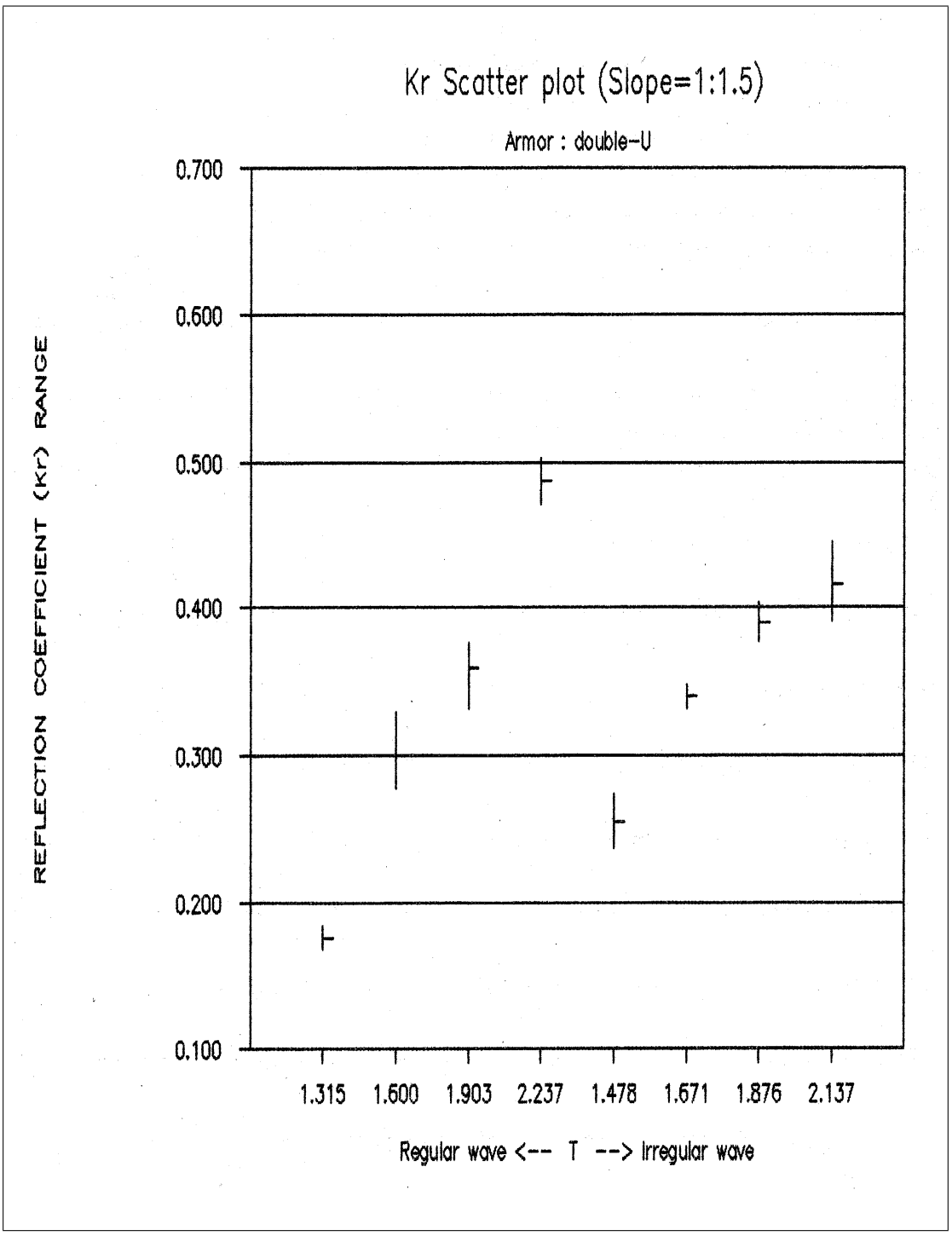

Fig 4.23 (Kr-Skt-12). The average and the range of variation of the reflection coefficients for each individual wave period (double-**U**, repeated tests). This figure are from the sole repeated tests of the double-**U**. And this armor type was not intensionally chosen, rather, it was because the odd number of total armor types were involved and this type happened to be placed just prior to the last batch (i.e., the 5th batch) of the experiments. Note the excellent conformity between the original and the repeated tests.

Armor type : triBar (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 1 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00143	4	0.00036	0.75935	0.57125
Period	0.16227	3	0.05409	114.52922	0.00000
Residual	0.00567	12	0.00047		
Nonadditivity	0.00043	1	0.00043	0.90179	0.36270
Total	0.16937	19		R-SQUARE ->	0.96654

Tab 4.21 (KrA-A-1). The one-way ANOVA of the K_r (slope:1:1.5) (tri**B**ar).

Armor type : tetra-hedroN (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 2 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00486	4	0.00121	3.74973	0.03341
Period	0.20676	3	0.06892	212.80534	0.00000
Residual	0.00389	12	0.00032		
Nonadditivity	0.00029	1	0.00029	0.89463	0.36454
Total	0.21550	19		R-SQUARE ->	0.98197

Tab 4.22 (KrA-A-2). The one-way ANOVA of the K_r (slope:1:1.5) (tetrahedro**N**).

Armor type : Dolos (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 3 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00011	4	0.00003	0.12600	0.97020
Period	0.27999	3	0.09333	422.09003	0.00000
Residual	0.00265	12	0.00022		
Nonadditivity	0.00007	1	0.00007	0.28474	0.60423
Total	0.28276	19		R-SQUARE ->	0.99062

Tab 4.23 (KrA-A-3). The one-way ANOVA of the K_r (slope:1:1.5) (**D**olos).

Armor type : Shake (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 4 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00012	4	0.00003	0.11563	0.97446
Period	0.34852	3	0.11617	432.95593	0.00000
Residual	0.00322	12	0.00027		
Nonadditivity	0.00000	1	0.00000	0.01184	0.91532
Total	0.35186	19		R-SQUARE ->	0.99085

Tab 4.24 (KrA-A-4). The one-way ANOVA of the K_r (slope:1:1.5) (Shake).

Armor type : Linko (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 5 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00057	4	0.00014	0.42787	0.78587
Period	0.25393	3	0.08464	253.37933	0.00000
Residual	0.00401	12	0.00033		
Nonadditivity	0.00037	1	0.00037	1.11014	0.31465
Total	0.25851	19		R-SQUARE ->	0.98449

Tab 4.25 (KrA-A-5). The one-way ANOVA of the K_r (slope:1:1.5) (Linko).

Armor type : Anchor (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 6 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00024	4	0.00006	0.08990	0.98387
Period	0.18458	3	0.06153	91.65198	0.00000
Residual	0.00806	12	0.00067		
Nonadditivity	0.00022	1	0.00022	0.31288	0.58713
Total	0.19288	19		R-SQUARE ->	0.95823

Tab 4.26 (KrA-A-6). The one-way ANOVA of the K_r (slope:1:1.5) (Anchor).

Armor type : Tetrapod (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 7 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00081	4	0.00020	0.46526	0.76021
Period	0.19362	3	0.06454	147.74257	0.00000
Residual	0.00524	12	0.00044		
Nonadditivity	0.00008	1	0.00008	0.16192	0.69510
Total	0.19968	19		R-SQUARE ->	0.97375

Tab 4.27 (KrA-A-7). The one-way ANOVA of the K_r (slope:1:1.5) (**T**etrapod).

Armor type : Hexapod (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 8 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00203	4	0.00051	1.44431	0.27906
Period	0.16096	3	0.05365	152.32732	0.00000
Residual	0.00423	12	0.00035		
Nonadditivity	0.00017	1	0.00017	0.46728	0.50838
Total	0.16722	19		R-SQUARE ->	0.97472

Tab 4.28 (KrA-A-8). The one-way ANOVA of the K_r (slope:1:1.5) (**H**exapod).

Armor type : double-Y (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 9 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00044	4	0.00011	0.64693	0.63966
Period	0.16076	3	0.05359	312.48911	0.00000
Residual	0.00206	12	0.00017		
Nonadditivity	0.00009	1	0.00009	0.49348	0.49698
Total	0.16326	19		R-SQUARE ->	0.98740

Tab 4.29 (KrA-A-9). The one-way ANOVA of the K_r (slope:1:1.5) (double-**Y**).

Armor type : double-U (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 10 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00014	4	0.00003	0.22038	0.92191
Period	0.24939	3	0.08313	531.33044	0.00000
Residual	0.00188	12	0.00016		
Nonadditivity	0.00024	1	0.00024	1.58014	0.23478
Total	0.25141	19		R-SQUARE ->	0.99253

Tab 4.30 (KrA-A-10). The one-way ANOVA of the K_r (slope:1:1.5) (double-**U**).

Armor type : ten-En (slope=1:1.5)
Table No : Kr-ANOVA - 1 ~ 11 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00103	4	0.00026	0.66435	0.62869
Period	0.20126	3	0.06709	172.86183	0.00000
Residual	0.00466	12	0.00039		
Nonadditivity	0.00012	1	0.00012	0.28116	0.60648
Total	0.20695	19		R-SQUARE ->	0.97750

Tab 4.31 (KrA-A-11). The one-way ANOVA of the K_r (slope:1:1.5) (ten-**E**n).

Armor type : triBar (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 1 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00015	4	0.00004	0.07551	0.98834
Period	0.17067	3	0.05689	115.09258	0.00000
Residual	0.00593	12	0.00049		
Nonadditivity	0.00042	1	0.00042	0.84377	0.37802
Total	0.17675	19		R-SQUARE ->	0.96644

Tab 4.32 (KrA-B-1). The one-way ANOVA of the K_r (slope:1:1.2) (tri**B**ar).

Armor type : tetra-hedroN (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 2 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00186	4	0.00046	0.42429	0.78833
Period	0.16692	3	0.05564	50.87305	0.00000
Residual	0.01312	12	0.00109		
Nonadditivity	0.00013	1	0.00013	0.11397	0.74202
Total	0.18191	19		R-SQUARE ->	0.92785

Tab 4.33 (KrA-B-2). The one-way ANOVA of the K_r (slope:1:1.2) (tetrahedro**N**).

Armor type : Dolos (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 3 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00257	4	0.00064	0.55305	0.70074
Period	0.16125	3	0.05375	46.35459	0.00000
Residual	0.01391	12	0.00116		
Nonadditivity	0.00312	1	0.00312	3.17578	0.10233
Total	0.17772	19		R-SQUARE ->	0.92171

Tab 4.34 (KrA-B-3). The one-way ANOVA of the K_r (slope:1:1.2) (**D**olos).

Armor type : Shake (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 4 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00058	4	0.00014	0.34489	0.84254
Period	0.18986	3	0.06329	151.57599	0.00000
Residual	0.00501	12	0.00042		
Nonadditivity	0.00014	1	0.00014	0.30646	0.59093
Total	0.19545	19		R-SQUARE ->	0.97436

Tab 4.35 (KrA-B-4). The one-way ANOVA of the K_r (slope:1:1.2) (Shake).

Armor type : Linko (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 5 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00003	4	0.00001	0.01598	0.99942
Period	0.16542	3	0.05514	124.46784	0.00000
Residual	0.00532	12	0.00044		
Nonadditivity	0.00003	1	0.00003	0.06747	0.79986
Total	0.17077	19		R-SQUARE ->	0.96887

Tab 4.36 (KrA-B-5). The one-way ANOVA of the K_r (slope:1:1.2) (Linko).

Armor type : Anchor (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 6 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00084	4	0.00021	0.26307	0.89603
Period	0.17289	3	0.05763	72.18684	0.00000
Residual	0.00958	12	0.00080		
Nonadditivity	0.00349	1	0.00349	6.29590	0.02903
Total	0.18331	19		R-SQUARE ->	0.94774

Tab 4.37 (KrA-B-6). The one-way ANOVA of the K_r (slope:1:1.2) (Anchor).

Armor type : Tetrapod (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 7 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00114	4	0.00028	0.46656	0.75932
Period	0.19688	3	0.06563	107.67548	0.00000
Residual	0.00731	12	0.00061		
Nonadditivity	0.00120	1	0.00120	2.15611	0.17001
Total	0.20533	19		R-SQUARE ->	0.96438

Tab 4.38 (KrA-B-7). The one-way ANOVA of the K_r (slope:1:1.2) (**T**etrapod).

Armor type : Hexapod (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 8 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00013	4	0.00003	0.09829	0.98100
Period	0.15526	3	0.05175	160.78841	0.00000
Residual	0.00386	12	0.00032		
Nonadditivity	0.00041	1	0.00041	1.30687	0.27723
Total	0.15925	19		R-SQUARE ->	0.97575

Tab 4.39 (KrA-B-8). The one-way ANOVA of the K_r (slope:1:1.2) (**H**exapod).

Armor type : double-Y (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 9 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00034	4	0.00009	0.15081	0.95903
Period	0.15777	3	0.05259	92.51852	0.00000
Residual	0.00682	12	0.00057		
Nonadditivity	0.00088	1	0.00088	1.63056	0.22792
Total	0.16494	19		R-SQUARE ->	0.95864

Tab 4.40 (KrA-B-9). The one-way ANOVA of the K_r (slope:1:1.2) (double-**Y**).

Armor type : double-U (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 10 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00173	4	0.00043	4.27432	0.02227
Period	0.24553	3	0.08184	809.16772	0.00000
Residual	0.00121	12	0.00010		
Nonadditivity	0.00008	1	0.00008	0.81578	0.38577
Total	0.24847	19		R-SQUARE ->	0.99512

Tab 4.41 (KrA-B-10). The one-way ANOVA of the K_r (slope:1:1.2) (double-U).

Armor type : ten-En (slope=1:1.2)
Table No : Kr-ANOVA - 2 ~ 11 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00018	4	0.00005	0.04197	0.99618
Period	0.15646	3	0.05215	48.62682	0.00000
Residual	0.01287	12	0.00107		
Nonadditivity	0.00167	1	0.00167	1.63564	0.22725
Total	0.16951	19		R-SQUARE ->	0.92407

Tab 4.42 (KrA-B-11). The one-way ANOVA of the K_r (slope:1:1.2) (ten-En).

TWO-WAY ANOVA - H ˜ T ˜ A (slope=1:1.5)

Table No : Kr-ANOVA - 1 ˜ 14 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00571	4	0.00143	1.21689	0.30484
Period	2.35482	3	0.78494	669.33015	0.00000
Interaction	0.03352	12	0.00279	2.38174	0.00683
Error	0.23455	200	0.00117		
Total	2.62859	219		R-SQUARE ->	0.91077

Tab 4.43 (KrA-A-HT/A). The two-way ANOVA of the K_r data (slope: 1:1.5), in which the armor type is treated as an unknown and the wave period and the wave height are the two specified treatment factors.

TWO-WAY ANOVA - A ˜ T ˜ H (slope=1:1.5)

Table No : Kr-ANOVA - 1 ˜ 15 08/13/91--16:36:52.59

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Armor type	0.12308	10	0.01231	36.71779	0.00000
Period	2.35482	3	0.78494	2341.67975	0.00000
Interaction	0.09170	30	0.00306	9.11881	0.00000
Error	0.05900	176	0.00034		
Total	2.62860	219		R-SQUARE ->	0.97756

Tab 4.44 (KrA-A-AT/H). The two-way ANOVA of K_r, (slope: 1:1.5), in which the wave height is treated as an unknown and the armor type and the wave period are the two specified treatment factors.

TWO-WAY ANOVA - H ˜ T ˜ A (slope=1:1.2)

Table No : Kr-ANOVA - 2 ˜ 14 07/09/91--15:01:08.71

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00005	4	0.00001	0.00933	0.99983
Period	1.89031	3	0.63010	513.07887	0.00000
Interaction	0.07233	12	0.00603	4.90835	0.00000
Error	0.24562	200	0.00123		
Total	2.20831	219		R-SQUARE ->	0.88878

Tab 4.45 (KrA-B-HT/A). The two-way ANOVA of the K_r data (slope: 1:1.2), in which the armor type is treated as an unknown and the wave period and the wave height are the two specified treatment factors.

TWO-WAY ANOVA - A ˜ T ˜ H (slope=1:1.2)

Table No : Kr-ANOVA - 2 ˜ 15 07/09/91--15:01:08.71

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Armor type	0.16975	10	0.01698	28.89643	0.00000
Period	1.89031	3	0.63010	1072.62187	0.00000
Interaction	0.04486	30	0.00150	2.54553	0.00008
Error	0.10339	176	0.00059		
Total	2.20831	219		R-SQUARE ->	0.95318

Tab 4.46 (KrA-B-AT/H). The two-way ANOVA of the K_r data (slope: 1:1.2), in which the wave height is treated as an unknown and the armor type and the wave period are the two specified treatment factors.

REFLECTION COEFFICIENT TABLE (Slope : 1 on 1.5)

Armor type	Kr (Regular waves)				Kr (Irregular waves)			
	T1.30	T1.60	T1.90	T2.20	T1.30	T1.60	T1.90	T2.20
ave T	1.30096	1.59660	1.89404	2.22505	1.40789	1.62395	1.86953	2.08890
1. triBar	0.32896	0.34919	0.35936	0.53789	0.27590	0.35937	0.40049	0.44574
2. t-hedroN	0.29423	0.33124	0.36865	0.56527	0.23349	0.32248	0.37607	0.42312
3. Dolos	0.23709	0.38635	0.38594	0.57300	0.30838	0.39148	0.43852	0.48163
4. Shake	0.20746	0.37243	0.39554	0.58553	0.29605	0.38593	0.44396	0.48710
5. Linko	0.29533	0.40068	0.39322	0.59616	0.29784	0.38963	0.43449	0.47411
6. Anchor	0.35593	0.37640	0.39007	0.59498	0.26845	0.36745	0.41793	0.46862
7. Tetrapod	0.32261	0.38313	0.37421	0.57112	0.28001	0.36847	0.42002	0.46293
8. Hexapod	0.33503	0.35622	0.37770	0.56875	0.27788	0.36745	0.41246	0.44944
9. double-Y	0.35789	0.37805	0.38258	0.56263	0.28722	0.37541	0.43314	0.46149
10. double-U	0.18913	0.30897	0.35462	0.50629	0.25772	0.34047	0.39286	0.41419
11. ten-En	0.29835	0.33615	0.35608	0.54951	0.25431	0.33695	0.39062	0.42980
std	0.05508	0.02651	0.01417	0.02492	0.02076	0.02153	0.02121	0.02301
ave	0.29291	0.36171	0.37618	0.56465	0.27611	0.36410	0.41460	0.45438

Tab 4.47 (KrAve-A). The table of the average reflection coefficients (averaged over wave heights) and the wave periods for all the individual armor types (slope: 1:1.5).

REFLECTION COEFFICIENT TABLE (Slope : 1 on 1.2)

Armor type	Kr (Regular waves)				Kr (Irregular waves)			
	T1.30	T1.60	T1.90	T2.20	T1.30	T1.60	T1.90	T2.20
ave T	1.30330	1.60363	1.89400	2.22340	1.40491	1.63790	1.88232	2.092102
1. triBar	0.36381	0.40036	0.44382	0.59688	0.32867	0.42740	0.46237	0.49554
2. t-hedroN	0.36089	0.37054	0.42577	0.58361	0.26563	0.36777	0.40692	0.44955
3. Dolos	0.36991	0.40333	0.44394	0.60012	0.32701	0.42186	0.46218	0.49735
4. Shake	0.34677	0.41605	0.47730	0.60809	0.35241	0.44026	0.47713	0.50016
5. Linko	0.39076	0.45919	0.48173	0.62930	0.36486	0.45849	0.49205	0.51832
6. Anchor	0.39173	0.46312	0.50328	0.63630	0.33169	0.43869	0.46784	0.49704
7. Tetrapod	0.35838	0.44283	0.45912	0.62380	0.34261	0.43430	0.47633	0.50528
8. Hexapod	0.37971	0.40422	0.45307	0.59065	0.34904	0.43471	0.47345	0.49839
9. double-Y	0.37914	0.42047	0.44504	0.60427	0.33040	0.42823	0.46851	0.50252
10. double-U	0.23614	0.35438	0.41873	0.53756	0.31063	0.39783	0.44926	0.48003
11. ten-En	0.37409	0.40424	0.45849	0.59825	0.32065	0.41833	0.45222	0.48964
std	0.04105	0.03197	0.02353	0.02538	0.02496	0.02297	0.02096	0.01668
ave	0.35921	0.41261	0.45548	0.60080	0.32942	0.42435	0.46257	0.49398

Tab 4.48 (KrAve-B). The table of the average reflection coefficients (averaged over wave heights) and the wave periods for all the individual armor types (slope: 1:1.2).

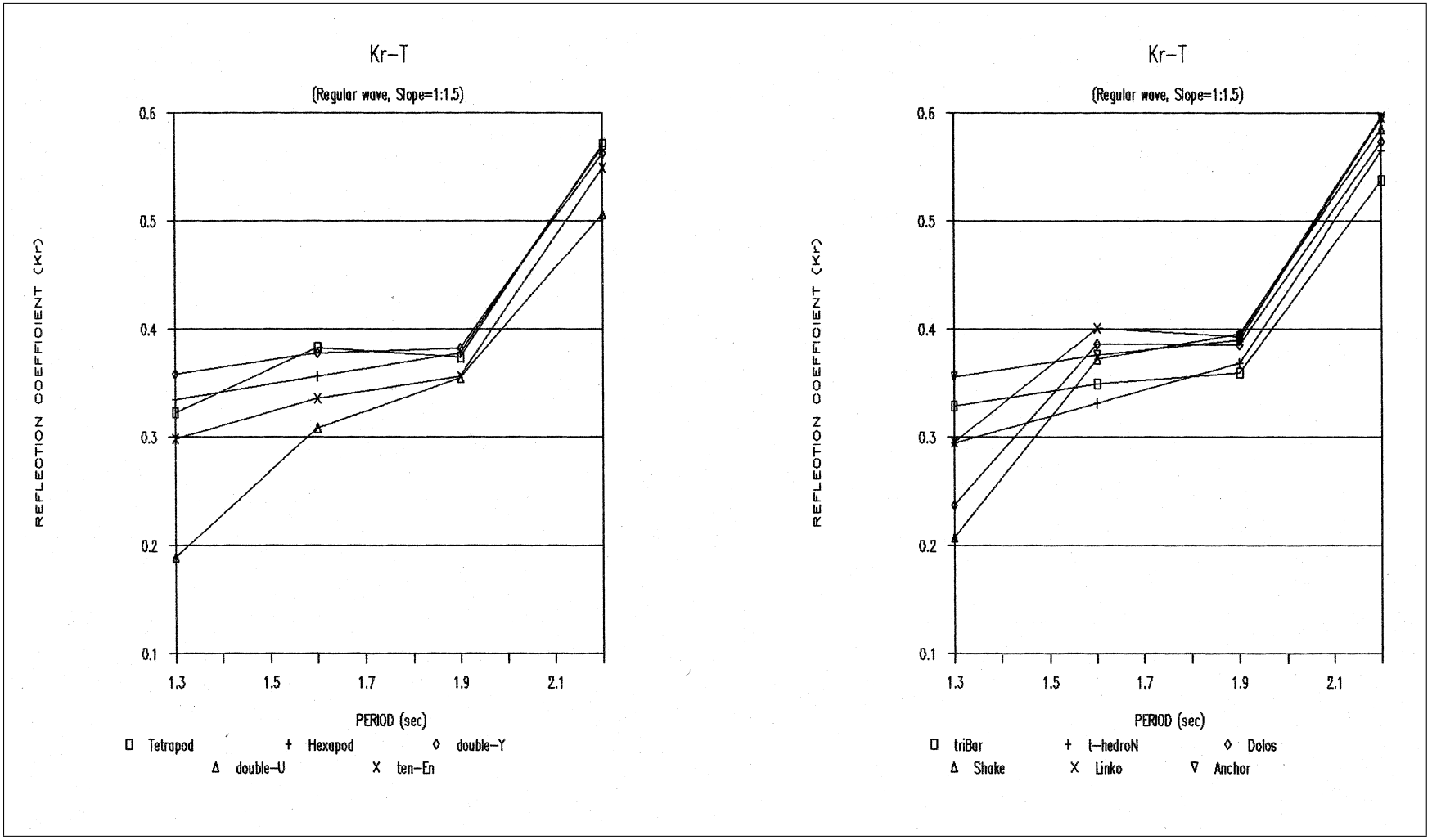

Fig 4.24 (KrAve-A-R). The variation of the average reflection coefficient with the wave period (regular waves, slope: 1:1.5).

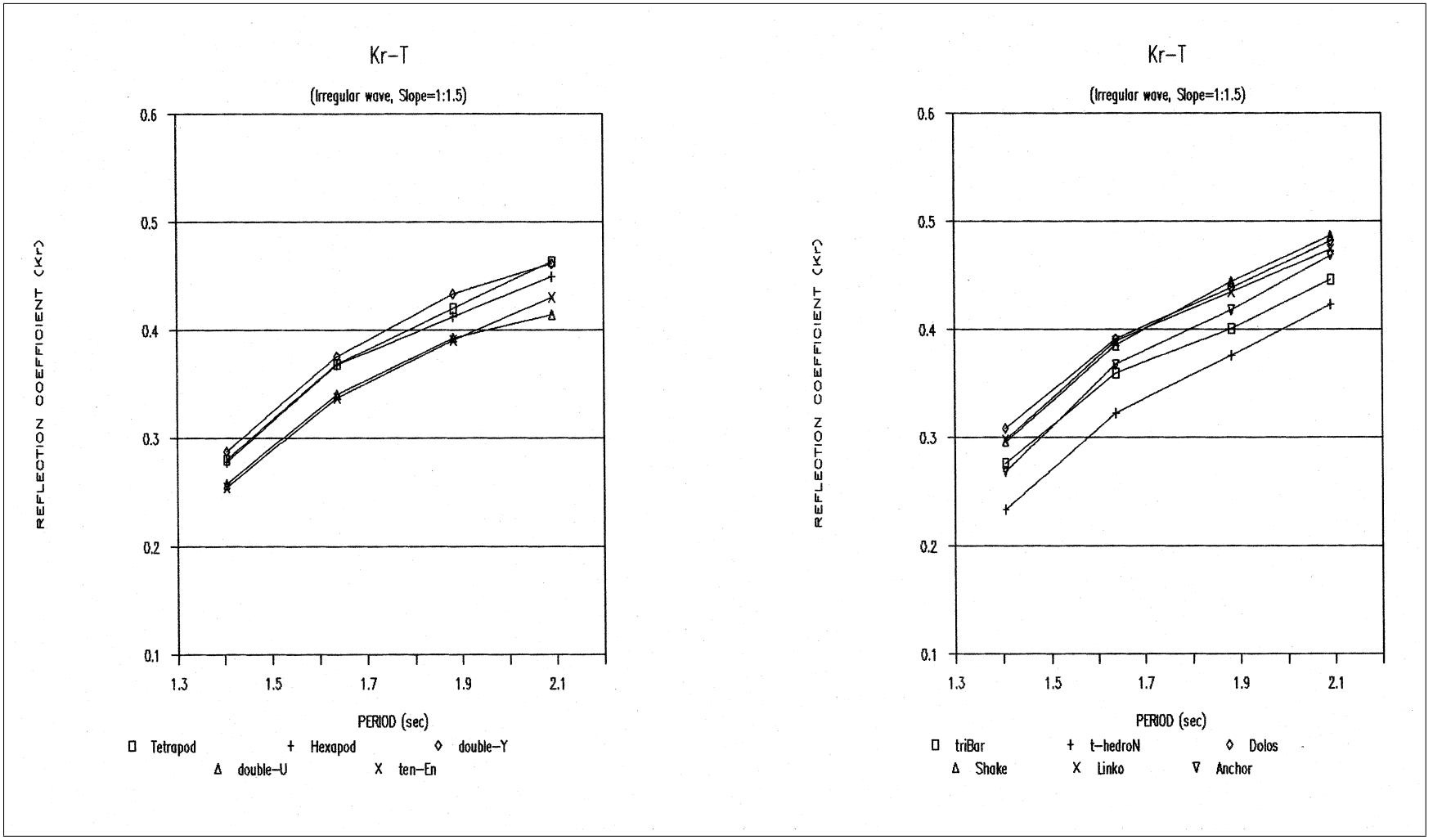

Fig 4.25 (KrAve-A-I). The variation of the average reflection coefficient with the wave period (irregular waves, slope: 1:1.5).

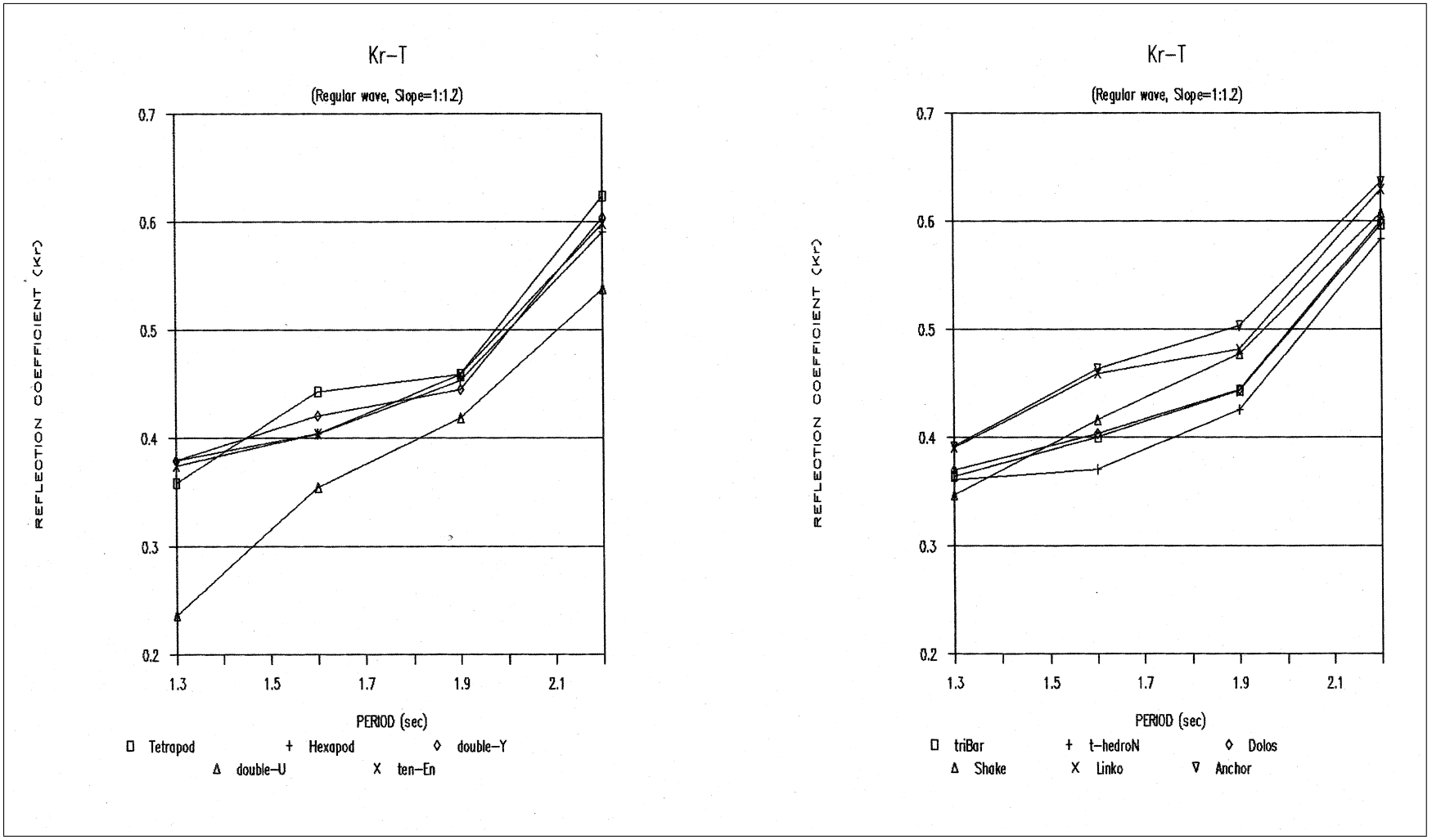

Fig 4.26 (KrAve-B-R). The variation of the average reflection coefficient with the wave period (regular waves, slope: 1:1.2).

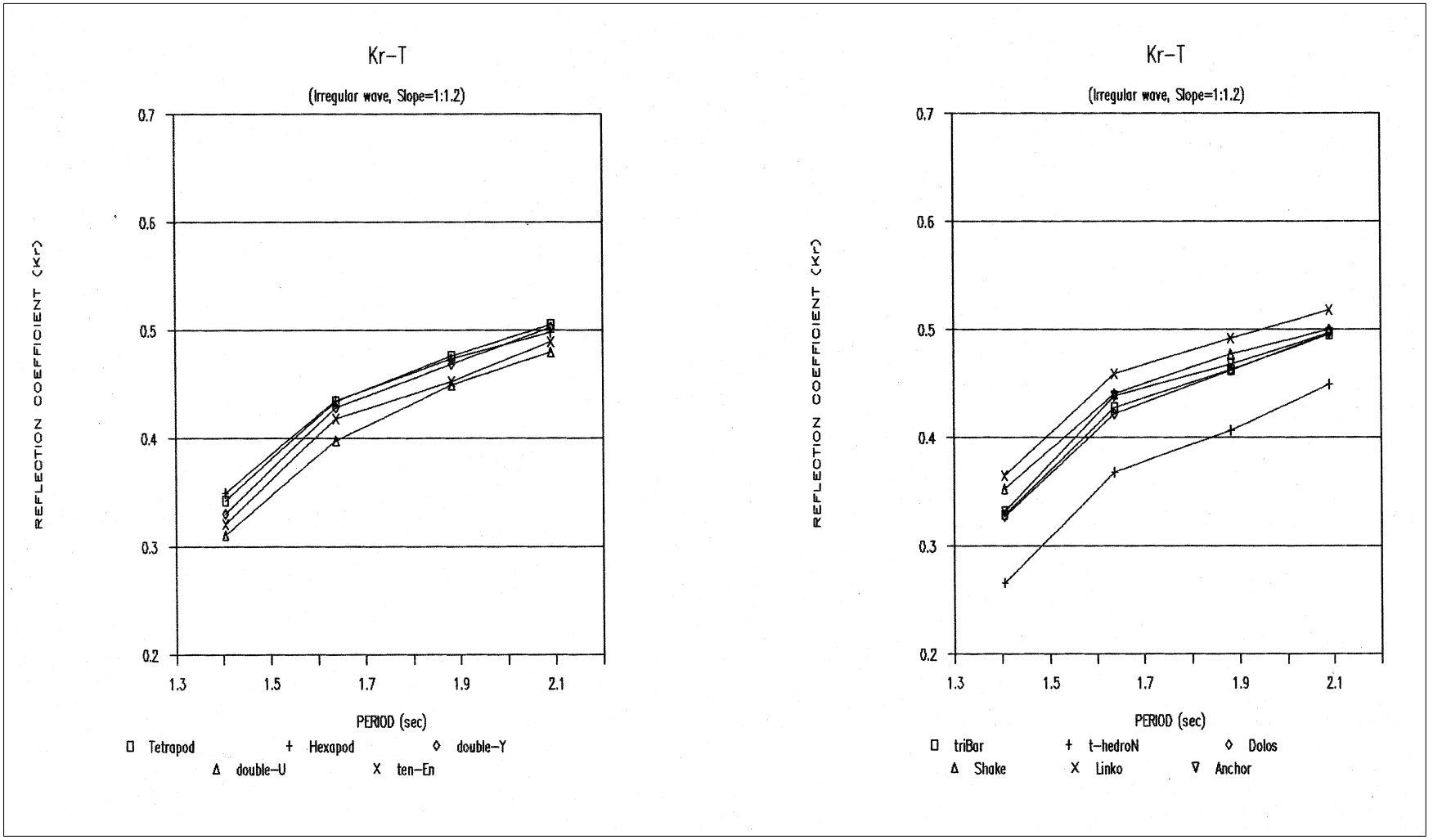

Fig 4.27 (KrAve-B-I). The variation of the average reflection coefficient with the wave period (irregular waves, slope: 1:1.2).

Reflection Coefficient Orthogonal Regression (**Regular** Waves, Slope=1:1.5)			
Coefficient matrix for orthonormal polynomials			
$P_0(x)$	$P_1(x)$	$P_2(x)$	$P_3(x)$
-0.15076	-0.78657	4.94144	41.92162
0.00000	0.44947	-5.86272	-74.93697
0.00000	0.00000	1.67506	43.69864
0.00000	0.00000	0.00000	-8.32355
Orthogonal polynomial coordinates			
-2.64575	0.61530	0.19845	-0.16934
Square error terms for each degree (degree: 0, 1, 2, 3)			
0.49681	0.11821	0.07882	0.05015
Fitted degree of polynomial: 3 ($n = 4$)			
Coefficients of fitted polynomial: (power: 3, 2, 1, 0)			
1.40949	-7.06742	11.80276	-6.20340
Fitted degree of polynomial: 2 ($n = 3$)			
Coefficients of fitted polynomial: (power: 2, 1, 0)			
	0.33242	-0.88691	0.89552

Tab 4.49 (KrReg-A-R). The orthogonal polynomial regression analysis of the overall-averaged (all armor types) reflection coefficient (regular waves, slope: 1:1.5).

Reflection Coefficient Orthogonal Regression (**Irregular** Waves, Slope=1:1.5)			
Coefficient matrix for orthonormal polynomials			
$P_0(x)$	$P_1(x)$	$P_2(x)$	$P_3(x)$
-0.15076	-.97981	9.01517	79.98100
0.00000	0.55989	-10.55287	-140.41885
0.00000	0.00000	3.01509	81.18459
0.00000	-.00000	0.00000	-15.46371
Orthogonal polynomial coordinates			
-2.50270	0.43092	-0.07994	-0.05583
Square error terms for each degree (degree: 0, 1, 2, 3)			
0.21581	0.03012	0.02373	0.02062
Fitted degree of polynomial: 3 ($n = 4$)			
Coefficients of fitted polynomial: (power: 3, 2, 1, 0)			
0.86341	-4.77392	8.92505	-5.23127
Fitted degree of polynomial: 2 ($n = 3$)			
Coefficients of fitted polynomial: (power: 2, 1, 0)			
	-0.24102	1.08483	-0.76557

Tab 4.50 (KrReg-A-I). The orthogonal polynomial regression analysis of the overall-averaged (all armor types) reflection coefficient (irregular waves, slope: 1:1.5).

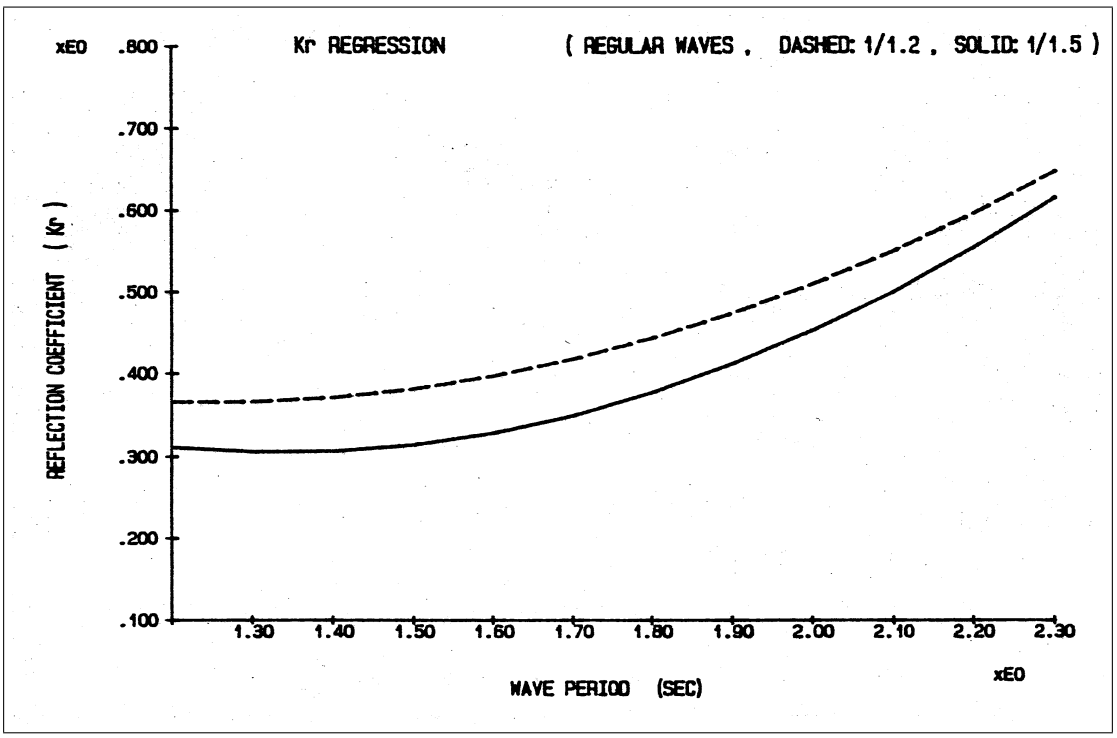

Fig 4.28 (KrReg-A-R). The regression curves of the overall-averaged (all armor types) reflection coefficients versus the wave periods for the two slopes (regular waves).

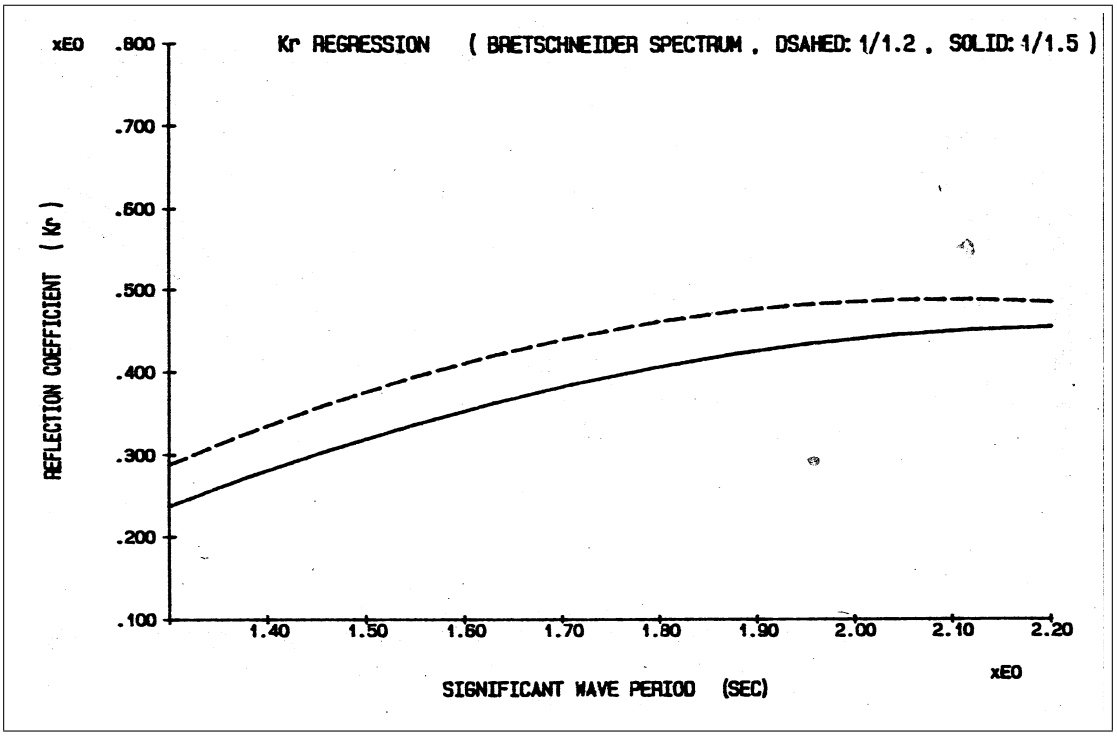

Fig 4.29 (KrReg-A-I). The regression curves of the overall-averaged (all armor types) reflection coefficients versus the wave periods for the two slopes (irregular waves).

4.3 Relative wave run-up R_u and run-down R_d

4.3.1 The R_u and R_d and the distributions and trends

Tables 4.51 (UD-A-1) ~ 4.56 (UD-A-6) and 4.57 (UD-B-1) ~ 4.62 (UD-B-6) show the relative wave run-up R_u and run-down R_d for all the individual armor types under the two slopes of 1:1.5 and 1:1.2, respectively. Figures 4.30 (UD-A-1) ~ 4.51 (UD-B-11) show the corresponding distributions of R_u and R_d with respect to the wave height for the individual wave period parameter. Apparently, when referencing to the existing or available literatures at home and abroad, the messily scattering of earlier data on such topic have been greatly reduced. And their degrees of improvement may be even more obtrusive when compared to that of the improvements on the K_r topic as shown in the prior section. Therefore, it is anticipated that physical features concerning the distributions, the trends or the consistency could be reasonably given.

Again, the reasons why the results of previous studies are so chaotic can be attributed to the three main factors both in data acquisitions and in analyses: no involvement of the wave separation, lack of "uniformization", and inadequacy of "signification".

Note that the relative run-up and run-down are based on the far-field incident wave height H_o. If near-field (near the breakwater) wave height H_d is used their values will be slightly larger and their scattering will also be relatively obvious since here the separated incident wave height is smaller here and the physics is somewhat more complex. Table 4.63 (UD-A-1(d)) shows the run-up and run-down based on the near field H_d for the **L**inko and **A**nchor. Overall, even though much improvement has been obtained for the wave run-up and run-down data, their convergence (i.e., less scattering) is still not as good as that of the reflection coefficients. But still, let have a look of their ANOVA analyses and check the insights.

4.3.2 The ANOVA of R_u and R_d

Tables 4.64 (UDA-A-1) $\sim$ 4.74 (UDA-A-11) are the single replicate one-way ANOVA of the relative run-up for all the armor types under the slope of 1:1.5. According to the F-values and the coefficients of determination of these tables, some of the armor types show the effects of the additivity of the wave period and wave height. For the slope of 1:1.2, the outcomes are similar. And there is the implication here that the relative run-up is somewhat influenced by the combined effects of the wave's period and height. Basically, the data in these tables and the purity of indicated trends are not as good as those of the K_r ANOVA. However, it is still completely clear that there is an absolute effect from the wave period factor. But the influence of wave height factor is somewhat unclear and not to be completely excluded.

Next, let us provide the two-way ANOVA analyses in the manners similar to those depicted in the K_r section. Table 4.75 (UA-A-HT/A) shows the two-way ANOVA that has an unknown factor as the armor type (the wave period and the wave height are the two treatment factors). Table 4.76 (UA-A-AT/H) shows the two-way ANOVA that has an unknown factor as the wave height (the wave period and the armor type are the two treatment factors). From the two tables, we have the similar conclusions as those of the two-way ANOVA for the K_r, even though their certainty levels are somewhat reduced. As for the role played by the wave height factor, they too indicate that the influence of wave height factor is unclear but not to be excluded completely. Overall, what can be firmly confirmed are the roles of the factors of wave period and armor type. Noted additionally is the reduction of the R-squared value for the table that encompasses wave height as a treatment factor. Its low value indicates that other important factors are absent and the armor type factor might be one of them. Of course we do not rule out the possible element related to the visual way of observation for the wave run-up and run-down.

4.3.3 Average run-up run-down and the regressions

Based upon the above data and the ANOVA arguments on R_u and R_d, it is quite reasonable to have the mean run-up and run-down for a specific wave period, i.e., by summing up all different wave heights under the same period. Though now the anticipated features may not be as outstanding as those of the K_r, it is still helpful in the performance judgements and in the acquaintance of the overall relations between the K_r, R_u and R_d, as well as the relevant physics. Tables 4.77 (UDAve-A) and 4.78 (UDAve-B) are the wave run-up run-down in variation with each wave period for all the armor types under the two different slopes respectively. Figures 4.52 (UAve-A) $\sim$ 4.55 (DAve-B) show the distribution curves from the two tables for the wave run-up, the wave run-down, and for the two slopes, as labeled in each sub-figure. Note that the run-up and run-down were observed for the regular waves only.

The orthonormal polynomial regressions (again, shown only the 1:1.5 slope) between the relative run-up and wave period are given in table 4.79 (UReg-A~T), and the best relevant curves are shown in figure 4.56 (UReg-A~T). And the orthonormal polynomial regressions between the relative run-down and wave period are given in table 4.80 (DReg-A~T), and the best relevant curves are shown in figure 4.57 (DReg-A~T). These regression curves are based upon the overall-averaged data, i.e., averaged over all the armor types.

Further discussions of relevant features will be provided next.

4.3.4 Trends and the relations with K_r phenomena

From all the tables, figures, and regressions for R_u, R_d and K_r, it is not difficult to be acquainted with the following prominent features and their consistent physics.

- From all those figures for wave run-up and run-down (figures 4.30(UD-A-1) $\sim$ 4.51(UD-B-11) and, in particular, figures 4.52 (UAve-A) $\sim$ 4.55 (DAve-B)), it can be seen that, for almost all the armor types, the relative run-up increases with the increasing of the wave period at the beginning, and later decreases. Moreover, the relative run-down (in absolute value) also behaves in the same manner. These trends of variational

changes are clearly depicted in the figures for the overall regression curves (figures 4.56 (UReg-A∼T) and 4.57 (DReg-A∼T)). Moreover, the differences among different armor types are larger for the run-up, and significantly smaller for the run-down. The very interesting feature here is the relation between the variational trends of the R_u and K_r, as well as those of R_d and K_r. For K_r, the characteristic curvatures of the regression curves are positive; whereas, for the R_u regressions, they are negative. This phenomenon is quite compatible with physics. Since if the reflection coefficient increases with an enhancing trend (i.e., a positive curvature), it means the time the water spends on the slope should be in a decelerated trend (i.e., a negative curvature). Another simple alternate explanation is: a longer relative travel distance (i.e., a larger relative run-up) means a milder variation of K_r, and viceversa.

- Comparing the R_u (or R_d) under the two different slopes, all the individual armor types consistently show that a milder breakwater slope corresponds to a smaller R_u as well as a smaller absolute R_d. This phenomenon is in exact agreement with those of the K_r. Again the simple reason is that an enhancement of K_r means a relatively shorter traveling distance on the slope and a higher impact response, such that shorter R_u and R_d.

- The trend of the variation of R_u regression is consistent with that of the R_d, that is to say, the negative curvature of the R_u matches with the positive curvature of R_d.

- Regarding the ranges of variation of R_u and R_d, we have the distinctive physics in three aspects. First, the range of variation of R_u is invariably larger to a significant extent than that of the R_d. Second, the distance between the two regression curves of the two different slopes is larger for the R_u, but very small for the R_d. Third, the run-up is invariably rather significant than the run-down. The simple reason that induces these features is easily apprehended like the following. Since the run-down is a recession process, it is a secondary and indirect response of an impact and an after effect of the run-up, the process of rising and retreating of the water and the

traveling distances have seriously dampen the original impingement.

- The group of figures 4.52 (UAve-A) ∼ 4.55 (DAve-B) concerns the comparisons of average run-up among different armor types, and the group of figures 4.24 (KrAve-A-R) ∼ 4.27 (KrAve-B-I) concerns the comparisons of average reflection coefficient. By cross-referencing these two groups of figures, it can be found that, if an armor type has a small K_r, its R_u will in general be small too. This feature manifests the fact that a low reflectivity stands for a better wave-damping or wave-absorbing ability of an armor type. Combining this phenomenon with the various descriptions given above, it helps to demonstrate the quality of the data, the meaningfulness of the analyses, as well as the significance of such comparisons.

- Effects of wave height on relative run-up and run-down are not clear-cut, but they are small when compared to the effects of wave period and armor type. Figures 4.30 (UD-A-1) ∼ 4.51 (UD-B-11) show that, for the wave periods of 1.6 and 1.9 second, the R_u are likely to increase with the increase of wave height, and, for the periods of 1.3 and 2.2 second the R_u go somewhat flatter. However the R_d values mostly follow a consistent trend that shows its value decreases (i.e. the curve goes upwards) with the increase of wave height. It is also noted that set-up of water may occur in some instances (see the waveform of figure 3.7 (Surface-4), as measured at gauge 3). Therefore, in addition to the factors of wave period and wave height, as well as the traveling history of the water on the slope, the set-up may play a role in the run-up and run-down.

- Comparing the R_u or the R_d data between the two breakwater slopes, as typically shown in the graphs of regression for the two slopes, the differences between the R_u values are significantly larger, while the differences between the R_d are very small. That is to say, the R_d is less affected by the slope and all their values for all the different armor types are close to each others. In general, the range of variation between the R_u and the R_d is about $1.45 \sim -0.8$ for the slope of 1:1.5, and about

$1.25 \sim -0.75$ for the slope of 1:1.2.

- Regardless of the one-way or two-way ANOVA, all the results for K_r, R_u and R_d exhibit quite similar features and consistent trends. All of them show, to an ultimate degree, the definiteness of the effect of wave period factor. And they also clearly demonstrate that the influence from the factor of armor type is greater than that of the wave height. Overall, it is concluded that the order of the influences is: "*wave period factor* $\gg$ *armor type factor* $>$ *wave height factor*" for both the reflection coefficient and the relative run-up run-down.

LAYOUT : 1-A (BN5) [Slope: 1 on 1.5]
Armor types : triBar(R) & tetrahedroN(L) Note : Ho~S , Hd~E
Table No. : 1 - A - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/12/91-21:50:19.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
UP												
RH08	7.833190	0.765971	0.638309	7.392591	0.879258	0.879258	6.491298	1.232419	1.032150	8.020213	1.122164	1.184507
RH10	9.763978	0.665712	0.665712	9.109750	1.042838	0.987952	8.272395	1.208839	1.087955	10.05357	1.193605	1.193605
RH12	11.76577	0.679938	0.679938	10.68750	1.122806	1.029239	10.19917	1.274612	1.176565	13.14761	1.102861	1.140890
RH14	14.30147	0.699228	0.699228	12.68577	1.103598	1.064184	12.17256	1.314431	1.191203	14.65132	1.228557	1.296810
RH16	16.73536	0.717044	0.776798	14.40397	1.249654	1.180229	13.82786	1.301718	1.229401	17.06270	1.172146	1.289361
RH18	19.42958	0.669082	0.720550	16.26821	1.167921	1.167921	15.39965	1.298730	1.168857	19.93451	1.053449	1.153777
DOWN												
RH08	7.833190	-0.51064	-0.44681	7.392591	-0.67635	-0.74398	6.491298	-1.00134	-0.84728	8.020213	-0.74810	-0.74810
RH10	9.763978	-0.56329	-0.51208	9.109750	-0.71352	-0.65863	8.272395	-0.84618	-0.78574	10.05357	-0.69626	-0.69626
RH12	11.76577	-0.59494	-0.55244	10.68750	-0.74853	-0.70175	10.19917	-0.78437	-0.68632	13.14761	-0.53241	-0.57044
RH14	14.30147	-0.52442	-0.52442	12.68577	-0.63062	-0.63062	12.17256	-0.69829	-0.65721	14.65132	-0.58015	-0.64840
RH16	16.73536	-0.47802	-0.44815	14.40397	-0.59011	-0.69425	13.82786	-0.65085	-0.65085	17.06270	-0.49816	-0.58607
RH18	19.42958	-0.41174	-0.41174	16.26821	-0.55322	-0.73763	15.39965	-0.64936	-0.64936	19.93451	-0.50164	-0.50164
std (U)		0.0346	0.0440		0.1150	0.1037		0.0386	0.0668		0.0588	0.0615
std (D)		0.0590	0.0500		0.0680	0.0403		0.1248	0.0764		0.0965	0.0821
ave (U)		0.699	0.697		1.094	1.051		1.272	1.148		1.145	1.210
ave (D)		-0.514	-0.483		-0.652	-0.694		-0.772	-0.713		-0.593	-0.625

Note :: Ho1/3 based on far field wave height Ho

Tab 4.51 (UD-A-1). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.5) (tri**B**ar and tetrahedro**N**).

LAYOUT : 2-A (DS5) [Slope: 1 on 1.5]
Armor types : Dolos (R) & Shake (L) Note : Ho~S , Hd~E
Table No. : 2 - A - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/12/91-22:45:55.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
UP												
RH08	7.736350	0.904819	0.904819	7.539447	1.100876	1.061085	6.454843	1.471763	1.239379	7.998416	1.312759	1.250247
RH10	9.491713	0.895517	0.842840	9.260855	1.241785	1.079813	8.111087	1.541100	1.232880	10.29706	1.311053	1.165380
RH12	11.52914	0.910735	0.780630	11.07063	1.219442	1.083948	10.14140	1.429781	1.183267	12.21508	1.350789	1.391722
RH14	13.39732	1.007664	0.858380	12.47655	1.322480	1.122104	11.99522	1.458914	1.167131	14.64297	1.331696	1.365842
RH16	14.99388	0.967061	0.947053	14.49151	1.345615	1.255907	13.39772	1.530110	1.380831	17.56952	1.223709	1.195251
RH18	17.18408	0.960191	0.989287	16.52248	1.240733	1.180209	16.94078	1.269126	1.210097	18.98113	1.343439	1.290755
DOWN												
RH08	7.736350	-0.45240	-0.45240	7.539447	-0.72949	-0.66317	6.454843	-0.85207	-0.80559	7.998416	-0.68763	-0.50009
RH10	9.491713	-0.47409	-0.47409	9.260855	-0.59389	-0.64788	8.111087	-0.67808	-0.67808	10.29706	-0.53413	-0.63124
RH12	11.52914	-0.47705	-0.47705	11.07063	-0.58713	-0.58713	10.14140	-0.69023	-0.64093	12.21508	-0.53212	-0.53212
RH14	13.39732	-0.41052	-0.41052	12.47655	-0.60112	-0.60112	11.99522	-0.62524	-0.62524	14.64297	-0.51219	-0.51219
RH16	14.99388	-0.36681	-0.36681	14.49151	-0.51754	-0.51754	13.39772	-0.63443	-0.67175	17.56952	-0.48379	-0.48379
RH18	17.18408	-0.34916	-0.32006	16.52248	-0.54471	-0.51445	16.94078	-0.56077	-0.56077	18.98113	-0.55318	-0.50049
std (U)		0.0404	0.0689		0.0791	0.0681		0.0898	0.0698		0.0422	0.0828
std (D)		0.0503	0.0578		0.0667	0.0574		0.0901	0.0742		0.0650	0.0490
ave (U)		0.941	0.887		1.245	1.131		1.450	1.236		1.312	1.277
ave (D)		-0.422	-0.417		-0.596	-0.589		-0.673	-0.664		-0.551	-0.527

Note :: Ho1/3 based on far field wave height Ho

Tab 4.52 (UD-A-2). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.5) (**D**olos and **S**hake).

LAYOUT : 3-A (LA5) [Slope: 1 on 1.5]
Armor types : Linko (R) & Anchor (L) Note : Ho~S , Hd~E
Table No. : 3 - A - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/12/91-23:38:15.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
UP												
RH08	7.667766	0.912912	0.782496	7.570640	1.056713	0.858579	6.947706	1.295391	1.079492	8.287925	1.206574	1.122114
RH10	9.773086	0.869735	0.818574	9.255384	1.080452	1.026429	8.551914	1.403194	1.169328	10.61952	1.129994	1.129994
RH12	11.99964	0.791689	0.750021	11.13744	1.077446	0.987659	10.24335	1.317927	1.122679	12.68988	1.260847	1.260847
RH14	14.33524	0.767339	0.697581	12.63598	1.266224	1.107946	13.08623	1.299075	1.146242	15.64593	1.278287	1.278287
RH16	16.62708	0.781856	0.781856	15.14457	1.254574	1.188544	14.15921	1.483133	1.271257	18.11737	1.269499	1.324695
RH18	19.61754	0.917545	0.917545	16.35735	1.222691	1.283826	16.87976	1.362578	1.362578	20.09879	1.094592	1.094592
DOWN												
RH08	7.667766	-0.65208	-0.52166	7.570640	-0.79253	-0.72649	6.947706	-0.86359	-0.86359	8.287925	-0.72394	-0.72394
RH10	9.773086	-0.56277	-0.56277	9.255384	-0.70229	-0.70229	8.551914	-0.76006	-0.81853	10.61952	-0.61208	-0.65916
RH12	11.99964	-0.50001	-0.50001	11.13744	-0.58361	-0.62851	10.24335	-0.63455	-0.68336	12.68988	-0.55162	-0.59102
RH14	14.33524	-0.41854	-0.41854	12.63598	-0.55397	-0.55397	13.08623	-0.61132	-0.53491	15.64593	-0.51131	-0.51131
RH16	16.62708	-0.42099	-0.42099	15.14457	-0.56125	-0.56125	14.15921	-0.63562	-0.60031	18.11737	-0.49676	-0.49676
RH18	19.61754	-0.40779	-0.40779	16.35735	-0.48907	-0.48907	16.87976	-0.59242	-0.56280	20.09879	-0.49754	-0.49754
std (U)		0.0622	0.0675		0.0894	0.1381		0.0667	0.0961		0.0712	0.0889
std (D)		0.0896	0.0593		0.1021	0.0842		0.0970	0.1252		0.0814	0.0871
ave (U)		0.840	0.791		1.160	1.075		1.360	1.192		1.207	1.202
ave (D)		-0.494	-0.472		-0.614	-0.610		-0.683	-0.677		-0.566	-0.580

Note :: Ho1/3 based on far field wave height Ho

Tab 4.53 (UD-A-3). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.5) (Linko and Anchor).

LAYOUT : 4-A (TH5) [Slope: 1 on 1.5]
Armor types : Tetrapod (R) & Hexapod (L) Note : Ho~S , Hd~E
Table No. : 4 - A - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-00:30:50.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
UP												
RH08	7.774634	0.836052	0.771740	7.229054	1.037480	0.899149	6.567490	1.218121	1.065856	8.463264	1.122498	1.181577
RH10	10.07011	0.893733	0.794429	9.121217	1.041527	0.986710	8.342067	1.198743	1.198743	10.85253	1.105732	1.197876
RH12	11.88941	0.799030	0.756975	10.81535	1.109533	1.017072	9.975181	1.303234	1.202985	12.78468	1.173279	1.251497
RH14	13.52877	0.813081	0.813081	12.37750	1.211875	1.131083	12.22134	1.309184	1.145536	14.78859	1.217153	1.318583
RH16	17.30754	0.780006	0.722228	14.34581	1.254721	1.185014	13.24729	1.358767	1.358767	17.25924	1.216738	1.274678
RH18	19.94112	0.802361	0.752214	16.14670	1.300574	1.238642	16.81187	1.308598	1.308598	19.41712	1.236022	1.236022
DOWN												
RH08	7.774634	-0.57880	-0.54021	7.229054	-0.82998	-0.80231	6.567490	-0.98972	-0.76132	8.463264	-0.76802	-0.70894
RH10	10.07011	-0.59582	-0.54617	9.121217	-0.71262	-0.71262	8.342067	-0.83912	-0.77918	10.85253	-0.69108	-0.73715
RH12	11.88941	-0.63081	-0.58875	10.81535	-0.87838	-0.83215	9.975181	-0.90223	-0.80199	12.78468	-0.62574	-0.70396
RH14	13.52877	-0.59133	-0.55437	12.37750	-0.72712	-0.76752	12.22134	-0.77732	-0.73641	14.78859	-0.64238	-0.67619
RH16	17.30754	-0.46222	-0.52000	14.34581	-0.64130	-0.73192	13.24729	-0.75487	-0.79261	17.25924	-0.57939	-0.69527
RH18	19.94112	-0.40118	-0.42625	16.14670	-0.61932	-0.68125	16.81187	-0.59481	-0.62455	19.41712	-0.61801	-0.66951
std (U)		0.0367	0.0295		0.1025	0.1184		0.0560	0.0974		0.0495	0.0459
std (D)		0.0824	0.0505		0.0934	0.0518		0.1239	0.0597		0.0608	0.0223
ave (U)		0.821	0.768		1.159	1.076		1.283	1.213		1.179	1.243
ave (D)		-0.543	-0.529		-0.735	-0.755		-0.810	-0.749		-0.654	-0.699

Note :: Ho1/3 based on far field wave height Ho

Tab 4.54 (UD-A-4). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.5) (**T**etrapod and **H**exapod).

LAYOUT : 5-A (YU5) [Slope: 1 on 1.5]
Armor types : double-Y (R) & double-U (L) Note : Ho~S , Hd~E
Table No. : 5 - A - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-01:23:22.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
UP												
RH08	7.896674	0.823131	0.633177	7.278096	0.961789	0.824391	6.740957	1.186775	0.890081	8.554899	0.935136	0.935136
RH10	10.07393	0.744495	0.595596	9.374087	1.013431	0.853416	8.471698	1.239420	0.944320	10.36301	1.061466	1.061466
RH12	12.67054	0.710308	0.631385	10.84628	1.060271	0.829777	10.05001	1.293529	0.995022	12.37828	1.131012	1.131012
RH14	15.45939	0.646855	0.646855	12.41146	1.087704	0.966848	12.13563	1.236029	0.988823	16.23706	1.108575	0.985400
RH16	17.28844	0.723026	0.665184	14.72554	1.147665	0.814910	13.99677	1.250287	1.071675	18.63206	1.073418	1.073418
RH18	20.13900	0.719995	0.595858	16.14841	1.114660	0.897921	16.73542	1.195070	1.075563	21.20615	1.084590	1.178903
DOWN												
RH08	7.896674	-0.63317	-0.63317	7.278096	-0.89309	-0.82439	6.740957	-0.96425	-0.74173	8.554899	-0.75979	-0.70135
RH10	10.07393	-0.59559	-0.59559	9.374087	-0.80007	-0.74673	8.471698	-0.94432	-0.76726	10.36301	-0.77197	-0.67547
RH12	12.67054	-0.55246	-0.47353	10.84628	-0.78367	-0.73758	10.05001	-0.84576	-0.79601	12.37828	-0.64629	-0.64629
RH14	15.45939	-0.51748	-0.48514	12.41146	-0.72513	-0.64456	12.13563	-0.74161	-0.70041	16.23706	-0.58508	-0.61587
RH16	17.28844	-0.46273	-0.40489	14.72554	-0.64513	-0.67909	13.99677	-0.67872	-0.64300	18.63206	-0.53670	-0.53670
RH18	20.13900	-0.39723	-0.39723	16.14841	-0.61925	-0.61925	16.73542	-0.59753	-0.59753	21.20615	-0.47156	-0.51871
std (U)		0.0521	0.0254		0.0621	0.0532		0.0356	0.0658		0.0627	0.0822
std (D)		0.0793	0.0889		0.0937	0.0691		0.1347	0.0694		0.1104	0.0677
ave (U)		0.728	0.628		1.064	0.865		1.234	0.994		1.066	1.061
ave (D)		-0.526	-0.498		-0.744	-0.709		-0.795	-0.708		-0.629	-0.616

Note :: Ho1/3 based on far field wave height Ho

Tab 4.55 (UD-A-5). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.5) (double-**Y** and double-**U**).

LAYOUT : 6-A (EU5) [Slope: 1 on 1.5]
Armor types : Ten-En (R) & double-U (L) Note : Ho~S , Hd~E
Table No. : 6 - A - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-02:18:51.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
UP												
RH08	8.111522	0.739688	0	7.252129	1.047968	0	6.564159	1.218739	0	8.272403	0.967070	0
RH10	9.704081	0.824395	0	9.144964	1.093497	0	8.082653	1.237217	0	10.75159	1.023104	0
RH12	12.49263	0.800471	0	10.81842	1.063001	0	10.27666	1.167694	0	12.54261	1.116194	0
RH14	14.54633	0.687458	0	12.47940	1.001650	0	11.82589	1.141563	0	14.40973	1.110360	0
RH16	16.48378	0.697655	0	14.29499	0.909409	0	13.51115	1.258219	0	17.57623	1.137900	0
RH18	18.61866	0.698224	0	16.32963	0.979813	0	15.66524	1.276711	0	19.37028	1.342262	0
DOWN												
RH08	8.111522	-0.61640	0	7.252129	-0.75839	0	6.564159	-0.83788	0	8.272403	-0.72530	0
RH10	9.704081	-0.61829	0	9.144964	-0.65609	0	8.082653	-0.80419	0	10.75159	-0.55805	0
RH12	12.49263	-0.52030	0	10.81842	-0.64704	0	10.27666	-0.68115	0	12.54261	-0.59796	0
RH14	14.54633	-0.44684	0	12.47940	-0.60099	0	11.82589	-0.76104	0	14.40973	-0.65927	0
RH16	16.48378	-0.36399	0	14.29499	-0.69954	0	13.51115	-0.74012	0	17.57623	-0.56895	0
RH18	18.61866	-0.34911	0	16.32963	-0.61238	0	15.66524	-0.70219	0	19.37028	-0.61950	0
std (U)		0.0533	0.0000		0.0607	0.0000		0.0480	0.0000		0.1173	0.0000
std (D)		0.1087	0.0000		0.0535	0.0000		0.0544	0.0000		0.0571	0.0000
ave (U)		0.741	0.000		1.016	0.000		1.217	0.000		1.116	0.000
ave (D)		-0.486	0.000		-0.662	0.000		-0.754	0.000		-0.622	0.000

Note :: Ho1/3 based on far field wave height Ho

Tab 4.56 (UD-A-6). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.5) (ten-**E**n and double-**U**).

LAYOUT : 1-B (NB2) [Slope: 1 on 1.2]
Armor types : triBar(R) & tetrahedroN(L) Note : Ho~S , Hd~E
Table No. : 1 - B - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-03:14:19.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)	Ho1/3	U/D(R)	U/D(L)
RH06 (U)	5.841880	0.770299	0.684710	5.509516	0.907520	0.816768	5.036674	1.151553	1.091990	6.501950	0.953560	0.922800
RH08	7.831109	0.766175	0.702327	7.292704	0.891301	0.822740	6.631360	1.055590	1.055590	8.189706	1.037888	1.001256
RH10	10.24973	0.731726	0.634163	9.231187	0.974955	0.866627	8.163345	1.102489	1.004490	10.21978	1.154623	1.125268
RH12	12.68700	0.630566	0.630566	11.09277	0.946561	0.856413	9.935019	1.107194	1.107194	12.37819	1.131020	1.131020
RH14	14.53212	0.653724	0.688130	13.00930	0.922417	0.768680	11.79324	1.102326	1.017532	14.83799	1.044615	1.213101
RH16	17.10281	0.701639	0.701639	14.85422	0.942492	0.841511	13.71924	1.093354	1.020464	17.07885	1.112486	1.171038
RH18	19.43737	0.643090	0.565920	16.31541	0.919376	0.919376	15.31119	1.077643	1.110298	19.40656	1.185165	1.082108
RH06 (D)	5.841880	-0.68471	-0.68471	5.509516	-0.72601	-0.72601	5.036674	-0.83388	-0.83388	6.501950	-0.64596	-0.69210
RH08	7.831109	-0.53632	-0.57463	7.292704	-0.68561	-0.68561	6.631360	-0.75399	-0.75399	8.189706	-0.67157	-0.70820
RH10	10.24973	-0.46830	-0.53659	9.231187	-0.64997	-0.64997	8.163345	-0.73499	-0.71049	10.21978	-0.56752	-0.58709
RH12	12.68700	-0.45716	-0.47292	11.09277	-0.58596	-0.54089	9.935019	-0.70457	-0.65425	12.37819	-0.52511	-0.52511
RH14	14.53212	-0.41287	-0.41287	13.00930	-0.61494	-0.61494	11.79324	-0.76314	-0.67835	14.83799	-0.64024	-0.60655
RH16	17.10281	-0.46775	-0.40928	14.85422	-0.60588	-0.53856	13.71924	-0.65601	-0.61956	17.07885	-0.49769	-0.52696
RH18	19.43737	-0.41157	-0.38585	16.31541	-0.55162	-0.49033	15.31119	-0.58780	-0.55514	19.40656	-0.48952	-0.51528
std (U)		0.0542	0.0467		0.0257	0.0434		0.0273	0.0418		0.0744	0.0930
std (D)		0.0880	0.1004		0.0555	0.0801		0.0737	0.0843		0.0701	0.0740
ave (U)		0.700	0.658		0.929	0.842		1.099	1.058		1.088	1.092
ave (D)		-0.491	-0.497		-0.631	-0.607		-0.719	-0.687		-0.577	-0.594

Note :: Ho1/3 based on far field wave height Ho

Tab 4.57 (UD-B-1). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.2) (tri**B**ar and tetrahedro**N**).

LAYOUT : 2-B (SD2) [Slope: 1 on 1.2]
Armor types : Dolos (R) & Shake (L) Note : Ho~S , Hd~E
Table No. : 2 - B - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-04:17:27.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)
RH06 (U)	5.768622	0.780082	0.780082	5.535429	0.903272	0.903272	5.070028	1.084806	0.986187	6.102148	1.065198	0.983260
RH08	8.025066	0.809962	0.685352	7.734045	0.905089	0.840439	6.553867	1.068071	1.068071	8.011611	1.185778	1.185778
RH10	9.929829	0.805653	0.755299	9.450603	0.952320	0.846506	8.260231	1.271150	1.271150	9.986791	1.251653	1.251653
RH12	11.81460	0.804089	0.719448	11.18105	1.117962	1.117962	9.778232	1.329483	1.176081	12.49899	1.160093	1.240099
RH14	13.91082	0.898581	0.898581	13.06413	1.033363	1.109909	12.01920	1.289603	1.248002	14.93760	1.238484	1.305429
RH16	16.89639	0.798986	0.858171	14.94510	1.170951	1.170951	14.00841	1.356327	1.249249	16.81901	1.278315	1.397228
RH18	19.03678	0.866742	0.919272	16.20443	1.203374	1.203374	16.09895	1.335490	1.397606	19.02827	1.235004	1.287557
RH06 (D)	5.768622	-0.60673	-0.69340	5.535429	-0.72261	-0.72261	5.070028	-0.78895	-0.78895	6.102148	-0.65550	-0.65550
RH08	8.025066	-0.49843	-0.56074	7.734045	-0.64649	-0.64649	6.553867	-0.76290	-0.76290	8.011611	-0.62409	-0.62409
RH10	9.929829	-0.50353	-0.50353	9.450603	-0.52906	-0.63488	8.260231	-0.60530	-0.72637	9.986791	-0.50066	-0.60079
RH12	11.81460	-0.46552	-0.50784	11.18105	-0.53662	-0.58134	9.778232	-0.61360	-0.76700	12.49899	-0.48003	-0.60004
RH14	13.91082	-0.43131	-0.43131	13.06413	-0.61236	-0.61236	12.01920	-0.66560	-0.66560	14.93760	-0.53556	-0.53556
RH16	16.89639	-0.41428	-0.41428	14.94510	-0.60220	-0.60220	14.00841	-0.67816	-0.64247	16.81901	-0.56483	-0.53510
RH18	19.03678	-0.47276	-0.47276	16.20443	-0.61711	-0.61711	16.09895	-0.62115	-0.62115	19.02827	-0.52553	-0.52553
std (U)		0.0394	0.0839		0.1162	0.1462		0.1117	0.1268		0.0670	0.1196
std (D)		0.0583	0.0870		0.0610	0.0422		0.0679	0.0621		0.0595	0.0469
ave (U)		0.823	0.802		1.041	1.027		1.248	1.199		1.202	1.236
ave (D)		-0.485	-0.512		-0.609	-0.631		-0.677	-0.711		-0.555	-0.582

Note :: Hol/3 based on far field wave height Ho

Tab 4.58 (UD-B-2). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.2) (**D**olos and **S**hake).

LAYOUT : 3-B (AL2) [Slope: 1 on 1.2]
Armor types : Linko (R) & Anchor (L) Note : Ho~S , Hd~E
Table No. : 3 - B - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-05:20:28.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)
RH06 (U)	6.058722	0.825256	0.825256	5.573372	1.076547	0.897122	4.980465	1.264942	1.064157	6.027891	1.194447	1.045141
RH08	8.000148	0.749986	0.687487	7.629402	0.917503	0.786431	6.586743	1.214560	1.062740	8.092367	1.173945	1.112159
RH10	10.11054	0.741799	0.593439	9.325475	1.018714	0.857865	8.162436	1.225124	1.163868	10.33441	1.161169	1.161169
RH12	11.76857	0.849720	0.679776	11.27029	1.020381	0.887287	9.943982	1.206760	1.005633	12.87851	1.164730	1.164730
RH14	14.24037	0.842674	0.702228	13.13666	0.989596	0.913473	11.89828	1.176640	1.134617	14.66829	1.363485	1.431659
RH16	16.22668	0.801149	0.739522	15.05852	1.062520	1.162132	13.37529	1.271000	1.345765	16.60677	1.264544	1.324760
RH18	18.75527	0.746456	0.693138	16.05134	1.059100	1.090251	16.25249	1.107522	1.169051	18.33024	1.309311	1.309311
RH06 (D)	6.058722	-0.57767	-0.66020	5.573372	-0.71769	-0.71769	4.980465	-0.80313	-0.80313	6.027891	-0.71335	-0.71335
RH08	8.000148	-0.62498	-0.56248	7.629402	-0.65535	-0.65535	6.586743	-0.80464	-0.75910	8.092367	-0.67965	-0.61786
RH10	10.11054	-0.59343	-0.59343	9.325475	-0.64339	-0.64339	8.162436	-0.79633	-0.73507	10.33441	-0.58058	-0.58058
RH12	11.76857	-0.50983	-0.50983	11.27029	-0.70983	-0.70983	9.943982	-0.80450	-0.75422	12.87851	-0.58236	-0.58236
RH14	14.24037	-0.52667	-0.56178	13.13666	-0.64704	-0.60898	11.89828	-0.71438	-0.67236	14.66829	-0.54539	-0.54539
RH16	16.22668	-0.49301	-0.49301	15.05852	-0.59766	-0.63087	13.37529	-0.59811	-0.52335	16.60677	-0.48173	-0.48173
RH18	18.75527	-0.42654	-0.42654	16.05134	-0.56070	-0.62300	16.25249	-0.61529	-0.67681	18.33024	-0.54554	-0.54554
std (U)		0.0438	0.0645		0.0507	0.1239		0.0516	0.1024		0.0743	0.1268
std (D)		0.0627	0.0699		0.0520	0.0393		0.0858	0.0851		0.0747	0.0668
ave (U)		0.794	0.703		1.021	0.942		1.210	1.135		1.233	1.221
ave (D)		-0.536	-0.544		-0.647	-0.656		-0.734	-0.703		-0.590	-0.581

Note :: Hol/3 based on far field wave height Ho

Tab 4.59 (UD-B-3). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.2) (Linko and Anchor).

LAYOUT : 4-B (HT2) [Slope: 1 on 1.2]
Armor types : Tetrapod (R) & Hexapod (L) Note : Ho~S , Hd~E
Table No. : 4 - B - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-06:22:09.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)
RH06 (U)	6.091511	0.820814	0.656651	5.870591	1.022043	0.851702	5.218745	1.207186	0.958084	5.952314	1.176013	1.008011
RH08	8.351797	0.778275	0.598673	7.593208	0.987724	0.856028	6.658014	1.201559	1.051364	8.143772	1.105138	1.043742
RH10	10.54810	0.711028	0.663626	9.599664	0.937532	0.885447	8.441328	1.066182	1.006950	10.53833	1.186145	1.138699
RH12	13.28162	0.677628	0.602336	11.35313	1.145058	0.968895	10.01519	1.298027	1.098330	12.50804	1.279176	1.279176
RH14	14.63770	0.785642	0.683167	13.28408	1.053892	0.978614	11.75522	1.318562	1.190960	15.22858	1.247653	1.116321
RH16	18.46031	0.704213	0.704213	14.51950	1.067529	0.964220	14.31169	1.187839	1.013157	17.39409	1.264797	1.149815
RH18	20.18473	0.792678	0.693593	16.44135	1.094800	0.973155	17.04328	1.114808	0.997460	19.92196	1.154504	1.029015
RH06 (D)	6.091511	-0.57457	-0.57457	5.870591	-0.63026	-0.68136	5.218745	-0.76646	-0.76646	5.952314	-0.72240	-0.72240
RH08	8.351797	-0.47893	-0.47893	7.593208	-0.65848	-0.65848	6.658014	-0.75097	-0.75097	8.143772	-0.73675	-0.73675
RH10	10.54810	-0.52142	-0.52142	9.599664	-0.72919	-0.72919	8.441328	-0.65155	-0.71078	10.53833	-0.66424	-0.66424
RH12	13.28162	-0.48939	-0.48939	11.35313	-0.70465	-0.70465	10.01519	-0.79878	-0.79878	12.50804	-0.63958	-0.63958
RH14	14.63770	-0.54653	-0.54653	13.28408	-0.60222	-0.60222	11.75522	-0.68054	-0.68054	15.22858	-0.55816	-0.59099
RH16	18.46031	-0.43336	-0.40627	14.51950	-0.58541	-0.58541	14.31169	-0.66379	-0.66379	17.39409	-0.54616	-0.54616
RH18	20.18473	-0.39633	-0.39633	16.44135	-0.66904	-0.66904	17.04328	-0.58674	-0.58674	19.92196	-0.50195	-0.50195
std (U)		0.0503	0.0391		0.0637	0.0539		0.0837	0.0722		0.0592	0.0865
std (D)		0.0578	0.0623		0.0484	0.0481		0.0693	0.0665		0.0841	0.0812
ave (U)		0.753	0.657		1.044	0.925		1.199	1.045		1.202	1.109
ave (D)		-0.492	-0.488		-0.654	-0.661		-0.700	-0.708		-0.624	-0.629

Note :: Hol/3 based on far field wave height Ho

Tab 4.60 (UD-B-4). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.2) (**T**etrapod and **H**exapod).

LAYOUT : 5-B (UY2) [Slope: 1 on 1.2]
Armor types : double-Y (R) & double-U (L) Note : Ho~S , Hd~E
Table No. : 5 - B - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-07:25:09.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)
RH06 (U)	6.147562	0.731997	0.650664	5.570049	0.897658	0.807892	5.162760	1.162169	0.968474	6.319530	1.028557	0.949437
RH08	8.091185	0.741547	0.617956	7.819745	0.831229	0.767288	6.580924	1.063680	1.063680	8.413904	1.010232	0.950807
RH10	10.43238	0.623059	0.575131	9.662900	0.879653	0.827908	8.331759	1.080204	1.020192	10.43641	1.149820	0.958183
RH12	12.66066	0.631878	0.552893	11.13929	0.942609	0.897723	10.27883	1.070160	1.070160	13.14367	1.065151	0.989069
RH14	14.68151	0.681128	0.613015	13.05415	0.995851	0.957549	12.02866	1.080751	1.080751	14.37447	1.113084	1.113084
RH16	18.33382	0.654528	0.599984	14.38447	0.973271	0.903752	14.24510	1.052993	1.123192	17.08302	1.112215	1.112215
RH18	20.13330	0.645696	0.596027	16.17608	0.989114	0.927294	16.08556	1.119015	0.994680	19.19324	1.146236	1.198338
RH06 (D)	6.147562	-0.48799	-0.60186	5.570049	-0.71812	-0.71812	5.162760	-0.77477	-0.77477	6.319530	-0.63295	-0.63295
RH08	8.091185	-0.49436	-0.49436	7.819745	-0.70334	-0.57546	6.580924	-0.91172	-0.71418	8.413904	-0.71310	-0.67745
RH10	10.43238	-0.47927	-0.43134	9.662900	-0.67267	-0.62093	8.331759	-0.84015	-0.72013	10.43641	-0.73780	-0.67072
RH12	12.66066	-0.51340	-0.47390	11.13929	-0.67329	-0.58351	10.27883	-0.77829	-0.72965	13.14367	-0.60865	-0.53257
RH14	14.68151	-0.47679	-0.40867	13.05415	-0.65113	-0.68943	12.02866	-0.74821	-0.66507	14.37447	-0.59132	-0.55654
RH16	18.33382	-0.43635	-0.40908	14.38447	-0.62567	-0.62567	14.24510	-0.63179	-0.59669	17.08302	-0.52683	-0.52683
RH18	20.13330	-0.42218	-0.39735	16.17608	-0.55637	-0.61819	16.08556	-0.62167	-0.62167	19.19324	-0.46891	-0.46891
std (U)		0.0439	0.0291		0.0576	0.0644		0.0352	0.0498		0.0514	0.0934
std (D)		0.0300	0.0671		0.0501	0.0487		0.0969	0.0588		0.0884	0.0742
ave (U)		0.673	0.601		0.930	0.870		1.090	1.046		1.089	1.039
ave (D)		-0.473	-0.460		-0.657	-0.633		-0.758	-0.689		-0.611	-0.581

Note :: Hol/3 based on far field wave height Ho

Tab 4.61 (UD-B-5). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.2) (double-**Y** and double-**U**).

LAYOUT : 6-B (IA2) [Slope: 1 on 1.2]
Armor types : ten-En (R) Note : Ho~S , Hd~E
Table No. : 6 - B - 6 [UD - Ho] Relative Run Up/Down TABLE (based on Ho) 06/13/91-08:28:12.

Wave type	Period											
	T1.3			T1.6			T1.9			T2.2		
	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)	Hol/3	U/D(R)	U/D(L)
RH06 (U)	6.153922	0.649991	0	5.571199	0.987220	0	5.029817	1.292293	0	6.102622	1.114275	0
RH08	8.054056	0.744966	0	7.376290	0.948986	0	6.740662	1.186826	0	7.986986	1.089271	0
RH10	10.01582	0.748815	0	9.549870	0.994777	0	8.146387	1.166161	0	10.76208	0.975647	0
RH12	12.35962	0.768632	0	11.35441	0.924750	0	9.967349	1.103603	0	12.61425	1.149492	0
RH14	13.99354	0.714615	0	13.02791	1.036236	0	11.71916	1.177558	0	14.39657	1.146106	0
RH16	17.34313	0.663086	0	13.32564	1.088127	0	13.32564	1.163170	0	16.41325	1.127137	0
RH18	18.51741	0.675040	0	16.77679	0.923895	0	15.19439	1.283368	0	20.11139	1.168491	0
RH06 (D)	6.153922	-0.64999	0	5.571199	-0.80772	0	5.029817	-0.79525	0	6.102622	-0.70461	0
RH08	8.054056	-0.49664	0	7.376290	-0.67784	0	6.740662	-0.78627	0	7.986986	-0.72618	0
RH10	10.01582	-0.54913	0	9.549870	-0.73299	0	8.146387	-0.85927	0	10.76208	-0.65043	0
RH12	12.35962	-0.68772	0	11.35441	-0.70457	0	9.967349	-0.80262	0	12.61425	-0.63420	0
RH14	13.99354	-0.60742	0	13.02791	-0.61406	0	11.71916	-0.76797	0	14.39657	-0.62514	0
RH16	17.34313	-0.46127	0	13.32564	-0.67538	0	13.32564	-0.67538	0	16.41325	-0.57880	0
RH18	18.51741	-0.54003	0	16.77679	-0.59606	0	15.19439	-0.59232	0	20.11139	-0.44750	0
std (U)		0.0434	0.0000		0.0561	0.0000		0.0631	0.0000		0.0599	0.0000
std (D)		0.0758	0.0000		0.0663	0.0000		0.0834	0.0000		0.0853	0.0000
ave (U)		0.709	0.000		0.986	0.000		1.196	0.000		1.110	0.000
ave (D)		-0.570	0.000		-0.687	0.000		-0.754	0.000		-0.624	0.000

Note :: Hol/3 based on far field wave height Ho

Tab 4.62 (UD-B-6). The R_u and R_d values for different wave periods and wave heights (slope: 1:1.2) (ten-**E**n and double-**U**).

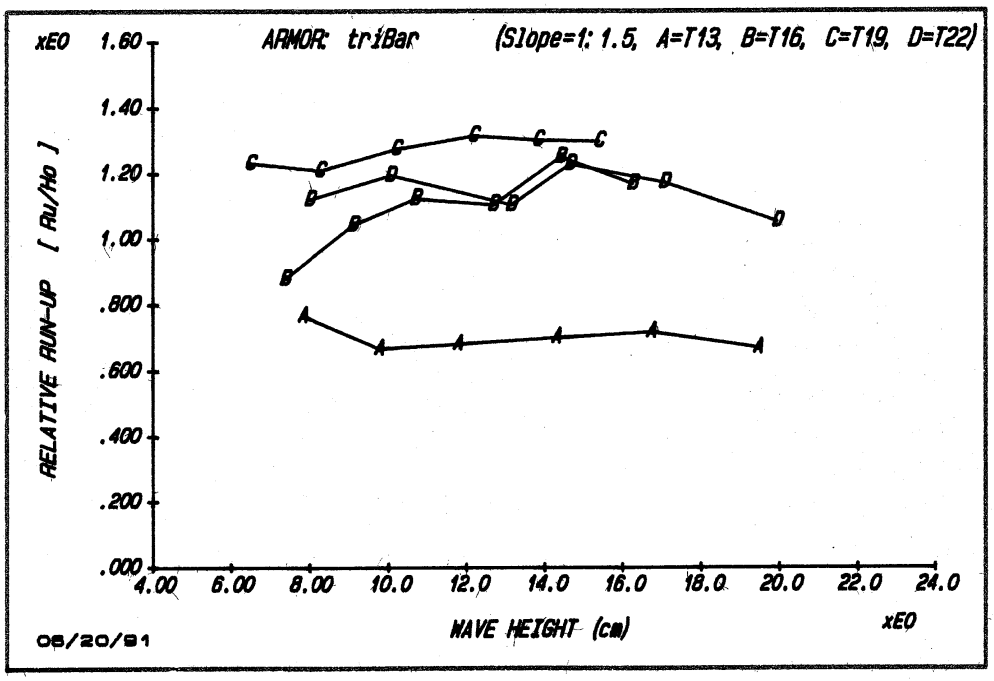

Fig : Ru -- A - 1

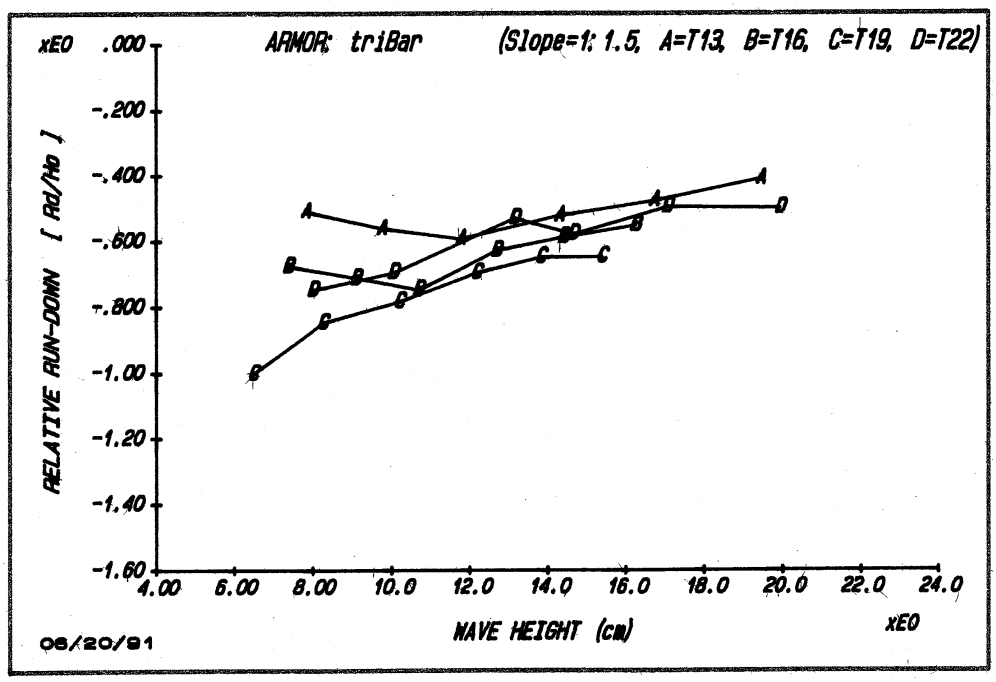

Fig : Rd -- A - 1

Fig 4.30 (UD-A-1). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (tri**B**ar).

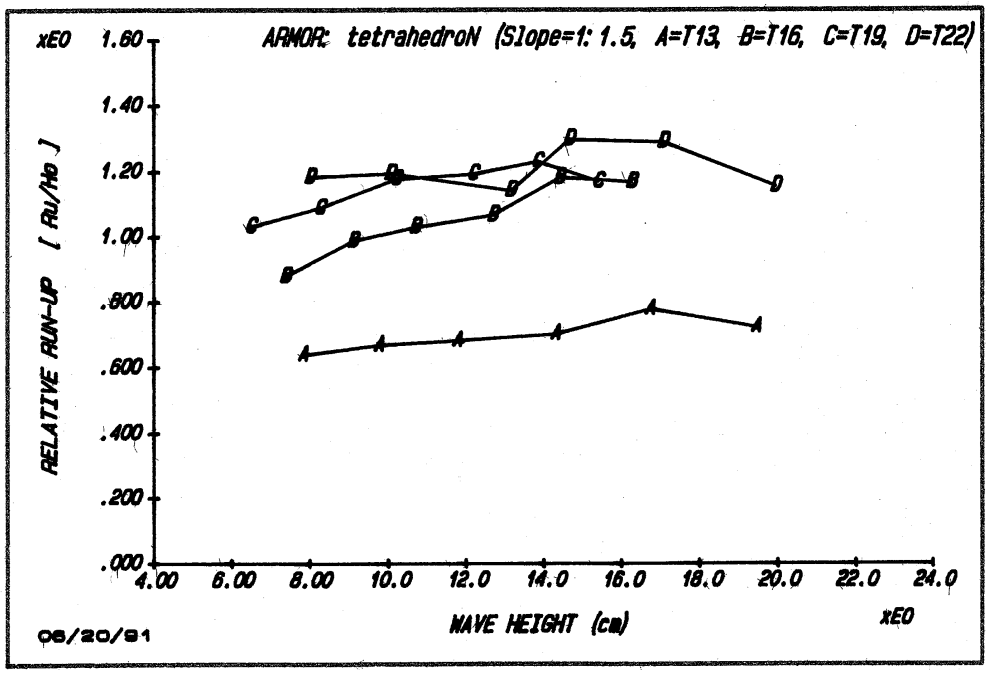

Fig : Ru -- A - 2

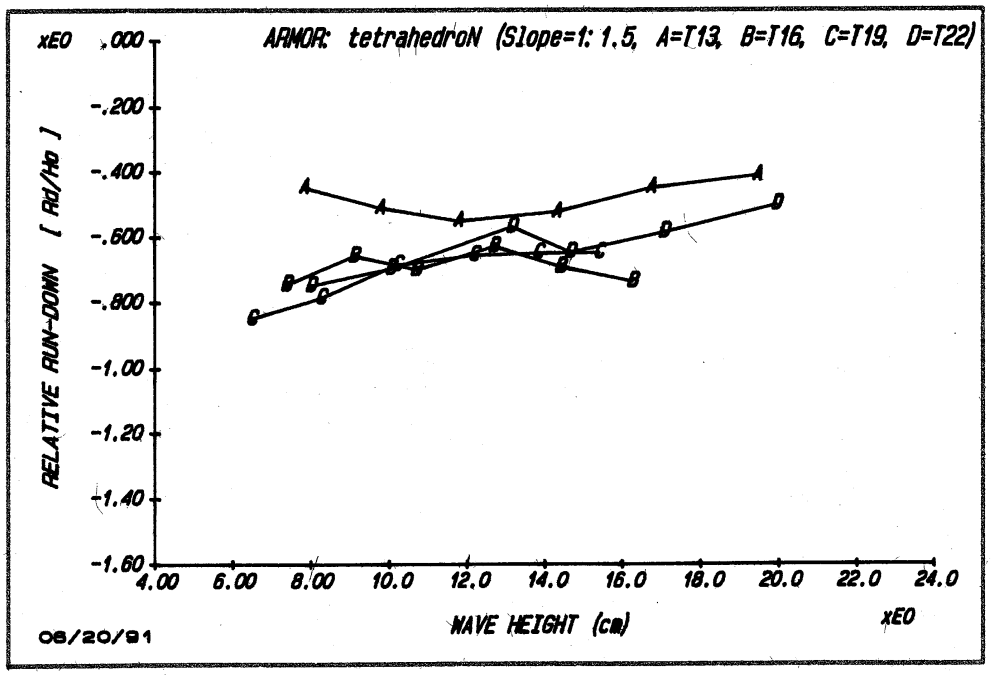

Fig : Rd -- A - 2

Fig 4.31 (UD-A-2). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (tetrahedro**N**).

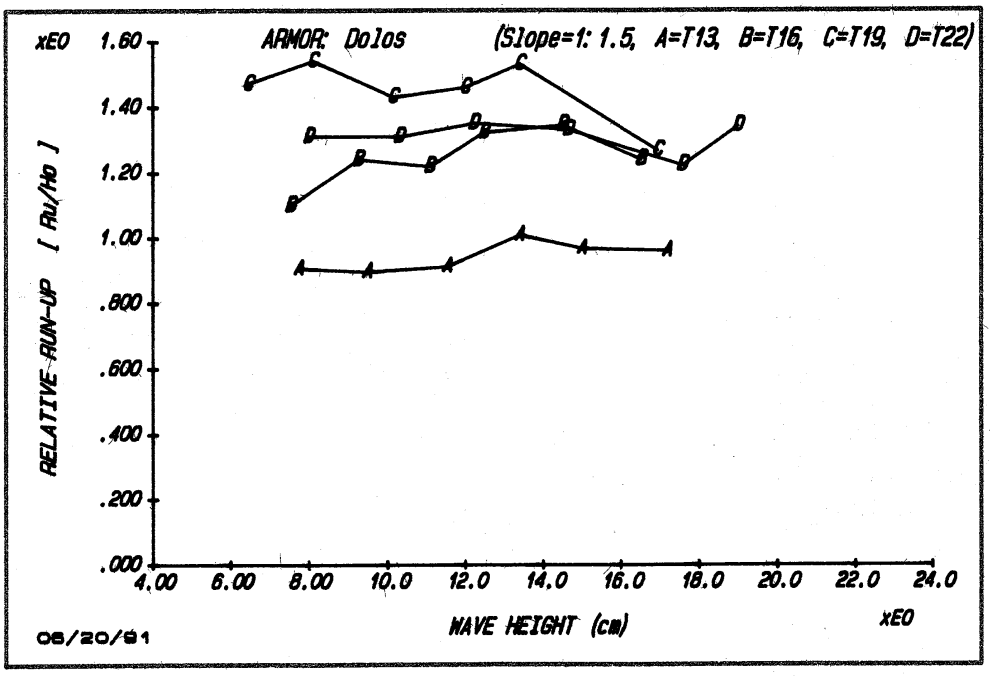

Fig : Ru -- A - 3

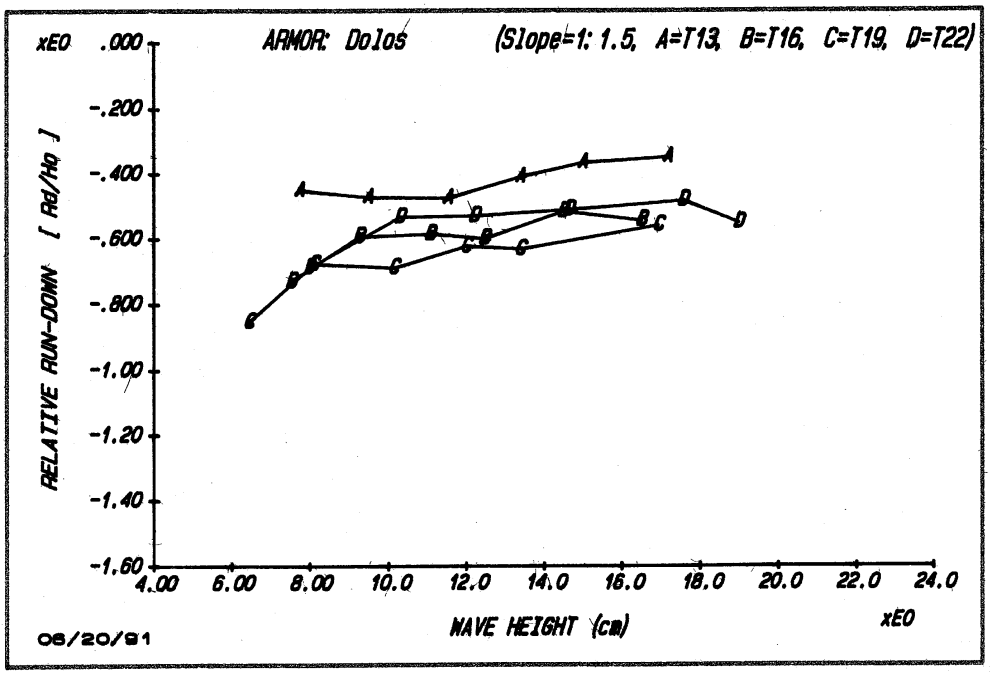

Fig : Rd -- A - 3

Fig 4.32 (UD-A-3). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (**D**olos).

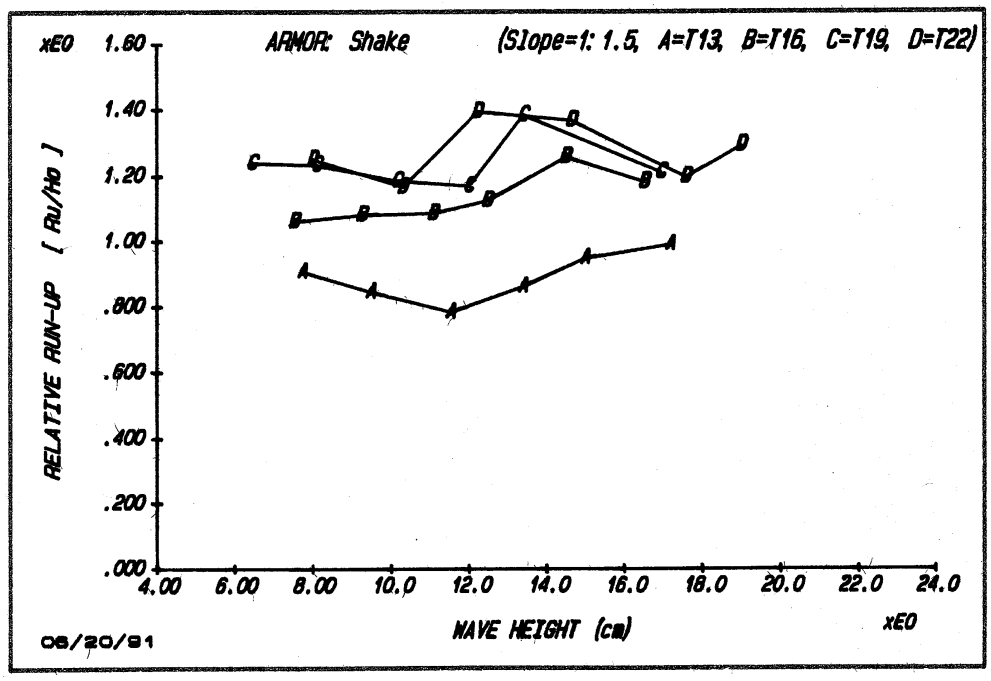

Fig : Ru -- A - 4

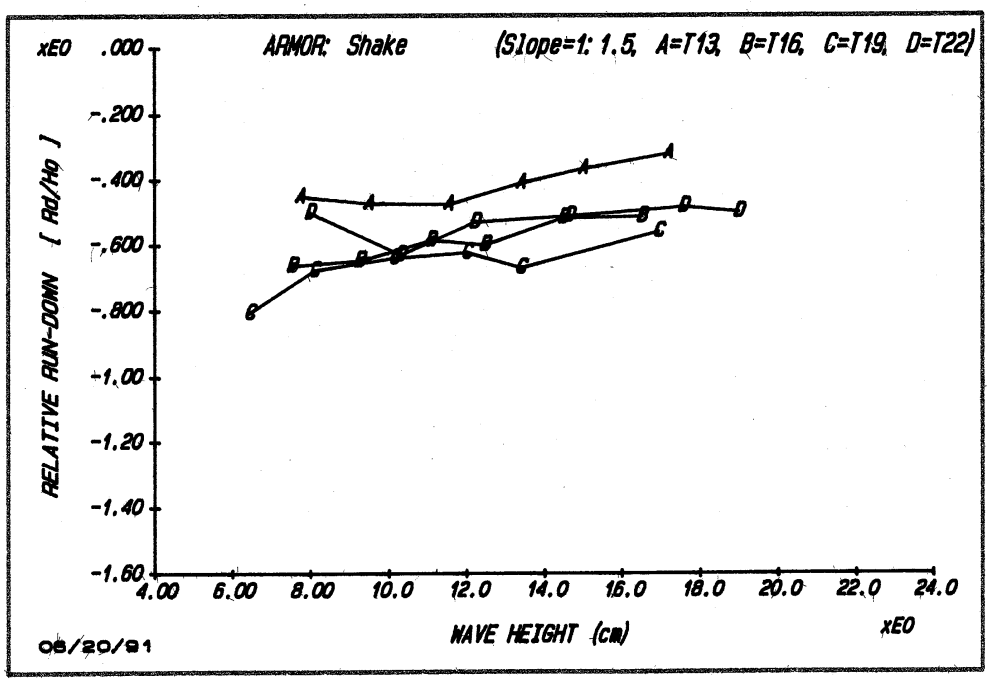

Fig : Rd -- A - 4

Fig 4.33 (UD-A-4). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (Shake).

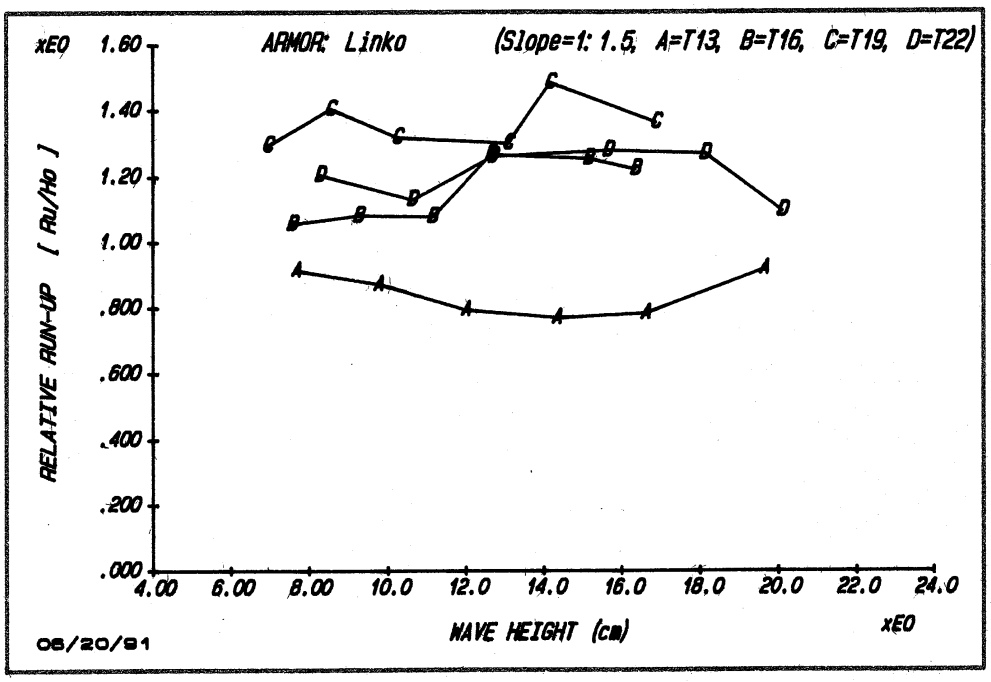

Fig : Ru -- A - 5

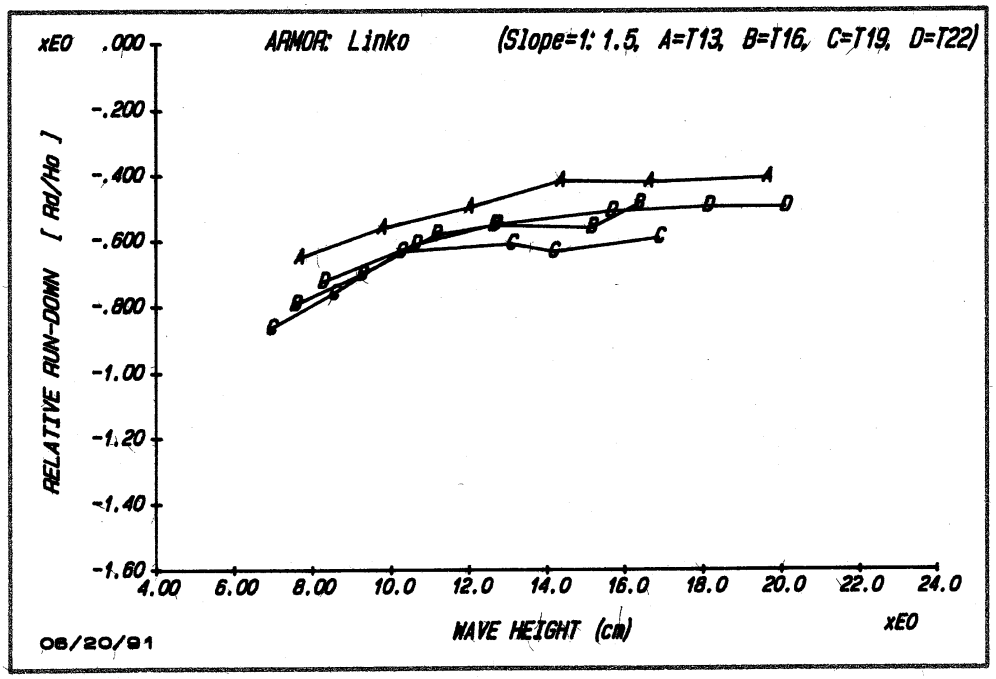

Fig : Rd -- A - 5

Fig 4.34 (UD-A-5). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (Linko).

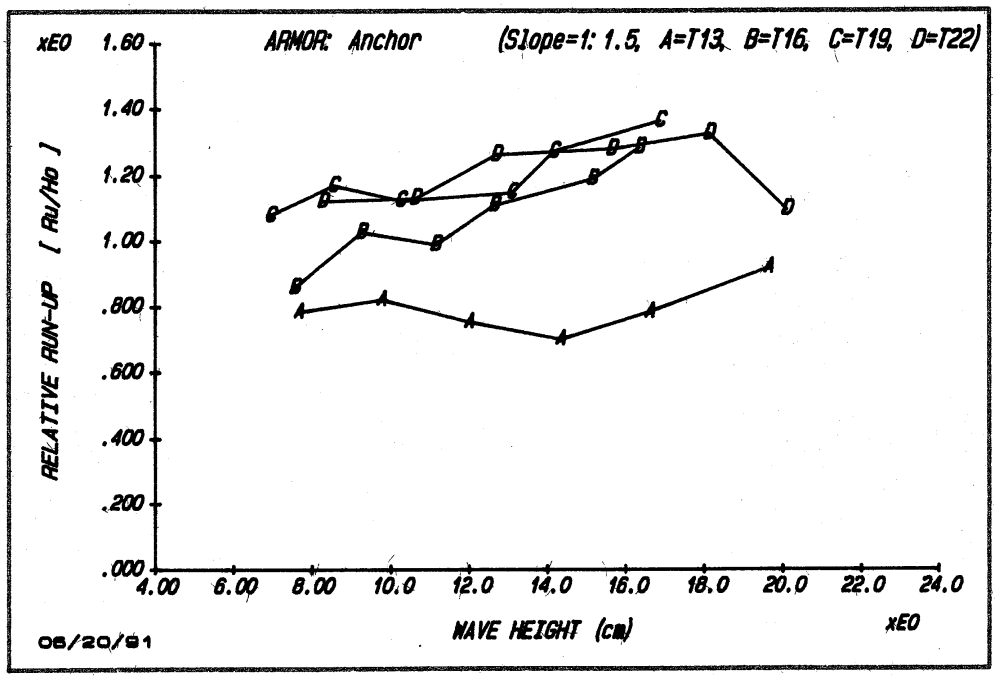

Fig : Ru -- A - 6

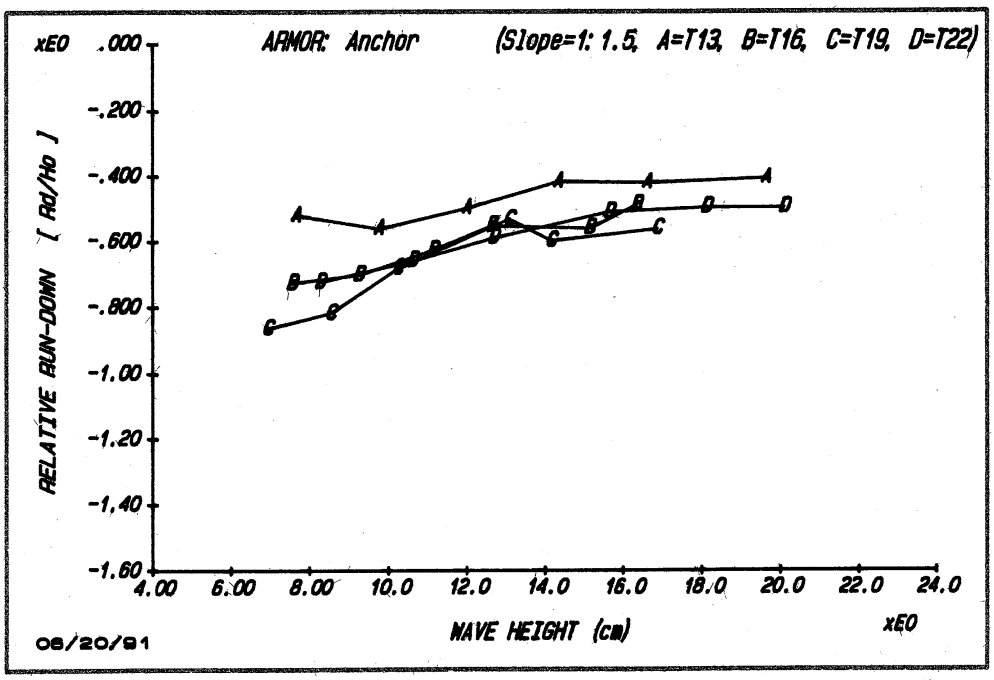

Fig : Rd -- A - 6

Fig 4.35 (UD-A-6). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (Anchor).

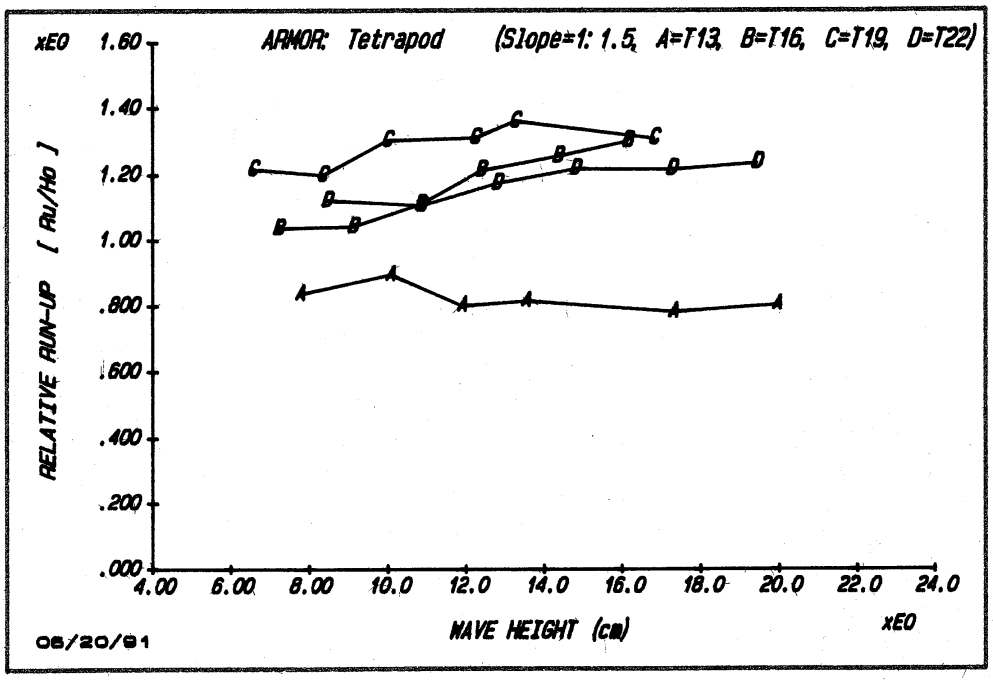

Fig : Ru -- A - 7

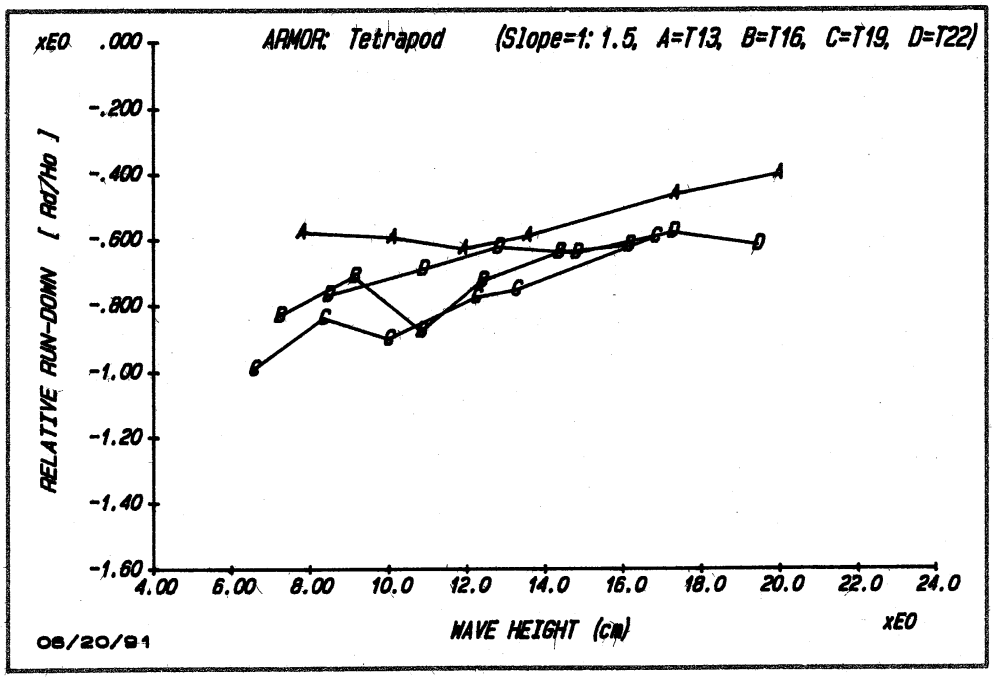

Fig : Rd -- A - 7

Fig 4.36 (UD-A-7). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (Tetrapod).

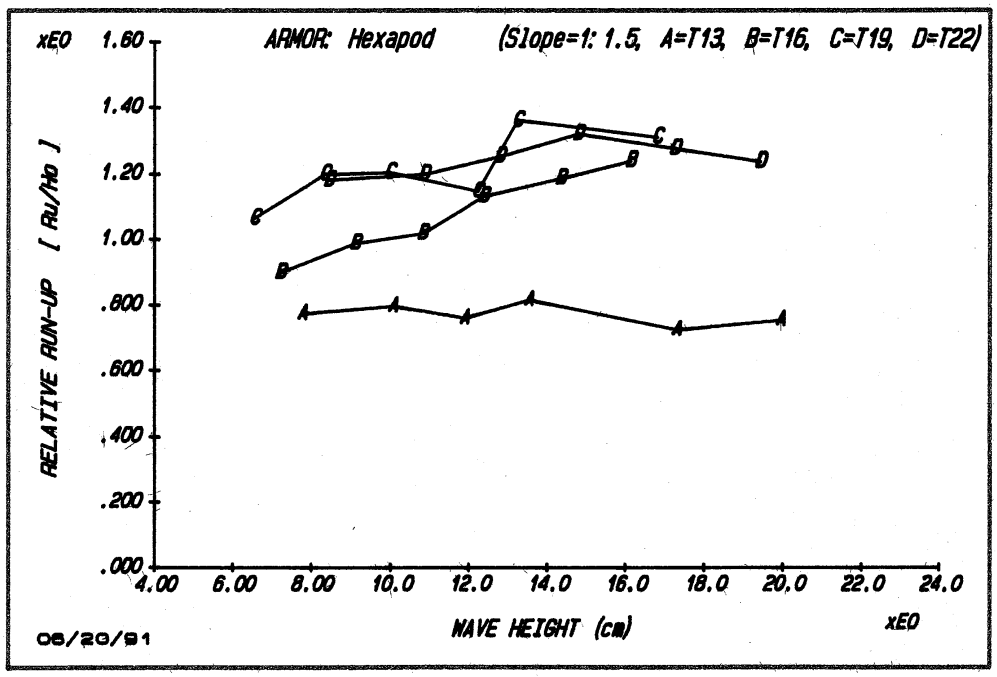

Fig : Ru -- A - 8

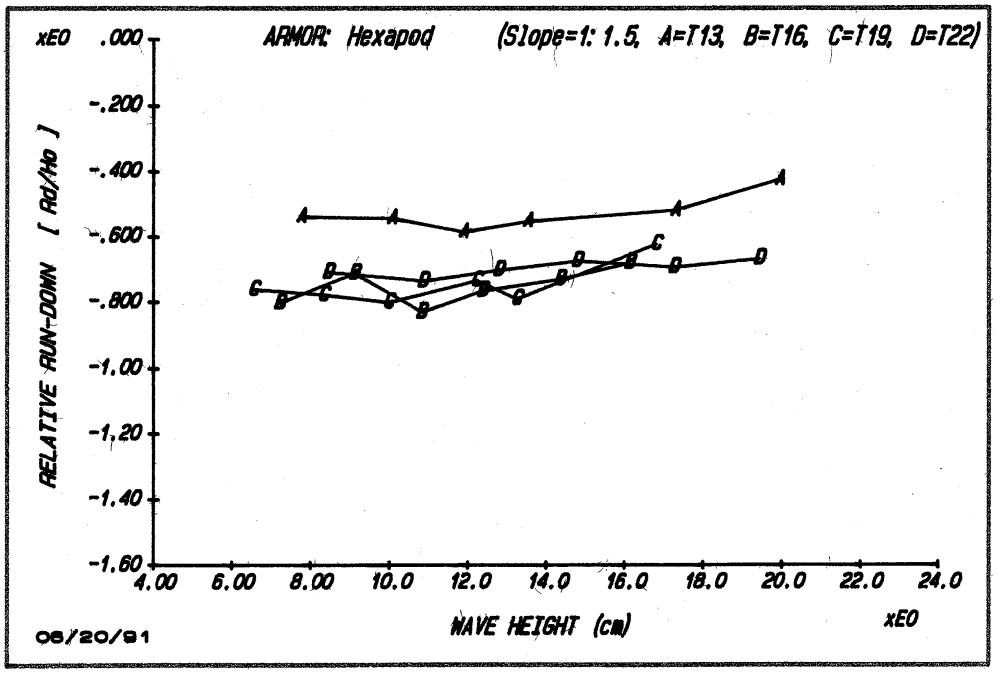

Fig : Rd -- A - 8

Fig 4.37 (UD-A-8). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (**H**exapod).

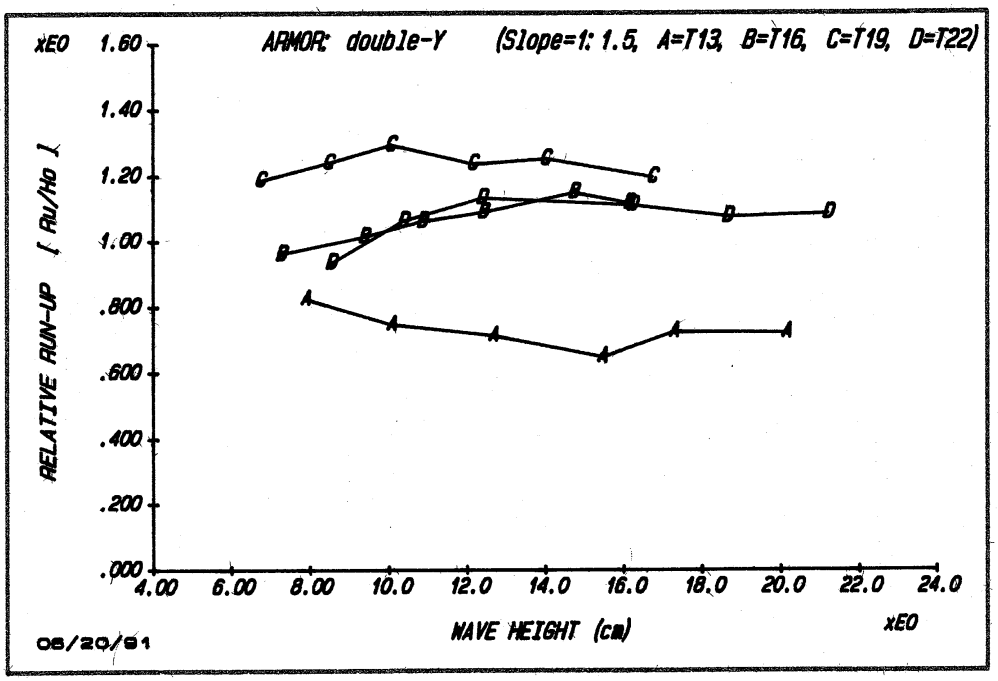

Fig : Ru -- A - 9

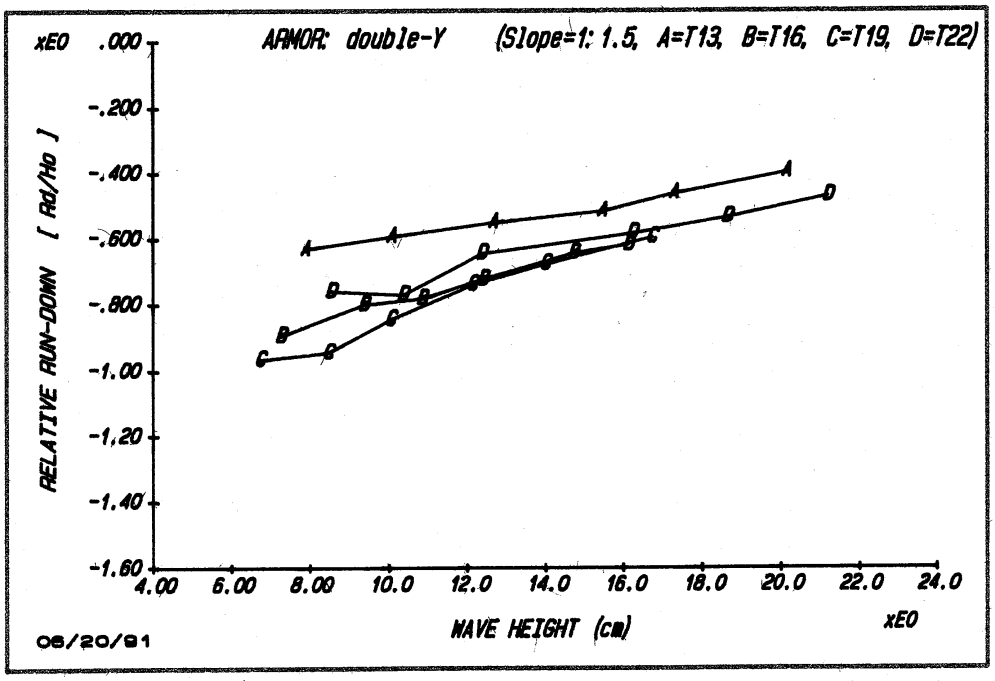

Fig : Rd -- A - 9

Fig 4.38 (UD-A-9). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (double-**Y**).

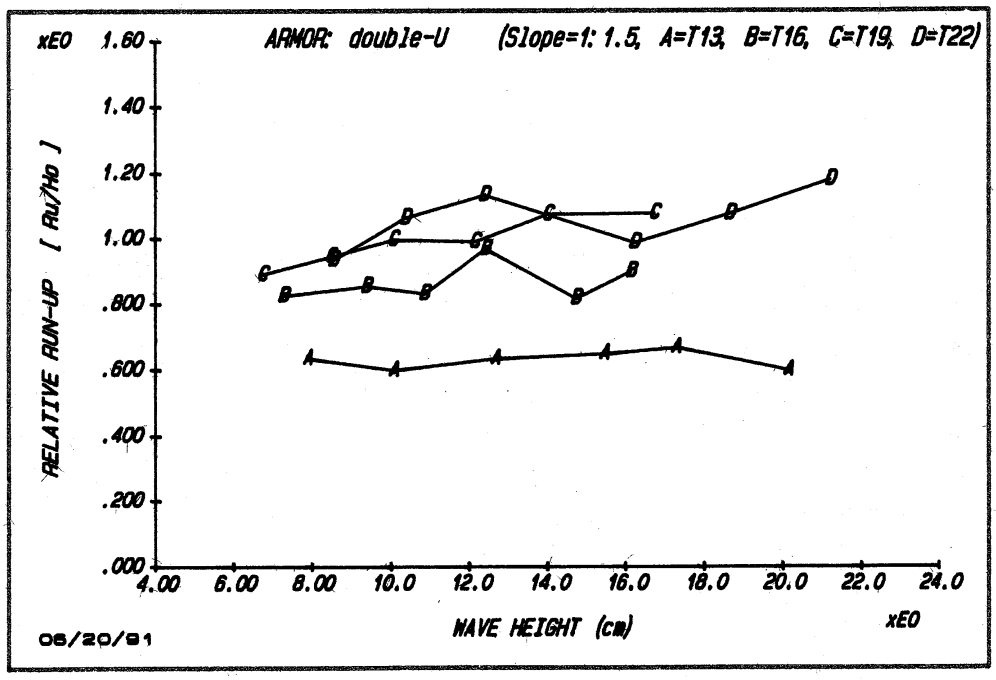

Fig : Ru -- A - 10

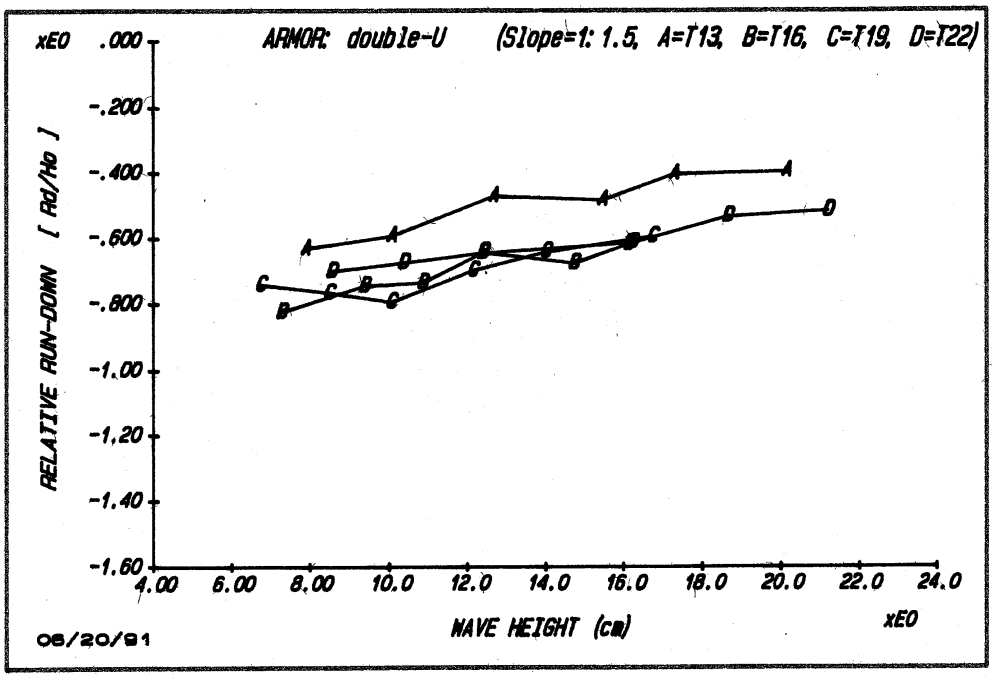

Fig : Rd -- A - 10

Fig 4.39 (UD-A-10). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (double-U).

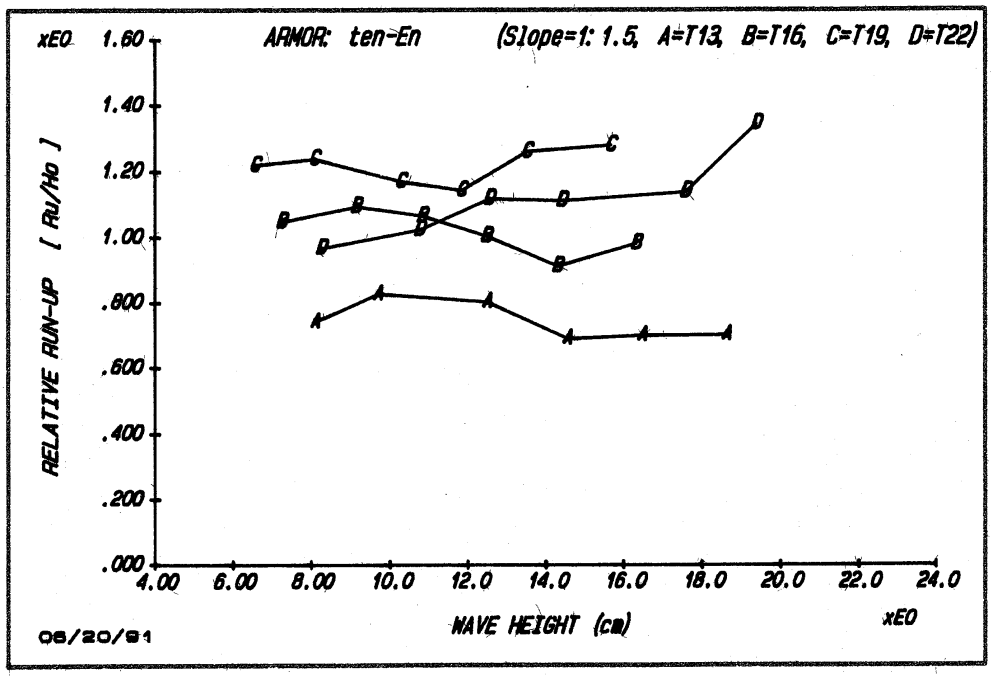

Fig : Ru -- A - 11

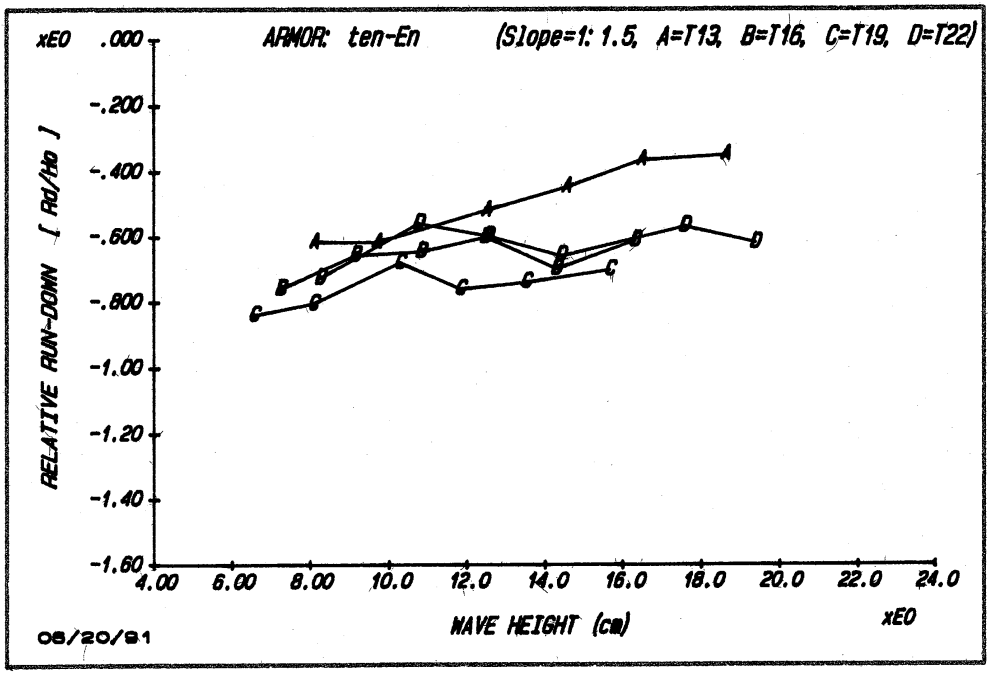

Fig : Rd -- A - 11

Fig 4.40 (UD-A-11). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.5) (ten-En).

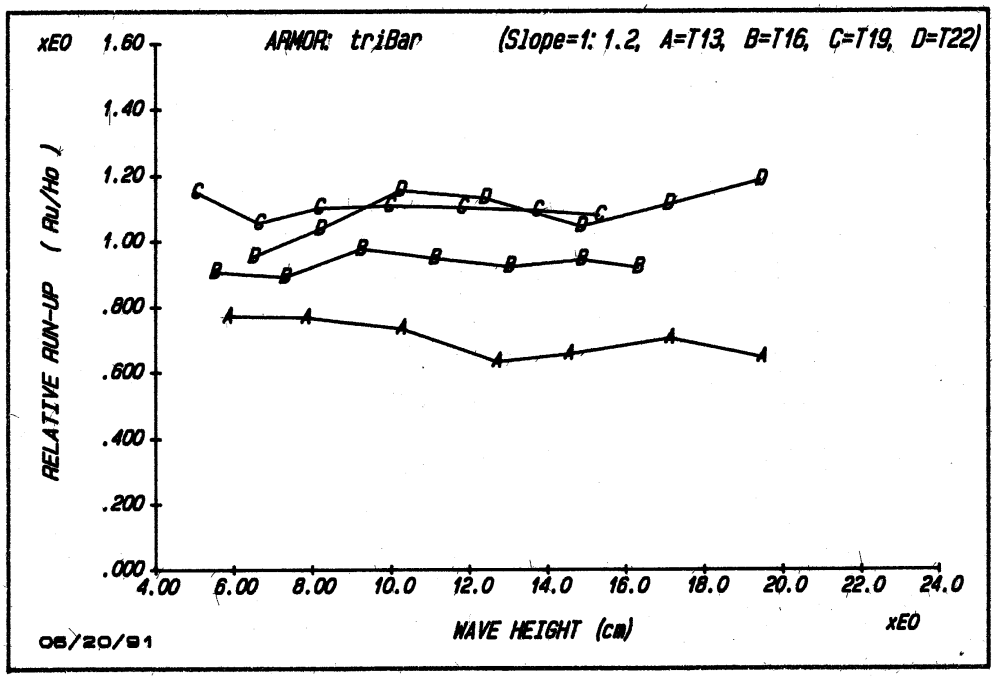

Fig : Ru -- B - 1

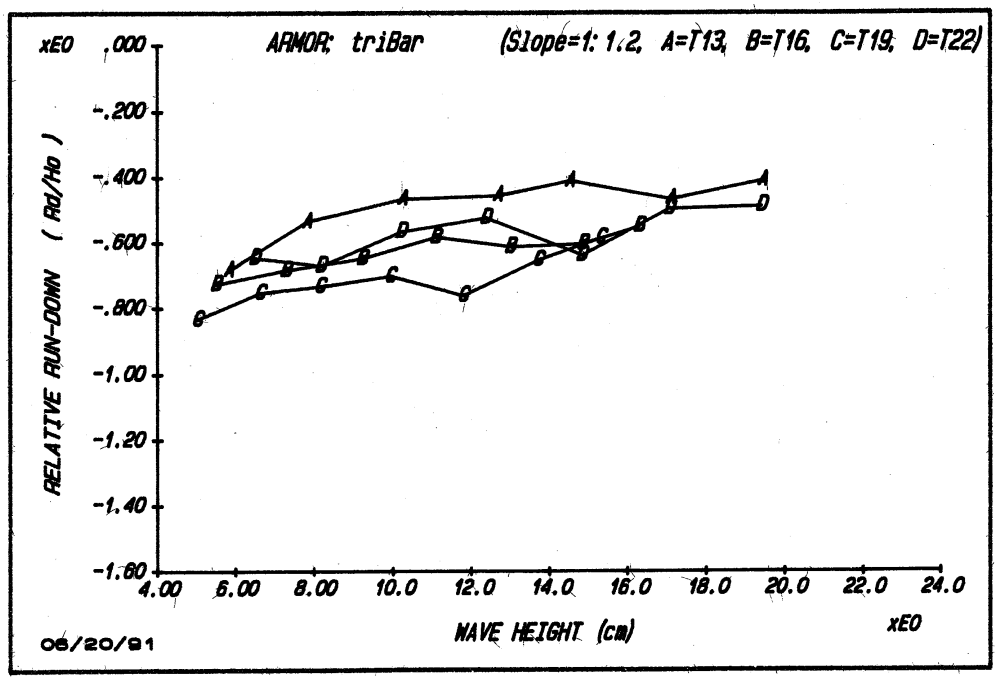

Fig : Rd -- B - 1

Fig 4.41 (UD-B-1). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (tri**B**ar).

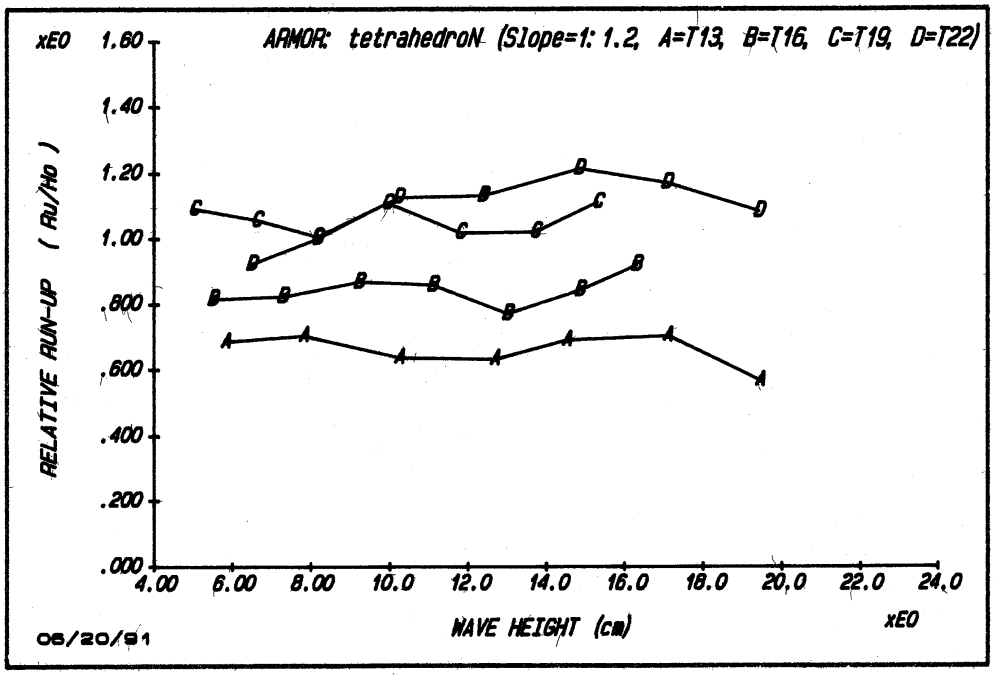

Fig : Ru -- B - 2

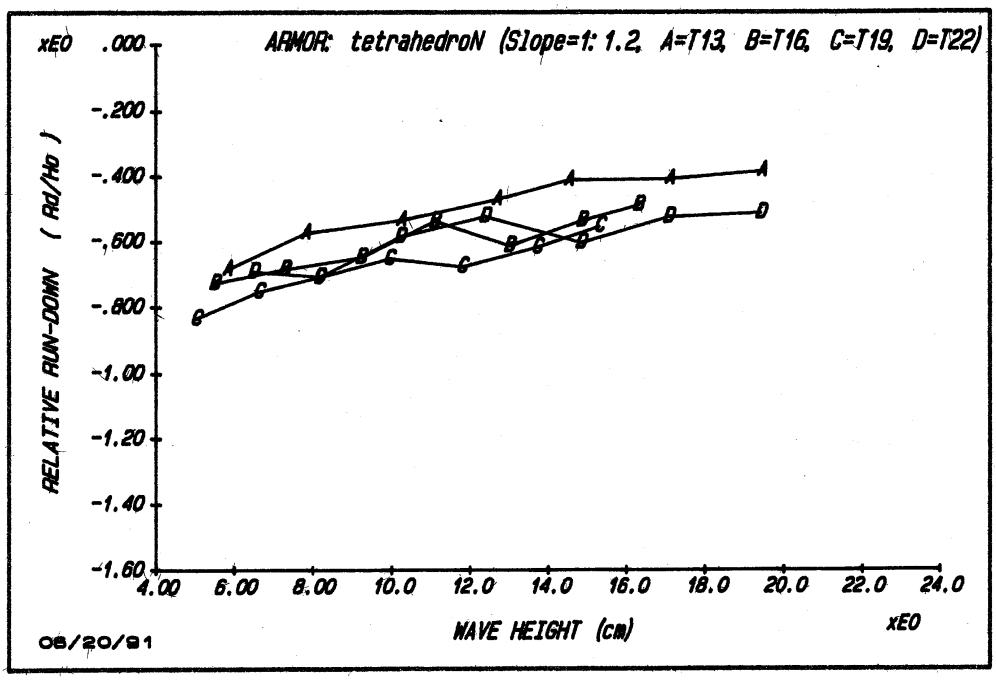

Fig : Rd -- B - 2

Fig 4.42 (UD-B-2). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (tetrahedro**N**).

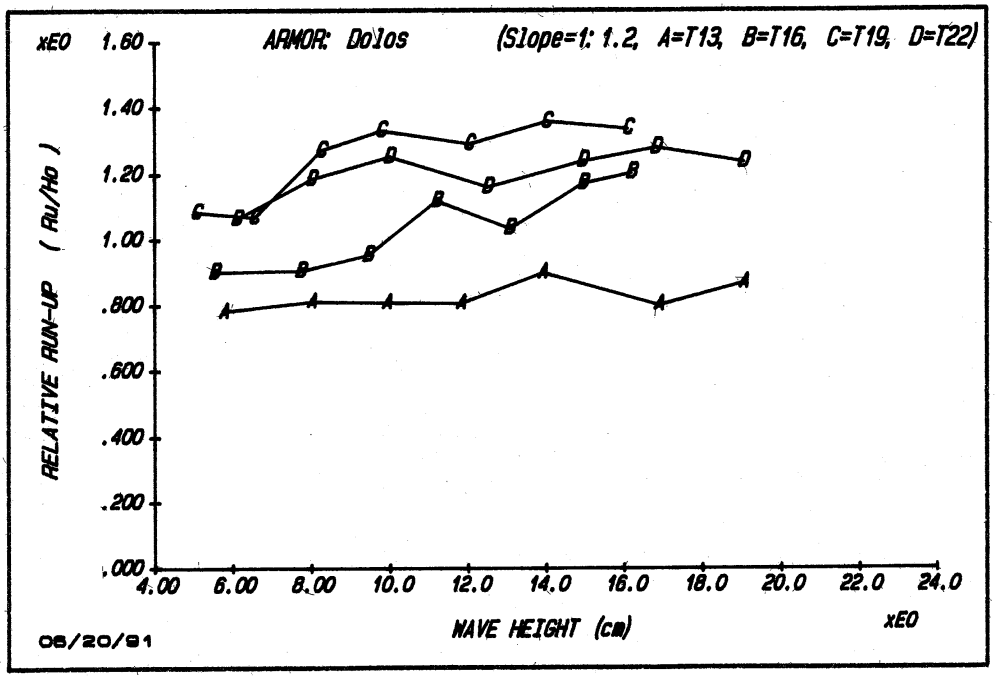

Fig : Ru -- B - 3

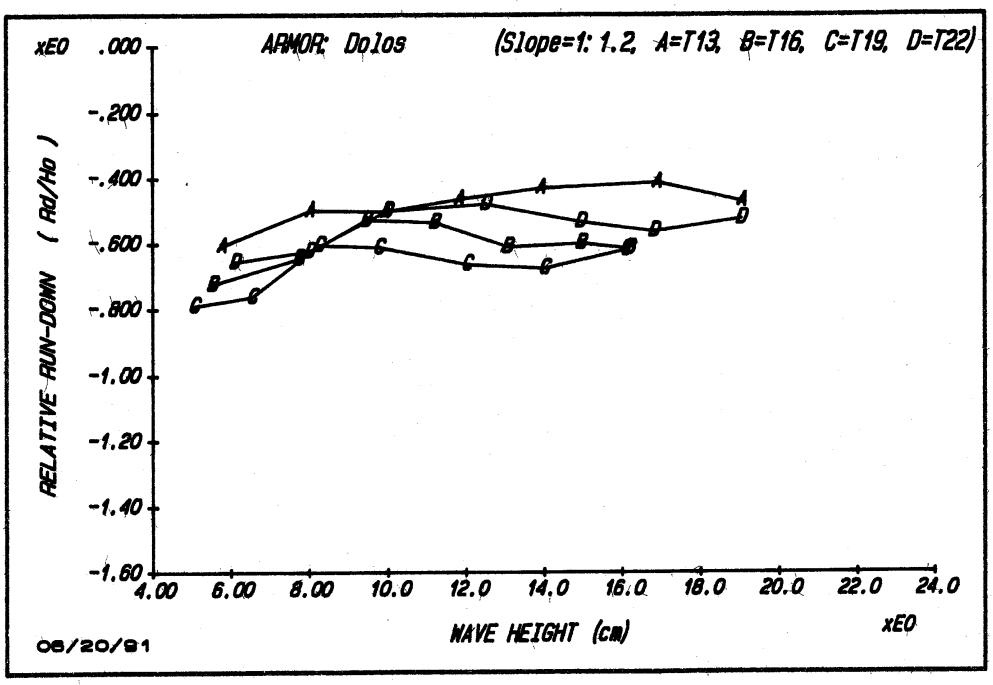

Fig : Rd -- B - 3

Fig 4.43 (UD-B-3). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (**D**olos).

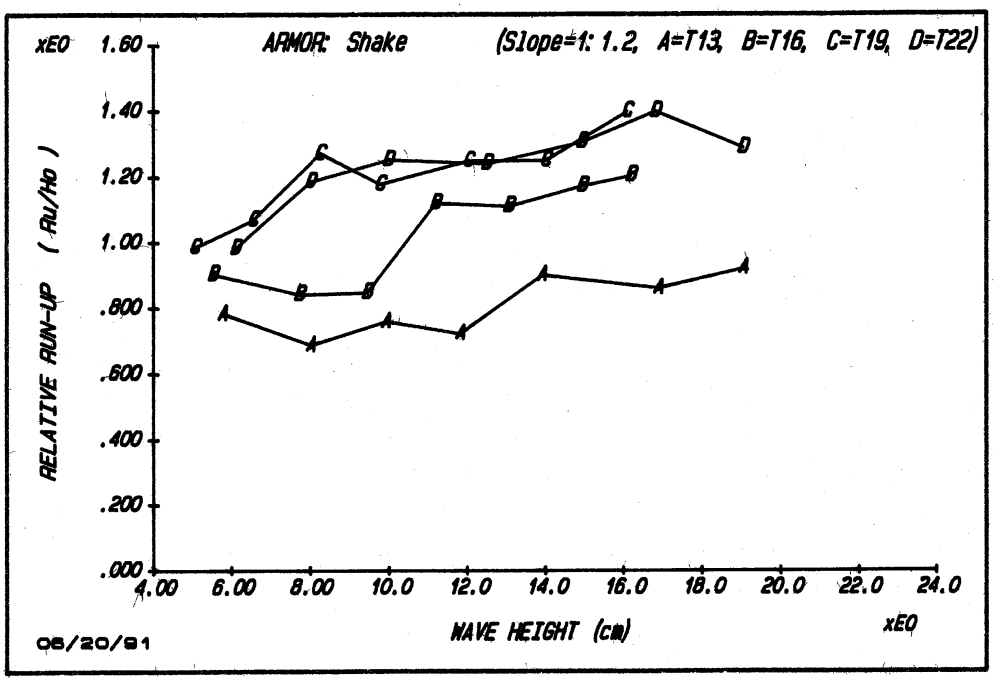

Fig : Ru -- B - 4

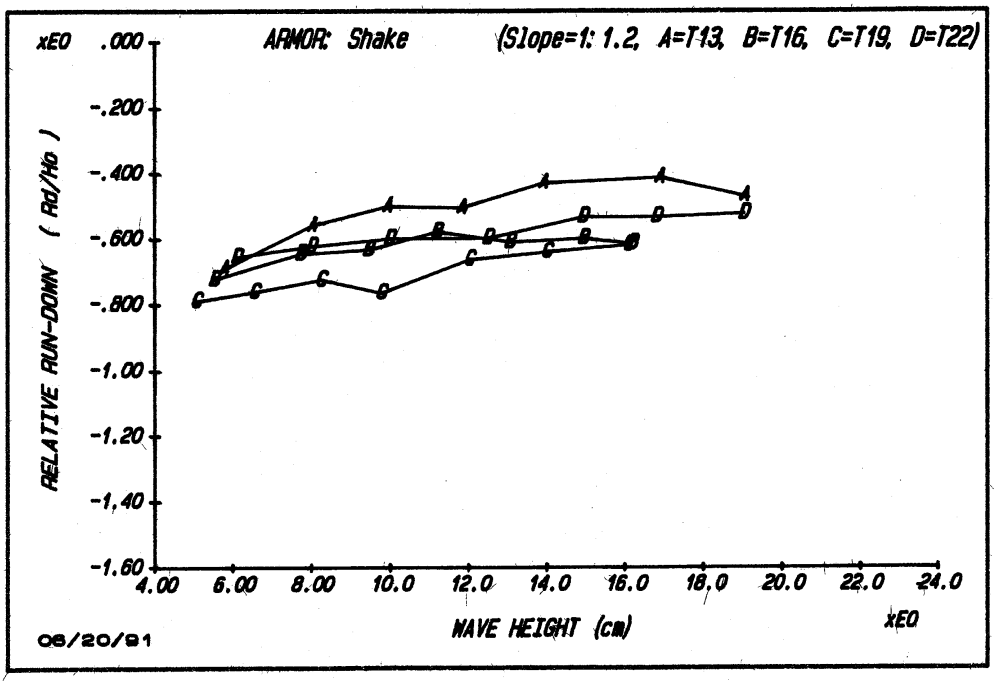

Fig : Rd -- B - 4

Fig 4.44 (UD-B-4). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (Shake).

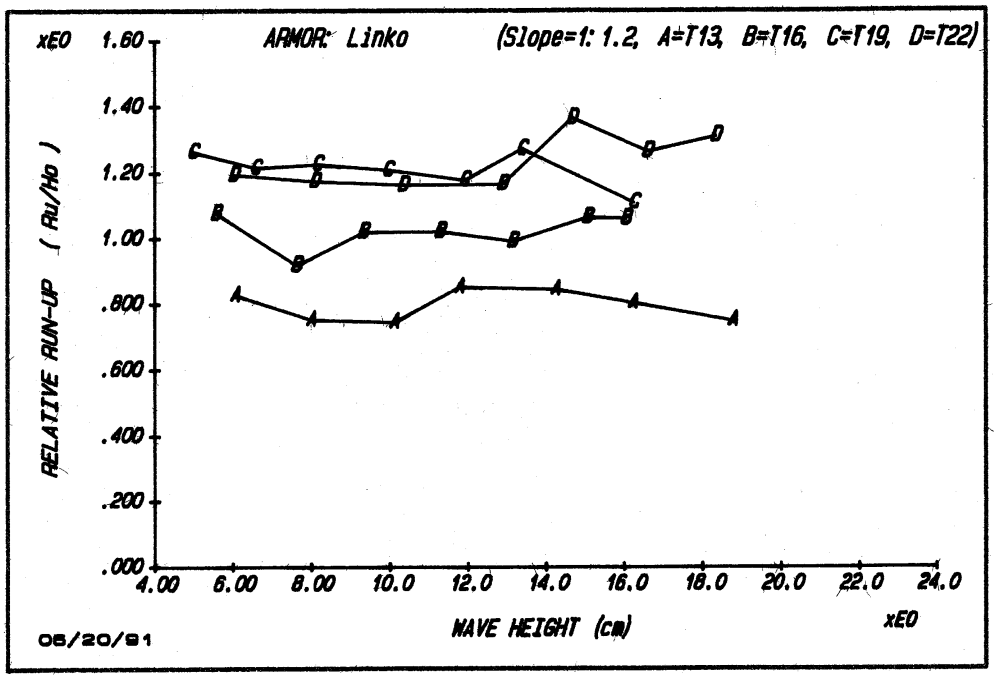

Fig : Ru -- B - 5

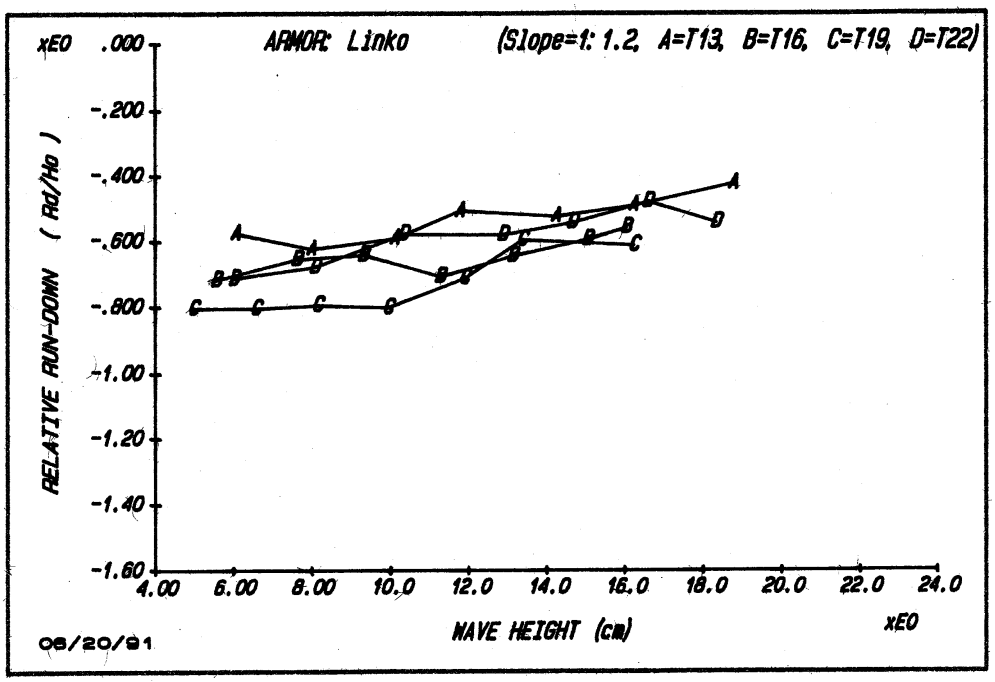

Fig : Rd -- B - 5

Fig 4.45 (UD-B-5). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (Linko).

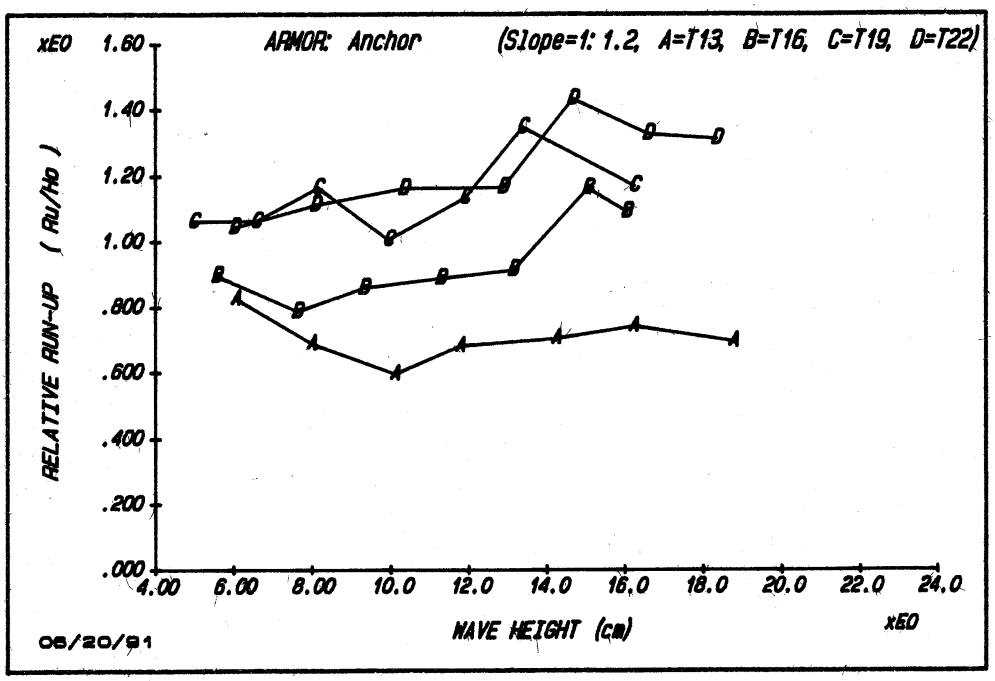

Fig : Ru -- B - 6

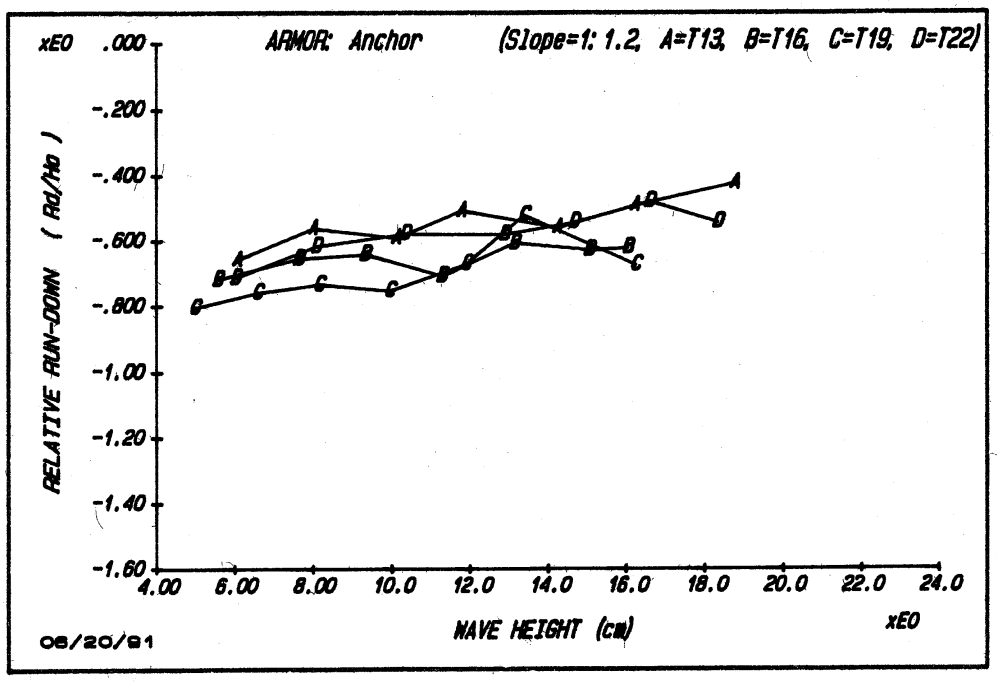

Fig : Rd -- B - 6

Fig 4.46 (UD-B-6). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (Anchor).

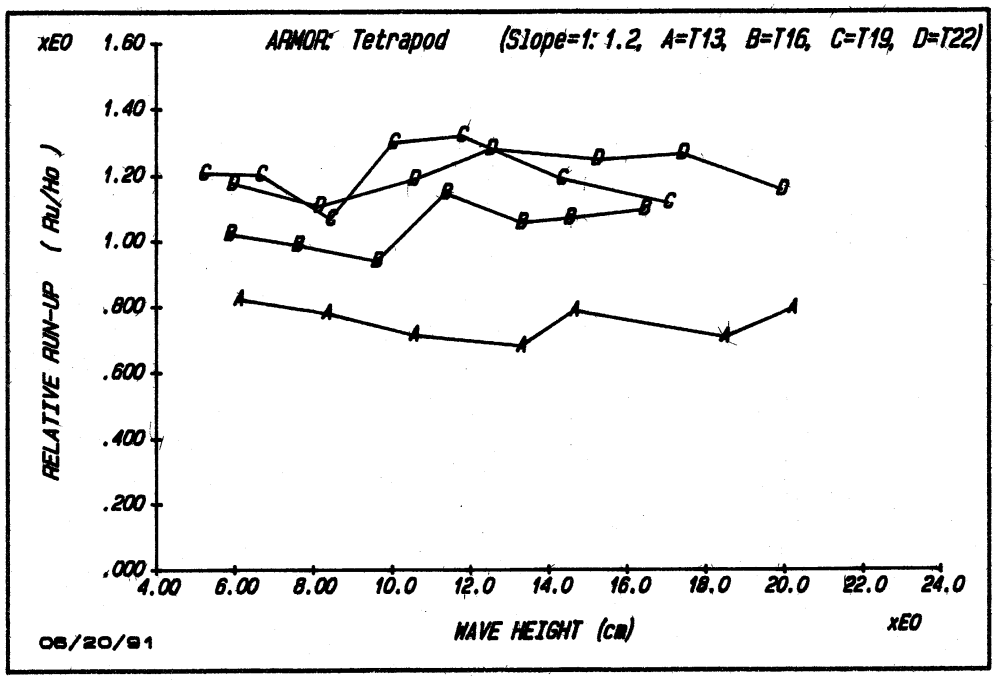

Fig : Ru -- B - 7

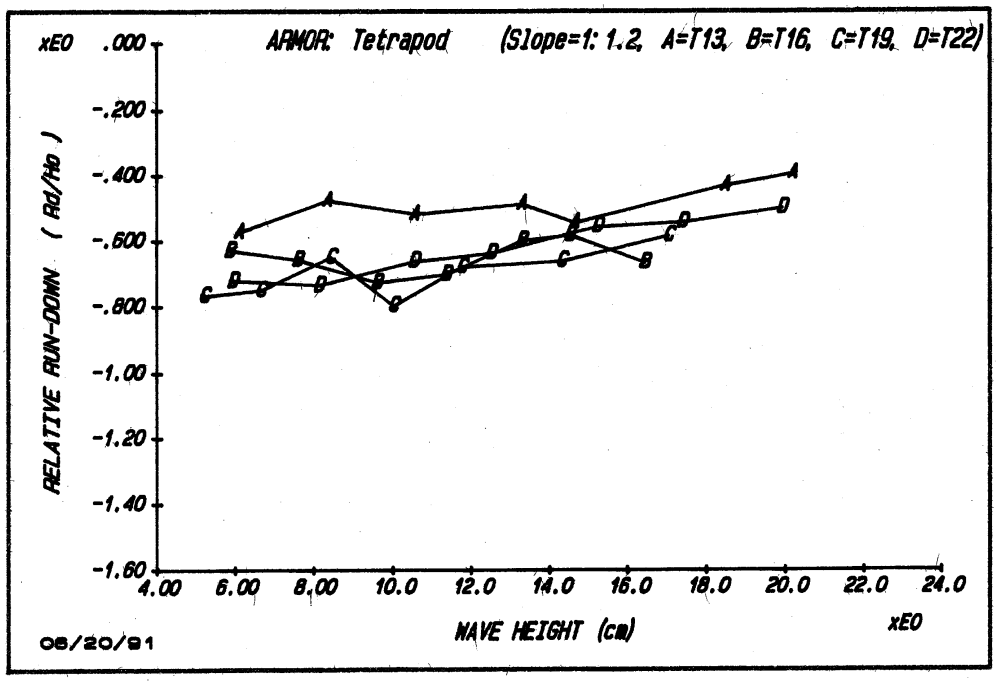

Fig : Rd -- B - 7

Fig 4.47 (UD-B-7). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (Tetrapod).

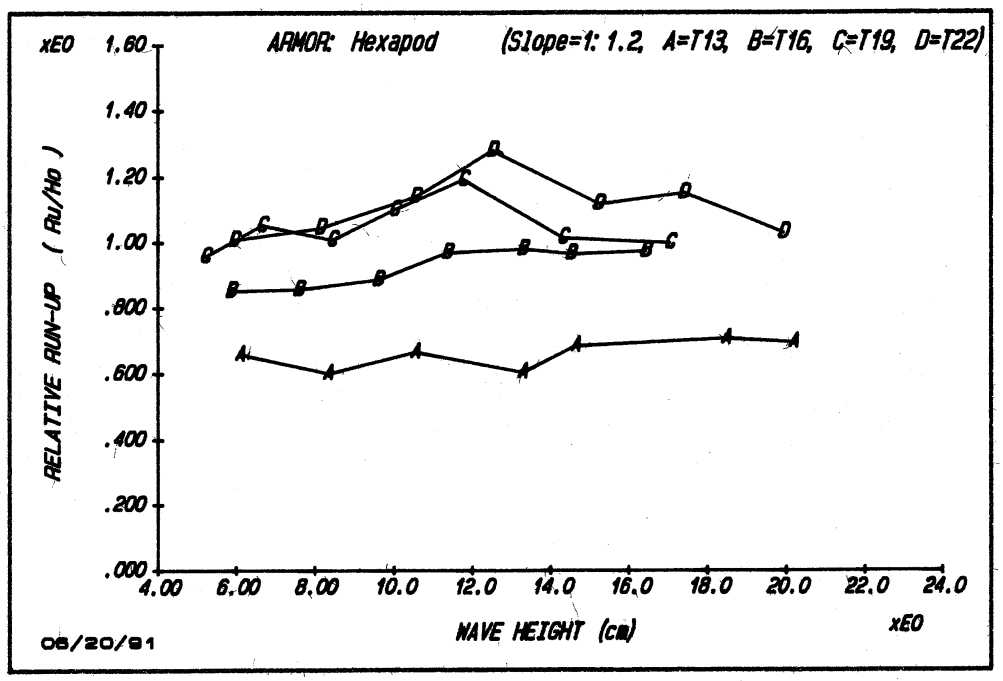

Fig : Ru -- B - 8

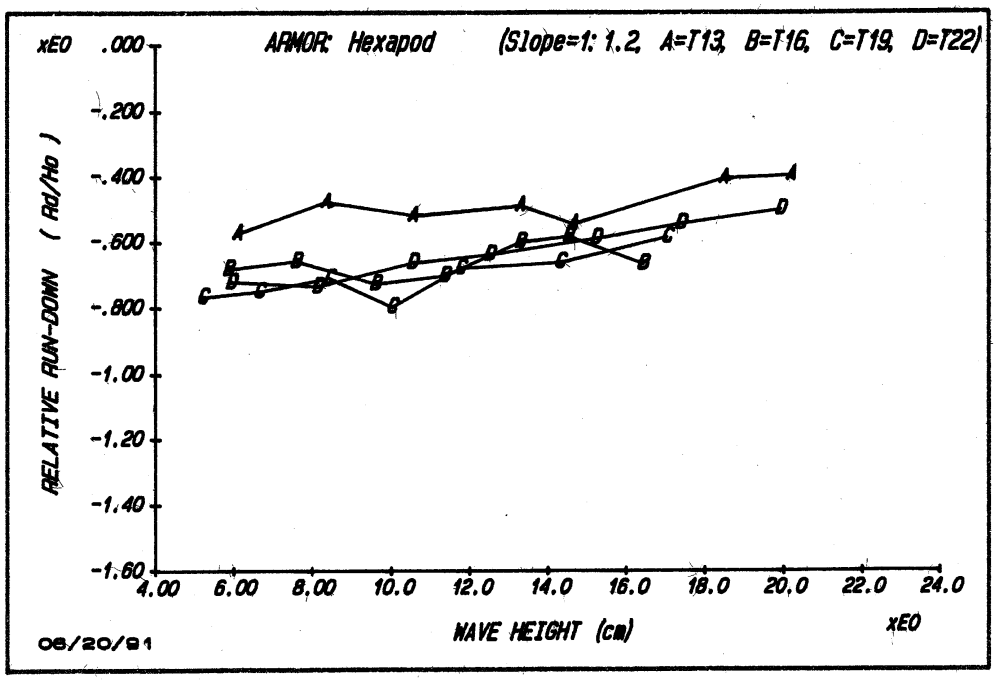

Fig : Rd -- B - 8

Fig 4.48 (UD-B-8). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (**H**exapod).

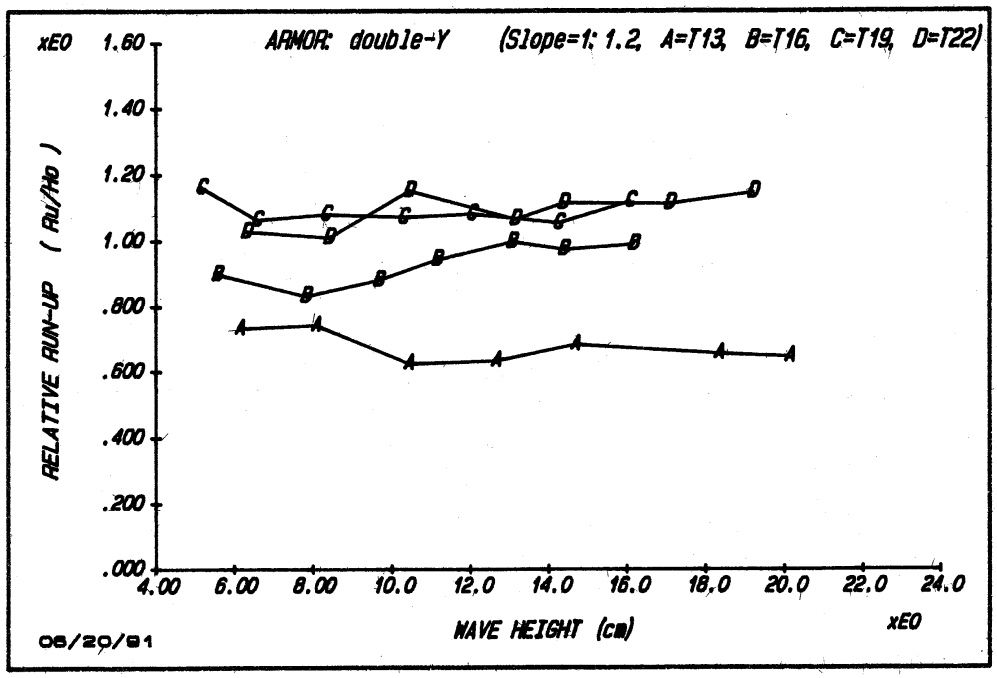

Fig : Ru -- B - 9

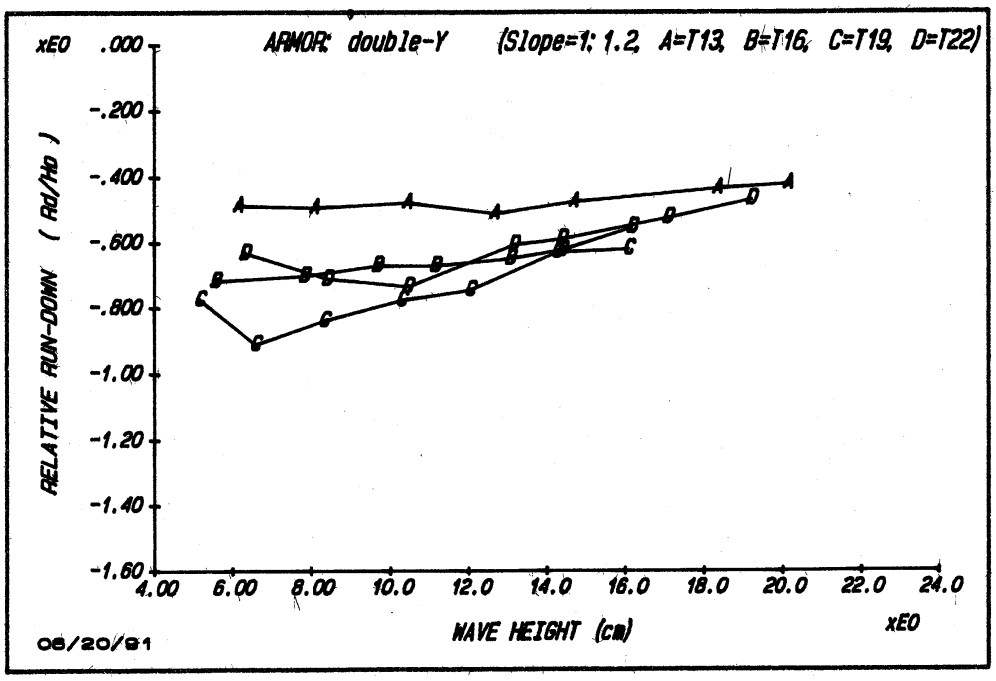

Fig : Rd -- B - 9

Fig 4.49 (UD-B-9). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (double-Y).

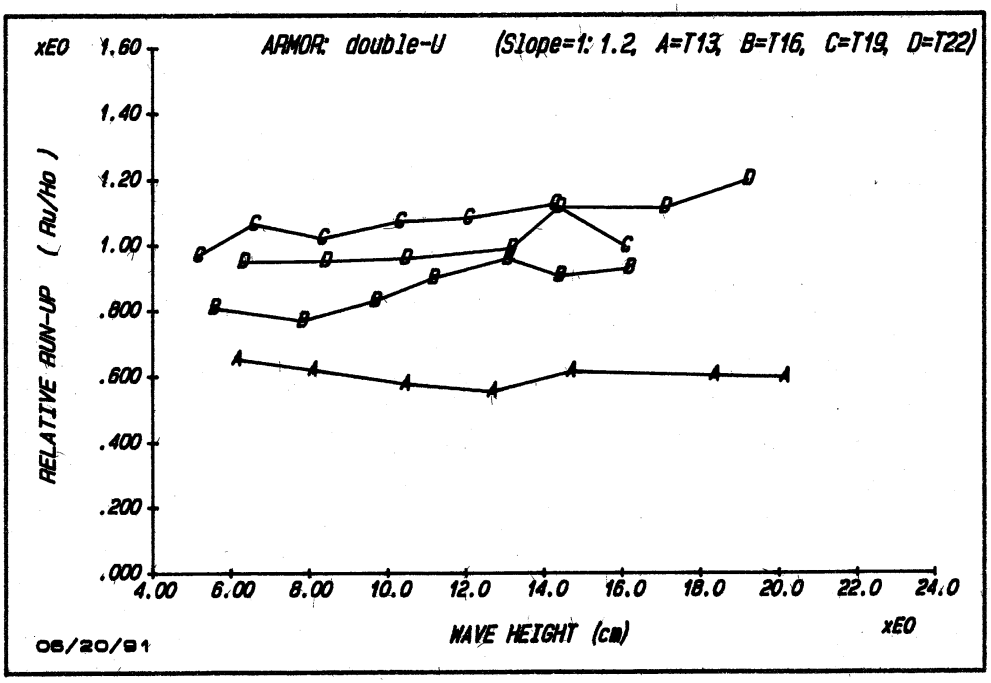

Fig : Ru -- B - 10

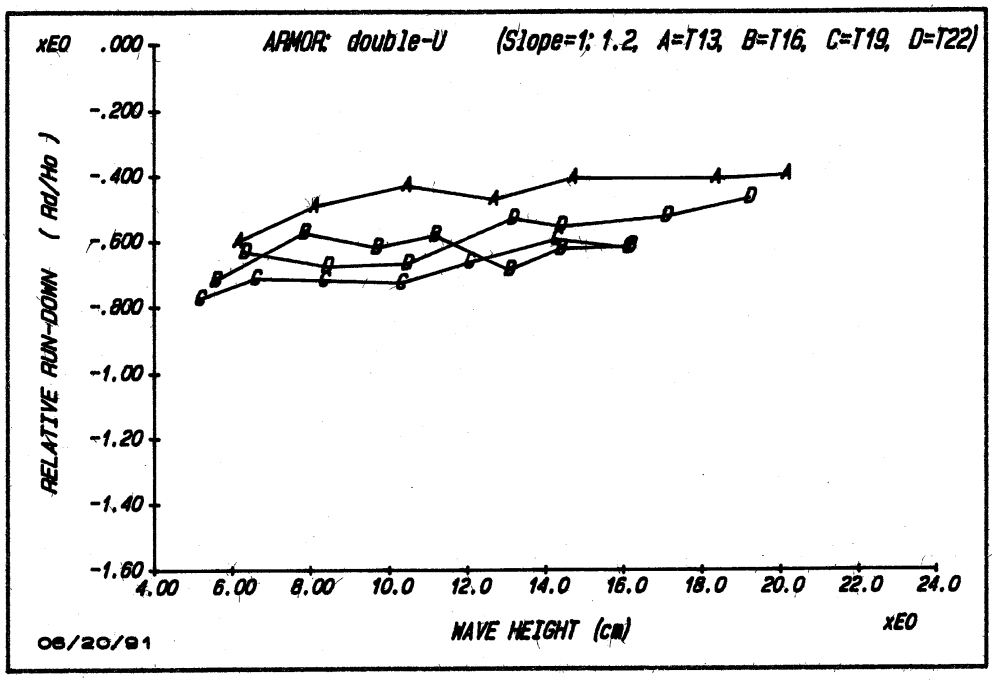

Fig : Rd -- B - 10

Fig 4.50 (UD-B-10). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (double-U).

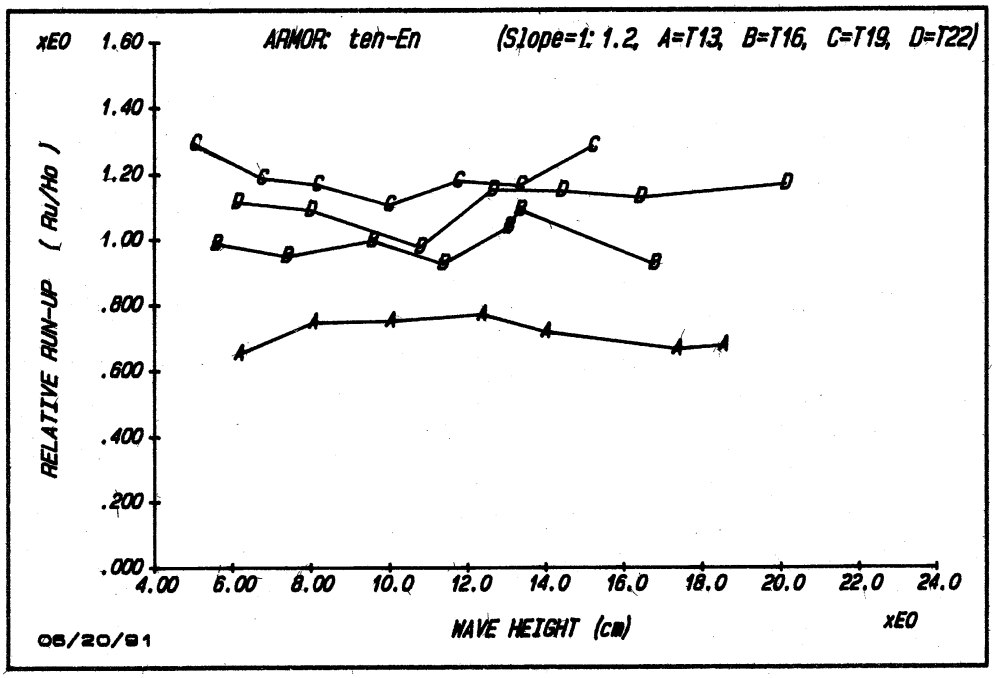

Fig : Ru -- B - 11

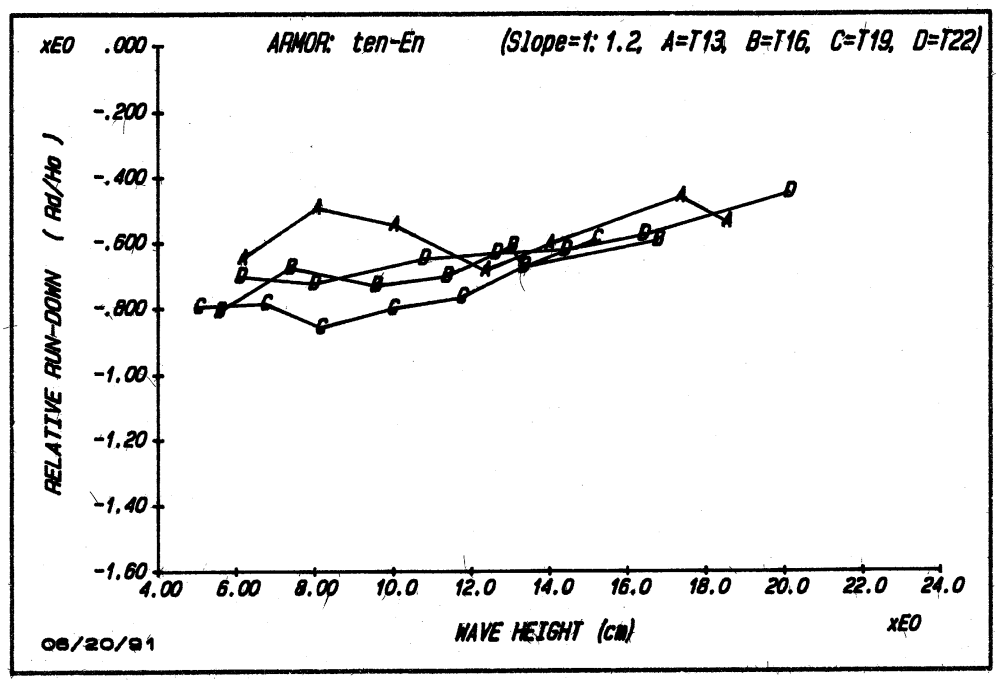

Fig : Rd -- B - 11

Fig 4.51 (UD-B-11). The variations of R_u and R_d with the wave height for individual wave period (slope:1:1.2) (ten-En).

LAYOUT : 4-A (TH5) [Slope: 1 on 1.5]
Armor types : Tetrapod (R) & Hexapod (L) Note : Ho~S , Hd~E
Table No. : 4 - A - 7 [UD - Hd_ind] Relative Run Up/Down TABLE (based on individual Hd) 06/13/91-00:30:50.

Wave type	Period															
	T1.3				T1.6				T1.9				T2.2			
	Hd(R)	Hd(L)	U/D(R)	U/D(L)	Hd(R)	Hd(L)	U/D(R)	U/D(L)	Hd(R)	Hd(L)	U/D(R)	U/D(L)	Hd(R)	Hd(L)	U/D(R)	U/D(L)
UP																
RH08	7.388282	6.758901	0.879771	0.887718	7.182754	6.977813	1.044167	0.931523	6.964607	6.451478	1.148664	1.085022	7.481166	7.461826	1.269855	1.340154
RH10	9.201972	8.399779	0.978051	0.952405	8.841938	8.553793	1.074425	1.052164	8.569128	7.851919	1.166979	1.273573	9.200869	9.133103	1.304224	1.423393
RH12	10.89776	10.11821	0.871738	0.889484	10.55503	10.19394	1.136897	1.079072	10.09251	9.277038	1.288083	1.293516	11.02036	10.97280	1.361116	1.458150
RH14	12.59455	12.04975	0.873393	0.912881	12.14329	11.69566	1.235250	1.197024	11.76274	10.72304	1.360226	1.305599	12.82104	12.67658	1.403942	1.538268
RH16	14.99066	14.38652	0.900560	0.868868	13.62491	13.07429	1.321109	1.300261	13.33446	12.22056	1.349885	1.472926	14.72504	14.46637	1.426141	1.520768
RH18	16.27432	16.66557	0.983143	0.900059	15.55010	14.64129	1.350473	1.365998	15.25236	13.77818	1.442398	1.596726	16.68219	16.38018	1.438659	1.465185
DOWN																
RH08	7.388282	6.758901	-0.60907	-0.62140	7.182754	6.977813	-0.83533	-0.83120	6.964607	6.451478	-0.93329	-0.77501	7.481166	7.461826	-0.86884	-0.80409
RH10	9.201972	8.399779	-0.65203	-0.65477	8.841938	8.553793	-0.73513	-0.75989	8.569128	7.851919	-0.81688	-0.82782	9.200869	9.133103	-0.81514	-0.87593
RH12	10.89776	10.11821	-0.68821	-0.69182	10.55503	10.19394	-0.90004	-0.88287	10.09251	9.277038	-0.89175	-0.86234	11.02036	10.97280	-0.72592	-0.82020
RH14	12.59455	12.04975	-0.63519	-0.62241	12.14329	11.69566	-0.74115	-0.81226	11.76274	10.72304	-0.80763	-0.83931	12.82104	12.67658	-0.74096	-0.78885
RH16	14.99066	14.38652	-0.53366	-0.62558	13.62491	13.07429	-0.67523	-0.80310	13.33446	12.22056	-0.74993	-0.85920	14.72504	14.46637	-0.67911	-0.82950
RH18	16.27432	16.66557	-0.49157	-0.51003	15.55010	14.64129	-0.64308	-0.75129	15.25236	13.77818	-0.65563	-0.76207	16.68219	16.38018	-0.59944	-0.73259
std (U)			0.0477	0.0262			0.1172	0.1493			0.1055	0.1614			0.0625	0.0652
std (D)			0.0683	0.0555			0.0885	0.0442			0.0907	0.0390			0.0875	0.0434
ave (U)			0.914	0.902			1.194	1.154			1.293	1.338			1.367	1.458
ave (D)			-0.602	-0.621			-0.755	-0.807			-0.809	-0.821			-0.738	-0.809

Note :: H1/3 based on individual incident wave height near breakwater (Hd)

Tab 4.63 (UD-A-1(d)). The relative run-up and run-down that take the near field wave height (gauge close to the breakwater) as the base of the relative reference.

Armor type : triBar (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 1 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.01710	4	0.00428	2.00535	0.15779
Period	0.98357	3	0.32786	153.77979	0.00000
Residual	0.02558	12	0.00213		
Nonadditivity	0.00458	1	0.00458	2.39935	0.14966
Total	1.02625	19		R-SQUARE ->	0.97507

Tab 4.64 (UDA-A-1). The one-way ANOVA of the R_u (slope: 1:1.5) (tri**B**ar).

Armor type : tetra-hedroN (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 2 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.03204	4	0.00801	4.98985	0.01330
Period	0.85954	3	0.28651	178.47813	0.00000
Residual	0.01926	12	0.00161		
Nonadditivity	0.00040	1	0.00040	0.23053	0.64054
Total	0.91084	19		R-SQUARE ->	0.97885

Tab 4.65 (UDA-A-2). The one-way ANOVA of the R_u (slope: 1:1.5) (tetrahedro**N**).

Armor type : Dolos (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 3 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.01718	4	0.00430	2.88908	0.06892
Period	0.74903	3	0.24968	167.90399	0.00000
Residual	0.01784	12	0.00149		
Nonadditivity	0.00114	1	0.00114	0.75215	0.40432
Total	0.78406	19		R-SQUARE ->	0.97724

Tab 4.66 (UDA-A-3). The one-way ANOVA of the R_u (slope: 1:1.5) (**D**olos).

```
Armor type : Shake          (slope=1:1.5)
Table No   : Ru-ANOVA - 1 ~ 4                              08/13/91--17:29:03.95
=============================================================================
Source of          Sum of   Degrees of      Mean        F-value  Significance
variation         squares     freedom     square                  (Prob > F)
-----------------------------------------------------------------------------
Wave height       0.06848        4        0.01712       6.85069      0.00413
Period            0.57408        3        0.19136      76.57800      0.00000
Residual          0.02999       12        0.00250
Nonadditivity     0.00317        1        0.00317       1.30159      0.27815
Total             0.67254       19                 R-SQUARE ->      0.95541
=============================================================================
```

Tab 4.67 (UDA-A-4). The one-way ANOVA of the R_u (slope: 1:1.5) (Shake).

```
Armor type : Linko          (slope=1:1.5)
Table No   : Ru-ANOVA - 1 ~ 5                              08/13/91--17:29:03.95
=============================================================================
Source of          Sum of   Degrees of      Mean        F-value  Significance
variation         squares     freedom     square                  (Prob > F)
-----------------------------------------------------------------------------
Wave height       0.01962        4        0.00490       1.16741      0.37307
Period            0.80156        3        0.26719      63.60679      0.00000
Residual          0.05041       12        0.00420
Nonadditivity     0.01654        1        0.01654       5.37349      0.04072
Total             0.87158       19                 R-SQUARE ->      0.94217
=============================================================================
```

Tab 4.68 (UDA-A-5). The one-way ANOVA of the R_u (slope: 1:1.5) (Linko).

```
Armor type : Anchor         (slope=1:1.5)
Table No   : Ru-ANOVA - 1 ~ 6                              08/13/91--17:29:03.95
=============================================================================
Source of          Sum of   Degrees of      Mean        F-value  Significance
variation         squares     freedom     square                  (Prob > F)
-----------------------------------------------------------------------------
Wave height       0.03310        4        0.00827       2.09574      0.14438
Period            0.61951        3        0.20650      52.30183      0.00000
Residual          0.04738       12        0.00395
Nonadditivity     0.02857        1        0.02857      16.70560      0.00180
Total             0.69998       19                 R-SQUARE ->      0.93231
=============================================================================
```

Tab 4.69 (UDA-A-6). The one-way ANOVA of the R_u (slope: 1:1.5) (Anchor).

Armor type : Tetrapod (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 7 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.02518	4	0.00629	1.96044	0.16497
Period	0.59689	3	0.19896	61.96785	0.00000
Residual	0.03853	12	0.00321		
Nonadditivity	0.01776	1	0.01776	9.41121	0.01070
Total	0.66059	19		R-SQUARE ->	0.94168

Tab 4.70 (UDA-A-7). The one-way ANOVA of the R_u (slope: 1:1.5) (**T**etrapod).

Armor type : Hexapod (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 8 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.05788	4	0.01447	5.91690	0.00722
Period	0.70485	3	0.23495	96.06828	0.00000
Residual	0.02935	12	0.00245		
Nonadditivity	0.01009	1	0.01009	5.76199	0.03521
Total	0.79208	19		R-SQUARE ->	0.96295

Tab 4.71 (UDA-A-8). The one-way ANOVA of the R_u (slope: 1:1.5) (**H**exapod).

Armor type : double-Y (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 9 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00657	4	0.00164	0.44078	0.77700
Period	0.73265	3	0.24422	65.50105	0.00000
Residual	0.04474	12	0.00373		
Nonadditivity	0.00951	1	0.00951	2.96772	0.11290
Total	0.78396	19		R-SQUARE ->	0.94293

Tab 4.72 (UDA-A-9). The one-way ANOVA of the R_u (slope: 1:1.5) (double-**Y**).

Armor type : double-U (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 10 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.01694	4	0.00424	2.80004	0.07461
Period	0.54979	3	0.18326	121.14055	0.00000
Residual	0.01815	12	0.00151		
Nonadditivity	0.00476	1	0.00476	3.91358	0.07349
Total	0.58488	19		R-SQUARE ->	0.96896

Tab 4.73 (UDA-A-10). The one-way ANOVA of the R_u (slope: 1:1.5) (double-U).

Armor type : ten-En (slope=1:1.5)
Table No : Ru-ANOVA - 1 ~ 11 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.00067	4	0.00017	0.03610	0.99715
Period	0.50985	3	0.16995	36.58643	0.00000
Residual	0.05574	12	0.00465		
Nonadditivity	0.01021	1	0.01021	2.46779	0.14450
Total	0.56626	19		R-SQUARE ->	0.90156

Tab 4.74 (UDA-A-11). The one-way ANOVA of the R_u (slope: 1:1.5) (ten-En).

TWO-WAY ANOVA - H ˜ T ˜ A (slope=1:1.5)

Table No : Ru-ANOVA - 1 ˜ 14 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Wave height	0.20643	4	0.05161	4.31084	0.00229
Period	7.24043	3	2.41348	201.60103	0.00000
Interaction	0.12708	12	0.01059	0.88463	0.56353
Error	2.39431	200	0.01197		
Total	9.96825	219		R-SQUARE ->	0.75981

Tab 4.75 (UA-A-HT/A). The two-way ANOVA of the R_u, in which the wave period and the wave height as the treatment factors, and the armor type as the unknown factor (slope: 1:1.5).

TWO-WAY ANOVA - A ˜ T ˜ H (slope=1:1.5)

Table No : Ru-ANOVA - 1 ˜ 15 08/13/91--17:29:03.95

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	Significance (Prob > F)
Armor type	1.73062	10	0.17306	44.76852	0.00000
Period	7.24041	3	2.41347	624.32948	0.00000
Interaction	0.31686	30	0.01056	2.73223	0.00002
Error	0.68036	176	0.00387		
Total	9.96825	219		R-SQUARE ->	0.93175

Tab 4.76 (UA-A-AT/H). The two-way ANOVA of the R_u, in which the wave period and the armor type as the treatment factors, and the wave height as the unknown factor (slope: 1:1.5).

RELATIVE RUN-UP AND RUN-DOWN TABLE (Slope : 1 on 1.5)

Armor type	RUN-UP				RUN-DOWN			
	T1.30	T1.60	T1.90	T2.20	T1.30	T1.60	T1.90	T2.20
ave T	1.30096	1.59660	1.89404	2.22505	1.30096	1.59660	1.89404	2.22505
1. triBar	0.69950	1.09435	1.27179	1.14546	-0.51385	-0.65206	-0.77174	-0.59279
2. t-hedroN	0.69676	1.05146	1.14769	1.20983	-0.48261	-0.69448	-0.71280	-0.62516
3. Dolos	0.94100	1.24516	1.45013	1.31224	-0.42168	-0.59565	-0.67348	-0.55051
4. Shake	0.88717	1.13051	1.23560	1.27653	-0.41683	-0.58855	-0.66373	-0.52666
5. Linko	0.84018	1.15968	1.36022	1.20663	-0.49370	-0.61379	-0.68293	-0.56554
6. Anchor	0.79135	1.07550	1.19193	1.20176	-0.47197	-0.61027	-0.67725	-0.57996
7. Tetrapod	0.82071	1.15929	1.28278	1.17857	-0.54336	-0.73479	-0.80968	-0.65411
8. Hexapod	0.76844	1.07628	1.21341	1.24337	-0.52930	-0.75463	-0.74935	-0.69851
9. double-Y	0.72797	1.06425	1.23352	1.06570	-0.52645	-0.74440	-0.79537	-0.62857
10. double-U	0.62801	0.86454	0.99425	1.06089	-0.49826	-0.70860	-0.70766	-0.61574
11. ten-En	0.74132	1.01589	1.21669	1.11615	-0.48583	-0.66241	-0.75443	-0.62151
std	0.08714	0.09244	0.11030	0.07704	0.03907	0.05896	0.04920	0.04665
ave	0.77658	1.08517	1.23618	1.18338	-0.48944	-0.66906	-0.72713	-0.60537

Tab 4.77 (UDAve-A). The average run-up and run-down with regard to each wave period for all individual armor types (slope: 1:1.5).

RELATIVE RUN-UP AND RUN-DOWN TABLE (Slope : 1 on 1.2)

Armor type	RUN-UP				RUN-DOWN			
	T1.30	T1.60	T1.90	T2.20	T1.30	T1.60	T1.90	T2.20
ave T	1.30330	1.60363	1.89400	2.22340	1.30330	1.60363	1.89400	2.22340
1. triBar	0.69960	0.92923	1.09859	1.08848	-0.49125	-0.63143	-0.71920	-0.57681
2. t-hedroN	0.65821	0.84173	1.05822	1.09237	-0.49670	-0.60662	-0.68653	-0.59448
3. Dolos	0.82344	1.04090	1.24785	1.20208	-0.48466	-0.60950	-0.67653	-0.55518
4. Shake	0.80232	1.02749	1.19948	1.23586	-0.51199	-0.63100	-0.71064	-0.58238
5. Linko	0.79386	1.02062	1.20951	1.23309	-0.53602	-0.64739	-0.73377	-0.58980
6. Anchor	0.70298	0.94208	1.13512	1.22128	-0.54390	-0.65559	-0.70344	-0.58098
7. Tetrapod	0.75290	1.04408	1.19917	1.20192	-0.49151	-0.65418	-0.69984	-0.62418
8. Hexapod	0.65747	0.92544	1.04519	1.10925	-0.48764	-0.66148	-0.70830	-0.62887
9. double-Y	0.67283	0.92991	1.08985	1.08933	-0.47291	-0.65723	-0.75809	-0.61137
10. double-U	0.60081	0.86992	1.04588	1.03873	-0.45951	-0.63305	-0.68889	-0.58086
11. ten-En	0.70931	0.98628	1.19614	1.11006	-0.57032	-0.68695	-0.75416	-0.62384
std	0.06661	0.06606	0.07098	0.06817	0.03168	0.02257	0.02541	0.02256
ave	0.71579	0.95979	1.13864	1.14750	-0.50422	-0.64313	-0.71267	-0.59534

Tab 4.78 (UDAve-B). The average run-up and run-down with regard to each wave period for all individual armor types (slope: 1:1.2).

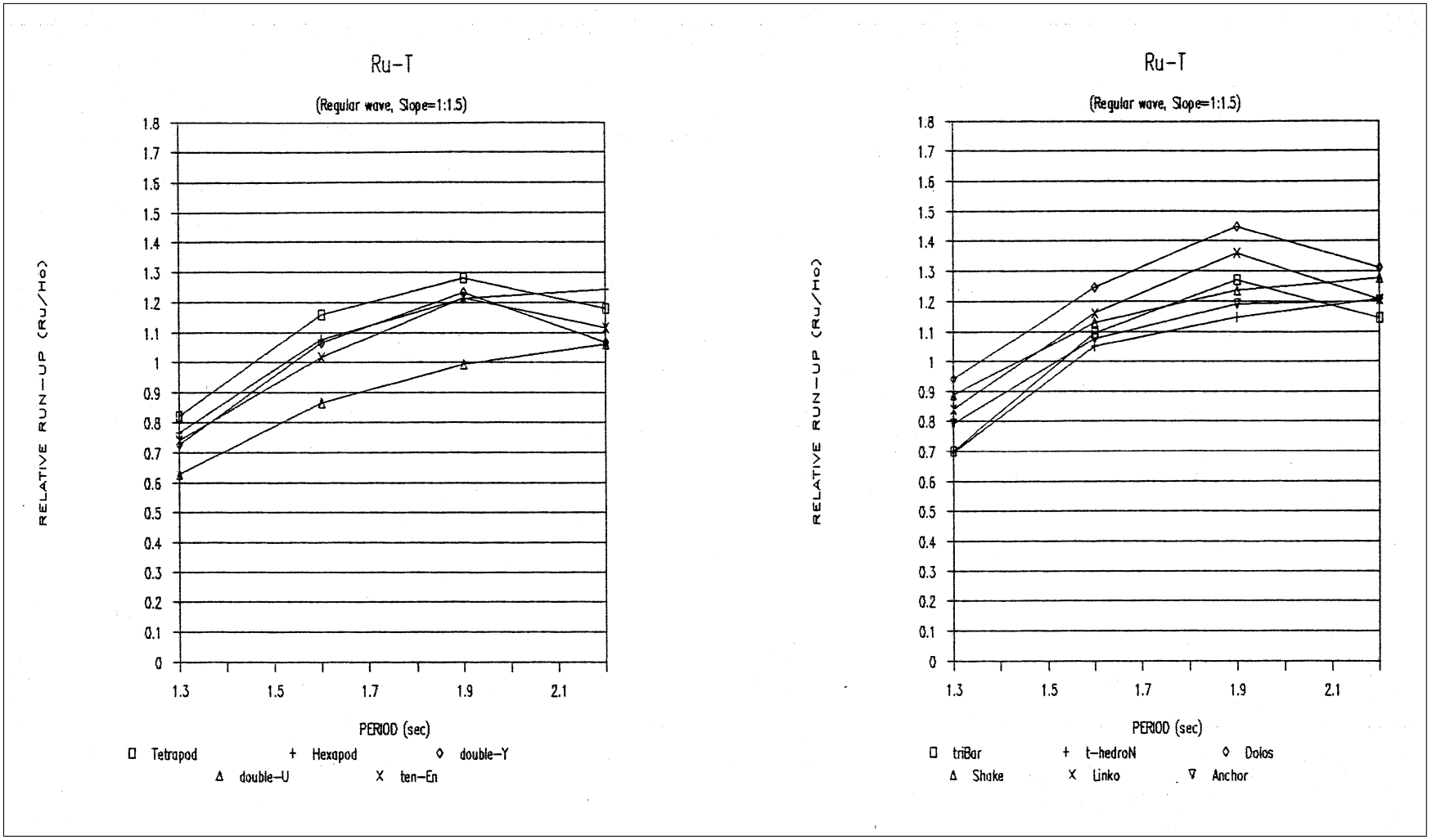

Fig 4.52 (UAve-A). The comparison of the average relative run-up among the different armor types (slope: 1:1.5).

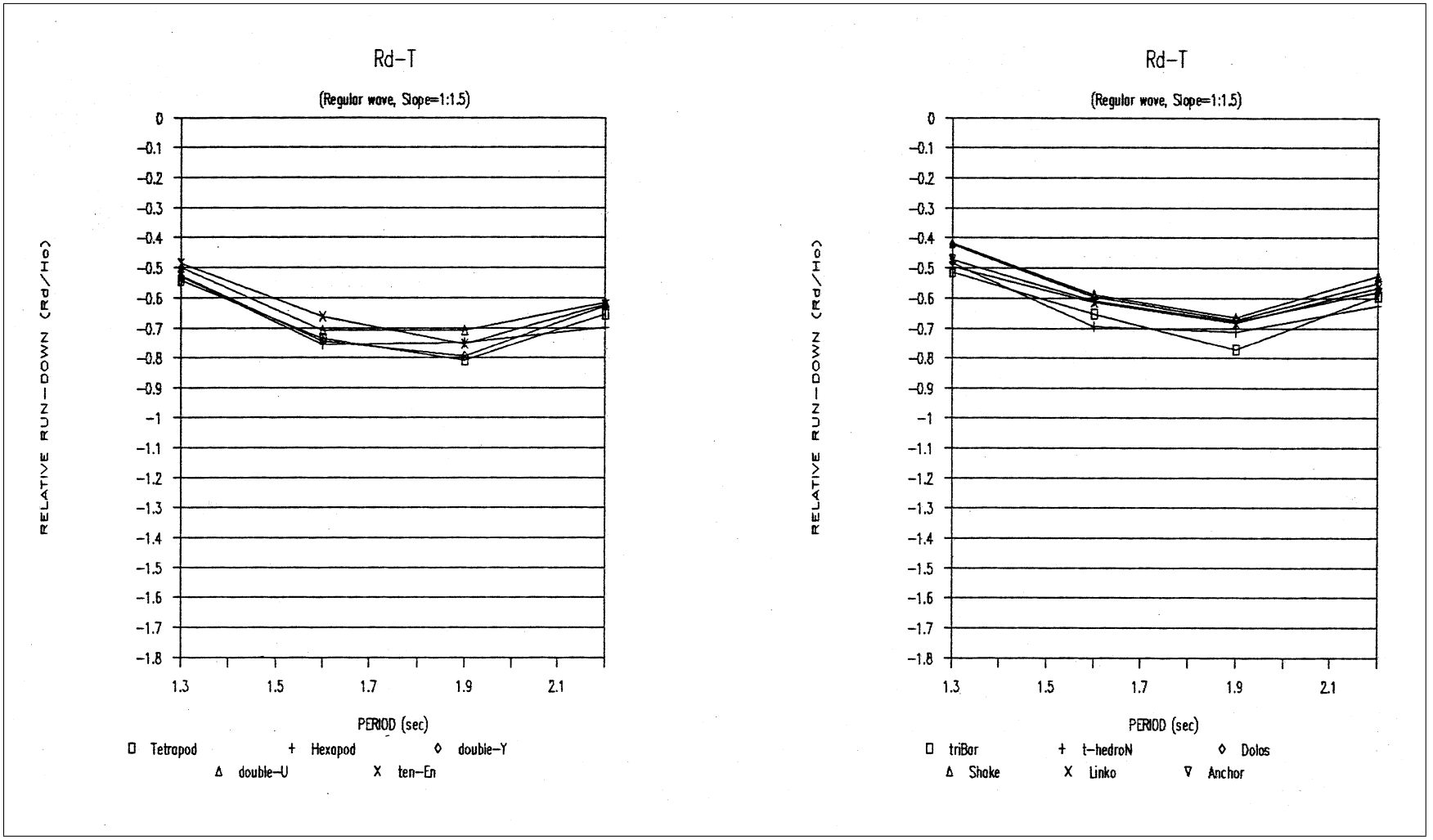

Fig 4.53 (DAve-A). The comparison of the average relative run-down among the different armor types (slope: 1:1.5).

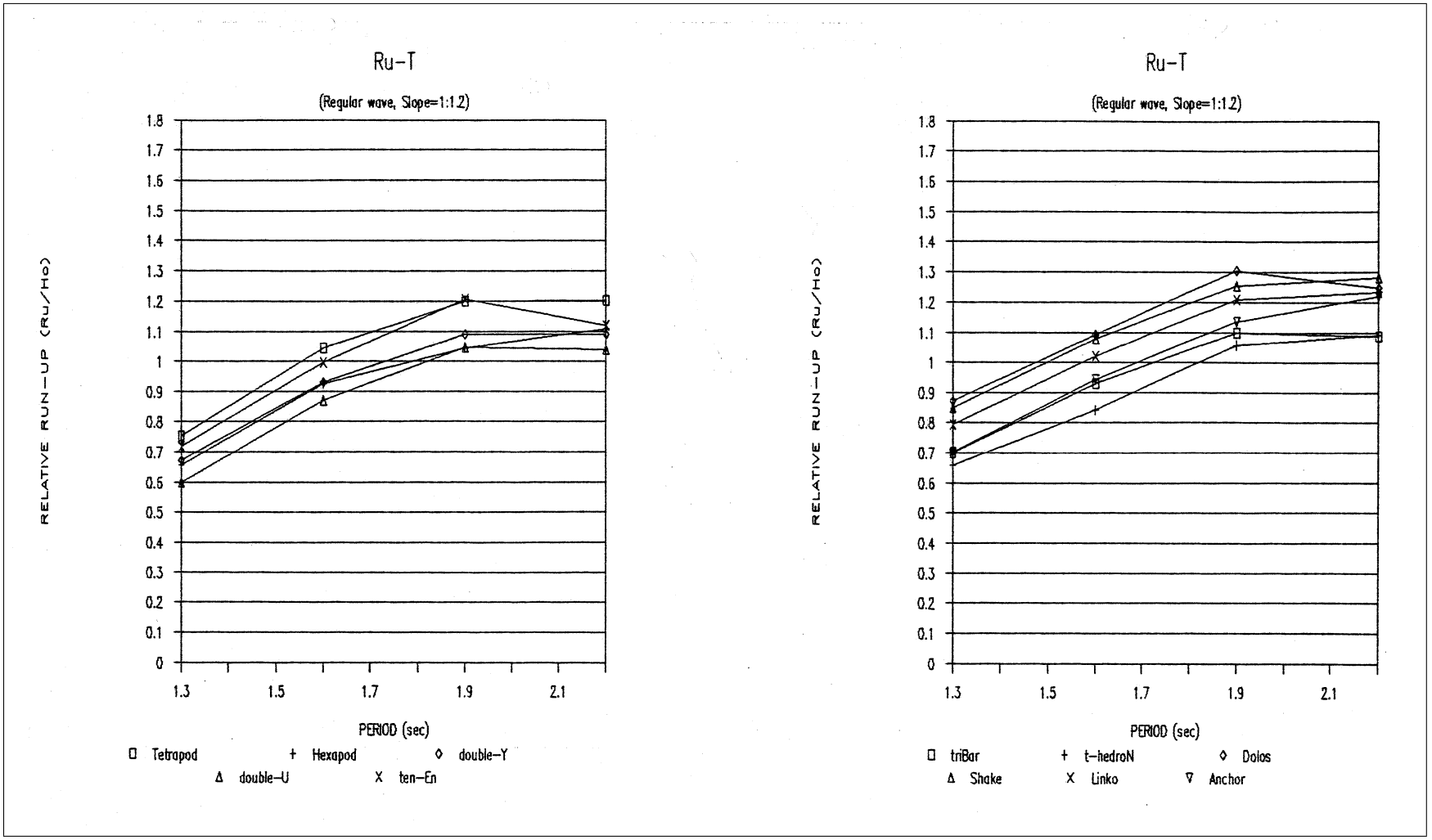

Fig 4.54 (UAve-B). The comparison of the average relative run-up among the different armor types (slope: 1:1.2).

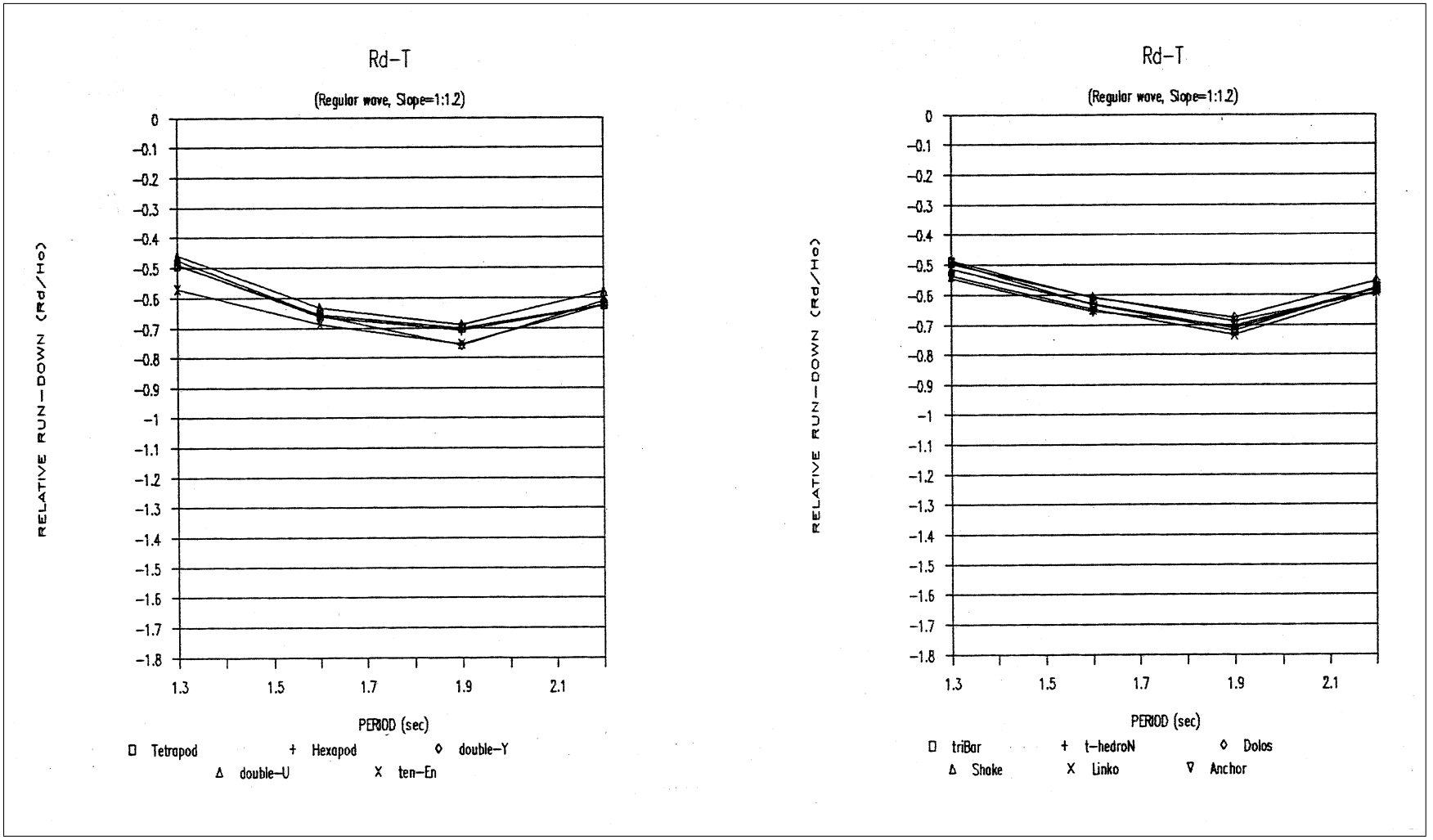

Fig 4.55 (DAve-B). The comparison of the average relative run-down among the different armor types (slope: 1:1.2).

Relative **Run-Up** Orthogonal Regression (Regular Waves, Slope=1:1.5)			
Coefficient matrix for orthonormal polynomials			
$P_0(x)$	$P_1(x)$	$P_2(x)$	$P_3(x)$
-0.15076	-0.78657	4.94144	41.92162
0.00000	0.44947	-5.86272	-74.93697
0.00000	0.00000	1.67506	43.69864
0.00000	0.00000	0.00000	-8.32355
Orthogonal polynomial coordinates			
-7.09976	1.01705	-0.59931	0.03428
Square error terms for each degree (degree: 0, 1, 2, 3)			
1.77140	0.73700	0.37783	0.37665
Fitted degree of polynomial: 3 ($n = 4$)			
Coefficients of fitted polynomial: (power: 3, 2, 1, 0)			
-0.28536	0.49427	1.40160	-1.25388
Fitted degree of polynomial: 2 ($n = 3$)			
Coefficients of fitted polynomial: (power: 2, 1, 0)			
	-1.00389	3.97073	-2.69111

Tab 4.79 (UReg-A~T). The orthonormal polynomial regression for the overall-averaged relative run-up as the function of wave period (slope: 1:1.5).

Relative **Run-Down** Orthogonal Regression (Regular Waves, Slope=1:1.5)			
Coefficient matrix for orthonormal polynomials			
$P_0(x)$	$P_1(x)$	$P_2(x)$	$P_3(x)$
-0.15076	-0.78657	4.94144	41.92162
0.00000	0.44947	-5.86272	-74.93697
0.00000	0.00000	1.67506	43.69864
0.00000	0.00000	0.00000	-8.32355
Orthogonal polynomial coordinates			
4.13085	-0.30099	0.49978	-0.04323
Square error terms for each degree (degree: 0, 1, 2, 3)			
0.44785	0.35725	0.10747	0.10560
Fitted degree of polynomial: 3 ($n = 4$)			
Coefficients of fitted polynomial: (power: 3, 2, 1, 0)			
0.35980	-1.05176	0.17387	0.27153
Fitted degree of polynomial: 2 ($n = 3$)			
Coefficients of fitted polynomial: (power: 2, 1, 0)			
	0.83717	-3.06537	2.08365

Tab 4.80 (DReg-A~T). The orthonormal polynomial regression for the overall-averaged relative run-down as the function of wave period (slope: 1:1.5).

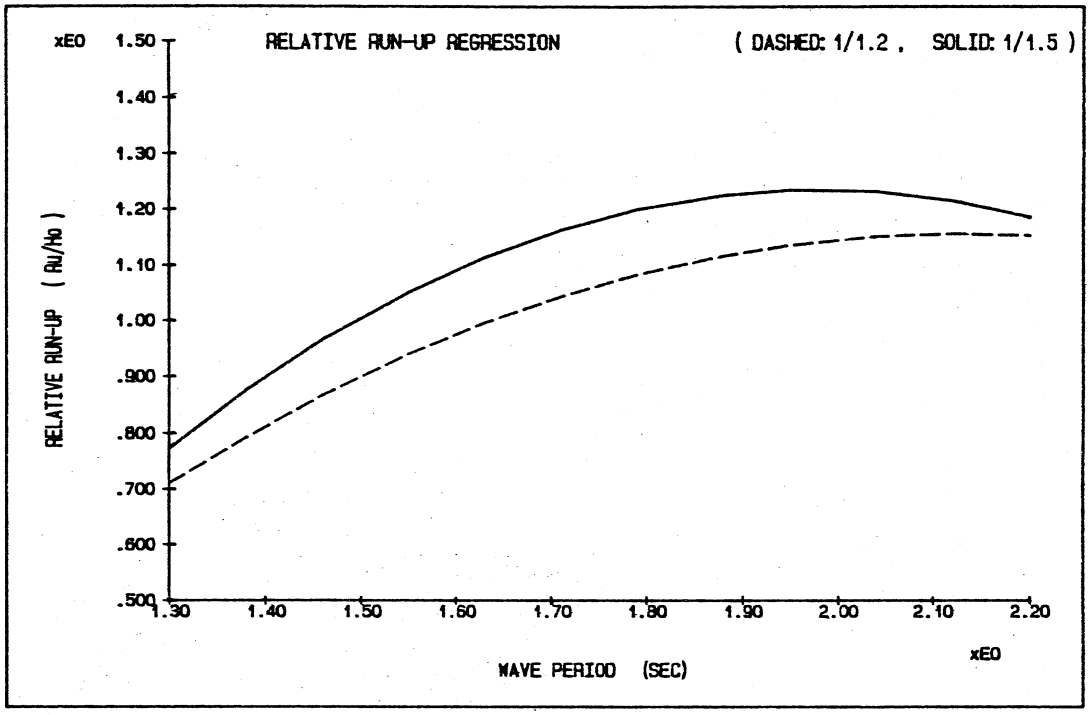

Fig 4.56 (UReg-A~T). The regression curves of the overall-averaged relative run-up for the two individual slopes.

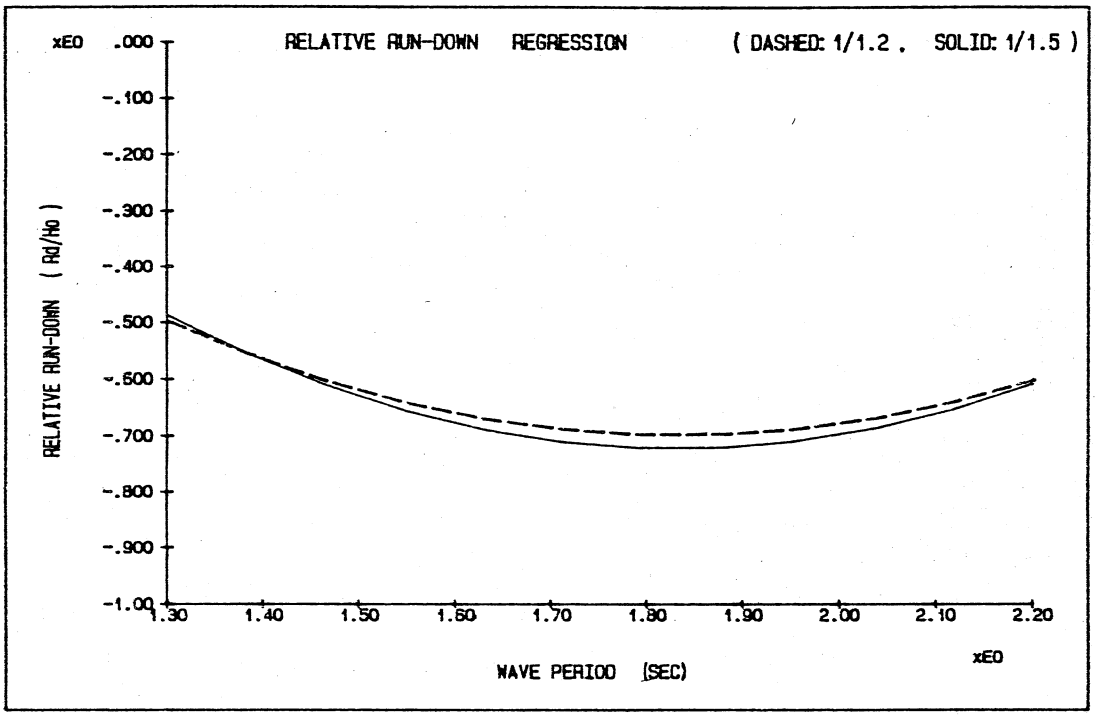

Fig 4.57 (DReg-A~T). The regression curves of the overall-averaged relative run-down for the two individual slopes.

4.4 Stability coefficients K_D

The conventional method, as specified in the "Costal Protection Manual", for determining the stability coefficient is by drawing an envelop line below the distribution points of the stability number and the breakwater slope on a double logarithmic plot (i.e., N_D vs $\cot\theta$ obtained from tests under various slopes), and the K_D is taken as the intercept of the envelop line. By the way, there is a hint to be thought here — what's the point for using the double logarithmic coordinates? And still, the main impediments are on the damage classification or the standard of destruction, as well as on the way of damage identification or measurement. In the present study, only two slopes are adopted and there are no test repetitions, therefore, the Hudson formula is chosen and the K_D is calculated directly for each slope. It is noted that the K_D of the Hudson formula is cubically proportional to the damage wave height H_D, therefore, the range of variation of the K_D values may be very large. For the slope of 1:1.5, the K_D values are about 9.8, 15.3, 22.5, and 31.0, respectively, for individual damage wave heights of 13, 15, 17, and 19 cm. Note additionally, the Hudson formula does not involve the wave period factor, whereas, the tests here adopt the four different wave periods that fit for the capacity of our facility, and the adopted wave height increment (instrument parameter) for all the wave periods is 2 cm (note that the separated incident wave height may not be fully in agreement with the instrument parameter, see the section 4.2 on K_r). Besides, the damage wave height H_D here is associated with the separated incident wave height at a proper distance from the breakwater (gauge 3 or gauge 5 in the individual water channel, which is located about 3.5 meters away from the breakwater toe). Also note that, when determining K_D, we do not differentiate the different wave periods. Let first describe a few stability phenomena based upon visual observations for all the tests.

- Armor activity occurs for all the different wave periods and their degrees of motion could hardly be differentiated visually. And no specific pattern could be marked for the the two individual slopes.

- It should be pointed out that, if subjected to the condition of repeated reflections, the activity of armors is significantly amplified for longer period waves. Such a phenomenon evidences the importance of a unified and consistent scheme for both data acquisition and analyses. Some additional depictions related to these observations are as follows. First, without repeated reflections, the energy of the incident wave can be reasonably predicted as that derived from the wave theory, which is related to the square of the original incident wave height; whereas, under repeated reflections, the high reflectivity of the longer waves causes the the energy of the combined incident wave to be relatively much larger, as well as more complex. And without the process of wave separation the actual wave height is impossible to get by. In this regard, even though here the wave separation is employed for all the tests either with regular or irregular waves, such a situation of repeated reflections is something to be avoided as best as possible in this study, in particular, for the regular wave cases. Second, in experiments of many prior researches on the stability topic the time durations of wave action were set to a very long length and there were no indications of the proper control of the timing of the data acquisitions and analyses. Sometimes their stated intentions were to simulate the so-called "sustained damage" or "continuous damage", or to achieve a certain percentage of damage. It is apprehensible that such relevant data are inherently problematic if explorations of the actual incident waves are not properly taken. Overall, one may also attribute these factors as some of the main causes that rendered immensely scattering outcomes among those multitude of literatures.

- From visual observations of all the tests, there is no indication of any particular stability issue or any damage tendency adjacent to the sidewalls of the tank. This may be due to the reason that the walls, though not providing the interlocking, serve as the firm immobile support. Based on this, the counting of failure rate does not involve the sidewall effect.

- For easier observations of armor activity and for the more convenience in the dumping or placement of armors, the two breakwater slopes in our tests do not involve a practical gentler slope than the limiting 1:1.5 (such as 1:2.0 slope that was originally planned), rather, an unpractical steeper slope of 1:1.2 was chosen. For this steeper slope, especially in the wet condition, the rocks of the breakwater core and underlayer are basically at the stage of critical stability and signal the condition of the angle of repose. Without the protection of the covering armors, they collapse immediately with the slight impact of a small wave. But with the armor covering, the rocks withstand the serial dashing of wave actions here. Here one can comprehend the basic function of the armors.

- For the chosen test settings and wave parameters, the activity or behaviors of the armors under the two adopted breakwater slopes could hardly be distinguished for the same individual armor type. That is to say, for the same armor type, the phenomena occurred under the two slopes were quite consistent. Therefore, it is anticipated that the stability coefficients of the two slopes should be close to each other.

Although it is difficult to determine quantitatively or technically the stability conditions of the armors, it is not difficult to comprehend qualitatively or visually the stability performances of all the eleven armor types tested under exactly the same sequence of wave actions. For example, a simple jurisdiction can be made by comparing the final states of the armor coverings. And in facts, the armor movements in the intermediate processes for some of the armor types were substantially apparent and confidently identifiable. Table 4.81 (K_D Modes) depicts some of these qualitative characterization from visual observations. And the performance level of each armor type is classified into one of the four categories listed in the table.

As far as visual observations are concerned, the differences between the performances of categories 2 and 3 are relatively small, but the recognition of category 4 is unmistakeably evident and can be fully discerned.

Stability Category (Degree of Stability)		Armor Type
1.	Apparent motions of the armors are lower for all the tests. Few armors are displaced. And the two slopes well remain.	double-**U** tri**B**ar
2.	The shaking or motion of the armors is higher than the first category. Somewhat more armors are displaced but their falling distances are shorter than the next category. And the slopes remain largely unchanged.	double-**Y** **S**hake **D**olos
3.	Number of dislodged armors increases. The slopes change slightly. And the displacements of the falling armors are greater, with some rolling to the toe of the breakwater.	**H**exapod **L**inko
4.	Massive armor movements and the complete changes in slopes.	**T**etrapod ten-**E**n **A**nchor tetrahedro**N**

Tab 4.81 (K_D Modes). The four qualitative categories of stability performances based upon visual observations from all the tests.

As to the quantitative determination of the stability of the armors, i.e., the K_D, the meaningful damage zone here is taken as the region that covers 20 cm vertically above and below the still water level, and the 20 cm is about the magnitude of the maximum run-up. And the damage percentage criterion for K_D is taken as 2%, that is, counting the amount of armors that are acting violently, displaced, rolling, or with apparent motion. Basically, all these occurrences happened (or initiated) within the statistical damage zone.

Tables 4.82 (K_D-A-1) ~ 4.85 (K_D-B-2) show samples of the reference tables for the decision making of the K_D value for each individual armor type under each specific breakwater slope. Table 4.86 (K_D) shows all the chosen K_D values for all the armor types under the two individual slopes. Additional descriptions of armor behaviors are also noted in the table. Basically, the behaviors of an individual armor type under the two slopes are quite consistent. That is to say, the performance, the trend, or the pattern of block movements of an armor type show the same tendency under the two slopes.

Followings are a few causal reasonings on the stability performances of the different armor types from all the observations.

- Armor types that are without extruding pods are extremely likely to perform poorly (at least for our setting of random placement). Those armors are the **A**nchor and the tetrahedro**N**. And the ten-**E**n also behaviors poorly due to the fact that its feet arrangement (all feet in one axial direction) does not provide the interlocking property under the random placement.

- Both the **S**hake and the **L**inko have the same four number of pots. But the **L**inko is inferior in its stability. This is because there are protrusions at the end of its pods and these protrusions hamper the interlocking among the littering armors. Moreover, the **T**etrapod is similar to **S**hake in shape, but due to the rounded nature of its pots, it suffers a high possibility of continuous damage.

- The ten-**E**n has a very strong directionality in its overall armor configuration and is almost shaped like a cylindrical object. Under the action of waves, there is a

tendency of directional movement. And the armors roll around its long axis and likely be taken far away from the breakwater. Therefore it is not suitable for the random placement.

- The **A**nchor has the essence of a composition of flat surfaces, and it lacks the functions of feet or corners. Meanwhile, the tetrahedro**N** is actually like a four-sided cone with a hollow center, and obviously it also does not own the function of the pods. They both seem to easily introduce drag force or to yield a large Reynolds' effect. Coupled with the lack of support from the pods, they both slide down easily and their stability performances are poor.

- Though differences among the K_r values may not be significant among the different armor types, it is interesting to note that the lowest reflection coefficients (K_r) are correlated with the highest stabilities (K_D) — an implication of the function of "wave-killing blocks 『消波塊』— armors" (the direct meaning of the most commonly used Chinese translation for the "armor").

The following words concludes the stability analysis in this section.

Even though here the data acquisition and the processing of waves can be regarded as quite rigorous and scientific, and those human-related works are implemented and observed in a spirit of objectivity, fairness, consistency and exactitude, it should still be discerned that the damage classifications are done in a rather subjective way. Nevertheless, together with the results of the previous sections on K_r, R_u and R_d, it is clear that the outcomes have been vastly improved when compared to the past, and the various inferences could be followed and linked in an easy, as well as natural, path. Notwithstanding, only two slopes are involved and no realistic gentler slopes are chosen here; moreover, the modeled influencing factors barely exist and there are no repetitions of the random armor placements. Therefore, it is the author's earnest wish that advancements in observational techniques could be available in the future and further studies and experiments be carried out, especially for the settings related to non-random placements. Lastly and hopefully,

those possible uncertainties in K_D be acknowledged. ❖

LAYOUT : 1-A (BN5) [Slope: 1 on 1.5]

Armor types : triBar(R) & tetrahedroN(L) Note : Ho~S , Hd~E

Table No. : 1 - A - 3 [Kd - Hd_ind] Kd TABLE (based on individual Hd) 06/12/91-21:50:19.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)
RH08	7.253888	6.983049	1.758354	1.568661	7.206131	7.133021	1.723854	1.671916	7.204284	6.477482	1.722528	1.252023	7.431893	7.702777	1.891003	2.105406
RH10	8.991766	8.780648	3.349107	3.118700	8.873148	8.683815	3.218305	3.016655	8.723247	7.900399	3.057936	2.271648	9.290259	9.529298	3.693834	3.986362
RH12	10.60650	10.40974	5.496807	5.196545	10.50388	10.24929	5.338802	4.959933	10.20477	9.305953	4.895577	3.712585	11.04383	11.30281	6.205164	6.652022
RH14	12.57026	12.56783	9.150128	9.144812	12.14043	11.82809	8.243208	7.623211	11.85988	10.81107	7.684849	5.821046	12.91858	13.10485	9.932037	10.36789
RH16	14.54295	14.66355	14.16940	14.52486	13.61118	13.24102	11.61668	10.69446	13.53025	12.35490	11.41068	8.687843	14.62104	14.61044	14.39888	14.36760
RH18	17.07552	16.67690	22.93591	21.36685	15.36659	15.09980	16.71578	15.86017	15.30481	13.74759	16.51499	11.96945	16.52247	16.90387	20.77873	22.25115
RH20					17.16245	17.27293	23.28799	23.74061	16.70562	14.89885	21.47742	15.23534				
RH22					18.74629	18.58802	30.34870	29.58650	18.28416	16.35398	28.15913	20.14951				
RH24					20.25632	19.48768	38.28917	34.09372	19.24435	17.49381	32.83252	24.66310				

Note :: Slope= 1: 1.5 ; Armor weight (R) = 151.5 g ; Armor weight (L) = 151.5 g ; Specific weight = 2.30

Tab 4.82 (K_D-A-1). The reference table for the choice of the K_D value (slope: 1:1.5) (tri**B**ar and tetrahedro**N**).

LAYOUT : 2-A (DS5) [Slope: 1 on 1.5]
Armor types : Dolos (R) & Shake (L) Note : Ho~S , Hd~E
Table No. : 2 - A - 3 [Kd - Hd_ind] Kd TABLE (based on individual Hd) 06/12/91-22:45:55.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)
RHO8	7.049368	6.815166	1.577340	1.443924	7.192776	7.089493	1.675577	1.625401	7.104255	6.379737	1.614472	1.184468	7.467593	7.744314	1.875067	2.118673
RH10	8.529595	8.596173	2.794217	2.897547	8.914335	8.705690	3.189640	3.009710	8.711311	7.848049	2.976634	2.204958	9.279125	9.473963	3.597459	3.878915
RH12	10.22393	10.02956	4.812034	4.602159	10.58551	10.30369	5.340848	4.989922	10.21583	9.234590	4.800616	3.592262	11.12944	11.25846	6.207191	6.509570
RH14	11.65094	11.79382	7.121278	7.483051	12.20139	11.86844	8.179062	7.626000	11.76838	10.73867	7.338808	5.648937	12.97340	13.13644	9.831893	10.34067
RH16	13.47412	13.38174	11.01479	10.93083	13.65746	13.36402	11.47058	10.88746	13.33042	12.27987	10.66612	8.446892	14.73232	14.92046	14.39755	15.15173
RH18	14.93675	14.78925	15.00526	14.75549	15.35278	15.17477	16.29433	15.93975	14.82195	13.56089	14.66194	11.37575	16.70969	16.46842	21.00778	20.37375
RH20					16.97185	17.06297	22.29990	22.66103			0	0				
RH22					19.19032	18.39607	32.23753	28.39818			0	0				
RH24					20.40209	19.58251	38.73817	34.25474			0	0				

Note :: Slope= 1: 1.5 ; Armor weight (R) = 155 g ; Armor weight (L) = 153 g ; Specific weight = 2.30

Tab 4.83 (K_D-A-2). The reference table for the choice of the K_D value (slope: 1:1.5) (**D**olos and **S**hake).

LAYOUT : 1-B (NB2) [Slope: 1 on 1.2]

Armor types : triBar(R) & tetrahedroN(L) Note : Ho~S , Hd~E

Table No. : 1 - B - 3 [Kd - Hd_ind] Kd TABLE (based on individual Hd) 06/13/91-03:14:19.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)
RH06	5.541696	5.282022	0.980013	0.848603	5.579590	5.376059	1.000255	0.894738	5.369870	4.833485	0.891651	0.650257	5.655454	5.876858	1.041612	1.168798
RH08	7.379282	6.904328	2.313909	1.895257	7.451053	7.185809	2.382083	2.136638	7.010286	6.325228	1.983861	1.457244	7.623286	7.817033	2.551118	2.750615
RH10	9.257326	8.592065	4.568363	3.652554	9.250904	8.864867	4.558862	4.011627	8.444432	7.607055	3.467490	2.534857	9.514403	9.759117	4.959622	5.352239
RH12	10.56495	10.52138	6.790581	6.706922	10.92177	10.40993	7.502102	6.496036	9.991312	8.934488	5.743432	4.106889	11.38799	11.61483	8.504445	9.022835
RH14	12.21106	11.97739	10.48491	9.894447	12.28001	12.22331	10.66351	10.51648	11.37934	10.27683	8.485064	6.250026	13.03236	13.36177	12.74600	13.73715
RH16	14.09964	14.16937	16.14091	16.38159	13.70211	13.82281	14.81381	15.20873	12.78275	11.55820	12.02756	8.891511	14.98825	15.36916	19.38907	20.90523
RH18	16.34215	16.68428	25.13230	26.74404	15.01234	14.96978	19.48271	19.31748	14.38838	12.97587	17.15299	12.58094	16.91751	17.19077	27.88131	29.25435
RH20					16.54375	16.69142	26.07391	26.77839	16.23046	14.61549	24.62050	17.97813				
RH22					17.92869	18.91491	33.18563	38.96881								

Note :: Slope= 1:1.200000 ; Armor weight (R) = 151.5 g ; Armor weight (L) = 151.5 g ; Specific weight = 2.30

Tab 4.84 (K_D-B-1). The reference table for the choice of the K_D value (slope: 1:1.2) (tri**B**ar and tetrahedro**N**).

LAYOUT : 2-B (SD2) [Slope: 1 on 1.2]
Armor types : Dolos (R) & Shake (L) Note : Ho~S , Hd~E
Table No. : 2 - B - 3 [Kd - Hd_ind] Kd TABLE (based on individual Hd) 06/13/91-04:17:27.

Wave type	Period															
	T1.30				T1.60				T1.90				T2.20			
	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)	Hd(R)	Hd(L)	Kd(R)	Kd(L)
RH06	5.371417	5.173090	0.872271	0.789360	5.590006	5.356377	0.983154	0.876271	5.263531	4.884634	0.820760	0.664540	5.646934	5.792531	1.013498	1.108231
RH08	7.194072	6.876041	2.095604	1.853704	7.366005	7.098238	2.249474	2.039280	6.812873	6.494802	1.779818	1.562150	7.563930	7.874912	2.435720	2.784596
RH10	8.871193	8.608303	3.929443	3.637288	9.140846	8.897333	4.298768	4.016101	8.366827	8.007382	3.296608	2.927499	9.430969	9.739111	4.721215	5.267241
RH12	10.64765	10.43812	6.794329	6.484736	10.81388	10.65103	7.117540	6.889702	9.740815	9.285607	5.202004	4.565160	11.21894	11.66583	7.947686	9.052574
RH14	12.42433	12.11787	10.79455	10.14622	12.35879	12.21916	10.62461	10.40279	11.23842	10.70300	7.989154	6.991046	13.02707	13.52836	12.44301	14.11761
RH16	14.64279	14.14827	17.67081	16.14863	13.82420	13.54848	14.86980	14.18070	12.64210	11.92212	11.37216	9.662433	14.85962	15.23945	18.46749	20.18058
RH18	16.80032	16.43307	26.68935	25.30355	15.29285	14.70796	20.13032	18.14189	14.32494	13.30619	16.54489	13.43343	16.93776	17.22664	27.34973	29.14924
RH20					16.95346	16.28805	27.42584	24.63954	15.89603	14.87518	22.60741	18.76774				
RH22					19.30807	18.68064	40.51366	37.17069								

Note :: Slope= 1:1.200000 ; Armor weight (R) = 155 g ; Armor weight (L) = 153 g ; Specific weight = 2.30

Tab 4.85 (K_D-B-2). The reference table for the choice of the K_D value (slope: 1:1.2) (**D**olos and **S**hake).

Armor Type		Slope 1:1.5	Slope 1:1.2	Ave.	Phenomenon Description
		K_D			
1.	tri**B**ar	23.29	26.07	24.68	Movements are small and displaced armors are few.
2.	tetrahedro**N**	10.69	9.02	9.86	Rapid and continuous movements, culminated in a complete destruction, and a sudden collapse under the slope of 1:1.2.
3.	**D**olos	15.01	17.67	16.34	Shaking of armors is observable and more common, some armors dislocated, but the slopes remain roughly unchanged.
4.	**S**hake	15.15	18.14	16.65	Some movements exist but the two slopes remain largely unchanged.
5.	**L**inko	14.27	13.15	13.71	Apparent tumbling tendency and some armors roll over a long distance.
6.	**A**nchor	9.67	9.41	9.54	Massive and rapid falling of armors and speedy changes of both slopes.
7.	**T**etrapod	11.93	11.29	11.61	Likely to roll down continuously and the armors on the upper layer peel off in a large area under the slope of 1:1.2.
8.	**H**exapod	13.81	15.66	14.74	Tumbled armors are somewhat apparent.
9.	double-**Y**	20.86	18.99	19.92	No significant Movements and displacements.
10.	double-**U**	27.07	28.56	27.81	Little motions and few shifts. And the packing of armors seems to be particularly voluminous and porous.
11.	ten-**E**n	9.20	13.31	11.26	Armors have a tendency to roll and continuous damage occurs. For both the slopes, two armors are taken far away from the breakwater.
Note: The test conditions are associated with two-layer random placement. And no simulation of material properties of armor unit.					

Tab 4.86 (K_D). The stability coefficient (K_D) for each individual armor type and some observations on armor activity.

Chapter 5

Conclusions

With the aims of performance comparisons, laboratory tests of eleven armor types were carried out. The comparisons are specifically targeting the condition of random placement upon the rubble mount breakwater with surface slope of 1:1.5 and 1:1.2. The three subjects of comparison are reflection coefficient, relative wave run-up run-down and stability coefficient.

First in the study, various influencing factors on armor behaviors were listed and the basis of modeling concerns and henceforth the test layout were given. Followingly, to make the comparisons possible and fair, the optimizations on data acquisition and wave processing were stressed, in particular, the implementation of the separation of incident and reflected waves. Specifically, the optimizations were focusing on the unformization and signification of all the processes involved. And these works were basically related to the development of a real-time laboratory system that encompasses both data acquisition and analyses and meets the requirements of integrity, automaticity, accuracy, friendliness, etc. The coding efforts, on the one hand, much reduce the demand of manpower and resources, on the other hand, greatly enhance the exactitude and representativeness of all the data and the analyses, thus renders the possibility of the comparisons. Included functions of the lab system are acquisition, calibration, monitoring, and various on-site analyses (such as fundamental statistics, spectral analysis, filtering, and wave separation).

With the exertions in uniformization and signification, a 100 percentage utilization

rate was achieved for the acquired data, and no repeated works or redundant tests had ever happened. That is to say, none of the data had ever been eliminated, let alone any selective or discriminating handling on them. In fact, the whole processing flow, from raw data to final results (such as those calculated coefficients, the figures and the tables) was completely free of human hands (except those related to visual observations and the handling of plotting machine). Overall, the qualities of the data are quite satisfactory and the yields of the analyses are much less scattering when compared with the past. Therefore, the phenomenal logics or cause and effect relations are rather straightforward and the various trends are ready to be linked in physics. Hopefully, these outcomes vindicate the efforts and suffice the purpose of the study.

Lastly, it is emphasized again that the most satisfactory, as well as the most definite, results are those related to the reflection coefficients, but the measurements of wave run-up un-down and the judgements of stability still suffer from the human factors. Thusly, it is desired that technical improvements in relevant observations could be available in the future and further studies or experiments be broadly expanded. ❖

BIBLIOGRAPHY

[1] Behnke, D.L., and F. Raichlen. Breakwater armor displacement thresholds: A possible correlation with cumulative wave energy. *Proc. of the 19th Conf. on Ocean Engineering*, pages 2760–2772, 1984.

[2] Brebner, A. Performance of dolos in an open channel situation. In *Proc. of the 16th Conf. on Coastal Engineering*, pages 2305–2307, 1978.

[3] Bronson, M., H. F. Burcharth, and T. Larsen. Stability of dolos slopes. In *Proc. of the 14th Conf. on Coastal Engineering*, pages 1692–1701, 1974.

[4] Bruun, P. and A. R. Gunbak. New design principals for rubber mound breakwater. In *Proc. of the 15th Conf. on Coastal Engineering*, pages 2429–2473, 1976.

[5] Burcharth, H.F. *The lessons from recent breakwater failures – breakwater design*. Symposium on inshore engineering, 1987.

[6] Carver, R. D., and D. D. Davidson. Dolos armored breakwaters: Special considerations. In *Proc. of the 16th Conf. on Coastal Engineering*, pages 2263–2284, 1978.

[7] Carver, R. D., and D. D. Davidson. Breakwater stability – breaking wave data. In *Proc. of the 18th Conf. on Coastal Engineering*, pages 2107–2128, 1982.

[8] Davidson, D. D., and D. G. Markle. Effect of broken doloses on breakwater stability – breaking wave data. In *Proc. of the 15th Conf. on Coastal Engineering*, pages 2544–2561, 1976.

[9] Gaillard, P., M. Gauthier, and F. Holly. Method of analysis of random wave experiments with reflecting coastal structures. In *Proc. of the 17th Conf. on Coastal Engineering*, pages 204–220, 1980.

[10] Coastal Engineering Research Center. *Shore Protection Manual*. Waterway Experiment Station, Corp of Engineers, U. S. Army, 1985.

[11] Goda, Y. *Random Seas and Design of Maritime Structures*. University of Tokyo Press, 1985.

[12] Goda, Y. Estimation of wave statistics from spectral information. In *Proc. of the International Symposium on Ocean Wave Measurement and analysis*, pages 320–337, 1974.

[13] Goda, Y., and Y. Suzuki. Estimation of incident and reflected waves in random sea experiments. In *Proc. of the 15th Conf. on Coastal Engineering*, pages 825–845, 1974.

[14] Healy, J.J. Wave damping effect of beaches. In *Proc. of Minnesota International Hydraulics Convention*, pages 213–220, 1952.

[15] Hudson, R. Y. Laboratory investigations of rubber mound breakwater. In *Proc. of the American Society of Civil Engineering, ASCE, Waterways and Harbors Division, Vol.85, No.WK3, Paper No.2171*, 1959.

[16] Hudson, R. Y., and D. D. Eschew. Reliability of rubber mound breakwater stability models. In *Modeling 1975*, pages 1603–1622, 1975.

[17] Ishida, A. Transformation of power spectra of wind-generated waves caused by reflection. In *Costal Engineering in Japan, Vol.15*, pages 25–33, 1972.

[18] Lillevang, P. E., F. Raichlen, J. C. Cox, and D. L. Behnke. A detail model study of damage to a large breakwater and model verification of concepts for repair and upgraded strength. In *Proc. of the 19th Conf. on Coastal Engineering*, pages 1773–2809, 1984.

[19] Mettan, J. D., and J. G. Berry. Factor of safety for the design of breakwaters. In *Proc. of the 18th Conf. on Coastal Engineering*, pages 2097–2106, 1982.

[20] Montgomery, D. C. *Design and Analysis of Experiments*. 1984.

[21] Ouellet, Y. Considerations of factors in breakwater model tests. In *Proc. of the 14th Conf. on Coastal Engineering*, pages 1809–1825, 1974.

[22] Paul, M. W., and W. F. Baird. Discussion of breakwater armor units. In *The 1st International Conf. on Port and Ocean Engineering Under Arctic Condition*, pages 1–27, 1972.

[23] Raichlen, F., and J. L. Jr. Hammack. Runup due to breaking and non-breaking waves. In *Proc. of the 14th Conf. on Coastal Engineering*, pages 1937–1955, 1974.

[24] Scholtz, D. J. P., J. A. Zwanborn, and M. Mierkerk. Dolos stability – effect of block density and waist thickness. In *Proc. of the 18th Conf. on Coastal Engineering*, pages 2062–2046, 1982.

[25] Sollitt, C. K., and D. H. DeBok. Large scale model tests of placed stone breakwater. In *Proc. of the 15th Conf. on Coastal Engineering*, pages 2572–2588, 1976.

[26] Thomsen, A. L., P. E. Wohlt and A. S. Harrison. Riprap stability on earth embankments tested in large- and small-scale wave tanks. Technical report, U. S. Army, Corps of Engineers, Coastal Engineering Research Center and Missouri River Division, 1972.

[27] Timco, G. W., and E. P. D. Mansard. Improvements in modeling rubble mound breakwaters. In *Proc. of the 18th Conf. on Coastal Engineering*, pages 2047–2061, 1982.

[28] Timco, G. W., E. P. D. Mansard, and J. Ploeg. Stability of breakwaters with variation in core permeability. In *Proc. of the 19th Conf. on Coastal Engineering*, pages 2487–2499, 1984.

[29] Whillock, A.F. Stability of dolos blocks under oblique wave attack. Technical report, Hydraulics Researcher Station, Wallingford, Oxon, England, 1977.

[30] Whillock, A. F., and W. A. Price. Armor blocks as slope protection. In *Proc. of the 15th Conf. on Coastal Engineering*, pages 2564–2571, 1976.

[31] Zawnborn, J. A. Dolos packing density and effect of relative block density. In *Proc. of the 16th Conf. on Coastal Engineering*, pages 2286–2303, 1978.

[32] Zawnborn, J. A., D. E. Bosman, and J. Moes. Doloses – past, present, future? In *Proc. of the 17th Conf. on Coastal Engineering*, pages 1948–1967, 1980.

[33] 山崎博、鳥居幸雄： 異形消波塊之設計與施工（日文）。 海文堂，1969。

[34] 林西川、張憲國、黃文財、黃煌煇： 新型消波塊發展及研究試驗報告。 成功大學台南水工試驗所報告，No.97，1987。

[35] 林西川、張憲國、高瑞棋： 雙U塊之發展與試驗研究。 中國土木水利學會第九屆海洋工程會議論文集，頁 669–675， 1987。

[36] 高瑞棋、黃煌煇、黃文財： 正六邊中空三腳塊受波浪作用之安定性及消波效果試驗研究。 成功大學台南水工試驗所，1987。

[37] 郭金棟、陳文俊： 安卡塊水工模型試驗研究報告。 成功大學水利及海洋研究所，1989。

[38] 蔡清標： 治水塊消波及安定試驗研究報告。 中興大學水工報告，1989。

[39] 劉文雄： 消波工程設計及施工概論。（個人交流），1989。

[40] 歐善惠、許泰文、武經文： 新型消波塊模型試驗。 成功大學水利及海洋工程研究所，1987。

APPENDIX 1： Asyst Programs

Lee.men

A01798-20161220-A001 ❖ December 20, 2016 ❖ [Page count: 13]

```
echo.off                                                                    1
\ ----------------------------- Lee.men
   -----------------------------------
\ 02/20/94
\ ------------------------------------------------------------------------
\ ---  Asyst Menu for real time experiments sys clear  (c) Lee, Yueon-
   Ron -- \
\                                                                           6
\ Requirements :  1.  Memory allocation sensitive
\                 2.  Overlay files included
\                 3.  Confirm device parameters
\                 4.  Configure system properly
\                 5.  Follow subprogram restrictions                       11
\
\ Keywords     :  1.  Acquisition plus analysis
\                 2.  Acquisition
\                 3.  Analysis
\                 4.  Calibration                                          16
\                 5.  Scrolling of data
\                 6.  Real time foreground and background multitasking
   system
\
\ Copyright    :      By Lee,  Oct, 1990.
                                                                            21
sc  ." --  Y.R. Lee --    "   .date   ." ---------   "    .time
1    29.flag :=   {29.line}
100  system.buffer.size
0  bell.flag :=
1  menu.flag  :=                                                            26
" y"  my.pause.flag ":=
forget.all
my.def.colors
  dir.lee.txt   " bell.txt"      "cat   defer> load
  dir.lee.txt   " def-winn.nam"  "cat   defer> load                         31
  dir.lee.txt   " def-acqn.nam"  "cat   defer> load
  dir.lee.txt   " def-acqs.spe"  "cat   defer> load
  dir.lee.txt   " def-anan.nam"  "cat   defer> load
  dir.lee.txt   " def-ana1.1sp"  "cat   defer> load
                                                                            36
echo.off
stack.reset
\ 7 set.file.parse
\ def.vuport line.edit
integer scalar row.beg                                                      41
        scalar lc.flag
1  row.beg  :=
\ ---------------------- Words for resetting parameter
   --------------------
\
   ---------------------------------------------------------------------------

: reset.par.str                                                             46
```



```
   \  Numbeer specifications
   \         " 12345678901234"
   1         " r.Station.1 ="      #spe.str "[   ]  ":=
   2         " r.Spacing.1 ="      #spe.str "[   ]  ":=
   3         " r.Depth.1   ="      #spe.str "[   ]  ":=                   51
   4         " r.Beg.pnt.1 ="      #spe.str "[   ]  ":=
   5         " r.Station.2 ="      #spe.str "[   ]  ":=
   6         " r.Spacing.2 ="      #spe.str "[   ]  ":=
   7         " r.Depth.2   ="      #spe.str "[   ]  ":=
   8         " r.beg.pnt.2 ="      #spe.str "[   ]  ":=                   56
\  9         " r.fft points="      #spe.str "[   ]  ":=

   9         " PS.#.fft.pts="      #spe.str "[   ]  ":=
   10        " PS.f.beg    ="      #spe.str "[   ]  ":=
   11        " PS.f.end    ="      #spe.str "[   ]  ":=                   61

   12        " #.group     ="      #spe.str "[   ]  ":=
   13        " group.ele.1 ="      #spe.str "[   ]  ":=
   14        " group.ele.2 ="      #spe.str "[   ]  ":=
   15        " Add Chnl    ="      #spe.str "[   ]  ":=                   66
\  15        " Pause Flag  ="      #spe.str "[   ]  ":=
\  15        " Reserved    "       #spe.str "[   ]  ":=
   \  String specifications
   1         " xy.axis(l/o)="      "spe.str "[   ]  ":=
   2         " wnd.str     ="      "spe.str "[   ]  ":=                   71
   3         " offset (y/n)="      "spe.str "[   ]  ":=
   4         " y.lab  (n/e)="      "spe.str "[   ]  ":=
   5         " H.copy (y/n)="      "spe.str "[   ]  ":=
   6         " Make ASCII  ="      "spe.str "[   ]  ":=
   7         " View data   ="      "spe.str "[   ]  ":=                   76
   8         " Print OnSite="      "spe.str "[   ]  ":=
   9         " Forced spe  ="      "spe.str "[   ]  ":=
   10        " Pause Flag  ="      "spe.str "[   ]  ":=
   11        " LC flag     ="      "spe.str "[   ]  ":=
   12        " Grid flag   ="      "spe.str "[   ]  ":=                   81
;

: c>"a  \  [ "ele , array ]
  \  1  #spe.str "[ ]  ":=
  "[ ]  ":=                                                                 86
;
: "a>c    \  [ ele.# , "array , offset ]  "array>comment
  \ function   \  #spe.str "[  1 ]              1 >comment
               \  1  #spe.str "[ ]  ":=
  swap                                                                      91
  dup
  "[ ]
  +
  >comment
;                                                                           96
: create.ini.par.file
  regular.datafile
  file.template
    60 comments
    real dim[ #.#spe ] subfile                                              101
```

```
  end
  \  dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.create
  \  dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.open
    spe.str                          defer>  file.create
    spe.str                          defer>  file.open                106
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  #spe.str  0  "a>c
      tmp.v.i  #.#spe  =                                               111
    until
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe.str  20 "a>c                                       116
      tmp.v.i  #.#spe  =
    until
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=                                        121
      tmp.v.i  "spe      40 "a>c
      tmp.v.i  #.#spe  =
    until
  1 subfile  #spe    array>file
  file.close                                                           126
;
dir.lee.txt  " lspe-acq.dat"  "cat
get.par.file  my.pause
recover.par.acq
                                                                       131
dir.lee.txt  " lspe-ana.dat"  "cat    \ spe.str
get.par.file  my.pause
reset.par.str          \ needed when first change
create.ini.par.file    \ needed when first change
\                                                                      136
   ------------------------------------------------------------------------

\ nd
\ ------------------------------------ Colon Defs FOR MENU
   -------------------
integer  scalar  ana.flag
: run.acq
  {29.line}                                                            141
  dir.lee.txt     " acq.men"     "cat defer> load
  stack.clear
;
: run.dma
  {29.line}                                                            146
  dir.lee.txt     " dma.men"     "cat defer> load
  stack.clear
;
: run.dma.or.acq
  {29.line}                                                            151
  dma.or.sync "upper  " D"  "=
  if
```



```
    dir.lee.txt     " dma.men"     "cat defer> load
  else
    dir.lee.txt     " acq.men"     "cat defer> load                  156
  then
  stack.clear
;
: run.a+a
  nd                                                                   161
  2 0 fix.format
  "  Use ANA menu (1, 2, 3, ..., 9:all) when analyzed? "
  s.type   2  get.val  ana.flag :=
  {29.line}
                                                                       166
  \  dir.lee.txt     " acq.men"     "cat defer> load

  " y"  non.stop.str  ":=
  ana.flag
  case                                                                 171
    1  of  dir.lee.txt     " lsta-0.txt"     "cat defer> load   endof
    2  of  dir.lee.txt     " lref-0.txt"     "cat defer> load   endof
    3  of  dir.lee.txt     " lwhp-0.txt"     "cat defer> load   endof
    4  of  dir.lee.txt     " lplt-0.txt"     "cat defer> load   endof
    5  of  dir.lee.txt     " lsta-0.txt"     "cat defer> load   endof  176
    9  of  dir.lee.txt     " lsta-0.txt"     "cat defer> load
           dir.lee.txt     " lref-0.txt"     "cat defer> load   endof
  endcase
  " n" non.stop.str  ":=
  stack.clear                                                          181
;
: run.mon
  {29.line}
  dir.lee.txt     " mon.men"     "cat defer> load
  stack.clear                                                          186
;
: run.cal
  {29.line}
  dir.lee.txt     " cal.men"     "cat defer> load
  cr .time                                                             191
  stack.clear
;
: run.sta
  {29.line}
  \ sd                                                                 196
  \ echo.on
  " n"  non.stop.str  ":=
  " n"  scr.str       ":=
  0  eps.flag :=
  dir.lee.txt     " lsta-0.txt"     "cat defer> load                   201
  stack.clear
;
: run.sta.e
  {29.line}
  " n"  non.stop.str  ":=                                              206
  " n"  scr.str       ":=
  1  eps.flag :=
```

```
  0 lc.flag  :=
  dir.lee.txt      " lsta-0.txt"      "cat defer> load
  stack.clear                                                    211
;

: run.ref
  {29.line}
  dir.lee.txt      " lref-0.txt"      "cat defer> load           216
  nd
  stack.clear
;
: run.whp
  {29.line}                                                      221
  cr.str   " >"   "= not
  if  else
  dir.lee.txt      " lwhp-0.txt"      "cat defer> load
  then
  nd                                                             226
  stack.clear
;
: run.plt
  {29.line}
  0 eps.flag :=                                                  231
  dir.lee.txt      " lplt-0.txt"      "cat defer> load
  nd
  stack.clear
;
: run.plt.e                                                      236
  {29.line}
  1 eps.flag :=
  0 lc.flag  :=
  dir.lee.txt      " lplt-0.txt"      "cat defer> load
  nd                                                             241
  stack.clear
;
: run.stas
  {29.line}
  " n"  non.stop.str   ":=                                       246
  " y"  scr.str        ":=
  dir.lee.txt      " lsta-0.txt"      "cat defer> load
  stack.clear
;
: run.scr                                                        251
  run.stas
;
\ integer scalar eps.flag
: rf1      0 eps.flag :=  run.sta  ;
: rf1.eps  1 eps.flag :=  run.sta.e  ;                           256
: rf2  run.ref  ;
: rf3  run.whp  ;
: rf4      0 eps.flag :=  run.plt  ;
: rf4.eps  1 eps.flag :=  run.plt.e  ;
: rf5  run.stas ;                                                261
: lacq-spe ;  \ dummy
: run.spe
```



```
  {29.line}
  dir.lee.txt      " lacq-spe.men"      "cat defer> load
  cr .time                                                       266
  forget lacq-spe
  stack.clear
;
\
   ^*************************************************************************

: sta.hlp                                                        271
  dir.lee.txt  " lsta.hlp"  "cat  defer> load
;
: plt.hlp
  dir.lee.txt  " lplt.hlp"  "cat  defer> load
;                                                                276
: scr.hlp
  dir.lee.txt  " lscr.hlp"  "cat  defer> load
;
: ref.hlp
  dir.lee.txt  " lref.hlp"  "cat  defer> load                    281
;
: kr.hlp
  dir.lee.txt  " lref.hlp"  "cat  defer> load
;
: whp.hlp                                                        286
  dir.lee.txt  " lwhp.hlp"  "cat  defer> load
;
: par.hlp
  dir.lee.txt  " lpar.hlp"  "cat  defer> load
;                                                                291
: let.hlp
  dir.lee.txt  " llet.hlp"  "cat  defer> load
;
: cal.hlp
  dir.lee.txt  " lcal.hlp"  "cat  defer> load                    296
;
: acq.hlp
  dir.lee.txt  " lacq.hlp"  "cat  defer> load
;
: a&a.hlp                                                        301
  dir.lee.txt  " LAnA.hlp"  "cat  defer> load
;
: mon.hlp
  dir.lee.txt  " lmon.hlp"  "cat  defer> load
;                                                                306

\ ----------------------- Words for resetting parameter
   ---------------------
: get.#spe.ini
  10  3 fix.format
  0  tmp.v.i  :=                                                 311
  begin
    tmp.v.i  1 +   tmp.v.i :=
    tmp.v.i  col.1.pos  col.1.w 1 + + over  row.beg +  goto.xy #spe swap
        [ ] .
```

```
    #spe.str  "[ tmp.v.i 1 + ]  "null    "=
  until                                                                  316
  \  21  3  goto.xy  #spe [ 1 ]  .
;
: get."spe.ini
  0  tmp.v.i  :=
  begin                                                                  321
    tmp.v.i  1 +   tmp.v.i :=
    tmp.v.i  col.2.pos  col.2.w 1 + + over row.beg + goto.xy "spe "[ ]
       "type
    "spe.str "[ tmp.v.i 1 + ]  "null  "=
  until
;                                                                        326
: get."spe.p1   \  [ ele.# - ]
  10  foreground
  10 3 fix.format
  tmp.v.i.2  :=
  tmp.v.i.2                                                              331
  17  col.2.pos +  tmp.v.i.2 row.beg +  goto.xy  "spe "[ tmp.v.i.2 ]
     get.str
                                                 "spe "[ tmp.v.i.2 ] ":=
  my.def.colors
;
: get.#spe.p1   \  [ ele.# - ]                                           336
  10  foreground
  10 3 fix.format
  tmp.v.i.2  :=
  tmp.v.i.2
  28  tmp.v.i.2 row.beg +  goto.xy  #spe [ tmp.v.i.2 ] get.val           341
                                    #spe [ tmp.v.i.2 ] :=
                                    my.def.colors
;
: get.#spe.1     1  get.#spe.p1  ;
: get.#spe.2     2  get.#spe.p1  ;                                       346
: get.#spe.3     3  get.#spe.p1  ;
: get.#spe.4     4  get.#spe.p1  ;
: get.#spe.5     5  get.#spe.p1  ;
: get.#spe.6     6  get.#spe.p1  ;
: get.#spe.7     7  get.#spe.p1  ;                                       351
: get.#spe.8     8  get.#spe.p1  ;
: get.#spe.9     9  get.#spe.p1  ;
: get.#spe.10    10 get.#spe.p1  ;
: get.#spe.11    11 get.#spe.p1  ;
: get.#spe.12    12 get.#spe.p1  ;                                       356
: get.#spe.13    13 get.#spe.p1  ;
: get.#spe.14    14 get.#spe.p1  ;
: get.#spe.15    15 get.#spe.p1  ;

: get."spe.1     1  get."spe.p1  ;                                       361
: get."spe.2     2  get."spe.p1  ;
: get."spe.3     3  get."spe.p1  ;
: get."spe.4     4  get."spe.p1  ;
: get."spe.5     5  get."spe.p1  ;
: get."spe.6     6  get."spe.p1  ;                                       366
: get."spe.7     7  get."spe.p1  ;
```



```
: get."spe.8     8  get."spe.p1  ;
: get."spe.9     9  get."spe.p1  ;
: get."spe.10    10 get."spe.p1  ;
: get."spe.11    11 get."spe.p1  ;                                       371
: get."spe.12    12 get."spe.p1  ;

\ ============================================================
: create.lspe.dat
  regular.datafile                                                       376
  file.template
    60 comments
    real dim[ #.#spe ] subfile
  end
  spe.str                              defer>  file.create               381
  spe.str                              defer>  file.open
\  dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.create
\  dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.open
    0  tmp.v.i  :=
    begin                                                                386
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  #spe.str  0  "a>c
      tmp.v.i  #.#spe  =
    until
    0  tmp.v.i  :=                                                       391
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe.str  20 "a>c
      tmp.v.i  #.#spe  =
    until                                                                396
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe      40 "a>c
      tmp.v.i  #.#spe  =                                                 401
    until
  1 subfile  #spe    array>file
  file.close
;
: done                                                                   406
    create.lspe.dat
    \    #.#spe 2 + 1 +    col.1.pos  7 + goto.xy
    \    ."  lspe-ana data file created : "
    \ ."  OK?"  spe.str       get.str   spe.str  ":=
    spe.str       get.str   spe.str  ":=                                 411
    stack.clear
;
\ ------------------------- Declaration of Menus
   ------------------------------!
Menu Main.Menu
\ ------------------------- Declaration of Menus                         416
   ------------------------------!
Menu par.menu
Menu hlp.Menu
Menu acq.Menu
Menu ana.Menu
```

```
Menu a+a.Menu                                                          421
Menu cal.Menu
Menu scr.Menu

\ ------------------------- Declaration of Vuports
   ----------------------------!
Vuport Bottom                                                          426
\ ------------------------- MENU STATUS WORDS
   ---------------------------------!
: Main.status             \ For menu.status on Main.menu
    0  background
    3  foreground
    3   0 +  4  goto.xy  ."         F6"                               431
    19  0 +  4  goto.xy  ."         F1"
    19  0 +  5  goto.xy  ."         F2"
    19  0 +  6  goto.xy  ."         F3"
    19  0 +  7  goto.xy  ."         F4"
    19  0 +  8  goto.xy  ."         F5"                               436
    35  0 +  4  goto.xy  ."         F7"
    50  0 +  4  goto.xy  ."         F8"
    65  0 +  4  goto.xy  ."         F9"
    2  11 goto.xy ." Press"  b.t  ."  <F10> "  b.t  ." for help"
    2  12 goto.xy ." Press"  b.t  ."  ARROW "  b.t  ." key to choose an   441
       item"
    2  13 goto.xy ." Press"  b.t  ."   ESC  "  b.t  ." key to  exit any
       menu"
    43 12 goto.xy ."          " ." Log in Time : "  .time
    43 13 goto.xy ."          "  " Y.R. Lee"  s.type ."  / 1990, 94, 96"
\   55 11 goto.xy ." Y.R. Lee / Oct. 22 1990"
\   43 11 goto.xy " Developed : Y.R. Lee"  s.type ."  / Oct. 22 1990"    446
    0  background         \ menu.color
    10 foreground
;
: par.status              \ For menu.status on Main.menu
    1  background                                                       451
    3  foreground
    get.#spe.ini
    get."spe.ini
    col.1.pos  7 +     #.#spe  row.beg + 2 -   goto.xy
    \    ."   lspe-ana data file created : "                           456
    \  " Resetting  " dir.lee.txt " lspe-ana.dat" "cat  "cat  "type
    spe.str                                              "type
    2  19 goto.xy ." Press"  b.t  ."  <F10> "  b.t  ." for help"
    2  20 goto.xy ." Press"  b.t  ."  ARROW "  b.t  ." key to choose an
       item"
    2  21 goto.xy ." Press"  b.t  ."   ESC  "  b.t  ." key to  exit any   461
       menu"
    43 21 goto.xy ."           " " Y.R. Lee"  s.type ."  / 1990, 94"
    1  background
    13 foreground
;
: hlp.status                                                           466
    5   background
    3   foreground
    1 0 goto.xy   ." <Enter> key to choose an item"
```



```
    1 1 goto.xy   ." <Esc> key to escape current menu"
    1 2 goto.xy   ." Choose an item: "                                 471
    5   background
    0   foreground
;
\
   ------------------------------------------------------------------------

par.menu                                                               476
    cdt
    Menu.Store.Disk
    Menu.status par.status
    Menu.no.protect
    " Reset Parameters ---  " "date  "cat    MENU.TITLE                481
    \    Menu.Pull.Down
    Menu.blow.up
    1 1 23 79                                    MENU.SHAPE
    1  13                                        MENU.COLOR
    14                                           Menu.Prompt.Color         486
    \ 4                                            Menu.Prompt.Color
    1  row.beg + col.1.pos  #spe.str  "[  1 ]   MENU.ITEM{ get.#spe.1  }
    2  row.beg + col.1.pos  #spe.str  "[  2 ]   MENU.ITEM{ get.#spe.2  }
    3  row.beg + col.1.pos  #spe.str  "[  3 ]   MENU.ITEM{ get.#spe.3  }
    4  row.beg + col.1.pos  #spe.str  "[  4 ]   MENU.ITEM{ get.#spe.4  }  491
    5  row.beg + col.1.pos  #spe.str  "[  5 ]   MENU.ITEM{ get.#spe.5  }
    6  row.beg + col.1.pos  #spe.str  "[  6 ]   MENU.ITEM{ get.#spe.6  }
    7  row.beg + col.1.pos  #spe.str  "[  7 ]   MENU.ITEM{ get.#spe.7  }
    8  row.beg + col.1.pos  #spe.str  "[  8 ]   MENU.ITEM{ get.#spe.8  }
    9  row.beg + col.1.pos  #spe.str  "[  9 ]   MENU.ITEM{ get.#spe.9  }  496
    10 row.beg + col.1.pos  #spe.str  "[ 10 ]   MENU.ITEM{ get.#spe.10 }
    11 row.beg + col.1.pos  #spe.str  "[ 11 ]   MENU.ITEM{ get.#spe.11 }
    12 row.beg + col.1.pos  #spe.str  "[ 12 ]   MENU.ITEM{ get.#spe.12 }
    13 row.beg + col.1.pos  #spe.str  "[ 13 ]   MENU.ITEM{ get.#spe.13 }
    14 row.beg + col.1.pos  #spe.str  "[ 14 ]   MENU.ITEM{ get.#spe.14 }  501
    15 row.beg + col.1.pos  #spe.str  "[ 15 ]   MENU.ITEM{ get.#spe.15 }

    1  row.beg + col.2.pos  "spe.str  "[  1 ]   MENU.ITEM{ get."spe.1  }
    2  row.beg + col.2.pos  "spe.str  "[  2 ]   MENU.ITEM{ get."spe.2  }
    3  row.beg + col.2.pos  "spe.str  "[  3 ]   MENU.ITEM{ get."spe.3  }  506
    4  row.beg + col.2.pos  "spe.str  "[  4 ]   MENU.ITEM{ get."spe.4  }
    5  row.beg + col.2.pos  "spe.str  "[  5 ]   MENU.ITEM{ get."spe.5  }
    6  row.beg + col.2.pos  "spe.str  "[  6 ]   MENU.ITEM{ get."spe.6  }
    7  row.beg + col.2.pos  "spe.str  "[  7 ]   MENU.ITEM{ get."spe.7  }
    8  row.beg + col.2.pos  "spe.str  "[  8 ]   MENU.ITEM{ get."spe.8  }  511
    9  row.beg + col.2.pos  "spe.str  "[  9 ]   MENU.ITEM{ get."spe.9  }
    10 row.beg + col.2.pos  "spe.str  "[ 10 ]   MENU.ITEM{ get."spe.10 }
    11 row.beg + col.2.pos  "spe.str  "[ 11 ]   MENU.ITEM{ get."spe.11 }
    12 row.beg + col.2.pos  "spe.str  "[ 12 ]   MENU.ITEM{ get."spe.12 }
                                                                          516
\   #.#spe row.beg + 1 +    col.1.pos  3 -  " Done?"   menu.item{ done }
    #.#spe row.beg + 2 -    col.1.pos  3 -  " Done?"   menu.item{ done }
\          row.beg   1 -    col.1.pos  3 -  " Done?"   menu.item{ done }

MENU.END                                                               521
```

```
: acq.status            \ For menu.status on Main.menu
    3   background
    0   foreground
    1  0  goto.xy ." Choose an item:"                                526
    1  11 goto.xy ." Press" b.t ."  F10 " b.t ." for help"
    3   background
    4   foreground
;                                                                    531
: ana.status            \ For menu.status on Main.menu
    3   background
    0   foreground
    1  0  goto.xy ." Choose an item:"
    1  11 goto.xy ." Press" b.t ."  F10 " b.t ." for help"           536
    3   background
    4   foreground
;

\ ------------------------------ MENUS                              541
  ---------------------------------------!
acq.MENU
    cdt
    Menu.Store.Disk
    "  ACQ "                                  Menu.Title
    menu.status acq.status                                          546
    \ Menu.Pop.UP
    Menu.blow.UP
    7   5  12  42                              Menu.Shape
    3  4                                       Menu.Color
    14                                         Menu.Prompt.Color    551
    1 2 " 1. Multitasking mode (better sync)"  Menu.Item{ run.acq }
    2 2 " 2. DMA mode (for huge & fast ACQ)"   Menu.Item{ run.dma }
MENU.END
ana.MENU
    cdt                                                             556
    Menu.Store.Disk
    "  ANA "                                     Menu.Title
    menu.status ana.status
    \ Menu.Pop.UP
    Menu.blow.UP                                                    561
    7  16  18  49                                Menu.Shape
    3  4                                         Menu.Color
    14                                           Menu.Prompt.Color
    1 2 " 1. Spectra & Statisitcs"             Menu.Item{ rf1 } \
       run.sta
\   2 2 " 2. Wave Form Analysis (and Kr)"      Menu.Item{ rf2 } \   566
   run.ref
    2 2 " 2. Wave Sta, Kr, IR seperation"      Menu.Item{ rf2 } \
       run.ref
\   3 2 " 3. Distribution Curves"              Menu.Item{ rf3 } \
   run.whp
    3 2 " 3. [Distribution Curves]"            Menu.Item{ rf3 } \
       run.whp
    4 2 " 4. Flexible Stripe Chart"            Menu.Item{ rf4 } \
       run.plt
```



```
    5 2 " 5. Data Scrolling"                   Menu.Item{ rf5 } \   571
      run.stas
    6 2 " 6. == Reset Parameters =="           Menu.Item{ par.menu } \
    7 2 " 7. [Wavelet Analysis]"               Menu.Item{ nop      }
    8 2 " 8. [Wavelet&Spectral Coherence]"     Menu.Item{ nop      }
    9 2 " 9. EPS--Flexible Stripe Chart"       Menu.Item{ rf4.eps }
   10 2 " 0. EPS--Spectra & Statisitcs"        Menu.Item{ rf1.eps }   576
\  10 1 " == Reset Acq Parameters =="           Menu.Item{ nop      }
    \ Make prompt color same as foreground because no items are chosen
      here
MENU.END

\ ------------------------ Designing The Main Menu                    581
  ---------------------------!
MAIN.menu
    cdt
    Menu.Store.Disk
    \ Menu.Store.memory
    Menu.status Main.status                                         586
    " REAL TIME SYSTEM   ---  " "date  "cat    MENU.TITLE
    Menu.Pull.Down
    1 1 14 79                                    MENU.SHAPE
    0  10                                        MENU.COLOR
    14                                           Menu.Prompt.Color  591
\   3  3  " ---ACQ---"                           MENU.ITEM{ run.acq }
\   3  3  " ---ACQ---"                           MENU.ITEM{ nop     }
    3  3  " ---ACQ---"                           MENU.ITEM{ acq.menu }
    3  19 " ---ANA---"                           MENU.ITEM{ ana.menu }
    3  35 " -ACQ+ANA-"                           MENU.ITEM{ run.a+a }   596
    3  50 " ---CAL---"                           MENU.ITEM{ run.cal }
    3  65 " ---MON---"                           MENU.ITEM{ run.mon }
\    3  50 " ---CAL---"                          MENU.ITEM{ nop     }
\    3  65 " ---MON---"                          MENU.ITEM{ nop     }
\    2  1  "  ACQ+ANA"                           MENU.ITEM{ run.a+a }   601
\    2  16 "  ACQUISITION"                       MENU.ITEM{ run.acq }
\    2  34 "  ANALYSIS"                          MENU.ITEM{ ana.menu }
\    2  49 "  CALIBRATION"                       MENU.ITEM{ run.cal }
\    2  66 "  SCROLLING"                         MENU.ITEM{ run.scr }
MENU.END                                                            606

Hlp.MENU
    " HELP"                                      Menu.Title
    Menu.status hlp.status
    Menu.Pop.UP                                                     611
\   10 43 22 78                                  Menu.Shape
    8 41 22 77                                   Menu.Shape
\   10  3 22 39                                  Menu.Shape
\    9  3 22 39                                  Menu.Shape
    5  0                                         Menu.color         616
    14                                           Menu.Prompt.Color
\   0 1 " <Enter> key to choose an item"         Menu.Item{ NOP }
\   1 1 " <Esc> key to escape current menu"      Menu.Item{ NOP }
\   2 1 " Choose an item: "                      Menu.Item{ NOP }
    3 3 " -- ACQ --"                             Menu.Item{ acq.hlp }   621
    4 3 " -- ANA & A+A --"                       Menu.Item{ a&a.hlp }
```

```
    5 6 " Spectra & Statisitcs"                  Menu.Item{ sta.hlp }
    6 6 " Wave Sta, Kr, IR seperation"           Menu.Item{ ref.hlp }
    7 6 " Distribution Curves"                   Menu.Item{ whp.hlp }
    8 6 " Flexible Stripe Chart"                 Menu.Item{ plt.hlp }      626
    9 6 " Data Scrolling"                        Menu.Item{ scr.hlp }
   10 6 " == Reset Parameters =="                Menu.Item{ par.hlp }
   11 6 " [Wavelet Analysis]"                    Menu.Item{ let.hlp }
   12 6 " [Wavelet & Spectral Coherence]"        Menu.Item{ let.hlp }
   13 3 " -- CAL --"                             Menu.Item{ cal.hlp }      631
   14 3 " -- MON --"                             Menu.Item{ mon.hlp }
    0 foreground
\   \ Make prompt color same as foreground because no items are chosen
   here
MENU.END
                                                                           636
\ ------------- Assigning Menus & Colon Defs To Function Keys
   -----------------!
  F6   Menu.key.does run.dma.or.acq
\ F3   Menu.key.does run.a+a
  F7   Menu.key.does ana.menu
  F8   Menu.key.does run.cal                                               641
  F9   Menu.key.does run.mon
  F10  Menu.key.does hlp.menu

  F1   menu.key.does rf1
  F2   menu.key.does rf2                                                   646
  F3   menu.key.does rf3
  F4   menu.key.does rf4
  F5   menu.key.does rf5

\ -------------------- Initializing and starting program                  651
   ----------------------!
: Start
    echo.off
    Stack.clear
    Menu.stack.clear            \ Clears all active menus
    Normal.display                                                         656
    Main.menu
    bell.1LL
    menu.execute
    0 menu.flag :=  \ restore
    Normal.display                                                         661
;
bell.1ll
\ cdt load load-eps.txt

start                                                                      666
32000  system.buffer.size
```

ACQ.men

A01799-20161220-A002 ❖ December 20, 2016 ❖ [Page count: 12]

```
\ ---- plea egula t file  EXP.DATA.ACQUISITION       (c) Lee Yueon-Ron
   ------- \

\ REQUIREMENTS : 1.  Memory allo  E.ASC ighly sensitive when incorpered
   into
\                   ANALYSIS program
\                2. Overlay files included ( Acq , Data, Alg )
\                3. Overall sampling frequency not to exceed 800 Hz
\                4. System CONFIGURED properly
\                5. Proper Gain setting
\
\ KEY WORDS    : 1. Background analog A/D
\                2. Foreground oscilloscope simulated simultaneous
   monitoring
\                3. Multitasking operations
\                4. User friendly control and performance
\                5. Optimized concurrent acquisition for different
   channels
\                6. Versatile acquisition choices
\
\ HINTS        : 1. Array   --- DAS  +  Pixel  + Minor
\                               ? *2   8000 *4
\                2. Token   --- no
\                3. Unnamed --- minor  ( + ramp for STD )
\                                      1 chnl *4 *2
\                4. DAS buf --- DAS
\
\ Copyright          May, 1990  by Lee  (02/20/94)

\ 0 set.file.parse
echo.off normal.display screen.clear
1 29.flag :=
{29.line}
: forget.word.acq
;

\ dir.lee.txt  " bell.txt"       "cat   defer> load
  dir.lee.txt  " pre-file.nam"  "cat   defer> load
\ dir.lee.txt  " def-winn.nam"  "cat   defer> load
\ dir.lee.txt  " def-acqn.nam"  "cat   defer> load
\ dir.lee.txt  " def-acqs.spe"  "cat   defer> load
\ dir.lee.txt  " def-anan.nam"  "cat   defer> load
\ dir.lee.txt  " def-ana1.1sp"  "cat   defer> load

5   5   19   75  window tmp.wnd  {border}
2 string drive.str
1 string terminate.str
" f:"    drive.str  ":=
nd
xlyl
dir.lee.txt  " filepass.asy"   "cat    filepass.asy   ":=
: check.file.exist  \  [ "filename.ext,  "dir  -  t/f ]
```



```
  my.def.colors
  chk.file.str  "upper  " Y"  "=   not
  if
    "drop  "drop
    false
    exit
  then
  15 11 goto.xy  b.t  ." ---- Checking existing files. Please wait. ----
     "  b.t
  tmp.s.9  ":=
  "upper
  tmp.s.8  ":=
  dir.lee.txt  " dat-file.lst"  "cat  defer> delete
  dir.lee.txt  " dat-file.lst"  "cat  defer> out>file
  console.off
  tmp.s.9   defer>  chdir
  tmp.s.8   defer>
  dir.brief
  out>file.close  console
  dir.lee.txt  " dat-file.lst"  "cat  defer> basic.open
  4  0 fix.format
  0  tmp.v.i  :=
  begin
    tmp.v.i 1 +  tmp.v.i  :=
    ?basic.eof
    if
      basic.close
      false  cdt
      exit
    then
    "basic.read
    tmp.s.8  "len  "drop  "left
    tmp.s.8  "=
    if
      \  cr  ." Got"
      true  cdt
      basic.close
      exit
    then
    ?basic.eof
  until
  basic.close
  false  cdt
  15 11 goto.xy  ."                                                  "
;

: get.del.time
  0  acq.del  :=
  datafile.dat.p2   del.str.pos  1  "sub    del.str.1  "=
    if   del.time.1           acq.del  :=  then
  datafile.dat.p2   del.str.pos  1  "sub    del.str.2  "=
    if   del.time.2           acq.del  :=  then
  datafile.dat.p2   del.str.pos  1  "sub    del.str.3  "=
    if   del.time.3           acq.del  :=  then
  datafile.dat.p2   del.str.pos  1  "sub    del.str.4  "=
```

```
    if   del.time.4            acq.del  :=  then
;

: get.acq.input                                                          106
  " n"  terminate.str  ":=
  upper.wnd {border}             \ <--
  screen.clear
\  inv.on
\  19 2  goto.xy  ."             WELCOME TO DMA                "   inv.of   111
\  19 2  goto.xy  ."       WELCOME TO MUTITASKING MODE          "   inv.of
  19 2  goto.xy  "       WELCOME TO MUTITASKING MODE          "
    s.type.3
  14 foreground
  19 4  goto.xy  ."  Sampling RATE            :             Hz "
  19 5  goto.xy  ."  Total sampling TIME      :            Sec "          116
\ 19 6  goto.xy  ."  Total sampling channels :         (1~16) "
  19 6  goto.xy  ."  Sampling chan FROM - TO :    ---         "
  19 7  goto.xy  ."  MONITORED  channel       :               "
  19 8  goto.xy  ."  CASE name                :               "
  19 9  goto.xy  ."  DELAY Time               :            Sec "          121
  19 10 goto.xy  ."  Any SPECIFICS            :               "
  em.color foreground
  7  0  fix.format
  46 4  goto.xy    s.freq   get.val  s.freq   :=
  7  3  fix.format                                                       126
  46 5  goto.xy    s.dura   get.val  s.dura   :=
\ 46 6  goto.xy    s.chnls  get.val  s.chnls  :=
  2 0 fix.format
  46 6  goto.xy    chan.beg.#    get.val  chan.beg.#  :=
  51 6  goto.xy    chan.end.#    get.val  chan.end.#  :=                 131
                   chan.end.#  chan.beg.# -  1 +  s.chnls :=
  7  0  fix.format
  46 7  goto.xy    p.chnl   get.val  p.chnl   :=
\ 46 7  goto.xy    p.chnl   get.val  p.chnl   :=
  9  4  fix.format                                                       136
                s.dura  s.freq  *   s.length :=
  46 8  goto.xy    tmp.s  s.type  s.input
  "dup
  "dup  "len  "drop  0  =
  if     tmp.s  datafile.dat.p2  ":=                                    141
  else   "dup   tmp.s  ":=  datafile.dat.p2  ":=
  then
  "len  "drop  0  =  not
  if
    tmp.wnd                                                              146
    datafile.dat.p2  " .dat"  "cat
    dir.lee.dat  "len  1 - "left     check.file.exist
    if
      15 11 goto.xy  ."                                              "
      15 11 goto.xy   " File already exists!!"  s.type                   151
                ."    ( " tmp.s.8 "type ."   at "  tmp.v.i 0 n>s "type
                  ." )"
      18 12 goto.xy  ." Please reenter! --- <cr>"
      18 13 goto.xy  ." To overwrite, press <F>!"
      pckey drop  not
```



```
      if                                                                 156
        18 12 goto.xy  ."                                    "
        18 13 goto.xy  ."                                  "
        myself
      then
    then                                                                 161
  then
  upper.wnd  {border}
  get.del.time
  7  0  fix.format
  46 9  goto.xy    acq.del  get.val  acq.del  :=                         166
  s.freq  s.dura *  s.chnls *   32000 >
  if
    20   11  goto.xy  b.t  ." ---- You must use DMA Mode A/D. ----"  b.t
    " q" terminate.str ":=
  then                                                                   171

  46 10 goto.xy    tmp.s.2  s.type  s.input
   "dup  "len  "drop  0  =
  if     tmp.s.2  specifics       ":=
  else   "dup   tmp.s.2  ":=  specifics       ":=                        176
  then
  my.def.colors
  3   13  goto.xy
  \  ." Reenter, press <F>;  To continue, press <non-F>; To exit, press
     q."
  ."    Reenter:"          " <F>"       s.type.3                        181
  ."    Continue:"         " <non-F>"   s.type.3
  ."    Exit:"             " <Q>"       s.type.3
  bell.2sl
  \  pckey drop if myself then
  pckey  ?dup                                                            186
  not
  if
    113  =  if  " q" terminate.str ":=           then
  else
  then                                                                   191
  if    myself        then
;
: data.filename.input
  " n"  terminate.str  ":=
  bell.2sl                                                               196
  nd  sc
  tmp.wnd  {border}
  pre.file.name
  my.def.colors
  tmp.wnd  {border}                                                      201
  inv.on
  14 foreground
  4  5  goto.xy  ." Please input CASE name  :          "
  {border}
  31 5  goto.xy                                                          206
  s.input  datafile.dat.p2  ":=
  datafile.dat.p2  " .dat"  "cat
  dir.lee.dat  "len  1 - "left     check.file.exist
```

```
  if
    15 11 goto.xy  ."                                                  "   211
    15 11 goto.xy   " File already exists!!"  s.type
                 ."    ( " tmp.s.8 "type ."   at "  tmp.v.i 0 n>s "type  .
                " )"
    18 12 goto.xy  ." Please reenter! --- <cr>"
    18 13 goto.xy  ." To overwrite, press <F>!"
    pckey drop  not                                                        216
    if
      18 12 goto.xy  ."                              "
      18 13 goto.xy  ."                            "
      myself
    then                                                                   221
  then
  cr
  inv.of
  lower.inner.wnd  {border}  \ <---
  cr                                                                       226
  ."                                    To reenter,  Press <F>."   cr
  ."                                    To continue, Press <cr>."
  bell.2sl
  pckey drop if    myself  then
  get.del.time                                                             231
;

: default.acq.input
  " n"  terminate.str  ":=
  nd      upper.wnd  {border}                                              236
  screen.clear
\  inv.on
\ 19 2  goto.xy  ."            WELCOME TO DMA               "   inv.of
\  19 2  goto.xy  ."       WELCOME TO MUTITASKING MODE       "   inv.of
  19 2  goto.xy  "       WELCOME TO MUTITASKING MODE         "            241
     s.type.3
  14 foreground
  19 4  goto.xy  ."  Sampling RATE           :            Hz "
  19 5  goto.xy  ."  Total sampling TIME     :           Sec "
\ 19 6  goto.xy  ."  Total sampling channels :        (1~16) "
  19 6  goto.xy  ."  Sampling chan FROM - TO :   ---         "            246
  19 7  goto.xy  ."  MONITORED  channel      :              "
  19 8  goto.xy  ."  CASE name               :              "
  19 9  goto.xy  ."  DELAY Time              :           Sec "
  19 10 goto.xy  ."  Any SPECIFICS           :              "
  em.color  foreground                                                     251
  7 0 fix.format
  46 4  goto.xy    s.freq   .
  7  3  fix.format
  46 5  goto.xy    s.dura   .
\ 46 6  goto.xy    s.chnls  .                                              256
  2 0 fix.format
  46 6  goto.xy    chan.beg.# .
  51 6  goto.xy    chan.end.# .    chan.end.#  chan.beg.# -  1 +
     s.chnls :=
  7 0 fix.format
  46 7  goto.xy    p.chnl   .                                              261
```



```
  46 8  goto.xy             datafile.dat.p2  s.type
  46 9  goto.xy    acq.del  . \  "   (1-16)" inv.on  "type inv.of

  s.freq  s.dura *  s.chnls *   32000 >
  if                                                                       266
    20   11  goto.xy  b.t  ." ---- You must use DMA mode A/D. ----"  b.t
    " q" terminate.str ":=
  then
  46 10 goto.xy    s.input  specifics      ":=
  my.def.colors                                                            271

  datafile.dat.p2  tmp.s    ":=
  specifics        tmp.s.2  ":=

  3   12  goto.xy                                                          276
  \ ." To reenter, press <F>;  To continue, press <non-F>; To exit,
     press q."
  ."    Reenter:"          " <F>"      s.type.3
  ."    Continue:"         " <non-F>"  s.type.3
  ."    Exit:"             " <Q>"      s.type.3
  bell.2sl                                                                 281
  pckey  ?dup
  not
  if
    113  =  if   " q" terminate.str ":=       then
  else                                                                     286
  then
  if    get.acq.input  then
;

nd   data.filename.input                                                   291

default.acq.input
lower.wnd {border}
dir.lee.dat  datafile.dat.p2  "cat  " .dat"   "cat  datafile.dat  ":=
                                                                           296
\  80 conversion.delay
1000.  s.freq  float / t.rate :=
s.freq 2 * p.points :=      \ osscilloscope display set to every two
   seconds

1 low.f.modulo   :=                                                        301
: find.t.rate               \ for low frequency acq
  t.rate   53   >
  if
  t.rate       2 /      t.rate       :=
  low.f.modulo 2 *      low.f.modulo  :=                                   306
  t.rate   53   >
    if
      myself
    then
  then                                                                     311
;
find.t.rate
: for.dummy.array
```

```
  s.dura  s.freq  *   s.length :=
  terminate.str  "upper  " Q"  "=                                    316
  if
    1  s.length :=
    1  p.points :=
  then
;                                                                    321
for.dummy.array
\ token db0    \    token db1        token db2
\ exp.mem> db0  \   exp.mem> db1     exp.mem> db2
  integer dim[ s.length , s.chnls ] unnamed.array    becomes> db0
\ integer dim[      p.points      ] unnamed.array    becomes> db1     326
\ integer dim[      p.points      ] unnamed.array    becomes> db2

  INTEGER DIM[ p.points ] ARRAY db1        \ buffer for plotted points
  INTEGER DIM[ p.points ] ARRAY db2
\ integer dim[ s.length , s.chnls ] array db0                        331
                                          \ buffer for raw data

chan.beg.#  1 -    s.chnls 1 -  chan.beg.# + 1 -   a/d.template
   chnls.in
\ s.chnls 1 - 0 swap  A/D.TEMPLATE CHNLs.IN      \ template for input on
db0   TEMPLATE.BUFFER                    \ channels ( 1 --> 16 )     336

\ p.chnl 1 - chan.beg.# + 1 -  dup  A/D.TEMPLATE CHNL.plot    \
   oscilloscope
p.chnl 1 - dup  A/D.TEMPLATE CHNL.plot          \ template for
   oscilloscope
db1  db2  CYCLIC DOUBLE.TEMPLATE.BUFFERS
                                                                     341
: START.ACQ                               \ start acquisition
  \ terminate.str  cr s.type
  \ s.length . ."   "    t.rate .
  \ my.pause
  terminate.str  "upper  " Q"  "=  if exit then                      346
  CLEAR.TASKS

    CHNLs.IN A/D.INIT
    1 TASK A/D.IN>ARRAY
    s.length 1 task.iterations                                       351
    low.f.modulo   1   task.modulo

    chnl.plot a/d.init
    2 task a/d.in>array
    1 2 task.deactivated.by                                          356
    low.f.modulo   2   task.modulo

  T.RATE TASK.period
  PRIME.TASKS
  TRIGGER.TASKS                                                      361
;

: STOP.ACQ                                \ stop acquisition
   STOP.TASKS
   CLEAR.TASKS                                                       366
```



```
;

 REAL DIM[ 3000 ] ARRAY PIXBUF \ pixel buffer to allow fast graphic data
    erase
\ REAL DIM[ 6000 ] ARRAY PIXBUF \ pixel buffer to allow fast graphic
   data erase                                                        371

\ token pixbuf
\ exp.mem> pixbuf
\ integer dim[ 10000 ] unnamed.array    becomes> pixbuf

: SET.GRAPHICS                \ setup the graphics scales            376
   0.025 .4  VUPORT.ORIG
   0.95  .45 VUPORT.SIZE       \ where to plot data

   .05 .05  AXIS.ORIG          \ center plotting area of vuport
   .9  .9   AXIS.SIZE                                                381

   10   10  axis.divisions

   HORIZONTAL   NO.LABELS
                grid.on                                              386
   NORMAL.COORDS .5 .5 AXIS.POINT           \ axis in center of vuport
\  0.8   0.1   position    " CHANNEL: "  p.chnl  get.chnl.str "cat label
   0.8   0.1   position    " CHANNEL: "  p.chnl  0  n>s        "cat label
   {29.line}  sc  ." RATE : "  4  0  fix.format s.freq  n.type  ."  Hz"
   ."      Unit: 1V <--> "  v.to.h  5  2  fix.format  n.type           391
   previous.window

   VERTICAL 0 1 LABEL.POINTS                \ plot vertical labels on
      even tick
            grid.on
   HORIZONTAL 0. p.points float WORLD.SET   \ set scales: indices on X  396
   VERTICAL   axis.fit.off
   VERTICAL   gra.lower.lim   gra.upper.lim   WORLD.SET   \  displayed
      on Y

   OUTLINE   \  grid
   XY.AXIS.PLOT                             \ axis and grid lines      401
   \  4096  ---  5V  ----  50cm
   \                      30      4096 * 0.8 = 3276.8
   \
   \                     -30      4096 * 0.2 =  819.2
   \     0  --- -5V  ---- -50cm                                        406
   VERTICAL    \  Reset world for AD Board digital Range
       gain  2. /  vol.lower.lim -  dig.lim  *   gain /   neg  dig.lim +
       gain  2. /  vol.upper.lim -  dig.lim  *   gain /   neg  dig.lim +
   WORLD.SET    \ signal on Y
   10 color                                                          411
   PIXBUF LINE.BUFFER.ON
;

19 5 23 75 WINDOW {PROMPT}                \ window for text prompts
                                                                     416
: PROMPT'EM                               \ put up prompts
```

```
   GRAPHICS.DISPLAY
   SCREEN.CLEAR
   {PROMPT}
   CR  cr                                                              421
   ."              Type any <F> to stop data acquisition" cr  cr
   ."         ______ ACQUIRING  of  "  datafile.dat int.text ."  _____"
   bell.2sl
;                                                                      426

integer scalar  dat.file.flag
1  dat.file.flag  :=

: PLOT.IT   \ loop to plot data,  synchronized to data acquisition
   BEGIN                                                               431
\      ERASE.LINES                  \ erase previous lines

      BEGIN                         \ wait for buffer to fill up
         ?BUFFER.SWITCH
          1  ?task.state  3  =  or                                     436
      UNTIL
      ERASE.LINES                   \ erase previous lines

      ?BUFFER.A/B                   \ choose which buffer to plot
      IF   db1                                                        441
      ELSE db2
      THEN
      Y.DATA.PLOT                   \ plot new data

      1 ?task.state 3 = ?key if pckey drop                            446
                             if  0  dat.file.flag :=   exit then
                          then  False or
    UNTIL
;                                                                     451

: CLEAN.UP                          \ clean up the system state when done
   LINE.BUFFER.OFF
   AXIS.DEFAULTS
   SCREEN.CLEAR \  b.t
   CR ." Data acquisition finished"                                   456
   bell.2sl
;

: DOIT              \ overall functioning
  terminate.str  "upper  " Q"  "=  if exit then                       461
   PROMPT'EM        \ write out prompts
   SET.GRAPHICS     \ Set up graphics area and scaling
   START.ACQ        \ Start up the tasks
   PLOT.IT          \ Plot the data continuously
   STOP.ACQ         \ Stop tasks                                      466
   CLEAN.UP
   \ when.onerr
;

\ ------------------------------------------------------------------  471
: acq.del.tes
```



```
  cr ."          Press " b.t ." <F>" b.t ."      to run  Syncronized
     Acquisition!"
  cr ."          Press " b.t ." <non-F>" b.t ." to run  Delayed
     Acquisition!"
  cr  cr cr  ."       "  .time
  BELL.2sl                                                            476
  pckey not   drop
  if
    \  get.del.time
    \  acq.del.def
    SCREEN.CLEAR                                                      481
    \   cr ."                Delayed  Acquisition !  ---- " acq.del 1000
        /    .
    cr ."               Delayed  Acquisition !  ---- " acq.del    .
    ."  Sec"
  else
    0.  acq.del  :=                                                   486
    SCREEN.CLEAR
    cr ."                Syncronized Acquisition !"
  then
  cr  cr cr  ."       "  .time
;                                                                     491

: acq.del.exe
  terminate.str  "upper  " Q"  "=  if exit then
  acq.del.tes
  acq.del  0  <>                                                      496
  if
    acq.del   tmp.v.i  :=
    50 20 goto.xy   tmp.v.i      .        ."  Sec"
    tmp.v.i  1 +   1
    do                                                                501
      1000  msec.delay
      50 20 goto.xy   tmp.v.i  i -    .
    loop
    bell.2sl
  then                                                                506
  bell.1sl
;
\ b.t
lower.wnd {border} screen.clear  cr  acq.del.exe
doit                                                                  511
\ ------------------------------------------------------------------
normal.display
\ ==================================================================

: get.datafile.dat.p23                                                516
  datafile.dat.p2   " .dat"   "cat   datafile.dat.p23  ":=
;
get.datafile.dat.p23

regular.datafile                                                      521
file.template
   8 comments
   integer dim[ 6 ] subfile
```

```
end
: create.filepass.asy                                                    526
  filepass.asy  defer> file.create
  filepass.asy  defer> file.open
  " Case         :   "  datafile.dat.p23 "cat mycase ":=  mycase     1 >
     comment
  " Date         :   "  "date            "cat mydate ":=  mydate     2 >
     comment
  " Time         :   "  "time            "cat mytime ":=  mytime     3 >  531
     comment
  " Specifics    :   "  specifics "cat  specifics ":=  specifics     4 >
     comment
                                              datafile.dat.p23     5 >
                                                 comment
  t.rate    acq.input  [ 1 ]  :=
  s.length  acq.input  [ 2 ]  :=
  s.freq    acq.input  [ 3 ]  :=                                         536
  s.chnls   acq.input  [ 4 ]  :=
  p.chnl    acq.input  [ 5 ]  :=
  p.points  acq.input  [ 6 ]  :=
  1 subfile  acq.input  array>file
  file.close                                                             541
  cr  ."       TMP data file created    :  "   filepass.asy     "type
     cr
;

\ ================================================================
\ !--------------------------------------------------------------!     546

  regular.datafile
  file.template
    8 comments
    integer dim[ 6 ] subfile                                           551
    integer dim[ s.length , s.chnls ] subfile
  end
: creat.datafile.dat
  datafile.dat  defer>  file.create
  datafile.dat  defer>  file.open                                      556
                                                  mycase          1
                                                     >comment
                                                  mydate          2
                                                     >comment
                                                  mytime          3
                                                     >comment
                                                  specifics       4
                                                     >comment
                                                  datafile.dat.p23 5   561
                                                     >comment
  1 subfile  acq.input  array>file
  2 subfile  db0 array>file
  file.close
  cr  ."     ASYST data file created    :  " datafile.dat "type  cr
  \ 1000 msec.delay                                                    566
  \ my.pause
;
```



```
: dat.file
  terminate.str  "upper  " Q"  "=  if exit then
  screen.clear                                                         571
  create.filepass.asy
  1  dat.file.flag    =
  if creat.datafile.dat
  then
; dat.file                                                             576
\ ================================================================

lower.inner.wnd {border}

nd                                                                     581
color.on
my.def.colors
forget forget.word.acq
.time
bell.1LL bell.2sl                                                      586
cdt
```

MON.men

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```
\ ---- plea egula t file      MONITERING       N        (c) Lee Yueon-Ron     1
   ------- \

\ Written             May, 1990  by Lee  (02/20/94)

\ 0 set.file.parse
echo.off normal.display screen.clear                                          6
\ forget.all   \ Be aware of the removal of all previous data and words.

: forget.word.acq
;
\ \ dir.lee.txt  " bell.txt"       "cat   defer> load                        11
\ dir.lee.txt  " pre-file.nam"  "cat   defer> load
  cdt load pre-file.nam
  screen.clear lower.inner.wnd  {border}
\ \ dir.lee.txt  " def-acqn.nam"  "cat   defer> load
\ \ dir.lee.txt  " def-mons.spe"  "cat   defer> load                          16
\ \  dir.lee.txt  " def-acqs.spe"  "cat   defer> load

\  dir.lee.txt  " def-acqs.sp2"  "cat   defer> load
\ \  dir.lee.txt  " def-anan.nam"  "cat   defer> load
\ \  dir.lee.txt  " def-ana1.1sp"  "cat   defer> load                         21
\  get.acq.spe
\  nd chk.file.str s.type  my.pause
dir.lee.txt  " filepass.asy"   "cat    filepass.asy   ":=

 1   1   17   78   window show.wnd                                            26
8  string  tmp.s.2
: chnls.in ;
: chnl.plot ;

: get.acq.input                                                               31
\ screen.clear
  14  foreground
\  inv.on
\  19 3  goto.xy  ."              WELCOME                  "   inv.of
  19 3  goto.xy   "              WELCOME                     "                36
     s.type.3
  19 5  goto.xy  ."   Channel          :              (1~16) "
  19 6  goto.xy  ."   Sampling Rate    :                  Hz "
  19 8  goto.xy  ."   Gain factor      :                     "
  19 9  goto.xy  ."   Plot Lower bound :                     "
  19 10 goto.xy  ."   Plot Upper bound :                     "                41
  em.color foreground
  5  0  fix.format
  46 5  goto.xy    s.chnls          get.val  s.chnls          :=
  46 6  goto.xy    s.freq           get.val  s.freq          :=
  7  3 fix.format                                                            46
  46 8  goto.xy    v.to.h           get.val  v.to.h          :=
  46 9  goto.xy    gra.lower.lim    get.val  gra.lower.lim   :=
  46 10 goto.xy    gra.upper.lim    get.val  gra.upper.lim   :=
  s.chnls   p.chnl  :=
```



```
  9  4  fix.format                                                           51
  s.dura  s.freq  *   s.length :=

  my.def.colors
  cr
                                                                            56
\   -5.     gra.lower.lim   :=
\    5.     gra.upper.lim   :=
\    1.     v.to.h          :=   \ linear factor
    gra.lower.lim   v.to.h /  vol.lower.lim  :=
    gra.upper.lim   v.to.h /  vol.upper.lim  :=                             61

  cr
  \ ." To reenter, Press <F>."
  \ ."                              To continue, Press <non-F>"
  10 15 goto.xy                                                             66
  ."    Reenter:"          " <F>"      s.type.3
  ."    Continue:"         " <non-F>"  s.type.3
  \    ." To reenter  : Press <F>"
  \  cr ."    continue : Press <non-F>"
  bell.2sl                                                                  71
  pckey drop if myself then
;
: data.filename.input
  \
  bell.2sl                                                                  76
  pre.file.name   \ -> old datafile.dat
  \
  lower.wnd \  screen.clear
  \  int.on  inv.on
  inv.on                                                                    81
  4  3  goto.xy  ." Please input CASE name    :          "
  33 3  goto.xy
  s.input  datafile.dat.p2  ":=
  \  inv.of  int.of       lower.inner.wnd
  inv.of         lower.inner.wnd                                            86
  cr
  10 15 goto.xy
  ."    Reenter:"          " <F>"      s.type.3
  ."    Continue:"         " <non-F>"  s.type.3
  \   ."                                  To reenter,  Press <F>."  cr      91
  \  ."                                 To continue, Press <non-F>."
  bell.2sl
  pckey drop if    myself  then
  re.or.ir.tes
;                                                                           96

: default.acq.input
  nd      show.wnd   {border}
  screen.clear
  \ int.on                                                                 101
  14  foreground
\  inv.on
\  19 3  goto.xy  ."              WELCOME                  "
   inv.of
```

```
  19 3  goto.xy    "                 WELCOME                          "
    s.type.3
  19 5  goto.xy  ."   Channel           :                 (1~16)  "          106
  19 6  goto.xy  ."   Sampling Rate     :                     Hz  "
  19 8  goto.xy  ."   Gain factor       :                         "
  19 9  goto.xy  ."   Plot Lower bound  :                         "
  19 10 goto.xy  ."   Plot Upper bound  :                         "
  em.color  foreground                                                    111
  5 0 fix.format
  46 5  goto.xy    s.chnls          n.type
  46 6  goto.xy    s.freq           n.type
  7 3 fix.format
  46 8  goto.xy    v.to.h           n.type                                 116
  46 9  goto.xy    gra.lower.lim    n.type
  46 10 goto.xy    gra.upper.lim    n.type
  my.def.colors

  datafile.dat.p2  tmp.s     ":=                                          121
  specifics        tmp.s.2   ":=

  cr
  cr cr
                                                                          126
  10 15 goto.xy
  ."    Reenter:"          " <F>"       s.type.3
  ."    Continue:"         " <non-F>"   s.type.3
  bell.2sl
  pckey drop if    get.acq.input  then                                    131
;
nd
\ data.filename.input

\ dir.lee.txt " def-acq.spe" defer> load                                  136
default.acq.input
lower.wnd {border}
dir.lee.dat  datafile.dat.p2  "cat  " .dat"   "cat  datafile.dat  ":=

1000.  s.freq / t.rate :=                                                 141
s.freq 2 * p.points :=      \ osscilloscope display set to every two
   seconds

1 low.f.modulo   :=
: find.t.rate               \ for low frequency acq
  t.rate   53   >                                                         146
  if
  t.rate       2 /      t.rate        :=
  low.f.modulo 2 *      low.f.modulo  :=
  t.rate   53   >
    if                                                                    151
      myself
    then
  then
;
find.t.rate                                                               156
```



```
  INTEGER DIM[ p.points ] ARRAY db1        \ buffer for plotted points
  INTEGER DIM[ p.points ] ARRAY db2
  INTEGER DIM[ p.points ] ARRAY db3        \ buffer for plotted points
  INTEGER DIM[ p.points ] ARRAY db4                                       161
\ integer dim[ s.length , s.chnls ] array db0
                                                \ buffer for raw data

\ s.chnls 1 - 0 swap  A/D.TEMPLATE CHNLs.IN      \ template for input on
s.chnls 1 -   s.chnls 1 -  swap  A/D.TEMPLATE CHNLs.IN                    166
\ db0   TEMPLATE.BUFFER                  \ channels ( 1 --> 16 )
db3  db4  CYCLIC DOUBLE.TEMPLATE.BUFFERs

p.chnl 1 - dup  A/D.TEMPLATE CHNL.plot          \ template for
   oscilloscope
db1  db2  CYCLIC DOUBLE.TEMPLATE.BUFFERS                                  171

: START.ACQ                                     \ start acquisition
   CLEAR.TASKS

       CHNLs.IN A/D.INIT                                                  176
       1 TASK A/D.IN>ARRAY
       \       s.length 1 task.iterations
       1 task a/d.in>array
       low.f.modulo   1   task.modulo
                                                                          181
       chnl.plot a/d.init
       2 task a/d.in>array
       1 2 task.deactivated.by
       low.f.modulo   2   task.modulo
                                                                          186
   T.RATE TASK.period
   PRIME.TASKS
   TRIGGER.TASKS
;                                                                         191
: STOP.ACQ                                      \ stop acquisition
   STOP.TASKS
   CLEAR.TASKS
;                                                                         196
 REAL DIM[ 3000 ] ARRAY PIXBUF \ pixel buffer to allow fast graphic data
    erase
\ REAL DIM[ 6000 ] ARRAY PIXBUF \ pixel buffer to allow fast graphic
   data erase

\ token pixbuf
\ exp.mem> pixbuf                                                         201
\ integer dim[ 10000 ] unnamed.array    becomes> pixbuf

: SET.GRAPHICS                \ setup the graphics scales
   0.025 .4  VUPORT.ORIG
   0.95  .45 VUPORT.SIZE       \ where to plot data                       206

   .05 .05  AXIS.ORIG          \ center plotting area of vuport
   .9  .9   AXIS.SIZE
```

```
\   10   12  axis.divisions                                          211
   10   10  axis.divisions

   HORIZONTAL   NO.LABELS
   VERTICAL 0 1 LABEL.POINTS                \ plot vertical labels on
      even tick
                                                                    216
   NORMAL.COORDS .5 .5 AXIS.POINT           \ axis in center of vuport
\  0.80   0.1    position   " CHANNEL: "  p.chnl  get.chnl.str "cat
   label
   0.80   0.1    position   " CHANNEL: "  p.chnl  0 n>s  "cat label
   {29.line}  sc ."  RATE:"   4  0   fix.format    s.freq  n.type ."  Hz
      "
   previous.window                                                  221

   HORIZONTAL 0. p.points float WORLD.SET   \ set scales: indices on X
   VERTICAL   axis.fit.off

   VERTICAL   gra.lower.lim   gra.upper.lim   WORLD.SET   \ ... on Y   226
   OUTLINE
   XY.AXIS.PLOT                             \ axis and grid lines
   \  4096  ---  5V  ----  50cm
   \                     30     4096 * 0.8 = 3276.8
   \                                                                231
   \                    -30     4096 * 0.2 =  819.2
   \     0  --- -5V  ---- -50cm
   VERTICAL
       gain  2. /  vol.lower.lim -  dig.lim  *   gain /   neg  dig.lim +
       gain  2. /  vol.upper.lim -  dig.lim  *   gain /   neg  dig.lim +  236
\       dig.lim   gain  v.to.h *  2. /  gra.lower.lim +  gain v.to.h * /
     *  1 -
\       dig.lim   gain  v.to.h *  2. /  gra.upper.lim +  gain v.to.h * /
     *  1 -
   WORLD.SET   \ signal on Y
   14  color
   PIXBUF LINE.BUFFER.ON                                            241
;

19 5 23 75 WINDOW {PROMPT}                \ window for text prompts

: PROMPT'EM                               \ put up prompts           246
   GRAPHICS.DISPLAY
   SCREEN.CLEAR
   {PROMPT}
   CR  cr
   ."                  Type any <F> to stop monitoring" cr  cr        251
                \
   ."                  ----------  MONITORING"  ."  ----------"
   bell.2sl
;

integer scalar  dat.file.flag                                       256
0  dat.file.flag  :=
\ 1  dat.file.flag  :=
```



```
: PLOT.IT   \ loop to plot data,  synchronized to data acquisition
   BEGIN                                                            261
\      ERASE.LINES                  \ erase previous lines

       BEGIN                        \ wait for buffer to fill up
          ?BUFFER.SWITCH
            1  ?task.state  3  =  or                                266
       UNTIL
       ERASE.LINES                  \ erase previous lines

       ?BUFFER.A/B                  \ choose which buffer to plot
       IF   db1                                                     271
       ELSE db2
       THEN
       Y.DATA.PLOT                  \ plot new data

       1 ?task.state 3 = ?key if pckey drop                         276
                                 if  0  dat.file.flag :=   exit then
                              then  False or
    UNTIL
;                                                                   281
: CLEAN.UP                          \ clean up the system state when done
   LINE.BUFFER.OFF
   AXIS.DEFAULTS
   SCREEN.CLEAR \  b.t
   CR ." Done."                                                     286
   bell.2sl
;

: DOIT              \ overall functioning
   PROMPT'EM        \ write out prompts                             291
   SET.GRAPHICS     \ Set up graphics area and scaling
   START.ACQ        \ Start up the tasks
   PLOT.IT          \ Plot the data continuously
   STOP.ACQ         \ Stop tasks
 \ {29.line}                                                        296
 \ nd
 \ cr  " New Channel (9 --> Exit): "  s.type  1  n.type  #input s.chnls
    :=
 \ s.chnls  p.chnl :=
 \ cr  ." ok"
 \ s.chnls 1 - 0 swap  A/D.TEMPLATE CHNLs.IN      \ template for input   301
    on
 \ db3  db4  CYCLIC DOUBLE.TEMPLATE.BUFFERs
 \ p.chnl 1 - dup  A/D.TEMPLATE CHNL.plot         \ template for
    oscilloscope
 \ db1  db2  CYCLIC DOUBLE.TEMPLATE.BUFFERS
 \ myself
 \                                                                  306
   CLEAN.UP
;

\
```

```
   ------------------------------------------------------------------------
                                                                          311
0     1000 *   acq.del   :=
: acq.del.tes
\ b.t
cr ."          Press " b.t ." <F>" b.t ."       to set  Syncronized
   Acquisition !"
cr ."          Press " b.t ." <non-F>" b.t ."  to set  Delayed            316
   Acquisition !"
cr  cr cr  ."        "  .time
BELL.2sl
pckey not   drop
if
\ \ \    acq.del.def                                                      321
   SCREEN.CLEAR
   cr ."                Delayed  Acquisition !  ---- " acq.del 1000 /
        .
   ."  Sec"
else
   SCREEN.CLEAR                                                          326
   cr ."                Syncronized Acquisition !"
then
cr  cr cr  ."        "  .time

;                                                                        331

: acq.del.exe
acq.del  0  <>
if
acq.del  1000 /   tmp.v.i  :=                                           336
50 20 goto.xy   tmp.v.i      .        ."  Sec"
\ 1000  msec.delay
tmp.v.i  1 +   1
do
1000  msec.delay                                                        341
50 20 goto.xy   tmp.v.i  i -    .
loop
bell.2sl
then
bell.1sl                                                                346
;
\ b.t
\ \\ lower.wnd {border} screen.clear  acq.del.tes  cr  acq.del.exe

doit                                                                    351
\
   ------------------------------------------------------------------------


normal.display

\                                                                       356
   ========================================================================
```



```
: get.datafile.dat.p23
  10 17  goto.xy
  datafile.dat.p2   " .dat"   "cat   datafile.dat.p23  ":=
  ." The CASE name is       : "                                         361
  inv.on  datafile.dat  "type  inv.of
  cr
;
nd
\ get.datafile.dat.p23                                                  366

\ integer dim[ 6 ] array acq.input

\ load.overlay datafile.sov
regular.datafile                                                        371
file.template
   8 comments
   integer dim[ 6 ] subfile
end
: creat.datafile.dat.pass.to.b                                          376
  filepass.asy  defer> file.create
  filepass.asy  defer> file.open
  " Case          :   "  datafile.dat.p23 "cat mycase ":=  mycase     1 >
    comment
  " Date          :   "  "date            "cat mydate ":=  mydate     2 >
    comment
  " Time          :   "  "time            "cat mytime ":=  mytime     3 >  381
    comment
  " Specifics     :   "  specifics "cat  specifics ":=  specifics     4 >
    comment
                                              datafile.dat.p23     5 >
                                                 comment
  t.rate    acq.input  [ 1 ]  :=
  s.length  acq.input  [ 2 ]  :=
  s.freq    acq.input  [ 3 ]  :=                                        386
  s.chnls   acq.input  [ 4 ]  :=
  p.chnl    acq.input  [ 5 ]  :=
  p.points  acq.input  [ 6 ]  :=
  1 subfile  acq.input  array>file
  file.close                                                            391
  cr  ."       TMP data file created    :  "   filepass.asy     "type
      cr
;
\ creat.datafile.dat.pass.to.b

\                                                                       396
   ========================================================================

\
   !*********************************************************************


\
   ^*********************************************************************
```

```
  regular.datafile                                                        401
  file.template
    8 comments
    integer dim[ 6 ] subfile
\     integer dim[ s.length , s.chnls ] subfile
  end                                                                     406
: creat.datafile.dat
  datafile.dat  defer>  file.create
  datafile.dat  defer>  file.open
                                                  mycase          1
                                                     >comment
                                                  mydate          2   411
                                                     >comment
                                                  mytime          3
                                                     >comment
                                                  specifics       4
                                                     >comment
                                                  datafile.dat.p23 5
                                                     >comment
  1 subfile  acq.input  array>file
\  2 subfile  db0 array>file                                            416
  file.close
  cr  ."     ASYST data file created    :  " datafile.dat "type  cr
;
\ screen.clear
: dat.file                                                                421
  1  dat.file.flag   =
  if creat.datafile.dat
  then
;
\ dat.file                                                                426
\
   ============================================================================


lower.inner.wnd {border}

nd                                                                        431
color.on
my.def.colors
forget forget.word.acq
.time
bell.1LL                                                                  436
bell.2sl

 ..........................................................................................
```

CAL.men

A01812-20161220-A015 ❖ December 20, 2016 ❖ [Page count: 5]

```
\ ------ Asyst text file  EXP.DATA.CALIBRATION       (c) Lee Yueon-Ron
   ------- \

\  conv ell TS : 1.  Memory insen dir.lee. ta.file ered into
\                2.  Overlay files included
\                3.  System CONFIGURED properly
\                4.  Proper Device setting
\
\ KEY WORDS    : 1.  Background analog A/D
\                2.  Foreground multichannel simultaneous monitoring
\                3.  Multitasking operations with two cycle per min
   display
\                4.  With unit option
\                5.  Optimized concurrent acquisition for different
   channels
\
\ HINTS        : 1.  Array    ---  Minor
\                2.  Token    ---  No
\                3.  Unnamed  ---  Minor
\                4.  DAS buf  ---  Minor
\
\ Copyright          Oct, 1990  by Lee, (02/20/94)

\ normal.display screen.clear
echo.off

: forget.mark.cal ;

\ 1  2  16 78  window  cal.upper.wnd
2  3  19  76  window  cal.upper.wnd
186 205 201 200 188 187 border.chars

\ dir.lee.txt    " def-acqn.nam" defer> load
\ dir.lee.txt    " def-acqs.spe" defer> load

real
       scalar  dig.to.v
       scalar  offset

: def.values.cal
  gain  dig.lim /  dig.to.v   :=
  gain  v.to.h  * dig.lim /  dig.to.h   :=
  dig.lim  2. /   offset  :=
;
def.values.cal

 5  s.length  :=            \ 2 hz display
10  s.freq    :=
16  s.chnls   :=

1000 s.freq / t.rate :=
```



```
1 low.f.modulo   :=
: find.t.rate                \ for low frequency acq
  t.rate   53   >
  if
  t.rate       2 /       t.rate        :=
  low.f.modulo 2 *       low.f.modulo  :=
  t.rate   53   >
    if
      myself
    then
  then
;
find.t.rate

INTEGER DIM[ s.length , s.chnls ] arrAY db1
INTEGER DIM[ s.length , s.chnls ] ARRAY db2

s.chnls 1 - 0 swap  A/D.TEMPLATE CHNL.cal             \ template for
   cali
db1  db2  CYCLIC DOUBLE.TEMPLATE.BUFFERS

: START.ACQ                                          \ start acquisition
   CLEAR.TASKS

       chnl.cal a/d.init
       1 task a/d.in>array

       low.f.modulo   1   task.modulo

   T.RATE TASK.period
   PRIME.TASKS
   TRIGGER.TASKS
;

: STOP.ACQ                                           \ stop acquisition
   STOP.TASKS
   CLEAR.TASKS
;

integer  scalar  unit.opt
: screen.1
   SCREEN.CLEAR
   gd  hp nd
   cal.upper.wnd  {border}
   my.def.colors
   {border}
    "    Multichannel Digital Voltmeter" s.type.3    ."
        -------------------  "
   ."    Oct. 19 1990"  cr
   ."    "                  cr
   ."    "                  cr
   ."    Unit options  :              "          cr
   ."                         1.  cm "          cr
   ."                         2.  volt"         cr
   ."                         3.  original"     cr
```

```
   ."                        "                        cr
   ."     Please select :     " \ #input  unit.opt  :=
   1  0   fix.format          2   get.val  unit.opt  :=
   9  4   fix.format                                          106
   4  15  goto.xy
   ."     Reenter:"           " <F>"       s.type.3
   ."     Continue:"          " <non-F>"   s.type.3

 \  cr cr cr                                                  111
 \  ."     Press <non-F> key to start gauge Calibration !"  cr
 \  ."     Press <F>     key to rechoose option !"
   bell.2SL
   pckey  if drop  myself then drop
;                                                            116

\ : unit.conv
\    unit.opt  1  =
\    if  offset -    dig.to.h  *    conv  :=  \ --- CM
\    else unit.opt  2  =                                     121
\         if  offset -  dig.to.v *     conv  :=  \ ---  VOLT
\         else   1.    conv  :=  \  ---  ORIGINAL
\         then
\    then
\ ;                                                          126

real scalar  dig.con
: tmp.word
   unit.opt  1  =
   if  offset  offset  :=                                    131
       dig.to.h  dig.con  :=  \ --- CM
   else unit.opt  2  =
        if  offset  offset  :=
            dig.to.v  dig.con  :=   \ ---  VOLT
        else   0.  offset  :=                                136
               1.  dig.con  :=    \  ---  ORIGINAL
        then
   then
;
: conv                                                       141
  offset -    dig.con *
;

9 4 fix.format
: fixed.screen                                               146
   SCREEN.CLEAR
   ."    Type any  <F>  to stop gauge CALIBRATION"
   unit.opt  1  =
   ."            Unit :  "
   color.on  1  background  14 foreground                    151
   if   ."   CM  "
   else unit.opt  2  =
        if    ."  VOLT "
        else     ."  ORIGINAL "
        then                                                 156
   then
```



```
\ 1  background  12 foreground
12 4  goto.xy   " Channel No /   value             Channel No /   value"
   s.type.3
1  background  12 foreground
12 6  goto.xy  ."          1                                  9 "          161
12 7  goto.xy  ."          2                                 10 "
12 8  goto.xy  ."          3                                 11 "
12 9  goto.xy  ."          4                                 12 "
12 10 goto.xy  ."          5                                 13 "
12 11 goto.xy  ."          6                                 14 "          166
12 12 goto.xy  ."          7                                 15 "
12 13 goto.xy  ."          8                                 16 "
color.off
cr  ."  "  cr
."                                              Y.R. Lee / "  .time       171
;

: cal.IT   \ loop to plot data,  synchronized to data acquisition
   BEGIN
      \ = ERASE.LINES                  \ erase previous lines          176

      BEGIN                          \ wait for buffer to fill up
         ?BUFFER.SWITCH
          1  ?task.state  3  =  or
      UNTIL                                                          181

      ?BUFFER.A/B                    \ choose which buffer to plot
      if
        8  0  do
               23   i 6 +  goto.xy    db1   [ 1 , i 1 + ] conv  .    186
               55   i 6 +  goto.xy    db1   [ 1 , i 9 + ] conv  .
              loop
               \ 66 15 goto.xy .time
      ELSE
        8  0  do                                                     191
               23   i 6 +  goto.xy    db2   [ 1 , i 1 + ] conv  .
               55   i 6 +  goto.xy    db2   [ 1 , i 9 + ] conv  .
              loop
              \ 66 15 goto.xy .time
        THEN                                                         196

      1 ?task.state 3 = ?key if pckey drop
                                if exit then
                             then  False or
    UNTIL                                                            201
;

: CLEAN.UP                           \ clean up the system state when done
   LINE.BUFFER.OFF
   AXIS.DEFAULTS                                                     206
   SCREEN.CLEAR b.t
   CR ." Data acquisition finished"
   BELL.2sl
;
   screen.clear cal.upper.wnd  {border}                              211
```

```
   screen.1 {border}
   tmp.word {border}

: doIT               \ overall functioning
   \ = PROMPT'EM         \ write out prompts                          216
   \ = SET.GRAPHICS      \ Set up graphics area and scaling
   START.ACQ          \ Start up the tasks
   fixed.screen
   cal.IT            \ Plot the data continuously
   STOP.ACQ           \ Stop tasks                                    221
   \ = CLEAN.UP
;

doit
color.on                                                            226
my.def.colors
\ ================================================================

lower.inner.wnd {border}
bell.1LL                                                            231
normal.display
forget forget.mark.cal
\ ================================================================
```

LSTA-0.TXT

A01807-20161220-A010 ❖ December 20, 2016 ❖ [Page count: 25]

```
\
\ ================================================================
\ lsta-0
\ Keywords       :  1. Create ASCII data files w or w/o unit conversion
\                   2. Data statistics
\                   3. Autocorrelation
\                   4. Power spectrum
\                   5. Wavelet transform
\                   6. File to array  &  Array to file
\
\ Written        :  Nov. 1993 by  Y-R Lee
\ ================================================================
1 29.flag :=
echo.off
{29.line}
\ echo.on
axis.defaults
: menu.word
  menu.flag 0 =
  if
    forget.all
  then
; menu.word
: lsta-0 ;

token     rds.a               exp.mem> rds.a
token     freq.a              exp.mem> freq.a
token     rds.a.app           exp.mem> rds.a.app
token     p.s.a.div           exp.mem> p.s.a.div
token     v.4&5               exp.mem> v.4&5
\ ================================================================
integer scalar v.4&5.size
        scalar #.sec
        scalar lin.#
        scalar f.no.c

3       string h&v.flag

dp.real    scalar v.min

integer scalar i.1
        scalar i.2
        scalar i.3
        scalar v.4&5.size
        scalar plot.flag
        scalar p.s.d.flag
        scalar shif.flag.2
\       scalar menu.flag
real    scalar v.4
        scalar v.5

integer scalar elem.no
```



```
        scalar #.chnl.p
        scalar #.item.p
        scalar console.flag
        scalar a.c.c.p.flag
        scalar p.s.plt.flag
        scalar wt.flag
\  1             console.flag  :=  \ 1: no output for item 1--12 , only
   p.s.d
0               console.flag  :=  \ 1: no output for item 1--12
: menu.word
  menu.flag 0 =
  if
    dir.lee.txt   " def-winn.nam"  "cat   defer> load
    dir.lee.txt   " def-acqn.nam"  "cat   defer> load
    dir.lee.txt   " def-anan.nam"  "cat   defer> load
  then

; menu.word
dir.lee.txt   " dwt.txt"  "cat  defer>  load
\ %%

\ 0  menu.flag  :=
: initial.parameter
  20              n.pwtset   :=
  1               #.item.p   :=
  2               #.chnl.p   :=   \ for 5D array
  3  0  fix.format
  cr
  " P.S.D:" s.type
\  0  get.val  p.s.d.flag   :=
  1    p.s.d.flag   :=
  0    p.s.d.flag   :=
  " shift:" s.type
\  0  get.val  shif.flag  :=
\ \  0    shif.flag  :=
  " Plot:" s.type
\  0  get.val  plot.flag  :=
  0    plot.flag  :=
  ." nor.type(X/N):"
\   " X"    get.str  nor.type  ":=
  " X"      nor.type  ":=
  ." ope.type(___/rat/dif):"
\   " ___"  get.str  ope.type  ":=
  " ___"    ope.type  ":=

    " ver"   h&v.flag  ":=
  \ " hor"   h&v.flag  ":=

    " d"     xeq.flag  ":=
  \ " N"     nor.type  ":=
  \ " X"     nor.type  ":=
  \ " ___"   ope.type  ":=   \ No operation for base
  \ " rat"   ope.type  ":=   \ ratio to base
  \ " dif"   ope.type  ":=   \ difference to base
     0       smo.flag   :=
```

```
  nor.type   " x"     "=  if      " X"      nor.type   ":=   then
  nor.type   " n"     "=  if      " N"      nor.type   ":=   then

  nor.type   " N"     "=                                                  111
  ope.type   " ___"   "=  and   if   " .sN"   file.ext   ":=  then
  nor.type   " N"     "=
  ope.type   " rat"   "=  and   if   " .sNR"  file.ext   ":=  then
  nor.type   " N"     "=
  ope.type   " dif"   "=  and   if   " .sND"  file.ext   ":=  then          116
  nor.type   " X"     "=
  ope.type   " ___"   "=  and   if   " .sX"   file.ext   ":=  then
  nor.type   " X"     "=
  ope.type   " rat"   "=  and   if   " .sXR"  file.ext   ":=  then
  nor.type   " X"     "=                                                  121
  ope.type   " dif"   "=  and   if   " .sXD"  file.ext   ":=  then

    0               a.c.c.p.flag  :=
    0               p.s.plt.flag  :=
\    1               p.s.plt.flag  :=                                     126
    0               wt.flag       :=
  1  plot.flag  =
  if
    0               a.c.c.p.flag  :=
    1               p.s.plt.flag  :=                                     131
    1               wt.flag       :=
  then
;
initial.parameter
                                                                         136
\ : 1st.token        token.2  sub[ 1025 , 1024 ]  ;    \ r03 -> 2&3
\ : 2nd.token        token.3  sub[ 1025 , 1024 ]  ;    \ r03 -> 2&3
  : 1st.token        token.1                      ;    \ r03 -> 2&3
  : 2nd.token        token.2                      ;    \ r03 -> 2&3
: p.s.xy.flag      xoyo  xnyn ;                                          141
: wt.xy.flag       xlyl  xnyn ;

\ ------------------------------------------------------------------
: menu.word.2
  menu.flag 0 =                                                          146
  if
\    dir.lee.txt  " def-acqs.spe"  "cat   defer> load
\    dir.lee.txt  " def-ana1.1sp"  "cat   defer> load
  then
\    def.values.ana                                                      151
    dir.lee.txt  " def-acqs.spe"  "cat   defer> load
    dir.lee.txt  " def-ana1.1sp"  "cat   defer> load
  dir.lee.txt  " def-anat.tsp"  "cat   defer> load
  dir.lee.txt  " lcri.cri"      "cat   defer> load
; menu.word.2                                                            156
\ 0  smo.flag  :=

: reset.dig.mid
\ ------------------------------------
  mid.flag  0  =   if   0      dig.mid :=   then                         161
```



```
  mid.flag  1  =   if   2048   dig.mid :=   then
  mid.flag  2  =   if   256    dig.mid :=   then
\ ------------------------------------
;
\ reset.dig.mid                                                          166

: find.s.chnls
\  bat.flag  "upper " Y" "= not
\  if
    input.case.flag                                                      171
\  then
;
find.s.chnls

dir.lee.txt  " Coef-" "cat  " gp"      "cat  " .dat" "cat   defer> load   176
\  put   " eee"  " r03"  " h01"  " ldv"
dir.lee.txt  " Coef-" "cat  " gp"      "cat  " .txt" "cat   defer> load
\  check exist
dir.lee.txt  " Coef-" "cat  cnst.flag  "cat  " .dat" "cat   defer> load
dir.lee.txt  " get-s-ch.txt"                         "cat   defer> load   181

{29.line}

: change.parameter
  case.flag  " ind"  "=  not                                             186
  if
  nor.type   " N"    "=
  ope.type   " ___"  "=  and   if   " -N.sta"   file.ext  ":=  then
  nor.type   " N"    "=
  ope.type   " rat"  "=  and   if   " -NR.sta"  file.ext  ":=  then      191
  nor.type   " N"    "=
  ope.type   " dif"  "=  and   if   " -ND.sta"  file.ext  ":=  then
  nor.type   " X"    "=
  ope.type   " ___"  "=  and   if   " -X.sta"   file.ext  ":=  then
  nor.type   " X"    "=                                                  196
  ope.type   " rat"  "=  and   if   " -XR.sta"  file.ext  ":=  then
  nor.type   " X"    "=
  ope.type   " dif"  "=  and   if   " -XD.sta"  file.ext  ":=  then
  then
;                                                                        201
change.parameter

\ for p.sub & plt
  1                 i.1          :=  \ lin.#
  1024              i.2          :=  \ fft.pts                           206
  7                 i.3          :=  \ #.sec
  .01               v.4          :=  \ Hz_init
  20.               v.5          :=  \ Hz_end
  0.1               v.4          :=  \ Hz_init
  10.               v.5          :=  \ Hz_end                            211

\ ------------------------------------------------------------------
 21                 v.4&5.size   :=
 real  dim[  v.4&5.size  ] unnamed.array
 dup   becomes> p.s.a.div                                                216
```

```
       becomes> v.4&5

\ v.4&5 @[ 1 ]  enter[
\  0.01 , 0.10 , 0.50 , 1.00 , 1.50  ,
\  1.75 , 2.00 , 2.25 , 2.50 , 2.75  ,                                  221
\  3.00 , 3.25 , 3.50 , 3.75 , 4.00  ,
\  4.50 , 5.00 , 6.00 , 8.00 , 10.00 ,
\ 20.00
\ ]
 v.4&5 @[ 1 ]  enter[                                                   226
  1.4  , 1.5  , 1.6  , 1.7  , 1.8   ,
  1.9  , 2.0  , 2.1  , 2.2  , 2.3   ,
  2.4  , 2.5  , 2.6  , 2.7  , 2.8   ,
  2.9  , 3.0  , 3.1  , 3.2  , 3.3   ,
  3.4                                                                   231
 ]
 v.4&5
 []size              v.4&5.size  :=
 v.4&5.size 1 -      #.elem      :=
 sub[ 1 , #.elem ]   becomes> el.a                                      236

 \ real  dim[ 1 , #.case , 2 , 1 , el.a.size ] unnamed.array
 \ real  dim[ 1 , #.case , #.chnl.p , #.item.p  , #.elem ] unnamed.array
   real  dim[ 1 , #.case , #.chnl.p , #.item.p  , #.elem ] unnamed.array
 dup  becomes> 5d.a          \ P.S. for channel 2 & 3                   241
      becomes> r.ba          \ for base

\ ------------------------------------------------------------------
\ p.s.plt
\ ------------------------------------------------------------------   246
: get.log.min
  11.  v.min :=
  begin
  dup
  v.min   1 -  v.min  :=                                                251
  10.  v.min  **    swap /     1.   <
  until
  10. v.min  **    v.min    :=
  drop
;                                                                       256

: p.s.div \ [ array , #.fft.pts , #.sec , wnd.str , div_array --  ]
  ."   "  " P.S.D"  s.type
  dup  1. *  becomes>  p.s.a.div
       1. *  becomes>  el.a                                             261
  wnd.str     ":=
  #.sec       :=
  #.fft.pts   :=
                                    \ #.plt.pts  ~  tmp.v.i.4
  #.fft.pts   #.sec   wnd.str     my.p.s.bat                            266
      v.4&5   [ 1 ]   s.freq /   #.fft.pts *   tmp.v.i.4  :=
      v.4&5.size  0 +  1
      do
          v.4&5   [ i 1 + ]   s.freq /   #.fft.pts *   #.plt.pts  :=
          dup                                                           271
```



```
          sub[  tmp.v.i.4  ,  #.plt.pts  tmp.v.i.4 - ]
          []sum  2.  *
          p.s.a.div  [ i ]  :=
          #.plt.pts   tmp.v.i.4  :=
      loop                                                              276
      drop
      0.    p.s.a.div [ v.4&5.size ]   :=
  "  OK"  s.type
;                                                                       281

\ ------------------------------------------------------------------
: p.s.sub
\ cr
\ " [ array , lin#, #.fft.pts , #.sec , s.wnd , Hz_b , Hz_e --  x_a ,
   y_a  ]"
\ s.type                                                                286
      tmp.v          :=   \  plt_hz_end   <  0.5 * s.freq
      tmp.v.4        :=   \  plt_hz_init  >  0.0
      wnd.str       ":=
      #.sec          :=
      #.fft.pts      :=                                                 291
      lin.#          :=
  tmp.v    #.fft.pts *   s.freq /     #.plt.pts   := \ plt_Hz --> #
     .plt.pts
  #.fft.pts   #.sec   wnd.str     my.p.s.bat
  sub[ 1 , #.plt.pts ]                \ y-array
                                                                        296
  #.plt.pts  real  ramp               \ x-array
  s.freq *   #.fft.pts /
  swap                                \ -->  x , y
      tmp.v.4  #.fft.pts *  s.freq /   tmp.v.i.4  :=
      swap  sub[  tmp.v.i.4 ,  #.plt.pts  tmp.v.i.4 - ]   \ --> y , x   301
      swap  sub[  tmp.v.i.4 ,  #.plt.pts  tmp.v.i.4 - ]   \ --> x , y
;

\ ------------------------------------------------------------------
\ ------------------------------------------------------------------   306
: p.s.plt  \ [ array , line.# , #.fft.pts , #.sec , s.wnd , Hz_b , Hz_e
   -- ]

  nd
  cr
  "  [ array , line.# , #.fft.pts , #.sec , s.wnd , Hz_b , Hz_e -- ]"  311
  s.type
  p.s.sub
  dup  []min/max       tmp.v   :=     \ v_world_set
\ dup  []min/max   drop     0.02    tmp.v   :=     \ v_world_set for r03
   -w111
  get.log.min                                                           316
  xy.data.fit

  gd
  p.s.xy.flag
  10  10  axis.divisions                                                321
  vertical
```

```
     " o"  y.axis.flag  "=   \ y_log
     if
         \ grid.off
         0          1  label.points                                    326
         -1.2  0.0  9  label.format
         -0.8  0.6  9  label.format
         -1.0  0.6  6  label.format
         10    6       axis.divisions
         0.0000001    0.10                                world.set     331
         \  v.min        tmp.v                                world.set
         \  ! Don't remove the above two lines
         axis.on
     else
         0          2  label.points                                    336
         -1.2  0.0  5  label.format
     \   0.           0.050                               world.set
     \ \    0.           0.015                                world.set
         0.           tmp.v                               world.set
         axis.on                                                       341
     then
 horizontal
     " o"  x.axis.flag  "=   \ y_log
     if
         \  grid.off                                                   346
         10  10  axis.divisions
         0          1  label.points
         -0.5 -1.2  5  label.format
         8     12      axis.divisions
         tmp.v.4    #.plt.pts  float  s.freq *  #.fft.pts /           351
            world.set
         axis.on
     else
         8   10  axis.divisions
         0          2  label.points
         -0.5 -1.2  5  label.format                                    356
\        0.         #.plt.pts  float  s.freq *  #.fft.pts /
   world.set
\        tmp.v.4    #.plt.pts  float  s.freq *  #.fft.pts /
   world.set
         v.4        v.5
            world.set
         axis.on
     then                                                              361

\ ------------------------------------------------------------------
 hp
    xy.axis.plot
    lin.# xydp                                                         366
\     "  Frequency (Hz)"  " Power spectral (cm**2 sec)"  0.02
   labxy.stack
       "  Frequency (Hz)"  " Power density  (cm**2 sec)"  0.02
           labxy.stack
      normal.coords
      0.75  0.85    position
      datafile.dat.p23  "len  4 -  "left  datafile.dat.p2 ":=          371
```



```
      " Case: "  datafile.dat.p2   "cat               label
      0.    0.      position
      world.coords  \  ---> important
;                                                                      376
\ ------------------------------------------------------------------
: p.s.plt.lap  \ [ array , line.# , #.fft.pts , #.sec , s.wnd , Hz_b ,
   Hz_e -- ]
  p.s.sub
  world.coords
      lin.# xydp                                                       381
;
\ ------------------------------------------------------------------

\ real dim[ 2 , #.case , #.chnl , #.item ] unnamed.array  1. * becomes>
   rds.a
real dim[ 1 , #.case , #.chnl , #.item ] unnamed.array  1. * becomes>  386
   rds.a

: chnl.added   \  col.3 - col.4
  tmp.v.i.4  :=
  tmp.v.i.3  :=
        tmp.v.i.3  channel.const                                       391
        db0  xsect[ ! , tmp.v.i.3 ]
        chnl.no  smooth.spe   \ add 04-20-97
        shift.raw.data  \  by drift
        conv.formula
        smooth.xeq                                                     396
\        shift.raw.data  \  by drift
        tmp.v.i.4  channel.const
        db0  xsect[ ! , tmp.v.i.4 ]
        chnl.no  smooth.spe   \ add 04-20-97
        shift.raw.data  \  by drift                                    401
        conv.formula
        smooth.xeq
\        shift.raw.data  \  by drift
        -
;                                                                      406

: pre.unit.conv   \  [   -  sub.array ]
    chnl.no   s.chnls  <=
    if
        chnl.no  channel.const                                         411
        get.forced.spe.sta
        \ db0  xsect[ ! , chnl.no ]
        chnl.no  get.chan.data
        chnl.no  smooth.spe   \ add 04-20-97
        shift.raw.data  \  by drift                                    416
        conv.formula

        smooth.xeq
        cr ." ---------sss" smo.flag n.type
\        shift.raw.data  \  by drift                                   421
        dup  chnl.no  copy.to.token
```

```
    else
        3  2  chnl.added  \ 3 - 2
    then                                                          426
;

: show.flag
  1 0 fix.format  ."  ("
  ."  f"  smo.flag  0 n>s  s.type  ."  p"  smo.p      0 n>s  s.type      431
  ."  e"  coef.flag 0 n>s  s.type  ."  s"  shif.flag  0 n>s  s.type
  ."  w"  wnd.str          s.type   ."  )"
;
: c.d.a      \ create ASCII file  w/o filter
  cr mycase       "type                                               436
  show.flag
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    48  mytime  "len  -  spaces            "drop
  ." Sampling frequency    :"   s.freq              .    ."   Hz"
  cr specifics    "type    48  specifics  "len  - spaces           "drop  441
  ." Sampling time length  :"   s.length s.freq /   .    ."  Sec"

    s.length 1 +  1
    DO cr
      i  get.token.smooth.element                                 446
      s.chnls 1 +   1
      do
       \ i   item.format
       \ 10  4   fix.format
        11  4   sci.format                                        451
        tmp.array [ i ]
        .    ."      "
      loop
    loop
  cr                                                              456
;

: make.ascii
\ asc.str  " y"  "=
\ if                                                              461
    b.t ."      ----->  ASCII : " b.t  datafile.asc s.type  cr
    datafile.asc   defer>  delete
    datafile.asc   defer>  out>file
    console.off
    c.d.a                                                         466
    out>file.close
\ else
\   console.off  echo.off
\ then
;                                                                 471

\ : create.1d.data.file
\   1st.token datafile.dat.p23  "len  3   -  "left  " 1" "cat
   atof.bat
\   2nd.token datafile.dat.p23  "len  3   -  "left  " 2" "cat
   atof.bat
\ ;                                                               476
```



```
\ dir.asy.sys  " spfn.sov"  "cat  defer> load.overlay
: rain.sta
  deg.fre  300  >
  if  300  deg.fre  :=                                            481
  then

  \ with.frequencies
  without.frequencies
  cr                                                              486
  #.chnl  1 +   1
  do
    i  chnl.no  :=                    \ channel No.
    chnl.no  .                          \ channel No.
    pre.unit.conv                                                 491

    p.s.d.flag  0  <>
    if
      dup   1   i.2   i.3   wnd.str   v.4   v.5     p.s.sub
      swap  drop              \ drop x_array of p.s               496
      []sum
      2.  *                   \ <-----  due to symmetry
      \  i.2  float  /    \ already in density <-- don't divide by #
         .fft.pts
    else
      0.                                                          501
    then
    rds.a [ #w , #r , chnl.no , 12 ]  :=  \ spectrum integral

    p.s.d.flag  0  <>
    chnl.no     1  <>  and                                        506
    if
      dup   i.2   i.3   wnd.str    v.4&5     p.s.div
      v.4&5.size    1
      do
        p.s.a.div  [ i ]                                          511
        5d.a  [ #w , #r , chnl.no 1 - , 1 , i ]  :=
        \ spectrum integral
      loop
    then
                                                                  516
    dup                                 []size  tmp.v.i   :=
    mean                          dup             std.mea   :=
                          rds.a [ #w , #r , chnl.no , 1  ]  :=  \ mean
    \   dup   std.mea  -   dup  *   []sum       tmp.v.i  /
    dup                    dup  *   []sum       tmp.v.i  /       521
                          rds.a [ #w , #r , chnl.no , 11 ]  :=  \ rms ** 2
    dup
    \ ----- no more than 11000 elements due to Memory
    sub[ 1 , 10500 ]
    \ ------------------------------------------------            526
    sample.variance     sqrt    dup           std.dev   :=
                          rds.a [ #w , #r , chnl.no , 2  ]  :=  \ std.  dev.
    std.dev  tmp.v.i  sqrt / dup              std.err   :=
                          rds.a [ #w , #r , chnl.no , 3  ]  :=  \ std.
```

```
                        error
    1.    1. conf.int - 2. /  -   \ confidence interval fractile
          deg.fre    student-t.fractile
          std.err *  dup  2 *
                       rds.a [ #w , #r , chnl.no , 10 ]  :=  \ conf. int.
                            range
                     dup      std.mea       +    conf.l.u   :=
                              std.mea  swap -    conf.l.l   :=
    conf.l.u           rds.a [ #w , #r , chnl.no , 4  ]  :=  \
    conf.l.l           rds.a [ #w , #r , chnl.no , 5  ]  :=  \
    tmp.v.i            rds.a [ #w , #r , chnl.no , 6  ]  :=  \ []size
    std.mea tmp.v.i *  rds.a [ #w , #r , chnl.no , 7  ]  :=  \ total
    []min/max          rds.a [ #w , #r , chnl.no , 8  ]  :=  \ max
                       rds.a [ #w , #r , chnl.no , 9  ]  :=  \ min
  loop

  #r  1 +  #r :=
  \  release.overlay
  asc.str  " y"  "=
  if
    make.ascii
  else
    console.off
  then
  \ \  create.1d.data.file
;
\ release.overlay
\ ================================================================
integer scalar dma.s.chnls
: d.d.o.c
  "dup   run.c.n   "[ #r ]  ":=
  \ d.d.o
  "dup
  dir.lee.asc  "swap "cat  " .asc" "cat  datafile.asc  ":=
  dir.lee.dat  "swap "cat  " .dat" "cat  defer> file.open
  1 comment>   mycase          ":=
  2 comment>   mydate          ":=
  3 comment>   mytime          ":=
  4 comment>   specifics       ":=
  5 comment>   datafile.dat.p23 ":=
  1 subfile    acq.input  file>array
               acq.input  [ 1 ]    t.rate   :=
               acq.input  [ 2 ]    s.length :=
               acq.input  [ 3 ]    s.freq   :=
               acq.input  [ 4 ]    s.chnls  :=
               acq.input  [ 5 ]    #.times  :=
  cr  ." ----------------"   #.times n.type

  acq.input  [ 1 ]    0  >
  if
    0                 #.times :=
  then
  #.times  0  =
  if
    2 subfile    file>unnamed.array  becomes> db0
```



```
  else
  then
  file.close
  real  s.length  ramp   becomes>  token.1
  0.  token.1  :=
  token.1   becomes>  token.2
  token.1   becomes>  token.3
  token.1   becomes>  token.4
  token.1   becomes>  token.5
  token.1   becomes>  token.6
  token.1   becomes>  token.7
  token.1   becomes>  token.8
  token.1   becomes>  token.9
  token.1   becomes>  token.10
  token.1   becomes>  token.11
  token.1   becomes>  token.12
  token.1   becomes>  token.13
  token.1   becomes>  token.14
  token.1   becomes>  token.15
  token.1   becomes>  token.16
  s.length     deg.fre          :=
  integer  dim[ s.length        ] unnamed.array  1. *  becomes> freq.a
  1. freq.a :=
  cr  show.flag    3 2 fix.format ."  conf:"  conf.int   .
  ."    "  " <----: " datafile.dat.p23  s.type
  5 0 fix.format
;

\ ================================================================
integer scalar #.c.app
2  #.c.app  :=
real dim[ 2 , #.case , #.c.app , #.item ] unnamed.array  1. * becomes>
   rds.a.app

: create.rds.a.app
  #.item 1 + 1   \  for appendix channel No.1
  do
    i  item.no  :=
    #r   1
    do
      i  case.no  :=
      \     #.c.app 1 +   1
      1       1 +   1
      do
        i  chnl.no  :=
        rds.a     [ #w , case.no ,    3    , item.no ]
        rds.a     [ #w , case.no ,    2    , item.no ]  /
        rds.a.app [ #w , case.no , chnl.no , item.no ]  :=
      loop
    loop
  loop

  #.item 1 + 1   \  for appendix channel No.2
  do
    i  item.no  :=
```

```
    #r    1
    do
      i   case.no   :=
\   1.   rds.a.app [ #w , case.no ,     2     , item.no ]    :=   \ initial
      2        1 +    2
      do
        i   chnl.no   :=
        rds.a.app [ #w , case.no ,     1     , item.no ]
        rds.a.app [ #w ,    1     ,     1     , item.no ]   /
        rds.a.app [ #w , case.no , chnl.no , item.no ]   :=
      loop
    loop
  loop
;
\ ================================================================
\ dir.lee.txt   " 1.1"   "cat   defer> load
\ ================================================================
: create.5d.a.X&N
  nor.type   " N"   "=
  if
    #.chnl.p   1 +   1
    do
    i   chnl.no   :=
      #.case   1 +    1
      do
        i      case.no   :=
        0.       tmp.v   :=
        #.item.p 1 +   1
        do
          i   item.no   :=
          #.elem 1 +    1
          do
            i elem.no   :=
            5d.a    [ #w , case.no , chnl.no , item.no , elem.no ]
            tmp.v   +       tmp.v   :=
          loop \ elem
          #.elem 1 +    1
          do
            i   elem.no :=
            5d.a    [ #w , case.no , chnl.no , item.no , elem.no ]
            tmp.v   /
            5d.a    [ #w , case.no , chnl.no , item.no , elem.no ]   :=
          loop   \ elem
        loop   \ item.p
      loop   \ case
    loop   \ chnl
  then
;

\
   ------------------------------------------------------------------------

: operation.binary
  ope.type   " rat"   "=   if       /     then
  ope.type   " dif"   "=   if       -     then
```



```
;
: ratio.or.difference.to.base
  ope.type   " rat"   "=
  ope.type   " dif"   "=    or
  if
    #.item.p     1 +    1    \ set base
    do
      i   item.no    :=
      #.chnl.p   1 +   1
      do
        i   chnl.no   :=
        #.case 1 +   1
        do
          i      case.no   :=
          #.elem 1 +     1
          do
              i   elem.no :=
              5d.a   [ #w , case.no , chnl.no , item.no , elem.no ]
              r.ba   [ #w , case.no , chnl.no , item.no , elem.no ]   :=
              \   cr     elem.no   .   chnl.no .    case.no .    item.no   .
              \     r.ba   [ #w , case.no , chnl.no , item.no , elem.no ]
                  .
          loop \ v.4&5
        loop \ case 1
      loop \ tmp.v.i
    loop   \ elem.app

    #.item.p     1 +    1
    do
      i   item.no    :=
      #.chnl.p   1 +   1
      do
        i   chnl.no   :=
        #r    1
        do
          i      case.no   :=
          #.elem 1 +     1
          do
            i   elem.no :=
            5d.a   [ #w , case.no , chnl.no , item.no , elem.no ]
            r.ba   [ #w ,     1     , chnl.no , item.no , elem.no ]        \
                 case 1
            operation.binary
            5d.a   [ #w , case.no , chnl.no , item.no , elem.no ] :=
          loop \ v.4&5
        loop \ case
      loop \ tmp.v.i
    loop   \ elem.app
  then
;
\ ================================================================
10              t.fmt.width   :=
: el.a.fmt
  " hor"   h&v.flag   "=
  if
```

```
    t.fmt.width          2           fix.format
    else
    t.fmt.width  0 -     2           fix.format                    746
  then
;
: data.format
  " N"  nor.type  "=
  if                                                               751
    t.fmt.width          4           fix.format
  else
    t.fmt.width  0 -     5           fix.format
  then
;                                                                  756
: get.item.title
  12          item.title
  item.name   s.type
  show.flag
                      ."   Wnd:"  wnd.str  s.type                  761
  4 0 fix.format      ."   fft:"   i.2  n.type
  1 0 fix.format      ."   sec:("  i.3  n.type  ." *2+1)"
  5 2 fix.format      ."   Freq:"  v.4  n.type  ." --"   v.5  n.type
  cr
  ."    Chan."                                                     766
  1 0 fix.format
  i   1 +   .   \ for r03
  \ i   .
  ." ("  nor.type  s.type  ." )"
;                                                                  771
: arrange.3d.a.asc.p  \  <-- el.a , run.c.n ,  3d.a
  becomes>  a.token
  #.las.loop 1 +  1
  do
      get.item.title                                               776
      \  print column titles
      " hor"  h&v.flag  "=  if   ."   "         then
      " ver"  h&v.flag  "=  if   ."     "       then
      #.inn.loop 1 +      #.col.ini  #.col +    <
      if                                                           781
        #.inn.loop 1 +
      else
        #.col.ini      #.col     +
      then
             #.col.ini                                             786
      do
        " hor"  h&v.flag  "=
        if
          el.a.fmt
          el.a [   i     ] . \  ."   "                           791
        else
          run.c.n   "[    i    ]   "type   ."   "
        then
      loop
      cr                                                           796

      \  print raw title and data
```



```
      #.out.loop  1 +   1
      do
        " hor"  h&v.flag  "=                                       801
        if
          ."     "
          run.c.n   "[    i    ]   "type   ."   "
        else
          ."   "  \ 2 spaces     __t.fmt.width__                   806
          el.a.fmt
          el.a [    i    ] .
          ."   "
        then
                                                                   811
        #.inn.loop 1 +       #.col.ini   #.col  +     <
        if
          #.inn.loop  1 +
        else
          #.col.ini  #.col +                                       816
        then
                   #.col.ini
        do
          data.format
          a.token      [  k  ,  j  ,  i  ]   .                     821
        loop
        cr
      loop
      cr
  loop                                                             826
;
: arrange.3d.a.asc           \ for case 1st , channel 2nd  [ array -- ]
  100  #.col            :=   \ increment , place at the same row
  10   #.col            :=   \  Cases arranged in the same row
  1    #.col.ini       :=                                          831
  begin
    dup
    arrange.3d.a.asc.p
    #.col       #.col.ini     +   #.col.ini       :=
    #.inn.loop  #.col.ini       <=                                 836
  until
  drop
;
token  t9    exp.mem> t9
: create.3d.a.asc                                                  841
  #.chnl.p   #.las.loop :=    \ 3rd
\ #r 1 -     #.out.loop :=    \ 2nd
\ #.elem     #.inn.loop :=    \ 1st

  " hor"  h&v.flag  "=                                             846
  if
    #r 1 -      #.out.loop :=
    #.elem      #.inn.loop :=
  else
    #r 1 -      #.inn.loop :=                                      851
    #.elem      #.out.loop :=
  then
```

```
  real dim[  #.las.loop , #.out.loop , #.inn.loop  ]  unnamed.array
  becomes> 3d.a                                                          856

      create.5d.a.X&N
      ratio.or.difference.to.base

  p.s.d.flag  0   <>                                                     861
  if
    #.item.p    1 +   1        \ 4th D
    do
      5d.a
      sub[ #w ;  1 , #r 1 - ;  1 , #.chnl.p ;  1 , #.item.p ;  1 , #     866
          .elem ]
      []copy  becomes>  t9
      t9
      " hor"  h&v.flag  "=
      if
           \         #r   #chnl              #.elem                      871
           \         out  las                inn
        xsect[ #w , ! ,  !     ,    i    , ! ]  []copy
           \ [       1 ,  2                  3 ]
        trans[       1 ,  2  ]                  []copy
      else                                                               876
           \         #r   #chnl              #.elem
           \         inn  las                out
        xsect[ #w , ! ,  !     ,    i    , ! ]  []copy
        becomes> t8     t8
        trans[       1 ,  2  ]                  []copy                  881
        becomes> t7     t7
        trans[       2 ,  3  ]                  []copy
        becomes> t6     t6
      then
      becomes> 3d.a                                                      886
      3d.a
      arrange.3d.a.asc
    loop
  then
; cr                                                                     891
\ ================================================================
: create.rain.sta.ary.asc
  1  console.flag  =
  if
    console                                                              896
  then
  \ \** create.rds.a.app
  #.item 1 + 1
  \ 2 1
  do                                                                     901
    i  item.no  :=
    item.no  item.title
    item.name  s.type
    show.flag
    item.no   dup  dup  dup  1 =  4 =  5 =  10 =  or  or  or            906
    if
```



```
      3 2 fix.format       ."  conf:"  conf.int   .
    then
    item.no   dup  1 =  12 =  or
    if                                                                   911
                           ."   Wnd:"  wnd.str  s.type
      4 0 fix.format       ."   fft:"   i.2  n.type
      1 0 fix.format       ."   sec:("  i.3  n.type  ." *2+1)"
      5 2 fix.format       ."   Freq:"  v.4  n.type  ." --"   v.5  n.type
    then                                                                 916
    item.no  item.format
    cr
    #r   1
    do
      i  case.no  :=                                                     921
      ."     "   run.c.n   "[ case.no ]   "type   ."   "
      #.chnl 1 +   1
      do
        i  chnl.no  :=
        rds.a [ #w , case.no , chnl.no , item.no ] .                     926
      loop
    \  print out of appended channels
    \  #.c.app 1 +   1
    \  do
    \    i  chnl.no  :=                                                  931
    \    rds.a.app  [ #w , case.no , chnl.no , item.no ] .
    \  loop
      cr
    loop
    cr                                                                   936
  loop
  cr
  1  console.flag  =
  if
    out>file.cont                                                        941
  then
  create.3d.a.asc
; cr

\                                                                        946
   ~~~
```

```
  #.pts  tmp.v.i.3 /  tmp.v.i.4  :=                                          961
  datafile.dat.p23  "len  4 -  "left  datafile.dat.p2  ":=
  1st.token sub[ tmp.v.i.2 , #.pts ] a.c.c
  \ sub[ #.pts ,  tmp.v.i.4 ]  swap  sub[ #.pts ,  tmp.v.i.4 ]   swap
  sub[ #.pts ,  tmp.v.i.4 ]  sub[ 1 , plt.pts ]
  swap                                                                       966
  sub[ #.pts ,  tmp.v.i.4 ]  sub[ 1 , plt.pts ]
  swap
  gd
  vertical
        0          2  label.points                                           971
        -1.2  0.0  4  label.format
        10    10      axis.divisions
  axis.on
  -1.   1.   world.set
  horizontal                                                                 976
        0          2  label.points
        -0.5 -1.2  5  label.format
  axis.on
  \  0.    tmp.v.i.4  s.freq /   world.set
  0.    plt.pts     s.freq /   world.set                                       981
  up   1  xy.axis.plot  xydp
       "  Time (sec),  [Up-stream (WG1)] "  " Correlation"    0.02
          labxy.stack
       normal.coords                    0.75  0.85    position
       " Case: "  datafile.dat.p2   "cat               label
  2nd.token    sub[ tmp.v.i.2 , #.pts ] a.c.c                                986
  sub[ #.pts ,  tmp.v.i.4 ]  sub[ 1 , plt.pts ]
  swap
  sub[ #.pts ,  tmp.v.i.4 ]  sub[ 1 , plt.pts ]
  swap
  dp   5  xy.axis.plot  xydp                                                 991
       " Time (sec),  [Down-stream (WG2)]"  " Correlation"    0.02
          labxy.stack
       normal.coords                    0.75  0.85    position
       " Case: "  datafile.dat.p2   "cat               label
       \ hp   datafile.dat.p2  " .acb"  "cat           dump.p.o.stack
       cda                                                                   996
       hp
       datafile.dat.p2  " .pac"  "cat         defer>   vup>pcx
  cdt
;                                                                            1001
\
   ------------------------------------------------------------------------

real  scalar a.v
      scalar b.v
: log.line.bat  \ y = a * x ** b  \ [ slope(b) , lin_# , a , init_x -- ]
             tmp.v.2  :=                                                     1006
             a.v      :=
             lin.#    :=
             b.v      :=
  10
  a.v  **    a.v      :=                                                     1011
```



```
  y.axis.flag  " o"  "=
  if
    7.  real ramp   tmp.v.2  +    \ for log plot
  else
    20. real ramp  8.  /  tmp.v.2  +    \ for linear plot                  1016
  then
  dup
  b.v  **  a.v *
  lin.#  xydp
;                                                                            1021

: log.6    -6.    2   0.1   2.5  log.line.bat   ;
: log.5    -5.    5   0.1   2.5  log.line.bat   ;
: log.4.5  -4.5   4   0.1   2.5  log.line.bat   ;
: log.4    -4.    3   0.1   2.5  log.line.bat   ;                           1026
: log.3.5  -3.5   2   0.1   3.5  log.line.bat   ;
: log.3    -3.    1   0.1   4.5  log.line.bat   ;

: log.line   \ y = a * x ** b
  " Y=A X ** b "  s.type                                                     1031
  "  b :    " s.type
  -6.       get.val  b.v  :=
  " A=10**a <-- a:" s.type
  10
  0.        get.val  **    a.v  :=                                           1036
  "  X_init : " s.type
  1.        get.val   tmp.v.2  :=
  "  line.#" s.type
  2         get.val  lin.# :=
  b.v  lin.#  a.v  tmp.v.2  log.line.bat                                     1041
;

\
   ------------------------------------------------------------------------


: p.s.plt.all                                                                1046
  nd
  datafile.dat.p23  "len  4 -  "left  datafile.dat.p2  ":=
  gd
  ." OKKK"
\ 1st.token  1  1024   7   " b"   0.1   10.            p.s.plt              1051
  1st.token  1  i.2   i.3   wnd.str   v.4   v.5           p.s.plt
  2nd.token  5  i.2   i.3   wnd.str   v.4   v.5           p.s.plt.lap
  log.3  log.3.5  log.4  log.4.5  log.5

  normal.coords                                                              1056
  0.    0.      position
  world.coords  \  ---> important

  \  datafile.dat.p2  " .psb"  "cat                  dump.p.o.stack
  cda                                                                        1061
    datafile.dat.p2  " .pps"  "cat         defer>   vup>pcx
  cdt
;
```

```
\
   ~~~
```

```
  abc.d.p1      1 subfile  TOKEN.1  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.2  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.3  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.4  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.5  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.6  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.7  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.8  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.9  array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.10 array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.11 array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.12 array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.13 array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.14 array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.15 array>file   abc.d.p2
  abc.d.p1      1 subfile  TOKEN.16 array>file   abc.d.p2
  cr  ." --- SCROLL data file created ---"
;

\ create.abc.dat
integer scalar clear.flag
: create.ind.dat
  s.chnls 1 +  1
  do
    i
    96 +
    ascii"
    DIR.LEE.ASC   "swap  "CAT " .dat" "cat
    cr "dup    "type
    defer>  file.open
    1 subfile    file>unnamed.array
    file.close

    datafile.dat.p23  "len  3   -  "left

\    i
\    48  +
\    ascii"                        "cat
    i   0  n>s    "cat
    "dup   defer> delete
    atof.bat
    drop  \ <-- clear.flag
  loop

  clear.flag 1 =
  if
  \  s.chnls *drop
  then
;
\ " n"  my.pause.flag ":=

DIR.LEE.TXT  " get-x-n.TXT"  "CAT   defer>  LOAD
parameter.1

DIR.LEE.TXT  " lsta-mai.TXT"   "CAT   defer>  LOAD
```



```
\ DIR.LEE.TXT  " lsta-mai.ASY"   "CAT   defer>  LOAD
\ DIR.LEE.TXT  " lsta-m-e.TXT"   "CAT   defer>  LOAD

\
  ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

: ref.ana.xeq    \  dummy
;

\ ================================================================
1  abc.mid.flag  :=
\ " y"  h.c.str     :=   \ plot's hard.copy
1  file.no  :=
1  clear.flag :=
\ 0  i.p.c      :=    \ same gp extension --- make.abc
1  i.p.c     :=       \ individual name    --- make.ind  --> .p?
\ ================================================================
: data.sta.xeq
                  cr
                  d.d.o.c   #w .   #r .
                  parameter.2
                  rain.sta  cr
                  create.abc.dat
                  create.ind.dat
                  " ldv"  plot.ext  ":=
                  scr.str  " y"  "=  if
                  else
                    ldv.p.s.plot
                  then
                  wt.flag       1  =  if    wt.plt      then
                  a.c.c.p.flag  1  =  if    a.c.c.plt   then
                  p.s.plt.flag  1  =  if    p.s.plt.all then
  stack.clear
;

: xeq.flag.xeq
  " r"  xeq.flag  "=   if   ref.ana.xeq    then
  " d"  xeq.flag  "=   if   data.sta.xeq    then
;

\ \ Do not use in menu <-- Not enough memory for dictionary!
\ \ dir.asy.sys  " ar-edit.sov"  "cat  defer>  load.overlay
\ \ : aedd
\ \   dir.asy.sys  " ar-edit.sov"  "cat  defer>  load.overlay
\ \   db0   2048 dp>sp +
\ \           array.edit
\ \ \ release.overlay
\ \ ;
\ \ release.overlay

\ %% eps.flag  1 =
\ %% if
\ %% else  gd
\ %% then
\ %% hp
```

```
dir.lee.txt  " def-ana3.3sp"  "cat   defer> load
\ dir.lee.txt  " get-s-ch.txt"                          "cat   defer>
   load
                                                                      1271
{mes.wnd}
1  file.no  :=
sta.or.ana.xeq
nd
: menu.word                                                           1276
  menu.flag  0 =
  if
    view.str  " y" "= if  DIR.LEE.TXT  " SCR-new.TXT"  "CAT  defer> LOAD
       then
  else
    non.stop.str  " n"  "=                                            1281
    view.str  " y"      "=
    scr.str  " y"       "=  or   and
    if  DIR.LEE.TXT  " SCR-n-m.TXT"  "CAT  defer> LOAD then

    \    forget/clr  lsta-0                                           1286
    axis.defaults
    forget  lsta-0
  then
  bell.3dn
;                                                                     1291

menu.word
cdt
```

LSta-mai.asy

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```
: LSta-Mai.asy ; \ %----- Asyst Prog                                    1
\ ------------------------------------------------------------------
: ldv-ps-n ;      \ lsta-mai
\ ------------------------------------------------------------------
integer scalar mkl.bat.flag
1 mkl.bat.flag  :=                                                    6

: set.eps
  1  eps.flag :=
  0  lc.flag :=
;                                                                     11
: set.mon
  0  eps.flag :=
  1  lc.flag :=
;
: tmp.word                                                            16
  eps.flag  1 =
  if    set.eps
  else  set.mon
  then
; tmp.word                                                            21
18 font.size.l :=
16 font.size.n :=
" Times-Roman"  font.type.n  ":=
\ " Times-Bold"   font.type.n  ":=
                                                                      26
\ horizontal grid.off
\ vertical   grid.off

\ ********************
: set.lc                                                              31
  lc.flag 0  =
  if
    0   lc1 :=
    lc1 lc2 :=  lc1 lc3 :=  lc1 lc4 :=  lc1 lc5 :=  lc1 lc6 :=
  else                                                                36
    \  select.color
    0  lc1 :=    9 lc2 :=   12 lc3 :=
    13 lc4 :=   11 lc5 :=   10 lc6 :=    0 lc7 :=
    \   9 lc1 :=   12 lc2 :=   10 lc3 :=
    \  13 lc4 :=    0 lc5 :=   11 lc6 :=    0 lc7 :=                 41
    \ 0 lc.flag :=
  then
; set.lc

    integer scalar  iii                                               46
            scalar  #.sec
            scalar  #.sec.fix
            scalar  channel.#
            scalar  line.#
            scalar  c.#.b                                             51
            scalar  i.p.c
```



```
            scalar  #.lines
            scalar  yo.flag
    real    scalar  y.v.min
    real    scalar  y.v.max                                           56
    real    scalar  x.v.min
    real    scalar  x.v.max
    real    scalar  y.lab.shift
\ 32  string  y.label
\ 64  string  misce.str                                               61

\ " Power density  (cm**2 sec)"  y.label ":=
" Power density  (cm^2 sec)"  y.label ":=
: f.limits
  cr.str  " x"  "=                                                    66
  if
    9.999 f.end  :=
    0.001 f.beg  :=
    8.000 f.end  :=
    0.001 f.beg  :=                                                   71
  then
  s.freq  float  #.fft.pts float  /     f.beg  >
  if
\    index 1 -> zero frequency
\    s.freq  float  #.fft.pts float  /   f.beg :=                     76
\    s.freq  float  #.fft.pts float  /   f.beg :=
  then
  s.freq  float  2.               /     f.end  <
  if
    s.freq  float  2.               /   f.end  :=                     81
  then
; f.limits

\ " ll" xy.axis.str ":=
                                                                      86
: tmp
  xy.axis.str   " oo"  "=
  xy.axis.str   " lo"  "=  or
  if
    1      yo.flag     :=                                             91
  else
    0      yo.flag     :=
  then
; tmp
999    #.sec.fix       :=                                             96
\ " y"   offset.str ":=

: change.world.set      \ for restore y
  channel.#    2  <=
  if                                                                  101
    horizontal
      eps.flag 1 =
      if    -0.5   -1.0    5   label.format
      else  \ default  -0.5  -0.8  5
      then                                                            106
       x.v.min    x.v.max     world.set
```

```
        \       0.2         x.v.max      world.set
    vertical
      axis.fit.on
      -1.2         0        7    label.format
       y.v.min     y.v.max       world.set
       \       10. -5. ** 10. 1. **    world.set
  else
    horizontal
      eps.flag 1 =
      if     -0.5    -1.0     5    label.format
      else  \ default  -0.5  -0.8  5
      then
       x.v.min     x.v.max       world.set
       \       0.2         x.v.max      world.set
    vertical
      axis.fit.on
      -1.2         0        7    label.format
       y.v.min     y.v.max       world.set
       \       10. -6. ** 10.  0. **   world.set
  then
;
: tmp.set
      horizontal
      \    axis.fit.off
         axis.fit.on
         xy.axis.str  " ll"  :=
         if
\           0.              x.v.max          world.set
           x.v.min          x.v.max          world.set
         else
           x.v.min          x.v.max          world.set
         then
      vertical
         axis.fit.on
         \  -1.2         0        7    label.format
         y.v.min     y.v.max      world.set
;

: change.y.lab
    yo.flag 1 =
    if    \ lo oo
      0.01  y.lab.shift  :=
      xy.axis.str  " oo"  "=   if  xoyl  then
      xy.axis.str  " lo"  "=   if  xlyl  then

      xy.axis.str  " lo"  "=
      if
        10    \ x    --- no function for log scale
      else
        x.v.min  log  fix
        x.v.max  log  FLOOR 1 +   swap  -  3 *
      then
      y.v.min  log  fix
      y.v.max  log  FLOOR 1 +   swap  -
      axis.divisions
```



```
      horizontal
        xy.axis.str  " lo"  "=
        if
          axis.fit.on
          0.              x.v.max          world.set
        else      \  oo
          axis.fit.off
          x.v.min         x.v.max          world.set
        then

         \ axis.fit.on
      vertical
         axis.fit.off
         label.scale.off
         0  1  label.points  \ label every tick
         -1.2         0        4      label.format
         y.v.min  log  fix
         y.v.max  log  FLOOR 1 +   world.set
    else  \  ol  ll
    \      tmp.set
      xy.axis.str  " ol"  "=
      if
      horizontal
    \ axis.fit.on
      axis.fit.off
      x.v.min              x.v.max          world.set
      then
    then
;
10 string lab.app

: lo.shift.x
  xy.axis.str  " lo"  "=
  if
      swap
      x.v.max   x.v.min  -  0.4  *    +
      swap
  then
;

: lo.x
  xy.axis.str  " lo"  "=
  if
      x.v.max   x.v.min  -  0.01  *
  else
      0.
  then
;
: grid.line&axis.sta

  grid.flag 1 =
  if
    0.5  ps.linewidth
    vertical
      grid.on
```

```
      \    no.labels
    horizontal
      xy.axis.str " lo"  "=
      xy.axis.str " ll"  "=  or                                    221
      if  f.beg  f.end  world.set  then   \ added 07-23-97
      grid.on
           no.labels
    xy.axis.plot
  then                                                             226

    horizontal
      0  2                    label.points  \ restore axis label
      eps.flag 1 =
      \  1or2     1 =  and                                        231
      if    -0.5   -1.1    5   label.format
      else  \ default  -0.5  -0.8  5
      then
\    y.lab.str  " e"  "=  not
\    if     \ ll lo ol oo -- exp y                                236
\      vertical    \ Don't use in Lsta-mai
\        0  2                    label.points  \ restore axis label
\    then

  1.0  ps.linewidth                                                241
  vertical
    grid.off
    \    0  2  label.points
  horizontal
    grid.off                                                       246
    \    0  2  label.points
  xy.axis.plot
;

: label.xy.axis                                                    251
    y.lab.str  " e"  "=
    if     \ ll lo ol oo -- exp y
    \ %  yo.flag 1 = if    "   [10 ** ]"
      yo.flag 1 = if    "   [10^]"
                  else  "null        then  lab.app  ":=           256
      change.y.lab

      xy.axis.str " oo"  "=
      xy.axis.str " ol"  "=  or
      if  horizontal  axis.fit.off then                            261

      xy.axis.str " lo"  "=
      xy.axis.str " oo"  "=  or
      if  vertical    axis.fit.off then
                                                                   266
      xy.axis.str " lo"  "=
      xy.axis.str " ll"  "=  or
      if horizontal  f.beg  f.end  world.set  then   \ added 07-23-97
  \   if horizontal  0  f.end  world.set  then   \ added 07-23-97
                                                                   271
      horizontal  axis.on     \ add 04-11-97
```



```
      grid.line&axis.sta
      \ %% xy.axis.plot
      yo.flag 1 =   \ additional tick                              276
      if
        label.scale.on     \ restore   y
        xy.axis.str  " oo"  "=   if  xoyo  then
        xy.axis.str  " lo"  "=   if  xlyo  then
        change.world.set  \ restore   y                            281
        no.labels
        xy.axis.str  " lo"  "=
        if
          10   \ x   --- no function for log scale
        else                                                       286
          x.v.min  log  fix
          x.v.max  log  FLOOR 1 +   swap  -  3 *
        then
  \     10          \ x   --- no function for log scale
  \     x.v.min  log  fix                                          291
  \     x.v.max  log  FLOOR 1 +   swap  -  3 *
        y.v.min  log  fix
        y.v.max  log  FLOOR 1 +   swap  -  2 *
        axis.divisions
        vertical    axis.on   no.labels                            296
        horizontal  axis.off  no.labels
        grid.line&axis.sta
        \ %% xy.axis.plot
      then
    else    \ ll lo ol oo -- normal y                              301
      "null          lab.app  ":=
      \ change.y.lab
      change.world.set
      grid.line&axis.sta
      \ %% xy.axis.plot                                            306
    then
;
: mark.deviation
    yo.flag 1 =
    if                                                             311
      x.v.max   x.v.min  -  .00025 *   x.v.min  +
      x.v.max   x.v.min  -  .00025 *   x.v.min  +          catenate
      y.v.max         y.v.max  1  1  #.sec sqrt / - *       catenate
      lo.shift.x
      1  xydp         \  vertical bar                             316
      x.v.max   x.v.min  -  .00025 *   x.v.min  +
      x.v.max   x.v.min  -  .00002 *           -   lo.x -
      x.v.max   x.v.min  -  .00025 *   x.v.min  +
      x.v.max   x.v.min  -  .00002 *           +   lo.x +  catenate
      y.v.max         y.v.max                              catenate  321
      lo.shift.x
      1  xydp         \  Upper horizontal bar
      x.v.max   x.v.min  -  .00025 *   x.v.min  +
      x.v.max   x.v.min  -  .00002 *           -   lo.x -
      x.v.max   x.v.min  -  .00025 *   x.v.min  +                 326
      x.v.max   x.v.min  -  .00002 *           +   lo.x +  catenate
```

```
      y.v.max  1  1  #.sec sqrt / - *
      y.v.max  1  1  #.sec sqrt / - *                          catenate
      lo.shift.x
      c.2                                                                331
      1  xydp          \  Lower horizontal bar
      [ 2 ] swap [ 2 ] swap position
      "  ESD"  label
    else
      x.v.max   x.v.min  -  .2 *   x.v.min  +    dup          catenate    336
      y.v.max         y.v.max  1  1  #.sec sqrt / - *         catenate
      1  xydp
      x.v.max   x.v.min  -  .2 *   x.v.min  +
      x.v.max   x.v.min  -  .02 *          -
      x.v.max   x.v.min  -  .2 *   x.v.min  +                  341
      x.v.max   x.v.min  -  .02 *          +                  catenate
      y.v.max         y.v.max                                 catenate
      1  xydp
      x.v.max   x.v.min  -  .2 *   x.v.min  +
      x.v.max   x.v.min  -  .02 *          -                  346
      x.v.max   x.v.min  -  .2 *   x.v.min  +
      x.v.max   x.v.min  -  .02 *          +                  catenate
      y.v.max  1  1  #.sec sqrt / - *
      y.v.max  1  1  #.sec sqrt / - *                          catenate
      c.2                                                                351
      1  xydp
      [ 2 ] swap [ 2 ] swap position
      "  ESD(max)"  label
    then
;                                                                        356
\ ------------------------------------------------------------------ eps
vuport ps.hp.port
   .900  .900 vuport.size
   .050  .050 vuport.orig
vuport ps.up.port                                                        361
   .900  .440 vuport.size
   .050  .510 vuport.orig
vuport ps.dp.port
   .900  .440 vuport.size
   .050  .050 vuport.orig                                                366
: ps.hp
      ps.hp.port
      horizontal  normal.coords  0.85  0.10  label.scale.point
         world.coords
                                 0     2     label.points
      vertical    normal.coords  0.07  0.87  label.scale.point          371
         world.coords
                                 0     2     label.points
      ps.graphics ;
: ps.up
      ps.up.port
      horizontal  normal.coords  0.85  0.10  label.scale.point          376
         world.coords
                                 0     2     label.points
      vertical    normal.coords  0.07  0.87  label.scale.point
         world.coords
```



```
                                 0     2     label.points
      ps.graphics ;
: ps.dp                                                                  381
      ps.dp.port
      horizontal  normal.coords  0.85  0.10  label.scale.point
         world.coords
                                 0     2     label.points
      vertical    normal.coords  0.07  0.87  label.scale.point
         world.coords
                                 0     2     label.points                386
      ps.graphics ;
: hp.new
  eps.flag 1 =
  if      ps.hp  0 2.wnd.flag :=
  else    hp                                                             391
  then
\  outline.color color solid  outline
;
: up.new
  eps.flag 1 =                                                           396
  if      ps.up  1 2.wnd.flag :=
  else    up
  then
\  outline.color color solid  outline
;                                                                        401
: dp.new
  eps.flag 1 =
  if      ps.dp  1 2.wnd.flag :=
  else    dp
  then                                                                   406
\  outline.color color solid  outline
;
\ ------------------------------------------------------------------

: p.s.exec   \  [ chan.#, line.#, #.fft.pts, #.sec, " wnd", f.beg, f.end  411
    - ]
  f.end      :=
  f.beg      :=
  tmp.s     ":=
  #.sec.fix  :=
  #.fft.pts  :=                                                          416
  line.#     :=
  channel.#  :=
  \ index 1 -> zero frequency
  f.beg           s.freq float /   #.fft.pts *   ceiling  1 +  pt.beg
        :=
\   f.beg           s.freq float /   #.fft.pts *   ceiling  pt.beg       421
   :=
  f.end           s.freq float /   #.fft.pts *   floor    pt.end     :=

  tmp.s  wnd.str  ":=
  xy.axis.str   " ll"  "=  if  xlyl  then
  xy.axis.str   " lo"  "=  if  xlyo  then                                426
  xy.axis.str   " ol"  "=  if  xoyl  then
  xy.axis.str   " oo"  "=  if  xoyo  then
```

```
  int.flag 1 =
  if                                                                    431
    cda
    cr   file.name.ary "[ channel.# ]  ftoa.bat
    cdt
  else
    channel.#                                                           436
    96  +  ascii"   dir.lee.asc  "swap  "cat   " .dat"  "cat
    "dup  cr  "type   \  s.type
    defer>  file.open
    1 subfile  file>unnamed.array
    file.close                                                          441
  then

  offset.str  " y" "=
  if    \ currently default to offset to all channels
\   channel.#  1  =                                                     446
\   channel.#  2  =   or    \  shift mean value
    channel.#  channel.const.now
    ldv.flag 1 =
    if
      dup   []size   swap   []sum   swap  /    -                        451
    else
      dup   []size   swap   []sum   swap  /    -
    then
  then
                                                                        456
  #.fft.pts   #.sec.fix      wnd.str      my.p.s
  tmp.v.i.2   #.sec :=
  sub[ 1 , #.fft.pts   2 / ]
  \  find minumum of intrger power of 10
  get.x.freq                                                            461

  swap
       sub[ pt.beg ,  pt.end  pt.beg -  1 + ]
       dup  []min/max   x.v.max   :=
       x.axis.flag  " o"  "=                                            466
       if   get.log.min  v.min
       then
       x.v.min  :=
  swap
       sub[ pt.beg ,  pt.end  pt.beg -  1 + ]                           471
       dup  []min/max   y.v.max   :=
       y.axis.flag  " o"  "=
       if   get.log.min  v.min
       then
       y.v.min  :=                                                      476

  line.#  1  =
  if
    xy.data.fit
    \ " Times-Roman" font.size.n ps.font                                481
    font.type.n   font.size.n   ps.font
    label.xy.axis
```



```
    \ Ploting standard deviation mark
    world.coords                                                        486
    mark.deviation
    " Courier-Bold"  font.size.n  ps.font
    normal.coords
    0.75  0.98  position  d&t.string
      label
    datafile.dat.p23    "len  4 -  "left  datafile.dat.p2  ":=          491
    int.flag  1 =
    if
      0.60  0.86   position  tmp.s.2    label
    else
      0.75  0.9    position  " CASE : "  datafile.dat.p2   "cat   label  496
      0.75  0.86   position  " GROUP: "  c.#.b   48  +  ascii" "cat
            " --"   c.#.b  #.lines + 1 -  48  +  ascii" "cat "cat label
    then
    1.   1.    position
    world.coords                                                        501
  then
  line.#  xydp

  mkl.bat.flag  1 =
  if                                                                    506
      normal.coords
      int.flag 1 =
      if    0.60
      else  0.75
      then        0.82   key.orig                                       511

      line.#   dup
      int.flag  1 =
      if
        "spe.str   "[ line.# ]                mkl.bat                   516
      else
        " Chan. "  f.no.c  48  -  ascii"  "cat   mkl.bat
      then
      key.done
      world.coords                                                      521
  then
;

: make.ind
  int.flag 1 =                                                          526
  if
    file.name.ary "[ 7 ]
    " .pcx"  "cat
  else
    datafile.dat.p2                                                     531
    " .p"    "cat
    i.p.c  48  +  ascii"  "cat
  then
  hp
  ptof.bat                                                              536
;
```

```
\ ------------------------------------------------------------------
3 string  plot.ext
: hard.copy
    h.c.str   " n"   "=  \  or                                          541
    if
    else
      abc.mid.flag   1  =      \                          and
      if
        i.p.c  0  >                                                    546
        if
          make.ind
        else
          plot.ext    make.abc   \ Cannot be used in Menu
        then                                                            551
      else
        f.no.c  2.  /    f.no.c  2 /   -     0  =
        if
        i.p.c  0  >
          if                                                            556
            make.ind
          else
            plot.ext    make.abc   \ Cannot be used in Menu
          then
        then                                                            561
      then
    then
;

: gen.p.s.plot  \  [ " ext"  -- ]                                       566

  eps.flag  1  =
  if
    sd
    ibm.graphics    \ device.init  \ Don't use init                     571
    def.vuport
    3   0  fix.format
    cr ." ------------------------------"  cr ." --> EPS: " i.p.c
       n.type

    b.t                                                                 576
    int.flag  1 =
    if
      \ %      file.name.ary "[ 7 ]  " .eps" "cat
      cdf.now.str  file.name.ary "[ 7 ]  "cat
      "dup  s.type.3                                                    581
      defer> ps.file
    else
    \ datafile.dat.p2  i.p.c 0 n>s "cat " .eps" "cat  s.type.3
    \ datafile.dat.p2  i.p.c 0 n>s "cat " .eps" "cat  defer> ps.file
      datafile.dat.p23    "len  4 -  "left  datafile.dat.p2  ":=        586
      dir.lee.asc
      datafile.dat.p2  "cat  " .y" "cat  i.p.c  0 n>s "cat
      "dup  s.type.3
      defer> ps.file
    then                                                                591
```



```
    b.t b.t cr ." ------------------------------"
    ps.graphics
    11 8.5 ps.paper.size
    ps.encapsulate
    ps.landscape                                                        596
    ps.start
    " Courier-Bold"  font.size.n  ps.font
    1.0 ps.linewidth
    ps.hp  ps.up  ps.dp  \ initializing
    \  %% ps.hp                                                        601
    hp.new
    ps.graphics
  else
    gd hp
  then                                                                  606

c.#.b   96 +   f.no.c  :=  \ " a"
begin
    abc.mid.flag   1  =      \                          and
    if                                                                  611
    \ %      gd  \ clear
    then
    f.no.c  2.  /    f.no.c  2 /   -     0  <>
    if
    \ %      up2                                                        616
    else
    \ %      dp2
    then
    normal.coords
    0.75  0.98  position  d&t.string                                    621
       label
    datafile.dat.p23    "len  4 -  "left  datafile.dat.p2  ":=
    int.flag  1 =
    if
      0.60  0.86   position  tmp.s.2    label
    else                                                                626
      0.75  0.9   position  " CASE : "  datafile.dat.p2   "cat   label
      0.75  0.86  position  " GROUP: "  c.#.b   48  +  ascii" "cat
            " --"   c.#.b  #.lines + 1 -  48  +  ascii" "cat "cat label
    then
    1.   1.    position                                                 631
    world.coords
    1  line.#  :=
    begin
      normal.coords
      0.75  0.82   key.orig                                             636
      \ %%% line.#   dup    " Chan. "  f.no.c  48  -  ascii"  "cat
      key.done
      world.coords
      f.no.c  96 -  line.#  #.fft.pts #.sec.fix  wnd.str  f.beg f.end
         p.s.exec
      f.no.c 1 +  f.no.c :=                                             641
      line.# 1 +  line.#  :=
      line.#      #.lines  >
    until
```

```
  \ 0  color
  lc7  color                                                              646
  normal.coords
  0.02  0.98  position
  " (Pts:"  #.fft.pts 0 n>s "cat    " , Wnd:" "cat  wnd.str "cat
  " , DF:" "cat  #.sec 0 n>s "cat
  " , Offset:" "cat  offset.str  "cat                                     651
  " , Lowpass:" "cat
  smo.flag  0 =
  if     0
  else   smo.p
  then   0 n>s  "cat                                                      656
  " )" "cat
  misce.str  ":=
  \      "dup   cr s.type   cr ." Press key" 1 get.val  drop
  misce.str
  label                                                                   661

  \ %%  " 123456789 123456789 123456789 123456789 123456789 1234567890
     " label
  world.coords

  \ font.type.n   font.size.l   ps.font                                   666
  " Times-Bold" font.size.l ps.font
  x.label       y.label lab.app    "cat
  eps.flag  1  =   if 0.025 else 0.01 then    y.lab.shift +
     labxy.stack
  \ %    x.label y.label lab.app  "cat   0.01 y.lab.shift +
     labxy.stack
  eps.flag  1  =                                                          671
  if
  else
     hard.copy
     my.pause
  then                                                                    676

  f.no.c 1 +  f.no.c  :=
  f.no.c     97  c.#.b   #.lines   +  +   =
until
                                                                          681
eps.flag  1  =
if
  ps.end
  \ ibm.graphics
  def.vuport                                                              686
  \ sd
else
  gd  hp
then
\ \\ ibm.graphics \ device.init   \ Don't use this!                       691
gd  hp
\ \\ def.vuport

i.p.c  0  >
if                                                                        696
```



```
    i.p.c  1  +  i.p.c  :=
  then
  prn.str   " y"  "=
  eps.flag  1     <>   and
  if                                                                      701
     " tmp"  dump.p.o.p
  then
  xlyl
;
: gen.p.s.plot.exec                                                       706
  #.lines  c.#.b  +  s.chnls  >
  if
    s.chnls   c.#.b  - 1 +   #.lines :=
  then
  #.lines  0  >                                                           711
  c.#.b  s.chnls  <=   and
  if
    gen.p.s.plot
  else
    exit                                                                  716
  then
;
: gen.p.s.plot.0gp
  0  c.#.b    :=
  1  #.lines  :=                                                          721
  begin
    c.#.b 1 +  c.#.b  :=
    gen.p.s.plot.exec
    s.chnls  c.#.b  =
  until                                                                   726
;
: gen.p.s.plot.1gp
  1        c.#.b    :=
  s.chnls  #.lines  :=
  gen.p.s.plot.exec                                                       731
;

1 integer scalar bat.flag
: int.p.s  \ [ name.1  name.2 ....   -  ]   [ #.files -  ]
  cr                                                                      736
  ." ------------------------------"
  cr  " --> File Name (with ext) :"   "type
  bat.flag 1 =
  if
    tmp.s  "dup s.type                                                    741
  else
    " 01.eps"  get.str
  then
  file.name.ary "[ 7 ]   ":=
  cr  " Case Legend :" "type                                              746
  bat.flag 1 =
  if
    misce.str   "dup s.type
  else
     "null  get.str                                                       751
```

```
  then
  tmp.s.2  ":=
\  cr  " --> File Name (with ext) :"   "type  " 01.eps"  get.str
\                                        file.name.ary "[ 7 ]   ":=
\  cr  " Case Legend :" "type  "null  get.str  tmp.s.2  ":=
  ." ------------------------------"
\  cr  1 get.str  drop
  cr  ." Please "  b.t  ." WAIT!"  b.t cr
  dup
  s.chnls   :=
  line.#    :=
  begin
     file.name.ary "[ line.# ]  ":=
     \ \\ Legend can be assigned thru "spe.str
     \     "spe.str  "[ 1 ]  "upper " XY.AXIS(L/O)"  "=
     "spe.str  "[ 1 ] 2 "left "upper " XY"  "=
     if
       file.name.ary "[ line.# ]     "spe.str   "[ line.# ]  ":=
     else
     then
     line.#    1  =
     line.#    1 -  line.#  :=
  until
  1         line.#    :=
  1         channel.# :=
  1         i.p.c     :=
  1         int.flag  :=
  1         c.#.b     :=
  \  "null    tmp.s.2  ":=
  s.chnls  #.lines   :=

  set.lc
  gen.p.s.plot.exec
  0         int.flag  :=
;
: gen.p.s.plot.2gp
  \ 0   i.p.c   :=       \ same gp extension
  \ 1   i.p.c   :=       \ individual name
  1                    c.#.b    :=
  group.ele [ 1 ]      #.lines  :=
  gen.p.s.plot.exec
  #.lines  c.#.b  +         c.#.b    :=
  s.chnls  c.#.b  -  1 +    #.lines  :=
  gen.p.s.plot.exec
;
: gen.p.s.plot.3gp
  1                    c.#.b    :=
  group.ele [ 1 ]      #.lines  :=
  gen.p.s.plot.exec
  #.lines  c.#.b  +    c.#.b    :=
  group.ele [ 2 ]      #.lines  :=
  gen.p.s.plot.exec
  #.lines  c.#.b  +         c.#.b    :=
  s.chnls  c.#.b  -  1 +    #.lines  :=
  gen.p.s.plot.exec
```



```
;

: ldv.p.s.plot
  \ 0   i.p.c   :=       \ same gp extension
  1   i.p.c   :=       \ individual name
  #.groups
  case
  0  of  gen.p.s.plot.0gp  endof
  3  of  gen.p.s.plot.3gp  endof
  2  of  gen.p.s.plot.2gp  endof
  1  of  gen.p.s.plot.1gp  endof
  endcase
;

: tmp
  menu.flag 1 =
  if
  else
    \ dir.lee.txt  " Ron-PS.txt"  "cat   defer> load
    cdt load Ron-PS.txt
  then
; tmp

\ 0 eps.flag :=
: run.int.p.s.1
  1024  #.fft.pts  :=
  " A"             "spe.str "[ 1 ] ":=
  \ \\ Don't change the order
  \ \\ Set "spe.str to " xy.axis(l/o)" to use file name as default
     caption
  " xy.axis(l/o)"  "spe.str "[ 1 ] ":=
  " B"  "spe.str "[ 2 ] ":=
  " C"  "spe.str "[ 3 ] ":=
  " D"  "spe.str "[ 4 ] ":=
  " E"  "spe.str "[ 5 ] ":=
  " F"  "spe.str "[ 6 ] ":=
\ " a0m1020.4"  " a0m1030.4"  " a0m1040.4"  " a0m1050.4"   4  int.p.s
\ " f0w6020.2"  " f0w6030.2"  " f0w6040.2"  " f0w6050.2"   4  int.p.s
  " r03-w018.3"  1  int.p.s
;
```

LREF-0.TXT

A01808-20161220-A011 ❖ December 20, 2016 ❖ [Page count: 2]

```
\ : lref-0 ; & : lplt-0 ;                                                    1
\ ================================================================
\
\ Keywords       :  1. Wav-anaa.all
\                   2.
\                                                                            6
\ Written        :  Nov. 1993 by  Y-R Lee  (updated Feb. 1994)
\ ================================================================
" r"    xeq.flag  ":=
echo.off
1 29.flag :=                                                                11
: menu.word
  menu.flag 0 =
  if
    forget.all
  then                                                                      16
; menu.word
: lcom-0 ;

integer scalar  smo.flag
: menu.word                                                                 21
  menu.flag 0 =
  if
    dir.lee.txt   " def-winn.nam"  "cat   defer> load
    dir.lee.txt   " def-acqn.nam"  "cat   defer> load
    dir.lee.txt   " def-anan.nam"  "cat   defer> load                       26
  \  dir.lee.txt   " def-acqs.spe"  "cat   defer> load
  \  dir.lee.txt   " def-ana1.1sp"  "cat   defer> load
  then
  dir.lee.txt   " def-acqs.spe"  "cat   defer> load
  dir.lee.txt   " def-ana1.1sp"  "cat   defer> load                         31
  \  1  smo.flag  :=
  dir.lee.txt   " def-anaT.Tsp"  "cat   defer> load
  dir.lee.txt   " lcri.cri"      "cat   defer> load
; menu.word
                                                                            36
input.case.flag

dir.lee.txt   " Coef-" "cat   " gp"      "cat   " .dat" "cat   defer> load
\  put    " eee"   " r03"   " h01"   " ldv"   ....  on stack
dir.lee.txt   " Coef-" "cat   " gp"      "cat   " .txt" "cat   defer> load   41
\  check exist or not
dir.lee.txt   " Coef-" "cat  cnst.flag  "cat   " .dat" "cat   defer> load
dir.lee.txt   " get-s-ch.txt"                          "cat   defer> load
dir.lee.txt   " def-pre.txt"                           "cat   defer> load
{29.line}                                                                   46

: create.rain.sta.ary.asc ;         \ dummy

: data.sta.xeq     \ dummy word
;                  \ reset at data-sta.bat                                  51
```



```
: wave.ana.xeq
  " ind"  case.flag  "=
  if
       datafile.dat.p2  "dup                                                56
  else          \  <--- [ file name - ]
       "dup
  then
                dir.lee.asc "swap "cat    " .prn"  "cat    defer> delete
                dir.lee.dat "swap "cat    " .dat"  "cat    datafile.dat    61
                   ":=
  \  xeq.flag  " r"  "=
  \  if   dir.lee.txt " lref-mai.txt"       "cat    defer> load   then
  \  xeq.flag  " p"  "=
  \  if   dir.lee.txt " lplt-mai.txt"       "cat    defer> load   then
                dir.lee.txt " lref-mai.txt"       "cat    defer> load     66
;

\
  ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

: xeq.flag.xeq
  \ nd                                                                      71
  " r"  xeq.flag  "=   if   wave.ana.xeq   then
  " p"  xeq.flag  "=   if   wave.ana.xeq   then
  " d"  xeq.flag  "=   if   data.sta.xeq   then
;                                                                           76
dir.lee.txt   " def-ana3.3sp"  "cat   defer> load

sta.or.ana.xeq

\ dir.asy.sys  " ar-edit.sov"  "cat  defer>  load.overlay                   81
\ : aedd
\   dir.asy.sys  " ar-edit.sov"  "cat  defer>  load.overlay
\   db0   2048 dp>sp +
\           array.edit
\  \ release.overlay                                                        86
\ ;
\  release.overlay

: menu.word
  menu.flag 1 =                                                             91
  if
    forget lcom-0
  then
  bell.3dn
  \  500 msec.delay                                                        96
; menu.word
cdt
\ sc
```

LRef-Mai.txt

A01835-20171122-A001 ❖ November 22, 2017 ❖ [Page count: 37]

```
\ ================================================================
\ Asyst text file        ------    wav-anac.cor  ------     (c) Lee Yueon-
   Ron  \

\ REQUIREMENTS : 1.  LIM EMM4
\                2.  Overlay files included ( Data, Wave, Alg )
\                3.  Compatible raw data file structure ( ACQ )
\                4.  Consistant Jumper or Gain setting parameters
\                5.  Maximum number of waves for each channel not to
   overflow
\                6.  System configured properly
\
\ KEY WORDS     : 1.  Raw data manipulation and analysis
\                2.  Wave statistics
\                3.  Convolution low pass filtering
\                4.  Fast Fourier transform
\                5.  Regular wave reflection coefficient
\                6.  Irregular wave reflection coefficient
\                7.  Reconstructed incident and reflection waves
\                8.  Modulated structure
\
\ MEM HINTS     : 1.  Array      --- minor
\                      old ver --- DAS       +  minor
\                                  1C *8 *2
\                2.  Token      --- minor
\                      old ver --- 1 cha +  FFT coef  + IFFT  +  w.h
   +  w.p
\                                  1C *4   1C *2*2 *4   2C *8  1000 *4
     1000 *4
\                3.  Unnamed    --- [FFT]      +   Re[FFT]   ( > Ramp for
    PSD )
\                                  1C *1*2*4    1C *1*1*4       1 ch
   *2*4
\                4.  DAS buf    --- 0
\
\ WRITTEN        -   Dec, 1990 by  Lee Yueon-Ron  (03/91, 11/93, 02/94)
\ ================================================================

echo.off

: lcom-mai ;
get.d&t.string
1 pass.id := \ Set the transferred data file to default(0) or to be
   assigned(1)

\ ================================================================
" Times-Roman" font.type.n   ":=
\ " Times-Bold" font.type.n   ":=
18              font.size.l    :=
16              font.size.n    :=
14              font.size.s    :=
\ 1             lc.flag        :=
```



```
\ 1               eps.flag :=
\ 1              grid.flag :=

\ ********************
: set.lc
  lc.flag 0  =
  if
    0   lc1 :=
    lc1 lc2 :=  lc1 lc3 :=  lc1 lc4 :=  lc1 lc5 :=  lc1 lc6 :=
  else
    \  select.color
    0  lc1 :=    9 lc2 :=   12 lc3 :=
    13 lc4 :=   11 lc5 :=   10 lc6 :=    0 lc7 :=
    \   9 lc1 :=   12 lc2 :=   10 lc3 :=
    \  13 lc4 :=    0 lc5 :=   11 lc6 :=    0 lc7 :=
    \ 0 lc.flag :=
  then
; set.lc
: set.eps
  1  eps.flag :=
  0  lc.flag :=
;
: set.mon
  0  eps.flag :=
  1  lc.flag :=
;
: set.tmp
  eps.flag 1 =
  if
     set.eps
  else
     set.mon
  then
; set.tmp

: get.fn  \ get output file name
  datafile.dat.p2
  "len  8  >=
  if
    datafile.dat.p2  7 "left   file.name.ary "[ 7 ]    ":=
  then
; \ file.name.ary "[ 7 ]  s.type.3

: get.datafile.dat
  datafile.dat defer> file.open

  1 comment>   mycase           ":=
  2 comment>   mydate           ":=
  3 comment>   mytime           ":=
  4 comment>   specifics        ":=
  5 comment>   datafile.dat.p23 ":=
  file.close

  datafile.dat.p23  "len   4  -  "left            datafile.dat.p2  ":=
  dir.lee.dat  DATAFILE.dat.p23              "CAT   datafile.dat   ":=
```

```
  dir.lee.asc   DATAFILE.dat.p2   " .asc" "cat "CAT    datafile.asc    ":=
  dir.lee.prn   DATAFILE.dat.p2   " .prn" "cat "CAT    datafile.prn    ":=

  dir.lee.prn   datafile.dat.p2
  "cat    " .prn"   "cat   datafile.prn   ":=

  \   screen.clear
  {mes.wnd}
  3 17   goto.xy
  ." Current data file is    "    datafile.dat   s.type   \ int.on "type
  \   int.of
  {29.line}

  datafile.dat   defer> file.open
  1 subfile   acq.input   file>array
              acq.input   [ 1  ] t.rate        :=
              acq.input   [ 2  ] s.length      :=
              acq.input   [ 3  ] s.freq        :=
              acq.input   [ 4  ] s.chnls       :=
              acq.input   [ 5  ] p.chnl        :=
              acq.input   [ 6  ] p.points      :=
  acq.input [ 1 ]   0   >
  if
    0     #.times   :=
    2 subfile    file>unnamed.array     becomes>   db0
  else
    acq.input [ 5 ]       #.times   :=
  then
  file.close
;
get.datafile.dat

integer scalar x.min.p    scalar x.max.p    scalar 1or2
real    scalar x.min      scalar x.max
        scalar y.min      scalar y.max
1 string been.set.str
" n"   been.set.str    ":=

: get.a.token
\ db0 xsect[ ! , add.chnl ]
  add.chnl   get.chan.data
  add.chnl   channel.const
  add.chnl   smooth.spe
\   add.chnl   pre.xeq
  shift.raw.data
  smooth.xeq
  conv.formula
  becomes>   a.token

  cr.str          " >"   "=   not if    " n" been.set.str    ":=   then
  been.set.str    " y"   "=
  if
  else
    1         array.size   x.max.p  :=   x.min.p  :=
    a.token   []min/max    y.max    :=   y.min    :=
```



```
    1                            x.min.p  :=
    0.        s.freq  float /    x.min    :=
    x.max.p   s.freq  float /    x.max    :=
  then

  a.token []size   6000 >=    drop
  if
    2   1or2   :=
  then

  " Case: "   datafile.dat.p2   "cat    misce.str ":=
  " Chan: "   add.chnl 0 n>s    "cat    "spe.str "[ 1 ]  ":=

  \ \\------------------------------ for non stop execuation
  non.stop.str   "upper " Y"   "=
  if
    " y"     been.set.str    ":=
    2    1or2   :=
    add.chnl   2   <=
    if
    \ " Velocity   (cm/sec)"   y.label    ":=
      " Velocity   (cm/sec)"   tmp.s.9    ":=
      0.       x.min     :=
      x.max    x.max     :=
      -20.     y.min     :=
      20.      y.max     :=
    else
      " Displacement   (cm)"   tmp.s.9    ":=
      0.       x.min     :=
      x.max    x.max     :=
      -2.      y.min     :=
      2.       y.max     :=
    then
  then   \   ^------------------------^
;

: reset.xy.min/max
  2   0 fix.format                                                {border}
  15    3    goto.xy    ." Channel:"              add.chnl   get.val   add.chnl
        :=
  get.a.token    {border}
  15    4    goto.xy    ." One or Two Plots?"     1or2       get.val   1or2   :=
  6   2 fix.format
  15    6    goto.xy    ." x and y ranges having been fixed (y/n)? "
                                 been.set.str  get.str  been.set.str  ":=
  get.a.token
  6   2 fix.format
  15    8    goto.xy    ." x.min="      x.min             get.val  x.min  :=
  15    9    goto.xy    ." x.max="      x.max             get.val  x.max  :=
  40    8    goto.xy    ." y.min="      y.min             get.val  y.min  :=
  40    9    goto.xy    ." y.max="      y.max             get.val  y.max  :=
  2   1 fix.format
  60    9    goto.xy    ." step size="  step.size         get.val  step.size  :=
  15    11   goto.xy    ." X label="    tmp.s.8           get.str  tmp.s.8  ":=
  40    11   goto.xy    ." Y label="    tmp.s.9           get.str  tmp.s.9  ":=
```

```
  15   13  goto.xy   ." T_Legend=" misce.str       get.str misce.str ":=
  15   14  goto.xy   ." B_Legend=" "spe.str "[ 1 ] get.str "spe.str "[ 1  211
      ] ":=

  12   16   goto.xy    " To change press <F>."  s.type

  non.stop.str "upper " Y"  "=  not
  if                                                                    216
    pckey  drop
    if
      myself
      \     reset.xy.min/max
    then                                                                221
  then
  \  " y"  been.set.str  ":=
;
: plot.lab
  normal.coords                                                         226
  \  line.c  color
  " Courier-Bold"  font.size.n   ps.font                \ set font to
     12 pt. Times-Roman
  lc7        color
  get.spe.str
  0.13  0.97  position             label                              231
  0.75  0.97  position  d&t.string  label
  \ 0.75  0.90  position  " Case: "  datafile.dat.p2 "cat label
  0.75  0.90  position   misce.str                   label
  \ \\
  0.75                                                                  236
  eps.flag 1 =
  if    0.83
  else  0.85
  \  then  position  " Chan: "  add.chnl 0 n>s  "cat label
  then  position  "spe.str "[ 1 ]  label                                241
  " Times-Bold" font.size.l  ps.font
  tmp.s.8  tmp.s.9
  eps.flag 1 =
  if    0.04
  else  0.02                                                            246
  then
  labxy.stack
  font.type.n  font.size.n   ps.font
;
\ ------------------------------------------------------------------ eps  251
vuport ps.hp.port
   .900  .900 vuport.size
   .050  .050 vuport.orig
vuport ps.up.port
   .900  .440 vuport.size                                               256
   .050  .510 vuport.orig
vuport ps.dp.port
   .900  .440 vuport.size
   .050  .050 vuport.orig
: ps.hp                                                                 261
      ps.hp.port
```



```
      horizontal  normal.coords  0.85  0.10  label.scale.point
         world.coords
                                 0     2     label.points
      vertical    normal.coords  0.07  0.87  label.scale.point
         world.coords
                                 0     2     label.points                266
      ps.graphics ;
: ps.up
      ps.up.port
      horizontal  normal.coords  0.85  0.10  label.scale.point
         world.coords
                                 0     2     label.points                271
      vertical    normal.coords  0.07  0.87  label.scale.point
         world.coords
                                 0     2     label.points
      ps.graphics ;
: ps.dp
      ps.dp.port                                                        276
      horizontal  normal.coords  0.85  0.10  label.scale.point
         world.coords
                                 0     2     label.points
      vertical    normal.coords  0.07  0.87  label.scale.point
         world.coords
                                 0     2     label.points
      ps.graphics ;                                                     281
: hp.new
  eps.flag 1 =
  if      ps.hp  0 2.wnd.flag :=
  else    hp
  then                                                                  286
\ outline.color color solid  outline
;
: up.new
  eps.flag 1 =
  if      ps.up  1 2.wnd.flag :=                                        291
  else    up
  then
\ outline.color color solid  outline
;
: dp.new                                                                296
  eps.flag 1 =
  if      ps.dp  1 2.wnd.flag :=
  else    dp
  then
\ outline.color color solid  outline                                    301
;
\ ------------------------------------------------------------------
def.vuport
\ ------------------------------------------------------------------ eps
: grid.line&axis                                                        306

  grid.flag 1 =
  if
    0.5  ps.linewidth
    vertical                                                            311
```

```
      grid.on
           no.labels
    horizontal
      grid.on
           no.labels                                                    316
    xy.axis.plot
  then

    horizontal
      0  2                        label.points   \ restore axis label   321
      eps.flag 1 =
      1or2      1 =  and
      if     -0.5    -1.1     5    label.format
      else   \ default  -0.5  -0.8  5
      then                                                              326
    vertical
      0  2                        label.points   \ restore axis label

  1.0  ps.linewidth
  vertical                                                              331
    grid.off
    \     0  2  label.points
  horizontal
    grid.off
    \     0  2  label.points                                            336
  xy.axis.plot
;

: plot.chnl
  set.lc                                                                341
  tmp.s.9   ":=
  tmp.s.8   ":=

  1or2       :=
  add.chnl   :=                                                         346
  add.chnl  0  =  if  exit  then
  get.a.token
  nd
  2  0  fix.format                                        {border}
  15   3   goto.xy    ." Channel: "            add.chnl   n.type        351
  get.a.token   {border}
  15   4   goto.xy    ." One or Two Plots? "   1or2       n.type
  6  2 fix.format
  15   6   goto.xy    ." x and y ranges having been fixed (y/n)? "
                          been.set.str   s.type.3                       356
  15   8   goto.xy    ." x.min="          x.min            n.type
  15   9   goto.xy    ." x.max="          x.max            n.type
  40   8   goto.xy    ." y.min="          y.min            n.type
  40   9   goto.xy    ." y.max="          y.max            n.type
  2  1 fix.format                                                       361
  60   9   goto.xy    ." step size="      step.size        n.type
  15   11  goto.xy    ." X label="        tmp.s.8          s.type.3
  40   11  goto.xy    ." Y label="        tmp.s.9          s.type.3
  15   13  goto.xy    ." T_Legend="       misce.str        s.type.3
  15   14  goto.xy    ." B_Legend="       "spe.str "[ 1 ]  s.type.3      366
```



```
  12   16 goto.xy     " To change press <F>."  s.type.3
  non.stop.str "upper  " Y"   "=  not
  if
    pckey  drop                                                         371
    if
      reset.xy.min/max
    then
  then                                                                  376

  eps.flag 1 =
  if
    cr cr ." --> EPS: "
    \     datafile.dat.p2  add.chnl 0 n>s "cat " .eps" "cat  s.type.3
    datafile.dat.p2   " .z" "cat add.chnl 0 n>s "cat   s.type.3         381
    \ file.name.ary "[ 7 ]  add.chnl 0 n>s "cat " .eps" "cat  s.type.3
    b.t ."      Please Wait!"  b.t  b.t
  else
  then                                                                  386

  \  get.a.token
  10  10  axis.divisions
  x.min  0.  =
  if
    1     x.min.p  :=                                                   391
  else
    x.min  s.freq  float *   floor   x.min.p  :=
    x.min.p  0  =
    if
      x.min.p 1 :=                                                      396
    then
  then
  x.max  s.freq  float *   floor   x.max.p  :=

  eps.flag 1 =                                                          401
  if
    ps.graphics
    11 8.5 ps.paper.size
    ps.encapsulate
    ps.landscape                                  \ output in landscape mode  406
    \     datafile.dat.p2 add.chnl 0 n>s "cat " .eps" "cat  defer>
       ps.file
    dir.lee.asc
    datafile.dat.p2  "cat   " .z" "cat add.chnl 0 n>s "cat
    defer> ps.file
    \ file.name.ary "[ 7 ] add.chnl 0 n>s "cat " .eps" "cat  defer>     411
       ps.file
    ps.start
    font.type.n  font.size.n  ps.font
    1.0 ps.linewidth
    ps.hp  ps.up  ps.dp  \ initializing
  else                                                                  416
    gd
  then
  1or2  1  =
```

```
  if
    hp.new                                                          421
\   %%     eps.flag 1 =
\   %%     if      ps.hp
\   %%     else     hp
\   %%     then
                                                                    426
    horizontal
      axis.fit.off
      x.min.p  1 =
      if
        0         x.max       world.set                           431
      else
        x.min     x.max       world.set
      then
      eps.flag 1 =
      1or2      1 =  and                                          436
      if     -0.5    -1.0     5    label.format
      else   \ default  -0.5  -0.8  5
      then
    vertical
      eps.flag  1 =                                               441
      if     -1.2
      else   -1.2
      then          0.0     5    label.format
      \       -1.2    0.0     5      label.format
      axis.fit.off                                                446
      y.min     y.max       world.set
    font.type.n  font.size.n  ps.font
    \ " Times-Bold"  font.size.n  ps.font
    grid.line&axis
    \  %  xy.axis.plot                                            451

    x.min.p  1  =
    if
      x.min.p                   x.max.p  x.min.p -  1 +  ramp          +
    else                                                          456
      x.min.p                   x.max.p  x.min.p -  1 +  ramp  1 -     +
    then
    s.freq  float  /
      []size  tmp.v.ii  :=
      sub[ 1         ,  tmp.v.ii  step.size /     ,  step.size ]  461
    a.token
\ \\       sub[ x.min.p  ,   x.max.p  x.min.p -  1 +  ]
      sub[ x.min.p  ,   x.max.p  x.min.p -  1 +  step.size /  ,
         step.size ]
    \     add.chnl  xydp    \ use different colors
    1          xydp         \ all use color 1                     466
    plot.lab
  else
    up.new
    eps.flag 1 =
    if    \ %%  ps.up                                             471
          1.0 ps.linewidth
    else \ %%   up
```



```
    then

    horizontal                                                    476
      axis.fit.off
      x.min.p  1 =
      if
        0   x.min  :=
        x.min          x.max  x.min -  2. /  x.min +     world.set  481
      else
        x.min          x.max  x.min -  2. /  x.min +     world.set
      then
    vertical
      eps.flag  1 =                                               486
      if     -1.2
      else   -1.2
      then          0.0     5    label.format
      axis.fit.off
      y.min     y.max       world.set                           491
    font.type.n  font.size.n  ps.font
    grid.line&axis
    \  %  xy.axis.plot
    x.min.p  1  =
    if                                                            496
      x.min.p      x.max.p  x.min.p - 2 /   1 +  ramp          +
    else
      x.min.p      x.max.p  x.min.p - 2 /   1 +  ramp  1 -     +
    then
    s.freq  float  /                                              501
      []size  tmp.v.ii  :=
      sub[ 1         ,  tmp.v.ii  step.size /     ,  step.size ]
    a.token
\ \\       sub[ x.min.p  ,   x.max.p  x.min.p - 2 /  1 +  ]
      sub[ x.min.p  ,   x.max.p  x.min.p - 2 /  1 + step.size /  ,  506
         step.size ]
    \     add.chnl  xydp    \ use different colors
    1          xydp         \ all use color 1
    plot.lab

    dp.new                                                        511
\ %%     eps.flag 1 =
\ %%     if      ps.dp
\ %%     else    dp
\ %%     then
                                                                  516
    horizontal
      axis.fit.off
      x.max  x.min -  2. /  x.min   +     x.max      world.set
    font.type.n  font.size.n  ps.font
    grid.line&axis                                                521
    \  %  xy.axis.plot
    x.min.p  1  =
    if
      0  x.min.p  :=
    then                                                          526
    x.max.p  x.min.p - 2 / floor  x.min.p +
```

```
    x.max.p  x.min.p - 2 / floor 1 +  ramp          +
    s.freq  float  /
      []size  tmp.v.ii  :=
      sub[ 1         ,  tmp.v.ii  step.size /     ,  step.size ]          531
    a.token
\ \\       sub[ x.max.p x.min.p - 2 / floor x.min.p + ,
\ \\            x.max.p x.min.p - 2 / floor 1 +  ]
      sub[ x.max.p x.min.p - 2 / floor x.min.p + ,
           x.max.p x.min.p - 2 / floor 1 +  step.size /     ,  step.size   536
              ]
    \    add.chnl  xydp   \ use different colors
    1         xydp        \ all use color 1
    plot.lab
  then
                                                                           541
  eps.flag 1 =
  if
    ps.end
    def.vuport
    \ ibm.graphics \ device.init   \ Don't use this!                       546
    gd
  else
  then
  hp
                                                                           551
  \  my.outline
  \  dir.lee.asc  datafile.dat.p2  "cat
  h.c.str  " y"  "=
  if
    eps.flag  1 =                                                          556
    if
    else
      datafile.dat.p2 " .t" "cat add.chnl 0 n>s "cat  hp ptof.bat
    then
  then                                                                     561
  my.def.colors
;
  def.vuport

cr cr  cr ."   DATA manipulation, please wait ............."               566
\  \ load c:\per\asy\Armo.Typ       \  armor.type
\ ================================================================
: creat.datafile.asc       \ create ASCII file of filtered raw data
  #.times  0  >  if exit  then
  cr mycase       s.type                                                 571
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    48  mytime  "len  -  spaces            "drop
  ." Sampling frequency    :"   s.freq              .   ."   Hz"
  cr specifics    "type    48  specifics  "len  - spaces          "drop
  ." Sampling time length  :"   s.length s.freq /   .   ."  Sec"         576

  cr  " Unit conversion (1) or Not (0): "  s.type  0  get.val
  0  =
  if
    10  0 fix.format                                                       581
```



```
    s.length 1 +  1
    DO cr
      s.chnls 1 +   1
      DO
                          db0   [ j  ,  i ]                                586
                          .
      loop
    loop
  else
    11   4  sci.format                                                     591
    s.length 1 +  1
    DO cr
      s.chnls 1 +   1
      DO
                          i  channel.const                                 596
                          i  smooth.spe
                          db0   [ j  ,  i ]    2048  -
                          conv.formula
                          ."    "
                          .                                                601
      loop
    loop
  then
;                                                                          606

: make.ascii
  nd
  #.times  0  >  if exit  then
  asc.str  " y"  "=  not  if  exit  then
  cr  " Create ASCII raw data with Unit conversion (1) or Without (0): "   611
  s.type
  0  get.val

  cr ."   Storing ASCII data to hard disk, please wait ............."
  datafile.asc   defer>  delete                                            616
  datafile.asc   defer>  out>file  console.off  echo.off

  cr mycase       s.type
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    48  mytime  "len  -  spaces            "drop   621
  ." Sampling frequency    :"   s.freq              .   ."   Hz"
  cr specifics    "type    48  specifics  "len  - spaces          "drop
  ." Sampling time length  :"   s.length s.freq /   .   ."  Sec"

  0  =                                                                     626
  if
    10  0 fix.format
    s.length 1 +  1
    DO cr
      s.chnls 1 +   1                                                      631
      DO
                          db0   [ j  ,  i ]
                          .
      loop
    loop                                                                   636
```

```
  else
    11   4  sci.format
    s.length 1 +  1
    DO cr
      s.chnls 1 +   1                                                641
      DO
                          i  channel.const
\                          i  smooth.spe
                          db0   [ j  ,  i ]    2048  -
                          conv.formula                                646
                          ."    "
                          .
      loop
    loop
  then                                                                651
\  creat.datafile.asc
  my.out>file.close
  cr  ."                 ASCII data file created    :  " datafile.asc
    "type  cr
;
make.ascii                                                            656
\ ======================================================================

\ !------------------------------------------------------------ Simulated
   spectrum
real scalar Amp.i.s
     scalar Amp.r.s                                                   661
     scalar x.pos.1
     scalar x.pos.2
     scalar phase

\ 2000.     g.depth      :=                                           666
\ g.depth   depth.1      :=
\ 1         b.p.1        :=
\ 2 10 **   fft.points   :=

: compute.wave.length            \  You should provide: w.l.o g.depth  671
   tmp.period
                                 \  Accelerated Newton Method
  {  2pid     := 2 * pi * g.depth                        }
  {  gtt/2pi  := gravity * tmp.period ** 2 / 2 / pi      }
  {  gttd     := gravity * tmp.period ** 2 *  g.depth    }
  {  w.l.o    := gtt/2pi    }     \  place outside to improve efficiency  676
    for FFT
  begin
    {  2pid/l := 2pid / w.l.o
                                                        }
    {  w.l.n  := w.l.o - ( w.l.o - gtt/2pi * tanh ( 2pid/l ) ) /
                         ( 1 + gttd / w.l.o ** 2 * sech ( 2pid/l ) ** 2
                           )  }
    w.l.n  w.l.o  -  abs  w.l.o /   epslon  <                         681
    w.l.n  w.l.o  :=
  until
;
```



```
: c.standing.w.amp  \  [ position of gauge ]  -> amp                  686
  2  pi  *  w.l.n  /    tmp.v  :=
  real   s.length  ramp  neg  s.freq  /
         2 * pi * tmp.period  /
         tmp.v   w.l.n  *  +
         sin                                                          691
         tmp.v   x.pos  w.l.n  -  *
         cos  *
         2  *  750  *
;                                                                     696
: com.std
  1      tmp.period  :=
  120    w.l.o       :=
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *                                          701
      x.pos  :=  c.standing.w.amp  2048  +  db0   xsect[ ! , 1 ]  :=
  8.  8.  /  w.l.n  2.  /  *
      x.pos  :=  c.standing.w.amp  2048  +  db0   xsect[ ! , 2 ]  :=
  2.  16.  /  w.l.n  *  del.l  :=
;                                                                     706
real scalar tmp.v.sp
: p.s.w.amp.ind  \  [ x.pos , amp.i , amp.r , T , phase ] -> amp
  phase        :=
  tmp.period   :=
  amp.r.s      :=                                                     711
  amp.i.s      :=
  x.pos        :=

  120.  w.l.o  :=
  compute.wave.length                                                 716
  2.  pi  *  w.l.n  /    tmp.v.sp  :=
  real      s.length  float  ramp  s.freq  /
  dp>sp
            2.  *  pi  *  tmp.period  /
            dup                                                       721
            tmp.v.sp  x.pos  * swap  -  phase  +  sin    amp.i.s  *
            swap
            tmp.v.sp  x.pos  *       +  phase  +  sin    amp.r.s  *
            -
;                                                                     726

: par.std.spec.0  \ kr=0
  1     tmp.period  :=    \  ---> del.l = 19.50
  120   w.l.o       :=
  compute.wave.length                                                 731
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=                                   736
    x.pos.1    1024      0    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
  db0   xsect[ ! , 1 ]  :=
    x.pos.2    1024      0    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
  db0   xsect[ ! , 2 ]  :=
```

```
;                                                                                741

: spec.show
  1      tmp.period   :=     \  ---> del.l = 19.50
  120    w.l.o        :=
  compute.wave.length                                                            746
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=                                              751
    x.pos.1     750     500     1.00    0     p.s.w.amp.ind  dp>sp  2048  +
    x.pos.1     800     400     1.10    0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     600     500     1.20    0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     400     250     1.05    0     p.s.w.amp.ind  dp>sp  2048  +
        +
\   x.pos.1     400     250     0.98    0     p.s.w.amp.ind  dp>sp  2048  +  756
    +
  db0   xsect[ ! , 1 ]  :=
    x.pos.2     750     500     1.00    0     p.s.w.amp.ind  dp>sp  2048  +
    x.pos.2     800     400     1.10    0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.2     600     500     1.20    0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.2     400     250     1.05    0     p.s.w.amp.ind  dp>sp  2048  +  761
        +
\   x.pos.2     400     250     0.98    0     p.s.w.amp.ind  dp>sp  2048  +
    +
  db0   xsect[ ! , 2 ]  :=
    x.pos.1     750       0     1.00    0     p.s.w.amp.ind  dp>sp  2048  +
    x.pos.1     800       0     1.10    0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     600       0     1.20    0     p.s.w.amp.ind  dp>sp  2048  +  766
        +
    x.pos.1     400       0     1.05    0     p.s.w.amp.ind  dp>sp  2048  +
        +
\   x.pos.1     400       0     0.98    0     p.s.w.amp.ind  dp>sp  2048  +
    +
  db0   xsect[ ! , 3 ]  :=
;
: par.std.spe  \ kr=0.5                                                          771
  1      tmp.period   :=     \  ---> del.l = 19.50
  120    w.l.o        :=
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=                                                                    776
  8.  8.  /  w.l.n  2.  /  *
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1     500     250     1.0     0     p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     300     150     1.15    0     p.s.w.amp.ind  dp>sp  2048  +  781
     +
    x.pos.1     400     200     1.1     0     p.s.w.amp.ind  dp>sp  2048  +
```



```
        +
    x.pos.1     500     250     0.9     0     p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 1 ]  :=
    x.pos.2     500     250     1.0     0     p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     300     150     1.15    0     p.s.w.amp.ind  dp>sp  2048  +  786
     +
    x.pos.2     400     200     1.1     0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.2     500     250     0.9     0     p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 2 ]  :=
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1     500       0     1.0     0     p.s.w.amp.ind  dp>sp  2048  +  791
\    x.pos.1     300       0     1.15    0     p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.1     400       0     1.1     0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     500       0     0.9     0     p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 3 ]  :=                                                       796
;
: par.std.spec.1  \ kr=1
  1      tmp.period   :=     \  ---> del.l = 19.50
  120    w.l.o        :=
  compute.wave.length                                                            801
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=                                              806
    x.pos.1    1024     512     1.0     0     p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     500     250     1.15    0     p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.1     400     200     1.1     0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     124      62     1.2     0     p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 1 ]  :=                                                       811
    x.pos.2    1024     512     1.0     0     p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     500     250     1.15    0     p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.2     400     200     1.1     0     p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.2     124      62     1.2     0     p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 2 ]  :=                                                       816
;
: par.std.spec.1.RES  \ kr=1
  1      tmp.period   :=     \  ---> del.l = 19.50
  120    w.l.o        :=
  compute.wave.length                                                            821
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
```

```
  8.  8.  /  w.l.n  2.  /  *
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=                                          826
    x.pos.1    1024   1024    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     500    500    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     400    400    1.1    0    p.s.w.amp.ind  dp>sp  2048  +
     +
\    x.pos.1     124    124    1.2    0    p.s.w.amp.ind  dp>sp  2048  +
     +
  db0   xsect[ ! , 1 ]  :=                                                 831
    x.pos.2    1024   1024    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     500    500    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     400    400    1.1    0    p.s.w.amp.ind  dp>sp  2048  +
     +
\    x.pos.2     124    124    1.2    0    p.s.w.amp.ind  dp>sp  2048  +
     +
  db0   xsect[ ! , 2 ]  :=                                                 836
;

: create.spec.DATAFILE.dat

  regular.datafile                                                         841
     file.template
     8 comments
     integer  dim[ 6 ]  subfile
     integer  dim[ s.length , s.chnls ]  subfile
  end                                                                      846

  cr
  datafile.dat " !!!!"  "cat  get.str datafile.dat  ":=
  datafile.dat  defer>  file.create
  datafile.dat  defer>  file.open                                          851
           mycase           1  >comment
           mydate           2  >comment
           mytime           3  >comment
           specifics        4  >comment
           datafile.dat.p23 5  >comment                                    856
  1  subfile  acq.input   array>file
  2  subfile  db0   array>file
  file.close
  cr  ."     Data file created   : "   datafile.dat  "type
;                                                                          861
\ \\ Now you only need to use this to specify any Kr (0 -- 1)
\ spec.show
\ create.spec.DATAFILE.dat
\ ^------------------------------------------------------------ Simulated
   spectrum
\ ================================================================        866

\ \datafile.asc defer> delete
\ \datafile.prn defer> delete

\ token a.token                                                          871
token w.h.ary
token w.p.ary
```



```
\ | real   dim[ n.of.w ] array  w.h.ary
\ | real   dim[ n.of.w ] array  w.p.ary
\ exp.mem>  a.token                                                      876
exp.mem>  w.h.ary
exp.mem>  w.p.ary

: out.of.index
  index 1 + array.size >                                                 881
;

: H.s.c    \ H.scale.conversion   \  [ Int-val  ,  Real-practical-val ]
  dig.to.h  *
;                                                                        886

: T.s.c    \ T.scale.conversion   \  [ Int-val  ,  Real-practical-val ]
  float     s.freq float    /
;                                                                        891

: index.p.1
    index  1 +  index   :=
;

\  dir.lee.txt  " lcri.cri"  "cat  defer>  load                          896
\ ======================================
: raw.exp.ana    \ 1
   ..........................................................1
  tmp.v.i  :=
  tmp.v.i  channel.const
  tmp.v.i  smooth.spe                                                    901
  get.forced.spe.ref
  \  1. *  becomes> a.token            \ real
  \  1  * 1. *  becomes> a.token     \ dp.real
  \  equiv> a.token                  \ integer
  real n.of.w  ramp  0 over :=  becomes>   w.h.ary                        906
           w.h.ary             becomes>   w.p.ary

\  conv.formula  becomes>   a.token
\  smooth.xeq
                                                                         911
\  tmp.v.i  pre.xeq

  shift.raw.data
  smooth.xeq
  conv.formula                                                           916
  becomes>   a.token
\  a.token
\  drop

\  smooth.xeq                                                            921
\  conv.formula  becomes>   a.token
\  a.token
\  shift.raw.data
\  drop
                                                                         926
   \ gd hp
```

```
  \ up  a.token 1 yap
  \ my.pause

0 index :=                                                          931
0 i.count :=

begin
 index.p.1
 a.token [ index ]  sgn    0  >          \   set to zero down crossing  936
 index  array.size           >=    or
until

index  array.size  <
if                                                                  941
  a.token [ index ]  sgn
  begin
      index.p.1
      a.token [ index ]  sgn  dup rot  <>
      dup                     0        <>    and                   946
      index  array.size                >=    or
  until
      index  left.index        :=
      dup    zero.up.or.down   :=
then                                                                951
\  cr  ." left.index"    left.index .

begin    \
   !2-------------------------------------------------------------!2
index  array.size  <
  if                                                                956
    begin
      index.p.1
      a.token [ index ]  sgn  dup rot  <>
      dup                     0        <>    and
      dup    zero.up.or.down           =     and                   961
      index  array.size                >=    or
    until
    index       right.index :=
  then
                                                                    966
  index  array.size  <
  if
    i.count  1 +   i.count :=
    \ cr ." right.index=  "    right.index .
    \ cr ." i.count=  "        i.count     .                        971
    right.index left.index -                    w.p.ary [ i.count ] :=
    a.token sub[ left.index ,   right.index left.index -  ]
    []min/max  swap -                            w.h.ary [ i.count ] :=

    right.index left.index  :=                                     976
  then

index array.size  >=
until   \
   ^2-------------------------------------------------------------^2
```



```
                                                                    981
  i.count  0  >
  if
    drop
  then
  \ cr ." i.count ="   i.count  .   ."              ch = "  i  .     986

  i.count 0 >
  if
    \  i.count     n.of.w.ary  [ 1 , i ]  :=
    w.p.ary    t.s.c    w.p.ary   :=  \ pratical unit               991
  then
  \  dp w.h.ary sub[ 1 , 50 ] 1 yap  hp i.count .   my.pause
; \ ^1
   ..............................................................................
   ^1

: w.h.sort&index   \ !3                                             996
   ...........................................................!3
  i.count 10 /          1/10.index          := \  cr 1/10.index  .
  i.count 3  /          1/3.index           := \  cr 1/3.index   .
  i.count 2  /          1/2.index           := \  cr 1/2.index   .

  1/10.index 0 >                                                   1001
  if
    1  tmp.v.i  :=
    real  i.count  ramp    becomes>  a.token

    w.h.ary  sub[ 1 , i.count ]    sort&index                       1006

    rev[ 1 ]
      begin  \  w.p stored in accordance with w.h in descent order
        dup  [ tmp.v.i ]     tmp.v.i.2  :=
        w.p.ary [ tmp.v.i.2 ]     a.token [ tmp.v.i ]  :=          1011
        tmp.v.i  i.count  >=
        tmp.v.i  1 +   tmp.v.i  :=
      until
    drop
    a.token  ^sum                                                  1016
      dup  [ 1/10.index ]       1/10.index  /  1/10.w.p :=
      dup  [ 1/3.index  ]       1/3.index   /  1/3.w.p  :=
      dup  [ 1/2.index  ]       1/2.index   /  1/2.w.p  :=
           [ i.count    ]       i.count     /  ave.w.p  :=
                                                                   1021
    rev[ 1 ]   \ dup   w.h.token  :=
    ^sum
      dup  [ 1/10.index ]       1/10.index  /  1/10.w.h :=
      dup  [ 1/3.index  ]       1/3.index   /  1/3.w.h  :=
      dup  [ 1/2.index  ]       1/2.index   /  1/2.w.h  :=          1026
           [ i.count    ]       i.count     /  ave.w.h  :=

    1  tmp.v.i  :=
    0. tmp.v    :=
    0. tmp.v.2  :=                                                 1031
```

```
    begin
      tmp.v     w.h.ary    [ tmp.v.i ]  2. **  +        tmp.v    :=
      tmp.v.2   w.p.ary    [ tmp.v.i ]  2. **  +        tmp.v.2  :=
      tmp.v.i   1 +     tmp.v.i    :=
      tmp.v.i   i.count >                                                    1036
    until
    tmp.v     i.count / sqrt                  rms.w.h   :=
    tmp.v.2   i.count / sqrt                  rms.w.p   :=

  then                                                                       1041
;  \ ^3
   ......................................................................
   ^3

\ ================================================================
token  wha   exp.mem>  wha
token  wpa   exp.mem>  wpa                                                   1046
: wh.wp
  dup  1  +   swap
  \ s.chnls 1 +   1
  DO
         \  db0     xsect[ ! , i ]                                         1051
         i  get.chan.data
         i  raw.exp.ana
         \ cr  i .   ." *********    ok    raw.exp.ana   *********"
            cr
               i.count 0 <=
               if                                                          1056
               4 0 fix.format  i  float . 5 0 fix.format i.count
                  n.type
         \     ."    ------- No complete wave cycle  --------"
               ."    ------- Not enough wave cycles --------"
               then
                                                                           1061
         i.count 0 >
         if
           w.h.sort&index
           \ cr i .  ." *********    ok w.h.sort&index   *********"
              cr
           1/10.index 0 <=                                                 1066
           if
               4 0 fix.format i  float  .  5 0 fix.format i.count
                  n.type
               ."    ------- Too small number of waves ------"
           then
                                                                           1071
           1/10.index 0 >
           if
               4 0 fix.format i  float  .  5 0 fix.format i.count
                  n.type
               \ =w.h.token  sort  rev[ 1 ]
               w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]                 1076

               wh.format
                              dup  [ 1 ]                    .
```



```
                                    dup  [ 2 ]                    .
                                         [ 3 ]                    .  2   1081
                                            spaces
                  1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .
                    rms.w.h  .
                  3 spaces
                  6 2 fix.format
                  1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .
                    rms.w.p  .
          then                                                             1086

        then
        cr
  loop
                                                                           1091
  w.h.ary  sub[ 1 , i.count ]  becomes>  wha
  w.p.ary  sub[ 1 , i.count ]  becomes>  wpa
;

: creat.datafile.prn       \ on site print out of wave statistics          1096
  get.forced.spe.ref
  \ \  cr case        slope  "cat         "type
  cr mycase        s.type
  1 0 fix.format
  \  ."   ( f"    smo.flag 0 n>s s.type    ."  p"  smo.p 0 n>s s.type      1101
  \  ."  c" conv.flag 0 n>s s.type    ."  s" shif.flag 0 n>s s.type ."
     )"
  get.spe.str    s.type
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    68  mytime  "len  -  spaces              "drop
  ." Sampling   frequency  :"   s.freq              .   ."  Hz"          1106
  cr specifics    "type    68  specifics  "len  - spaces              "drop
  ." Sampling time length  :"   s.length s.freq /   .   ."  Sec"
  cr       cr  \     cr

  ."  Ch   #_W"  ."    "                                                  1111
  "  H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms" s.type
   3 spaces
                                      "  T1/10  T1/3  T1/2 T.ave T.rms"
                                         s.type
  cr  cr
        s.chnls 1 +   1                                                  1116
        do
          i  wh.wp
        loop
;                                                                        1121
\ datafile.prn  defer>  out>file      echo.off  \   console.off

\ creat.datafile.prn
\ my.out>file.close
\ {29.line}                                                              1126
\ cr  ."                PRN   data file created    :  " datafile.prn
   "type  cr
\ datafile.prn defer> print
```

```
-1 4 fix.format

\ ================================================================          1131
\
    !*************************************************************************

real    scalar  a.ch1          scalar  cos.k.dl
        scalar  a.ch2          scalar  sin.k.dl
        scalar  b.ch1          scalar  kr                                     1136
        scalar  b.ch2

integer scalar  m.max
        scalar  m.min
dp.real scalar  sum.ai.sq                                                     1141
        scalar  sum.ar.sq
real    scalar  l.max
        scalar  l.min
        scalar  t.max
        scalar  t.min                                                         1146

token   Re.fft.ary
token   Im.fft.ary
token   ifft.ary.inc
token   ifft.ary.ref                                                          1151

exp.mem>  Re.fft.ary
exp.mem>  Im.fft.ary
exp.mem>  ifft.ary.inc
exp.mem>  ifft.ary.ref                                                        1156

\
    !4-------------------------------------------------------------------------

dp.real scalar amp.i                scalar apha.max             scalar
   apha.min
        scalar amp.r                scalar apha.ran             scalar
           apha.old
        scalar apha                 scalar acos.sn1             scalar      1161
           acos.sn2
        scalar out.s                scalar out.o
        scalar apha.max.sec         scalar apha.min.sec
        scalar as1      scalar as2          scalar theta        scalar beta
        scalar apha.1   scalar apha.2       scalar beta.1       scalar
           beta.2
                                                                              1166
: f.as1.as2
  a.ch1 2 **   b.ch1 2 **  +   amp.i 2 **  +   amp.r 2 **   -
  2 /   amp.i /   a.ch1 2 **   b.ch1 2 **  +  sqrt   /
  dup   abs  1  >
  if                                                                          1171
      cr  ." ----- Modified ----  As1 is out of bound  -----  "  dup  .
      sgn  1.  *
  then
  asin    as1   :=
```



```
                                                                              1176
  a.ch1 2 **   b.ch1 2 **  +    amp.r 2 **  +   amp.i 2 **   -
  2 /   amp.r /   a.ch1 2 **   b.ch1 2 **  +  sqrt   /
  dup   abs  1  >
  if
      cr  ." ----- Modified ----  As2 is out of bound  -----  "  dup  .      1181
      sgn  1.  *
  then
  asin    as2   :=
;                                                                             1186

: f.theta
  a.ch1    a.ch1 2 **    b.ch1 2 **    +  sqrt  /   asin
  b.ch1    0    <
  if
     neg  pi   +                                                              1191
  then
  theta   :=
;

: chk.apha.beta.agn                                                           1196
  a.ch1  amp.i apha cos  *  amp.r beta cos  *   +  - a.ch1 /  abs dup
     epslon  >
  b.ch1  amp.i apha sin  *  amp.r beta sin  *   -  - b.ch1 /  abs dup
     epslon  >
  OR
  if
    cr   ."    Need to be modified  ( > epslon ) ------  "         swap     1201
       .  .
  else
  2 *drop
  then
;                                                                             1206

: chk.apha.beta
  a.ch1  amp.i apha cos  *  amp.r beta cos  *   +  - a.ch1 /  abs
     epslon  >
  b.ch1  amp.i apha sin  *  amp.r beta sin  *   -  - b.ch1 /  abs
     epslon  >
  OR
;                                                                             1211

: f.apha.beta
  f.as1.as2       f.theta
  as1   theta   -                 apha.1   :=
  pi    theta   -     as1   -     apha.2   :=                                 1216
  theta   as2   -                 beta.1   :=
  as2      pi   -   theta   +     beta.2   :=
  apha.1                          apha     :=
  beta.1                          beta     :=
  chk.apha.beta                                                               1221
  if apha.2                       apha     :=
     chk.apha.beta
     if beta.2                    beta     :=
        chk.apha.beta
```

```
        if apha.1                  apha      :=                                 1226
        then
      then
    then
  chk.apha.beta.agn
;                                                                               1231
\
    ^4-------------------------------------------------------------------------


integer scalar s.min  integer scalar s.max
   \      scalar chnl.#1
   \      scalar chnl.#2                                                        1236

: s.min.max  \ shifts of integration limits
  \  normal.display screen.clear
  cr    ."          shifts of integration limits :  "
  cr    ."                                        s.min = " #input   s.min    1241
      :=
  cr    ."                                        s.max = " #input   s.max
      :=
;
0 s.min :=    0 s.max :=
\ s.min.max
                                                                                1246
\ | real  dim[ fft.points ,       2 ]  array  Re.fft.ary
\ |       dim[ fft.points ,       2 ]  array  Im.fft.ary
  real
: FFT.ref.coe
                                                                                1251
  get.forced.spe.ref
  1  get.chan.data  sub[ 1 , fft.points ]   1. * dup
  laminate  trans[ 1 , 2 ]   becomes> Re.fft.ary
\ db0   sub[ 1 , fft.points  ;  1 , 2 ]  1.  *        becomes>
   Re.fft.ary
                                        re.fft.ary   becomes>                   1256
                                           Im.fft.ary
  dp.real
  fft.points  complex  ramp                          becomes>
     ifft.ary.inc
                                        ifft.ary.inc becomes>
                                           ifft.ary.ref
  0.    0.   z=x+iy      ifft.ary.inc   :=
  0.    0.   z=x+iy      ifft.ary.ref   :=                                      1261
  real

 \   3.884826    del.l    :=  \ for spectrum test

   \ db0   xsect[ ! , r.ch1 ]                                                   1266
   r.ch1  get.chan.data
   \  \     sub[ 1 , #.fft.pts ]
            shift.raw.data
            r.ch1  smooth.spe
            smooth.xeq   \  smooth                                              1271
            sub[ b.fft.p , fft.points ]
```



```
                                  r.ch1  channel.const   conv.formula
           fft  dup   \ not xsect[ ! , i ]
           Zreal     Re.fft.ary   xsect[ ! , 1 ]   :=
           Zimag     Im.fft.ary   xsect[ ! , 1 ]   :=                           1276
  \ db0   xsect[ ! , r.ch2 ]
  r.ch2  get.chan.data
           shift.raw.data
           r.ch2  smooth.spe
           smooth.xeq   \   smooth                                              1281
           sub[ b.fft.p , fft.points ]
                                  r.ch2  channel.const   conv.formula
           fft  dup   \ not xsect[ ! , i ]
           Zreal     Re.fft.ary   xsect[ ! , 2 ]   :=
           Zimag     Im.fft.ary   xsect[ ! , 2 ]   :=                           1286

  del.l   20  *    l.max  :=
  l.max   9   /    l.min  :=
  { tmp.v := 2 * pi  }
                                                                                1291
  { t.max := tmp.v /
       ( gravity * tmp.v / l.max * tanh ( tmp.v * g.depth / l.max ) )
          ** .5 }
  { t.min := tmp.v /
       ( gravity * tmp.v / l.min * tanh ( tmp.v * g.depth / l.min ) )
          ** .5 }
  \   t.max  s.freq *    fix   M.max  :=                                        1296
  \   t.min  s.freq *    fix   M.min  :=
  fft.points    t.max /   s.freq /    fix   M.min  :=
  fft.points    t.min /   s.freq /    fix   M.max  :=
  0.  sum.ai.sq  :=
  0.  sum.ar.sq  :=                                                             1301

  \   m.max 0 -  m.max  :=   m.min 10 -  m.min :=        \  extended
     limits
  fft.points  2  +  tmp.v.i  :=

  m.max 1 + s.min -     m.min s.max +                                           1306
  do
    \ fft.points i /    s.freq /   float  tmp.period  :=   \ T=N/m
       points/cycle
    fft.points float   i /    s.freq /    tmp.period  :=   \ T=N/m
       points/cycle
    compute.wave.length
    2  pi *   w.l.n /   del.l *    dup                   \ k * del.l            1311
    cos     cos.k.dl  :=
    sin     sin.k.dl  :=

    re.fft.ary [ i ,     1 ]                        a.ch1  :=
    im.fft.ary [ i ,     1 ]    neg                 b.ch1  :=                   1316
    re.fft.ary [ i ,     2 ]                        a.ch2  :=
    im.fft.ary [ i ,     2 ]    neg                 b.ch2  :=
\    chnl.#1  channel.const
\    re.fft.ary [ i ,     1 ]         conv.formula   a.ch1  :=
\    im.fft.ary [ i ,     1 ]    neg  conv.formula   b.ch1  :=                  1321
\    chnl.#2  channel.const
```

```
\     re.fft.ary [ i ,     2 ]          conv.formula   a.ch2  :=
\     im.fft.ary [ i ,     2 ]    neg   conv.formula   b.ch2  :=

             {  ( ( a.ch2 - a.ch1 * cos.k.dl - b.ch1 * sin.k.dl ) ** 2 +  1326
                  ( b.ch2 + a.ch1 * sin.k.dl - b.ch1 * cos.k.dl ) ** 2 )
                       sqrt
                     / 2. / sin.k.dl  abs }
             dup     neg
                  z=x+iy         ifft.ary.inc [ i ]  :=
                                                                          1331
             {  ( ( a.ch2 - a.ch1 * cos.k.dl + b.ch1 * sin.k.dl ) ** 2 +
                  ( b.ch2 - a.ch1 * sin.k.dl - b.ch1 * cos.k.dl ) ** 2 )
                       sqrt
                     / 2. / sin.k.dl  abs }
             dup   \ neg
                  z=x+iy         ifft.ary.ref [ i ]  :=                  1336

    ifft.ary.inc [ i ] zimag  neg     amp.i  :=
    ifft.ary.ref [ i ] zimag          amp.r  :=

    { sum.ai.sq  :=  sum.ai.sq  +     amp.i ** 2 }                        1341
    { sum.ar.sq  :=  sum.ar.sq  +     amp.r ** 2 }
\
   !5-------------------------------------------------------------------------

  rad
  1  r.ch1  =
  if                                                                      1346

\  { ( ( a.ch1  + amp.r ) / amp.i ) }   1     min    acos  \  apha.min  :=
\  { ( ( b.ch1  - amp.r ) / amp.i ) }  -1     max    acos neg
\             pi  2. /  +                      max       apha.min  :=
\  { ( ( a.ch1  - amp.r ) / amp.i ) }  -1     max    acos  \  apha.max  :=  1351
\  { ( ( b.ch1  - amp.r ) / amp.i ) }  -1     max    acos  \  neg
\            pi  2. /  +                      min       apha.max  :=

  { ( ( a.ch1  + amp.r ) / amp.i ) }   1     min    acos     apha.min  :=
  { ( ( a.ch1  - amp.r ) / amp.i ) }  -1     max    acos     apha.max  :=  1356

  apha.max  apha.min  -       apha.ran :=
  apha.max  apha.min  +  2  /   apha  :=
  pi  2. /   { ( ( b.ch1  + amp.r ) / amp.i ) } 1 min acos  +
     apha.max.sec  :=
  pi  2. /   { ( ( b.ch1  + amp.r ) / amp.i ) } 1 min acos  -             1361
     apha.min.sec  :=

\ -1 4 fix.format
\ cr  i .
f.apha.beta
  0  tmp.v.i.2  <>                                                       1366
  if
    -1 4 fix.format
    cr  i .
    11 4 fix.format
    cr 3 spaces                                                           1371
```



```
    a.ch1 . b.ch1 . amp.i . amp.r . apha . beta . theta . apha.min .
       apha.max .
    cr                                  80 spaces  apha.min.sec .
       apha.max.sec .
  then

apha  dup                                                                 1376
\             rand.unif   6.283185307  *   dup  dup  dup
              cos         ifft.ary.inc  [ i ]  zreal  *        swap
              sin         ifft.ary.inc  [ i ]  zimag  *
              z=x+iy  dup ifft.ary.inc  [ i ]         :=
              conj        ifft.ary.inc [ tmp.v.i  i  - ]  :=            1381
beta  dup
              cos         ifft.ary.ref  [ i ]  zreal  *        swap
              sin  neg       ifft.ary.ref  [ i ]  zimag  *
              z=x+iy  dup ifft.ary.ref  [ i ]         :=
              conj        ifft.ary.ref [ tmp.v.i  i  - ]  :=            1386

then
\
   ^5-------------------------------------------------------------------------


   loop                                                                   1391
   sum.ar.sq    sum.ai.sq /  sqrt    kr   :=
;
\ ================================================================

: App.datafile.prn            \ append FFT parameters to .prn file      1396
  get.forced.spe.ref
  cr
  9   4  fix.format
  cr  cr
  ." Energy reflection level (%): " kr 2. ** 100. *    .                 1401
  cr
  ." Program parameters, etc. :: "              cr
  ."              Kr       : " kr  n.type   ."      r.ch1  : "  r.ch1
      n.type
                                                   ."      r.ch2  : "  r.ch2
                                                              .  cr
\ ."              H.eng    : "          .  ."      depth  : "          1406
   g.depth .
  ."                                        "     ."      depth  : "
     g.depth .
  \                                                ."      w.l.n  : "  w.l.n
       .  cr
                                                   ."      del.L  : "  del.l
                                                              .  cr
  \ ."              del.L    : " del.l       .  ."      depth  : "
     g.depth .
  ."              L.min    : " l.min       .  ."      T.min  : "  t.min  1411
       .
                                                   ."      M.max  : "  m.max
                                                              .  cr
  ."              L.max    : " l.max       .  ."      T.max  : "  t.max
```

```
      .
                                                ."       M.min   : "  m.min
                                                     .  cr
  ."                 smo.flag   : " smo.flag   .   ."       f.cut   : "
                                                          s.freq smo.p / .   1416
      12  4   sci.format                           ."       aR.sq   : "
         sum.ar.sq    .
  cr    9  4   fix.format
  ."                 fft.point : " fft.points . ."       b.pnt   : "
     b.fft.p      .
      12  4   sci.format                           ."       aI.sq   : "
         sum.ai.sq    .
;                                                                         1421

\
   ------------------------------------------------------------------------

\ dir.lee.txt   " wav-anai.iff"   "cat   defer>   load     \ -->   sep.wave

: raw.exp.ana.fft   \ 1                                                  1426
   ..........................................................1
  tmp.v.i   :=
  tmp.v.i   channel.const
  tmp.v.i   smooth.spe
  \  1. *   becomes> a.token             \ real
  real n.of.w   ramp    becomes>    w.h.ary                             1431
            w.h.ary    becomes>    w.p.ary

  1. * becomes> a.token
  a.token []size array.size :=   drop
                                                                        1436
  0 index :=
  0 i.count :=

  begin
   index.p.1                                                            1441
   a.token [ index ]   sgn     0   >           \    set to zero down crossing
   index   array.size              >=     or
  until

  index   array.size   <                                                1446
  if
    a.token [ index ]   sgn
    begin
        index.p.1
        a.token [ index ]   sgn   dup rot   <>                          1451
        dup                       0         <>     and
        index   array.size                  >=     or
    until
        index   left.index          :=
        dup     zero.up.or.down     :=                                  1456
  then
  \   cr   ." left.index"     left.index .

  begin     \
```



```
      !2-----------------------------------------------------------------!2
  index   array.size   <                                                1461
    if
      begin
        index.p.1
        a.token [ index ]   sgn   dup rot   <>
        dup                       0         <>     and                  1466
        dup     zero.up.or.down             =      and
        index   array.size                  >=     or
      until
      index        right.index :=
    then                                                                1471

    index   array.size   <
    if
      i.count   1 +    i.count :=
      \ cr ." right.index=   "     right.index .                        1476
      \ cr ." i.count=   "         i.count      .
      right.index left.index -                        w.p.ary [ i.count ] :=
      a.token sub[ left.index ,    right.index left.index -  ]
      []min/max   swap -                               w.h.ary [ i.count ] :=
                                                                        1481
      right.index left.index   :=
    then

  index array.size   >=
  until    \                                                            1486
     ^2-----------------------------------------------------------------^2


  i.count   0   >
  if
     drop
  then                                                                  1491
  \ cr ." i.count ="    i.count   .    ."                ch = "   i   .

  i.count 0 >
  if
    \   i.count      n.of.w.ary   [ 1 , i ]   :=                        1496
    w.p.ary     t.s.c     w.p.ary    :=   \ pratical unit
  then
; \ ^1
   ..........................................................................
    ^1

\ ======================================================================  1501

: sep.wave         \ on site print out of wave statistics
  cr.str.sep   " x"   "=   not if else exit then
  r.ch1
  dup                                                                   1506

  cr       cr
  ." Reconstructed incident and reflected waves : "   cr cr
  ."  Ch    #_w"    ."     "
```

```
  "  H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms"  s.type
3 spaces
  "  T1/10  T1/3  T1/2 T.ave T.rms"  s.type
 cr  cr

  \    s.chnls 1 +   1
  \    \     2 1 +   1
  \    DO
  \    data.buf.0    xsect[ ! , i ]

ifft.ary.inc  ifft  Zreal
swap
        \ raw.exp.ana
        raw.exp.ana.fft
        \ cr  i .   ." *********    ok    raw.exp.ana   *********"
           cr
                i.count 0 <=
                if
                4 0 fix.format   r.ch1  . 5 0 fix.format i.count
                   n.type
                ."    ------- Not enough wave cycles --------"
        \       ."    ------- No complete wave cycle  --------"
                then

        i.count 0 >
        if
          w.h.sort&index
          \ cr i .  ." *********    ok w.h.sort&index   *********"
             cr
          1/10.index 0 <=
          if
                4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                   n.type
                ."    ------- Too small number of waves ------"
          then

          1/10.index 0 >
          if
                4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                   n.type
                \ =w.h.token  sort  rev[ 1 ]
                w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]

                wh.format
                                dup  [ 1 ]                      .
                                dup  [ 2 ]                      .
                                     [ 3 ]                      .  2
                                        spaces
                1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .
                   rms.w.h  .
                3 spaces
                6 2 fix.format
                1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .
                   rms.w.p  .
          then
```



```
        then
        cr

  1/3.w.p  1/3.w.p.sep.i  :=
  1/3.w.h  1/3.w.h.sep.i  :=

ifft.ary.ref  ifft  Zreal
swap
       raw.exp.ana.fft
         \ cr  i .   ." *********    ok    raw.exp.ana   *********"
            cr
                i.count 0 <=
                if
                4 0 fix.format   r.ch1  . 5 0 fix.format i.count
                   n.type
         \      ."    ------- No complete wave cycle  --------"
                ."    ------- Not enough wave cycles --------"
                then

         i.count 0 >
         if
           w.h.sort&index
           \ cr i .  ." *********    ok w.h.sort&index   *********"
              cr
           1/10.index 0 <=
           if
                4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                   n.type
                ."    ------- Too small number of waves ------"
           then

           1/10.index 0 >
           if
                4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                   n.type
                \ =w.h.token  sort  rev[ 1 ]
                w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]
                wh.format
                                dup  [ 1 ]                      .
                                dup  [ 2 ]                      .
                                     [ 3 ]                      .  2
                                        spaces
                1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .
                   rms.w.h  .
                3 spaces
                6 2 fix.format
                1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .
                   rms.w.p  .
           then

        then
        cr

  1/3.w.p  1/3.w.p.sep.r  :=
```

```
    1/3.w.h  1/3.w.h.sep.r  :=
;                                                                              1606

\
   ------------------------------------------------------------------------------

\
   ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

\  datafile.prn defer> print
\                                                                              1611
   ------------------------------------------------------------------------------

: Add.chnl.prn
  add.chnl  :=
  add.chnl  0  =  if  exit  then
  \  db0 xsect[ ! , add.chnl ]
  add.chnl  get.chan.data                                                      1616

  add.chnl  channel.const
  add.chnl  smooth.spe
  shift.raw.data
  smooth.xeq                                                                   1621
  conv.formula
  becomes>  a.token

  12  tmp.v.i.1  :=
  cr                                                                           1626
  ." Histroy of Cummulated Overtopping : "
  cr
  4 0 fix.format
  add.chnl  float  n.type
  "  Time" s.type                                                              1631
  7 2 fix.format
  0  tmp.v.i  :=
  tmp.v.i  s.freq  float  *  .
  begin
    tmp.v.i 1 +  tmp.v.i  :=                                                   1636
    array.size  tmp.v.i.1 float / tmp.v.i float *  s.freq float /  .
    tmp.v.i  tmp.v.i.1  =
  until

  cr                                                                           1641
  4 0 fix.format
  add.chnl  float  n.type
  "  Load" s.type
  7 2 fix.format
  a.token [ 1          ]  a.token [ 1 ] -  .                                   1646
  0  tmp.v.i  :=
  begin
    tmp.v.i 1 +  tmp.v.i  :=
  \ tmp.v.i  3 =  tmp.v.i  8 = or
  \ if                                                                         1651
  \  ." "
  \ then
```



```
    a.token [ array.size  tmp.v.i.1 float / tmp.v.i float *  floor ]
    a.token [ 1 ] -  .
    tmp.v.i  tmp.v.i.1  =                                                      1656
  until
;
\
   ------------------------------------------------------------------------------


real    scalar  Kr.r  scalar Kr.L  scalar Hd1/3.R scalar Hd1/3.L              1661
        scalar  H.eng.R scalar H.eng.L scalar Ho1/3
        scalar horms

normal.display
                                                                             1666
: fft.sta.p1  \  [ r.ch1,  r.ch2,  del.l,  depth,  b.fft.p  -- ]
  \  get.forced.spe.ref
               b.fft.p  :=
               g.depth  :=
               del.l  :=                                                     1671
               r.ch2  :=
               r.ch1  :=
  \  nd  ." -----"  r.ch1  .  cr  cr.str.sep  s.type  my.pause
  get.forced.spe.ref  \  update  cr.str
  \  r.ch1  .  cr  cr.str.sep  s.type  my.pause                               1676
\ ============================
  0  tmp.v.i.2  :=
  fft.ref.coe
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *  conv.formula  Ho1/3
      :=
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *  Ho1/3                     1681
     :=
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *  Horms
      :=
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *  H.eng.r
     :=
  \ kr  kr.r  :=
  \  sum.ai.sq  float sqrt  2 *  fft.points /  2 *  h.s.c  H.eng.l
    :=
  \ kr  kr.l  :=                                                             1686
  \ ho1/3 = 1.4116 horms  \ assuming Rayleigh
    Distribution
  \ ho1/3
  \ 1/3.w.h.sep.i  Hd1/3.R  :=
  \ 1/3.w.h.sep.i  Hd1/3.L  :=
  app.datafile.prn                                                           1691
  sep.wave
;

: fft.sta.1
  get.forced.spe.ref                                                         1696
  r.ch1.1  r.ch1.1  1 +  del.l.1  depth.1  b.p.1
  fft.sta.p1
;
: fft.sta.2
```

```
  get.forced.spe.ref                                                    1701
  r.ch1.2  r.ch1.2  1 +   del.l.2  depth.2   b.p.2
  fft.sta.p1
;
: fft.sta.3
  get.forced.spe.ref                                                    1706
  5        6              del.l.3  depth.3   b.p.3
  fft.sta.p1
;
: Kr.xeq
  \  nd cr.str.sep  s.type  my.pause                                    1711
  datafile.prn  defer>  out>file   1 out>file.flag :=   echo.off
  sc
  creat.datafile.prn
  add.chnl  add.chnl.prn
  r.ch1.2  0 <>                                                         1716
  if
    fft.sta.2
  then
  r.ch1.1  0 <>
  if                                                                    1721
    fft.sta.1
  then
  my.out>file.close
  cr  ."   PRN data file created    :  " datafile.prn s.type
  prn.str  " y"  "=                                                     1726
  if
    datafile.prn defer> print
  then
  my.pause
  onerr:                                                                1731
    0  menu.flag  :=
  \    cr
\    ?error#  error.message  \ cr
\    "   Error!  Try again :"  s.type
\    \    pckey  drop  if  then                                         1736
    my.out>file.close
;
\ 1  1or2  :=
: plot&plot
  axis.defaults                                                         1741

   \  ibm.graphics
  eps.flag 1 =
  if
    def.vuport                                                          1746
  else
  then
   add.chnl  1or2  tmp.s.8  tmp.s.9  plot.chnl

  eps.flag 1 =                                                          1751
  if
    def.vuport
    gd
    hp cr
```



```
  else                                                                  1756
    hp cr
  then
   " Plot another channel?  (Exit:<F>)  --->"   s.type.3
   add.chnl 1 +   add.chnl  :=
                                                                        1761
   non.stop.str "upper " Y"  "=  not
   if
     add.chnl  s.chnls > if  1 add.chnl := then
     add.chnl .  ." /"  s.chnls  .
   else                                                                 1766
     add.chnl  s.chnls > if  exit  then
   \     add.chnl  2 > if  exit  then
   then

   non.stop.str "upper " Y"  "=  not                                    1771
   if
     pckey  drop  not
     if
     \     add.chnl 1 +  add.chnl :=
     \     add.chnl  s.chnls  >  if  1 add.chnl :=  then                1776
       myself
     then
   else
     myself
   then                                                                 1781
   1 add.chnl :=
;

: choice
  xeq.flag  " p"  "=  if     1 add.chnl :=   then                      1786
  1  1or2  :=
  " Time (sec)"  tmp.s.8  ":=
  " Signal"  tmp.s.9  ":=
  xeq.flag  " r"  "=  if     kr.xeq       then
  xeq.flag  " p"  "=  if     plot&plot    then                         1791
; choice
\ ================================================================
  real dim[ 4 ]  array  to.123.ary
  real dim[ 2 ]  array  Hd1/3RL
: for.123                                                               1796
  1/3.w.p.sep.i          to.123.ary   [ 1 ]    :=
  1/3.w.h.sep.i          to.123.ary   [ 2 ]    :=
  \ Ho1/3                to.123.ary   [ 2 ]    :=
  kr.R                   to.123.ary   [ 3 ]    :=
  Kr.L                   to.123.ary   [ 4 ]    :=                     1801
  H.eng.R                Hd1/3RL      [ 1 ]    :=
  H.eng.L                Hd1/3RL      [ 2 ]    :=
; for.123
\ ================================================================
-1 4 fix.format                                                         1806
7 set.file.parse
cdt
: ind.or.else.end
  " ind" case.flag  "=
```

```
  " gen" cnst.flag   "=   or                                          1811
  if
  else
  \ forget   lref-mai
    forget   lcom-mai
  then                                                                1816
;
ind.or.else.end
```

.....

LWHP-0.TXT

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```
\ lwhp-0                                                                    1
\ ================================================================
\
\ Keywords       :  1. Drift of mean water level correctable
\                   2. Data statistics
\                                                                           6
\ Written        :  Mar. 1994  by  Y-R Lee
\ ================================================================

echo.off
1 29.flag :=                                                               11
: menu.word
  menu.flag 0 =
  if
    forget.all
  then                                                                     16
; menu.word
: lwhp-0 ;

" w"       xeq.flag     ":=
                                                                           21
: menu.word
  menu.flag 0 =
  if
    dir.lee.txt   " def-winn.nam"  "cat   defer> load
    dir.lee.txt   " def-acqn.nam"  "cat   defer> load                      26
    dir.lee.txt   " def-anan.nam"  "cat   defer> load
\    dir.lee.txt   " def-acqs.spe"   "cat   defer> load
\    dir.lee.txt   " def-ana1.1sp"   "cat   defer> load
  then
   dir.lee.txt   " def-acqs.spe"  "cat   defer> load                       31
   dir.lee.txt   " def-ana1.1sp"  "cat   defer> load
  \  1  smo.flag  :=
  dir.lee.txt   " def-anaT.Tsp"  "cat   defer> load
  dir.lee.txt   " lcri.cri"      "cat   defer> load
; menu.word                                                                36

" .whp"   file.ext     ":=
input.case.flag
dir.lee.txt   " Coef-" "cat   " gp"       "cat   " .dat" "cat    defer> load
\  put    " eee"   " r03"   " h01"   " ldv"   ....  on stack                41
dir.lee.txt   " Coef-" "cat   " gp"       "cat   " .txt" "cat    defer> load
\  check exist or not
dir.lee.txt   " Coef-" "cat  cnst.flag  "cat   " .dat" "cat    defer> load
dir.lee.txt   " get-s-ch.txt"                          "cat    defer> load
{29.line}                                                                  46
\ ----------------------------------------------------------------
: show.flag
  get.forced.spe.whp
  1 0 fix.format  ."  ("
  ."  f"  smo.flag  0 n>s  s.type  ."  p"  smo.p       0 n>s  s.type       51
  ."  e"  coef.flag 0 n>s  s.type  ."  s"  shif.flag  0 n>s  s.type
```



```
  \ ."  w"  wnd.str           s.type
  ."  )"
;
\ !--------------------------------------------------------------          56
   Simulated spectrum
real scalar Amp.i.s
     scalar Amp.r.s
     scalar x.pos.1
     scalar x.pos.2
     scalar phase                                                          61

: compute.wave.length            \  You should provide: w.l.o g.depth
   tmp.period
                                 \  Accelerated Newton Method
  {  2pid     := 2 * pi * g.depth                          }
  {  gtt/2pi  := gravity * tmp.period ** 2 / 2 / pi        }               66
  {  gttd     := gravity * tmp.period ** 2 *  g.depth      }
  {  w.l.o    := gtt/2pi     }     \  place outside to improve efficiency
    for FFT
  begin
    {  2pid/l  := 2pid / w.l.o
                                                           }
    {  w.l.n   := w.l.o - ( w.l.o - gtt/2pi * tanh ( 2pid/l ) ) /          71
                          ( 1 + gttd / w.l.o ** 2 * sech ( 2pid/l ) ** 2
                            )  }
    w.l.n  w.l.o  -  abs  w.l.o /   epslon  <
    w.l.n  w.l.o  :=
  until
;                                                                          76

\ ================================================================
\ ^--------------------------------------------------------------
   Simulated spectrum
\ ================================================================
                                                                           81
\ \datafile.asc defer> delete
\ \datafile.prn defer> delete

token w.h.ary
token w.p.ary                                                              86
exp.mem>  w.h.ary
exp.mem>  w.p.ary

: out.of.index
  index 1 + array.size >                                                   91
;

: H.s.c    \ H.scale.conversion   \  [ Int-val  ,  Real-practical-val ]
  dig.to.h  *
;                                                                          96

: T.s.c    \ T.scale.conversion   \  [ Int-val  ,  Real-practical-val ]
  float     s.freq float    /
;
                                                                          101
```

```
: index.p.1
    index  1 +  index   :=
;

\                                                                                106
   ------------------------------------------------------------------------------


: raw.exp.ana     \ 1
   ..........................................................1
  tmp.v.i  :=
  tmp.v.i  channel.const
  tmp.v.i  smooth.spe                                                            111
  get.forced.spe.whp
  real n.of.w  ramp   becomes>   w.h.ary
                      0          w.h.ary  :=
            w.h.ary   becomes>   w.p.ary
                                                                                 116
  shift.raw.data
  conv.formula
  smooth.xeq   becomes> a.token
  a.token  []size  swap drop  array.size  :=
                                                                                 121
  0 index :=
  0 i.count :=

  begin
   index.p.1                                                                     126
   a.token [ index ]  sgn    0  >          \   set to zero down crossing
   index  array.size            >=    or
  until

  index  array.size  <                                                           131
  if
    a.token [ index ]  sgn
    begin
        index.p.1
        a.token [ index ]  sgn  dup rot  <>                                      136
        dup                     0        <>    and
        index  array.size               >=    or
    until
        index  left.index        :=
        dup    zero.up.or.down   :=                                            141
  then
  \  cr  ." left.index"    left.index .

  begin    \
     !2-------------------------------------------------------------------!2
  index  array.size  <                                                           146
    if
      begin
        index.p.1
        a.token [ index ]  sgn  dup rot  <>
        dup                     0        <>    and                               151
        dup    zero.up.or.down           =     and
```



```
        index  array.size                 >=    or
      until
      index       right.index :=
    then                                                                         156

    index  array.size  <
    if
      i.count  1 +   i.count :=
      \ cr ." right.index=  "    right.index .                                   161
      \ cr ." i.count=  "        i.count     .
      right.index left.index -                    w.p.ary [ i.count ] :=
      a.token sub[ left.index ,   right.index left.index -  ]
      []min/max  swap -                            w.h.ary [ i.count ] :=
                                                                                 166
      right.index left.index  :=
    then

  index array.size  >=
  until   \                                                                      171
     ^2-------------------------------------------------------------------^2


  i.count  0  >
  if
     drop
  then                                                                           176
  \ cr ." i.count ="   i.count  .   ."              ch = "  i  .

  i.count 0 >
  if
    \  i.count     n.of.w.ary  [ 1 , i ]  :=                                     181
    w.p.ary    t.s.c    w.p.ary   :=  \ pratical unit
  then
; \ ^1
   ..........................................................................
   ^1

: w.h.sort&index   \ !3                                                          186
   ..........................................................!3
  i.count 10 /          1/10.index          :=  \  cr 1/10.index  .
  i.count 3  /          1/3.index           :=  \  cr 1/3.index   .
  i.count 2  /          1/2.index           :=  \  cr 1/2.index   .

  1/10.index 0 >                                                                 191
  if
    1  tmp.v.i  :=
    real  i.count  ramp    becomes>  a.token

    w.h.ary  sub[ 1 , i.count ]    sort&index                                    196

    rev[ 1 ]
      begin  \  w.p stored in accordance with w.h in descent order
        dup  [ tmp.v.i ]     tmp.v.i.2  :=
        w.p.ary [ tmp.v.i.2 ]     a.token [ tmp.v.i ]  :=                        201
        tmp.v.i  i.count  >=
```

```
        tmp.v.i  1 +   tmp.v.i  :=
      until
    drop
    a.token  ^sum                                                    206
      dup  [ 1/10.index ]       1/10.index  /  1/10.w.p  :=
      dup  [ 1/3.index  ]       1/3.index   /  1/3.w.p   :=
      dup  [ 1/2.index  ]       1/2.index   /  1/2.w.p   :=
           [ i.count    ]       i.count     /  ave.w.p   :=
                                                                     211
    rev[ 1 ]   \ dup   w.h.token  :=
    ^sum
      dup  [ 1/10.index ]       1/10.index  /  1/10.w.h  :=
      dup  [ 1/3.index  ]       1/3.index   /  1/3.w.h   :=
      dup  [ 1/2.index  ]       1/2.index   /  1/2.w.h   :=          216
           [ i.count    ]       i.count     /  ave.w.h   :=

    1  tmp.v.i  :=
    0. tmp.v    :=
    0. tmp.v.2  :=                                                   221
    begin
      tmp.v    w.h.ary   [ tmp.v.i ]  2. **  +       tmp.v   :=
      tmp.v.2  w.p.ary   [ tmp.v.i ]  2. **  +       tmp.v.2 :=
      tmp.v.i  1 +    tmp.v.i   :=
      tmp.v.i  i.count >                                             226
    until
    tmp.v    i.count / sqrt                 rms.w.h  :=
    tmp.v.2  i.count / sqrt                 rms.w.p  :=

  then                                                               231
;  \ ^3
   ......................................................................
   ^3

\ ================================================================
token  wha  exp.mem>  wha
token  wpa  exp.mem>  wpa                                          236
: wh.wp
        dup  1  +   swap
        \     s.chnls 1 +   1
        DO
        \ db0     xsect[ ! , i ]                                   241
          i  get.chan.data
          i  raw.exp.ana
          \ a.token  []size  swap drop  array.size  :=
                 i.count 0 <=
                 if                                                246
                 4 0 fix.format  i  float . 5 0 fix.format   i.count
                    n.type \ .
                 ."    ------- No complete wave cycle  --------"
                 then

          i.count 0 >                                              251
          if
            w.h.sort&index
            1/10.index 0 <=
```



```
            if
                  4 0 fix.format i  float  .  5 0 fix.format  i.count   256
                     n.type \ .
                  ."    ------- Too small number of waves ------"
            then

            1/10.index 0 >
            if                                                         261
                  4 0 fix.format i  float  .  5 0 fix.format  i.count
                     n.type \ .
                  \ =w.h.token  sort  rev[ 1 ]
                  w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]
                  wh.format
                                dup  [ 1 ]                      .    266
                                dup  [ 2 ]                      .
                                     [ 3 ]                      .  2
                                        spaces
                  1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .
                     rms.w.h  .
                  3 spaces
                  6 2 fix.format                                       271
                  1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .
                     rms.w.p  .
            then

          then
          cr                                                           276
        loop

  i.count  0  =
  if
    w.h.ary                      becomes>  wha                       281
    w.p.ary                      becomes>  wpa
  else
    w.h.ary  sub[ 1 , i.count ]  becomes>  wha
    w.p.ary  sub[ 1 , i.count ]  becomes>  wpa
  then                                                                 286
;

: whwp.for.rain.proposal
        whwp.flag  " wha"  "=
         if                                                            291
           token.2
           datafile.dat.p23  "len  3 -  "left  " 2wh" "cat  atof.bat
              drop
           token.3
           datafile.dat.p23  "len  3 -  "left  " 3wh" "cat  atof.bat
              drop
         else                                                          296
           token.2
           datafile.dat.p23  "len  3 -  "left  " 2wp" "cat  atof.bat
              drop
           token.3
           datafile.dat.p23  "len  3 -  "left  " 3wp" "cat  atof.bat
              drop
```

```
          then                                                                  301
;

: creat.datafile.prn       \ on site print out of wave statistics
  datafile.prn  defer>  delete
  datafile.prn  defer>  out>file  1 out>file.flag  :=  echo.off  \          306
     console off
  cr mycase       s.type
  show.flag
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    68  mytime  "len  -  spaces              "drop
  ." Sampling   frequency  :"   s.freq              .   ."  Hz"          311
  cr specifics    "type    68  specifics  "len  - spaces              "drop
  ." Sampling time length  :"   s.length s.freq /   .   ."  Sec"
  cr      cr  \     cr

\   ."  Ch   #_W    H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave        316
   H.rms"
\   3 spaces
\                                    ."  T1/10  T1/3  T1/2 T.ave
   T.rms"
  ."  Ch   #_W"   ."    "
  "  H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms" s.type
  3 spaces                                                                  321
                       "  T1/10  T1/3  T1/2 T.ave T.rms"  s.type

  cr  cr
  s.chnls 1 +   1
  do
          i  wh.wp                                                          326
          whwp.flag  " wha"  "=    if  wha  else  wpa  then
          i  array.to.token
  loop
  my.out>file.close
  \ \\ whwp.for.rain.proposal                                               331
;

\ normal.display

-1 4 fix.format                                                             336
7 set.file.parse
cdt
\
   ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^


\                                                                           341
   ************************************************************************


token    rds.a
exp.mem> rds.a
token    freq.a
exp.mem> freq.a                                                            346

integer dim[ 1 , #.case , #.chnl , #.item ] unnamed.array  0.  * becomes
```



```
   > rds.a
\       dim[ 2 , #.case , #.chnl , #.item ] unnamed.array  0.  * becomes
   > rds.a

\ dir.asy.sys  " spfn.sov"  "cat  defer> load.overlay                       351
: rain.sta
\  dir.asy.sys  " spfn.sov"  "cat  defer> load.overlay
  \  #r :=
  \  #w :=
  deg.fre  300  >                                                           356
  if  300  deg.fre  :=
  then

  without.frequencies
  cr                                                                        361
  #.chnl  1 +   1
  do
    i  chnl.no  :=                    \ channel No.
    chnl.no  .                          \ channel No.
    chnl.no  get.token                                                      366
    dup                                 []size  tmp.v.i   :=
    tmp.v.i  2  >=
    if

    \ freq.a                                                                371
    mean                    dup                 std.mea   :=
                      rds.a [ #w , #r , chnl.no , 1  ]  :=  \ mean

    chnl.no  channel.const
    get.forced.spe.whp                                                      376
    chnl.no  smooth.spe
    \    db0 xsect[ ! , chnl.no ]
    chnl.no  get.chan.data
    shift.raw.data
    conv.formula   \ becomes>   a.token                                     381
    smooth.xeq

    dup   mean  tmp.v.2  :=
    []size   tmp.v.i.2  :=
    tmp.v.2  dp>sp  -  dup  *  []sum   tmp.v.i.2  /                         386
\                   rds.a [ #w , #r , chnl.no , 11 ]  :=  \ spectrum
   integral
                    rds.a [ #w , #r , chnl.no , 12 ]  :=  \ spectrum
                       integral

    dup
    dup   mean  tmp.v.2  :=                                                 391
    []size   tmp.v.i.2  :=
    tmp.v.2  dp>sp  -  dup  *  []sum   tmp.v.i.2  /
                    rds.a [ #w , #r , chnl.no , 11 ]  :=  \ rms**2
    dup
    \ ----- no more than 11000 elements due to Memory                       396
    sub[ 1 , 10500 ]
    sample.variance sqrt    dup               std.dev   :=
                    rds.a [ #w , #r , chnl.no , 2  ]  :=  \ std.  dev.
```

```
    std.dev  tmp.v.i sqrt / dup                std.err    :=                  401
                      rds.a [ #w , #r , chnl.no , 3  ]   :=  \ std.
                         error
    1.    1. conf.int - 2. /  -   \ confidence interval fractile
          deg.fre   student-t.fractile
          std.err *  dup  2 *
                      rds.a [ #w , #r , chnl.no , 10 ]   :=  \ conf. int.  406
                         range
                    dup     std.mea       +    conf.l.u   :=
                            std.mea  swap -    conf.l.l   :=
    conf.l.u          rds.a [ #w , #r , chnl.no , 4  ]   :=  \
    conf.l.l          rds.a [ #w , #r , chnl.no , 5  ]   :=  \
    tmp.v.i           rds.a [ #w , #r , chnl.no , 6  ]   :=  \ []size      411
    std.mea tmp.v.i * rds.a [ #w , #r , chnl.no , 7  ]   :=  \ total
    []min/max         rds.a [ #w , #r , chnl.no , 8  ]   :=  \ max
                      rds.a [ #w , #r , chnl.no , 9  ]   :=  \ min

    else                                                                     416
    mean                    dup                std.mea    :=
                      rds.a [ #w , #r , chnl.no , 1  ]   :=  \ mean
    tmp.v.i           rds.a [ #w , #r , chnl.no , 6  ]   :=  \ []size
    std.mea tmp.v.i * rds.a [ #w , #r , chnl.no , 7  ]   :=  \ total
    []min/max         rds.a [ #w , #r , chnl.no , 8  ]   :=  \ max       421
                      rds.a [ #w , #r , chnl.no , 9  ]   :=  \ min
    then
  loop

  #r  1 +  #r :=                                                             426
\ release.overlay
;
\ release.overlay

: d.d.o.c                                                                    431
  tmp.s    ":=
  tmp.s     run.c.n    "[ #r ]   ":=
  \  d.d.o
  tmp.s dir.lee.asc  "swap "cat   " .pr2" "cat  datafile.prn   ":=
  tmp.s dir.lee.asc  "swap "cat   " .asc" "cat  datafile.asc   ":=          436
  tmp.s                                       datafile.dat.p2  ":=
  tmp.s dir.lee.dat  "swap "cat   " .dat" "cat  defer> file.open
  1 comment>    mycase            ":=
  2 comment>    mydate            ":=
  3 comment>    mytime            ":=                                        441
  4 comment>    specifics         ":=
  5 comment>    datafile.dat.p23  ":=
  1 subfile     acq.input  file>array
                acq.input  [ 1 ]     t.rate    :=
                acq.input  [ 2 ]     s.length  :=                           446
                acq.input  [ 3 ]     s.freq    :=
                acq.input  [ 4 ]     s.chnls   :=

  acq.input [ 1 ]  0  >
  if                                                                         451
    0     #.times  :=
```



```
    2 subfile    file>unnamed.array     becomes>  db0
  else
    acq.input [ 5 ]             #.times  :=
  then                                                                       456
  file.close
  s.length      deg.fre            :=
  integer  dim[ s.length         ] unnamed.array  1. *  becomes> freq.a
  1. freq.a :=
\  datafile.prn  defer>  delete                                             461
\  datafile.prn  defer>  out>file       echo.off  \   console.off
  creat.datafile.prn
  cr  cr  \ two blank lines
\  out>file.close
  5 0 fix.format                                                             466
;
\ ============================================================

: create.rain.sta.ary.asc
  12     #.item  :=                                                          471
  xeq.flag  " d"   "=  if  #.item 1 + 1   then
  xeq.flag  " w"   "=  if  #.item     1   then
\  ||  xeq.flag  " w"   "=  if  #.item 1 + 1   then
  \ 2 1
  do                                                                         476
    i  item.no  :=      \  item.no .
    item.no  item.title
    item.name  s.type
    4 2 fix.format ."  conf="  conf.int   .
                                                                             481
    show.flag
    item.no  item.format
    cr
    #r   1
    do                                                                       486
      i  case.no  :=
      ."     "   run.c.n   "[ case.no ]   "type   ."   "
      #.chnl 1 +   1
      do
        i  chnl.no  :=                                                       491
        rds.a [ #w , case.no , chnl.no , item.no ] .
      loop
      cr
    loop
    cr                                                                       496
  loop
  cr
; cr

\ ============================================================              501

: whp.p
  ." #    ' a/d' "
  dup
  case                                                                       506
  1   of  token.1   endof
```

```
  2   of  token.2   endof
  3   of  token.3   endof
  4   of  token.4   endof
  5   of  token.5   endof                                          511
  6   of  token.6   endof
  7   of  token.7   endof
  8   of  token.8   endof
  9   of  token.9   endof
  10  of  token.10  endof                                          516
  11  of  token.11   endof
  12  of  token.12   endof
  13  of  token.13   endof
  14  of  token.14   endof
  15  of  token.15   endof                                         521
  16  of  token.16   endof
  endcase
  sort&index   drop   rev[ 1 ]   swap
  " a"   "=  if    yap
             else  ydp                                            526
             then
;

: whp.plt
  " array , line_#  , '' a/d'' "  s.type                         531
  swap
  sort&index   drop   rev[ 1 ]   swap
  " a"   "=  if    yap
             else  ydp
             then                                                 536
;

DIR.LEE.TXT  " get-x-n.TXT"  "CAT   defer>  LOAD
parameter.1
\ dir.lee.txt   " lwhp-m03.txt" "cat defer> LOAD                  541
dir.lee.txt  " lwhp-mai.txt" "cat defer> LOAD

\
   ~~~
```

LWHP-MAI.TXT

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```
: whp-dist ;                                                                    1
\ ------------------------------------------------------------------
    integer scalar  iii
            scalar  #.sec
            scalar  channel.#
            scalar  line.#                                                      6
            scalar  c.#.b
            scalar  i.p.c
            scalar  #.lines
            scalar  yo.flag
    integer scalar  #.sec                                                      11
    real    scalar  y.v.min
    real    scalar  y.v.max
    real    scalar  x.v.min
    real    scalar  x.v.max
    real    scalar  y.lab.shift                                                16

s.freq  #.fft.pts float  /   f.beg :=
s.freq  float  2.        /   f.end :=

10.   f.end  :=                                                                21
0.2   f.beg  :=

\ " ll" xy.axis.str ":=

: tmp                                                                          26
  xy.axis.str    " oo"  "=
  xy.axis.str    " lo"  "=  or
  if
    1       yo.flag      :=
  else                                                                         31
    0       yo.flag      :=
  then
; tmp
999     #.sec        :=
\ " y"   offset.str ":=                                                        36

: change.world.set      \ for restore y
  channel.#    2  <=
  if
    horizontal                                                                 41
       x.v.min     x.v.max      world.set
       \       0.2          x.v.max      world.set
    vertical
      axis.fit.on
      -1.2         0        7   label.format                                  46
       y.v.min     y.v.max      world.set
       \       10. -5. ** 10. 1. **    world.set
  else
    horizontal
       x.v.min     x.v.max      world.set                                      51
       \       0.2          x.v.max      world.set
```



```
    vertical
      axis.fit.on
      -1.2         0        7   label.format
       y.v.min     y.v.max      world.set                                      56
       \       10. -6. ** 10.  0. **  world.set
  then
;
: tmp.set
      horizontal                                                               61
      \   axis.fit.off
         axis.fit.on
         xy.axis.str " ll"  :=
         if
\           0.              x.v.max          world.set                        66
           x.v.min          x.v.max          world.set
         else
           x.v.min          x.v.max          world.set
         then
      vertical                                                                 71
         axis.fit.on
         \  -1.2         0        7   label.format
         y.v.min     y.v.max      world.set
;                                                                              76
: change.y.lab
    yo.flag 1 =
    if   \ lo oo
      0.01  y.lab.shift  :=
      xy.axis.str  " oo"  "=   if  xoyl  then                                  81
      xy.axis.str  " lo"  "=   if  xlyl  then

      xy.axis.str  " lo"  "=
      if
        10   \ x   --- no function for log scale                               86
      else
        x.v.min  log  fix
        x.v.max  log  FLOOR 1 +   swap  -  3 *
      then
      y.v.min  log  fix                                                        91
      y.v.max  log  FLOOR 1 +   swap  -
      axis.divisions
      horizontal
        xy.axis.str  " lo"  "=
        if                                                                     96
          axis.fit.on
          0.              x.v.max          world.set
        else      \  oo
          axis.fit.off
          x.v.min          x.v.max          world.set                        101
        then

         \ axis.fit.on
      vertical
         axis.fit.off                                                          106
         label.scale.off
```

```
        0  1  label.points  \ label every tick
        -1.2       0       4     label.format
        y.v.min  log  fix
        y.v.max  log  FLOOR 1 +   world.set
    else  \  ol  ll
    \     tmp.set
      xy.axis.str  " ol"  "=
      if
      horizontal
    \ axis.fit.on
      axis.fit.off
      x.v.min             x.v.max          world.set
      then
    then
;
10 string lab.app

: lo.shift.x
  xy.axis.str  " lo"  "=
  if
      swap
      x.v.max   x.v.min  -  0.4  *    +
      swap
  then
;

: lo.x
  xy.axis.str  " lo"  "=
  if
      x.v.max   x.v.min  -  0.01  *
  else
      0.
  then
;

: make.ind
  datafile.dat.p2  " ."   "cat
  " h"  "cat
  i.p.c  48  +  ascii"  "cat
  hp
  ptof.bat
;
\ ------------------------------------------------------------------
3 string  plot.ext
: hard.copy
    h.c.str   " n"   "=  \  or
    if
    else
      abc.mid.flag   1  =      \                          and
      if
        i.p.c  0  >
        if
          make.ind
        else
          plot.ext    make.abc    \ Cannot be used in Menu
```



```
        then
      else
        f.no.c  2.  /    f.no.c  2 /   -     0  =
        if
        i.p.c  0  >
          if
            make.ind
          else
            plot.ext    make.abc    \ Cannot be used in Menu
          then
        then
      then
    then
;
: gen.p.s.plot  \  [ " ext"  -- ]
\  plot.ext     ":=

  xlyl
  \ xoyo
  gd
  c.#.b   96 +   f.no.c  :=  \ " a"
  begin
  \  gd  hp
    abc.mid.flag   1  =      \                          and
    if
      gd  \ clear
    then
    f.no.c  2.  /    f.no.c  2 /   -     0  <>
    if     up2
    else   dp2
    then
    normal.coords
    0.75  0.98  position  d&t.string
       label
    datafile.dat.p23    "len  4 -  "left  datafile.dat.p2  ":=
    0.75  0.9   position  " CASE : "  datafile.dat.p2       "cat  label
\   0.75  0.86  position  " CHANNEL : "       f.no.c  48  -  ascii"
   "cat label
    0.75  0.86  position  " GROUP: "  c.#.b   48  +  ascii" "cat \ label
                " --"   c.#.b  #.lines + 1 -  48  +  ascii" "cat "cat
                  label
    1.   1.    position
    world.coords
    1  line.#  :=
    begin
\     f.no.c  96  -   #.fft.pts    #.sec  " b"  f.beg  f.end   p.s.exq
    \  f.no.c  96  -
      line.#
      line.# 1   =
        if    " a"
        else  " d"
        then
      whp.p

      normal.coords
```

```
      0.75  0.82   key.orig
      line.#   dup    " Chan. "  f.no.c  48  -  ascii"  "cat   mkl.bat    216
      key.done
      world.coords
      normal.coords
      0.75  0.98  position  d&t.string          label
      datafile.dat.p23    "len  4 -  "left  datafile.dat.p2   ":=          221
      0.75  0.9   position  " CASE : "  datafile.dat.p2       "cat
         label
      0.75  0.86  position  " GROUP: "  c.#.b   48  +  ascii" "cat \
         label
            " --"   c.#.b  #.lines + 1 -  48  +  ascii" "cat "cat
               label
      1.   1.    position
      world.coords                                                    226
      f.no.c 1 +  f.no.c :=
      line.# 1 +  line.#  :=
      line.#      #.lines  >
    until
    normal.coords                                                     231
\     "  #.pts:" "cat  #.fft.pts 0 n>s "cat   " , Wnd:" "cat  wnd.str
   "cat
\     " , #.secs:" "cat  #.sec 0 n>s "cat
\     " , Offset:" "cat  offset.str  "cat
\     " , Lowpass:" "cat
    0.02  0.98  position                                              236
\      "   ("
\     " Lowpass:" "cat
\     smo.flag  0 =
\     if     0
\     else   smo.p                                                    241
\     then   0 n>s  "cat
\      " )" "cat       label
    get.spe.str  label
    world.coords
                                                                      246
    " Cumulative Distribution"    " Wave Height"
    lab.app  "cat   0.01 y.lab.shift +  labxy.stack
    \ " Frequency (Hz)   " Power Density"   lab.app  "cat   0.01
       labxy.stack
    hard.copy
    \ sc                                                              251
    my.pause

    f.no.c 1 +  f.no.c  :=
    \   f.no.c  97  s.chnls  +    =
    f.no.c     97  c.#.b   #.lines   +  +   =                        256
  until
  i.p.c  0  >
  if
    i.p.c  1  +  i.p.c  :=
  then                                                                261
  prn.str  " y"  "=
  if
    " tmp"  dump.p.o.p
```



```
  then
  xlyl                                                                266
;

: gen.p.s.plot.exec
  #.lines  c.#.b  +  s.chnls  >
  if                                                                  271
    s.chnls   c.#.b  - 1 +   #.lines :=
  then
  #.lines  0  >
  c.#.b  s.chnls  <=   and
  if                                                                  276
    gen.p.s.plot
  else
    exit
  then
;                                                                     281
: gen.p.s.plot.0gp
  0  c.#.b    :=
  1  #.lines  :=
  begin
    c.#.b 1 +  c.#.b  :=                                              286
    gen.p.s.plot.exec
    \   s.chnls  c.#.b  =
  until
;
: gen.p.s.plot.1gp                                                    291
  1        c.#.b    :=
  s.chnls  #.lines  :=
  gen.p.s.plot.exec
;
: gen.p.s.plot.2gp                                                    296
  \ 0   i.p.c   :=       \ same gp extension
  \ 1   i.p.c   :=       \ individual name
  1                    c.#.b    :=
  group.ele [ 1 ]      #.lines  :=
  gen.p.s.plot.exec                                                   301
  #.lines  c.#.b  +         c.#.b    :=
  s.chnls  c.#.b  -  1 +    #.lines  :=
  gen.p.s.plot.exec
;
: gen.p.s.plot.3gp                                                    306
  1                    c.#.b    :=
  group.ele [ 1 ]      #.lines  :=
  gen.p.s.plot.exec
  #.lines  c.#.b  +    c.#.b    :=
  group.ele [ 2 ]      #.lines  :=                                    311
  gen.p.s.plot.exec
  #.lines  c.#.b  +         c.#.b    :=
  s.chnls  c.#.b  -  1 +    #.lines  :=
  gen.p.s.plot.exec
;                                                                     316

: whp.d.plot
  \ 0   i.p.c   :=       \ same gp extension
```

```
  1   i.p.c    :=        \ individual name
  #.groups                                                                 321
  case
  0   of   gen.p.s.plot.0gp   endof
  3   of   gen.p.s.plot.3gp   endof
  2   of   gen.p.s.plot.2gp   endof
  1   of   gen.p.s.plot.1gp   endof                                        326
  endcase
;
```

LPLT-0.TXT

A01810-20161220-A013 ❖ December 20, 2016 ❖ [Page count: 3]

```
\ : lref-0 ; & : lplt-0 ;                                                    1
\ ================================================================
\
\ Keywords       :  1. Wav-anaa.all
\                   2.
\                                                                            6
\ Written        :  Nov. 1993 by  Y-R Lee  (updated Feb. 1994)
\ ================================================================
" p"    xeq.flag  ":=
echo.off
1 29.flag :=                                                                11
: menu.word
  menu.flag 0 =
  if
    forget.all
  then                                                                      16
; menu.word
: lcom-0 ;

integer scalar  smo.flag
: menu.word                                                                 21
  menu.flag 0 =
  if
    dir.lee.txt   " def-winn.nam"  "cat   defer> load
    dir.lee.txt   " def-acqn.nam"  "cat   defer> load
    dir.lee.txt   " def-anan.nam"  "cat   defer> load                       26
  \  dir.lee.txt   " def-acqs.spe"  "cat   defer> load
  \  dir.lee.txt   " def-ana1.1sp"  "cat   defer> load
  then
  dir.lee.txt   " def-acqs.spe"  "cat   defer> load
  dir.lee.txt   " def-ana1.1sp"  "cat   defer> load                         31
  \  1  smo.flag  :=
  dir.lee.txt   " def-anaT.Tsp"  "cat   defer> load
  dir.lee.txt   " lcri.cri"      "cat   defer> load
; menu.word
                                                                            36
: tmp.word
  menu.flag 0 =
  if
    cr ." Non stop execuation (y/n)? "   " n"  get.str   non.stop.str
       ":=
  then                                                                      41
;
\  %% tmp.word  --- Placed in
tmp.word

input.case.flag                                                             46
dir.lee.txt   " Coef-" "cat   " gp"      "cat   " .dat" "cat   defer> load
\  put    " eee"   " r03"   " h01"   " ldv"   ....  on stack
dir.lee.txt   " Coef-" "cat   " gp"      "cat   " .txt" "cat   defer> load
\  check exist or not
dir.lee.txt   " Coef-" "cat  cnst.flag  "cat   " .dat" "cat   defer> load   51
```



```
dir.lee.txt   " get-s-ch.txt"                          "cat   defer> load
{29.line}

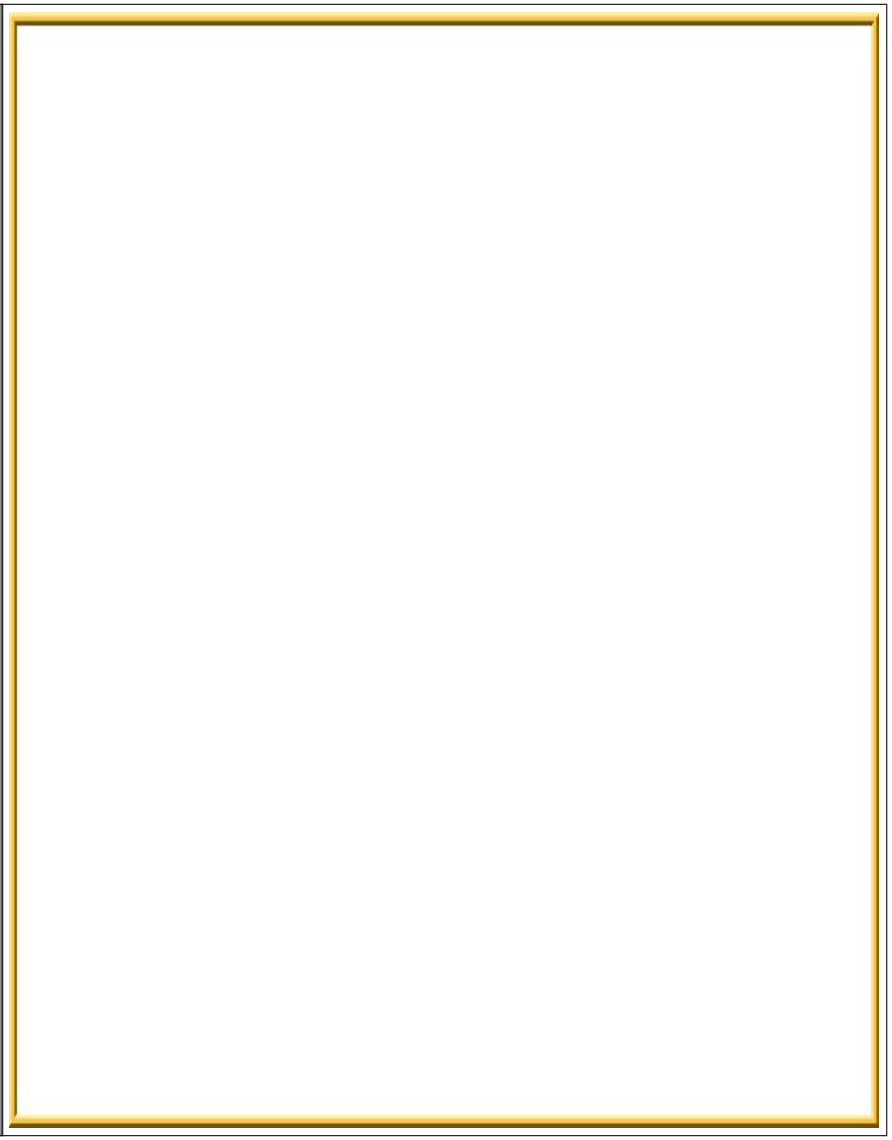
: create.rain.sta.ary.asc ;         \ dummy
                                                                            56
: data.sta.xeq     \ dummy word
;                  \ reset at data-sta.bat

\ 1 eps.flag :=

                                                                            61
: wave.ana.xeq
  " ind"  case.flag  "=
  if
       datafile.dat.p2  "dup
  else          \  <--- [ file name - ]                                     66
       "dup
  then
                dir.lee.asc "swap "cat    " .prn"  "cat    defer> delete
                dir.lee.dat "swap "cat    " .dat"  "cat    datafile.dat
                  ":=
  \  xeq.flag  " r"  "=                                                     71
  \  if   dir.lee.txt " lref-mai.txt"       "cat    defer> load   then
  \  xeq.flag  " p"  "=
  \  if   dir.lee.txt " lplt-mai.txt"       "cat    defer> load   then
\  1  eps.flag  =
\  if                                                                       76
\                dir.lee.txt " lref-m-e.txt"       "cat    defer> load
\  else
                dir.lee.txt " lref-mai.txt"       "cat    defer> load
\  then
;                                                                           81

\
   ^^^
```

```
: menu.word
  menu.flag 1 =
  if                                                    106
    axis.defaults
    forget lcom-0
  then
  bell.3dn
  \   500 msec.delay                                   111
; menu.word
\ sc
cdt
```



LPlt-Mai.txt

A01838-20171122-A004 ❖ November 22, 2017 ❖ [Page count: 30]

```
\ ================================================================
\ Asyst text file        ------    wav-anac.cor  ------     (c) Lee Yueon-
   Ron  \

\ REQUIREMENTS : 1.  LIM EMM4
\                2.  Overlay files included ( Data, Wave, Alg )
\                3.  Compatible raw data file structure ( ACQ )
\                4.  Consistant Jumper or Gain setting parameters
\                5.  Maximum number of waves for each channel not to
   overflow
\                6.  System configured properly
\
\ KEY WORDS     : 1.  Raw data manipulation and analysis
\                2.  Wave statistics
\                3.  Convolution low pass filtering
\                4.  Fast Fourier transform
\                5.  Regular wave reflection coefficient
\                6.  Irregular wave reflection coefficient
\                7.  Reconstructed incident and reflection waves
\                8.  Modulated structure
\
\ MEM HINTS     : 1.  Array      --- minor
\                      old ver --- DAS       +  minor
\                                  1C *8 *2
\                2.  Token      --- minor
\                      old ver --- 1 cha +  FFT coef  + IFFT  +  w.h
   +  w.p
\                                  1C *4   1C *2*2 *4   2C *8  1000 *4
     1000 *4
\                3.  Unnamed    --- [FFT]      +   Re[FFT]   ( > Ramp for
    PSD )
\                                  1C *1*2*4    1C *1*1*4       1 ch
   *2*4
\                4.  DAS buf    --- 0
\
\ WRITTEN        -   Dec, 1990 by  Lee Yueon-Ron  (03/91, 11/93, 02/94)
\ ================================================================

echo.off

: lcom-mai ;
get.d&t.string
1 pass.id := \ Set the transferred data file to default(0) or to be
   assigned(1)

\ ================================================================
: get.datafile.dat
  datafile.dat defer> file.open

  1 comment>   mycase          ":=
  2 comment>   mydate          ":=
  3 comment>   mytime          ":=
```



```
  4 comment>   specifics       ":=
  5 comment>   datafile.dat.p23 ":=
  file.close

  datafile.dat.p23  "len   4  -  "left            datafile.dat.p2  ":=
  dir.lee.dat  DATAFILE.dat.p23              "CAT   datafile.dat   ":=
  dir.lee.asc  DATAFILE.dat.p2  " .asc" "cat "CAT   datafile.asc   ":=
  dir.lee.prn  DATAFILE.dat.p2  " .prn" "cat "CAT   datafile.prn   ":=

  dir.lee.prn  datafile.dat.p2
  "cat   " .prn"  "cat  datafile.prn  ":=

  \  screen.clear
  {mes.wnd}
  3 17  goto.xy
  ." Current data file is   "   datafile.dat  s.type  \ int.on "type
  \  int.of
  {29.line}

  datafile.dat  defer> file.open
  1 subfile  acq.input  file>array
             acq.input  [ 1  ] t.rate       :=
             acq.input  [ 2  ] s.length     :=
             acq.input  [ 3  ] s.freq       :=
             acq.input  [ 4  ] s.chnls      :=
             acq.input  [ 5  ] p.chnl       :=
             acq.input  [ 6  ] p.points     :=
  2 subfile   file>unnamed.array    becomes>  db0
  file.close
;
get.datafile.dat

integer scalar x.min.p   scalar x.max.p   scalar 1or2
real    scalar x.min     scalar x.max
        scalar y.min     scalar y.max

: get.a.token
  db0 xsect[ ! , add.chnl ]
  add.chnl  channel.const
  add.chnl  smooth.spe
  shift.raw.data
  smooth.xeq
  conv.formula
  becomes>  a.token
  1        array.size  x.max.p :=  x.min.p :=
  a.token  []min/max   y.max   :=  y.min   :=

  1                          x.min.p :=
  0.       s.freq float /    x.min :=
  x.max.p  s.freq float /    x.max :=
  a.token []size  6000 >=   drop
  if
    2  1or2  :=
  then
;
```

```
                                                                        101
: reset.xy.min/max
  2  0 fix.format                                              {border}
  15   3   goto.xy   ." Channel:"            add.chnl  get.val  add.chnl
       :=
  get.a.token   {border}
  15   4   goto.xy   ." One or Two Plots?"   1or2      get.val  1or2  :=  106
  6  2 fix.format
  15   6   goto.xy   ." x.min="          x.min   get.val    x.min :=
  15   7   goto.xy   ." x.max="          x.max   get.val    x.max :=
  40   6   goto.xy   ." y.min="          y.min   get.val    y.min :=
  40   7   goto.xy   ." y.max="          y.max   get.val    y.max :=      111
  15   9   goto.xy   ." Y label="        tmp.s.9 get.str    tmp.s.9 ":=
  12  11   goto.xy    " To change press <F>."  s.type
;
: plot.lab
  normal.coords                                                         116
  line.c  color
  get.spe.str
  0.13  0.97  position             label
  0.75  0.97  position  d&t.string  label
  0.85  0.90  position  " Chan: "  add.chnl 0 n>s  "cat label            121
  " Time (Sec)"  tmp.s.9  0.02  labxy.stack
;

: plot.chnl
  10  10 axis.divisions                                                 126

  tmp.s.9  ":=
  1or2      :=
  add.chnl  :=
  add.chnl  0  =  if  exit  then                                        131
  get.a.token
  nd
  2  0  fix.format                                            {border}
  15   3   goto.xy   ." Channel: "           add.chnl  n.type
  get.a.token   {border}                                                136
  15   4   goto.xy   ." One or Two Plots? "  1or2      n.type
  6  2 fix.format
  15   6   goto.xy   ." x.min="          x.min   n.type
  15   7   goto.xy   ." x.max="          x.max   n.type
  40   6   goto.xy   ." y.min="          y.min   n.type                  141
  40   7   goto.xy   ." y.max="          y.max   n.type
  15   9   goto.xy   ." Y label="        tmp.s.9  s.type

  12   11  goto.xy    " To change press <F>."  s.type
  pckey  drop                                                           146
  if
    reset.xy.min/max
  then
  \  get.a.token

                                                                        151
  x.min  0.  =
  if
    1    x.min.p  :=
```



```
  else
    x.min  s.freq  float *   floor   x.min.p  :=                       156
    x.min.p  0  =
    if
      x.min.p 1 :=
    then
  then                                                                  161
  x.max  s.freq  float *   floor   x.max.p  :=

  1or2  1  =
  if
    hp                                                                  166
    horizontal
      axis.fit.off
      x.min.p  1 =
      if
        0        x.max      world.set                                   171
      else
        x.min    x.max      world.set
      then
    vertical
      axis.fit.off                                                      176
      y.min    y.max      world.set
    xy.axis.plot

    x.min.p  1  =
    if                                                                  181
      x.min.p                  x.max.p  x.min.p -  1 +  ramp          +
    else
      x.min.p                  x.max.p  x.min.p -  1 +  ramp  1 -     +
    then
    s.freq  float  /                                                    186
    a.token  sub[ x.min.p  ,   x.max.p  x.min.p -  1 +  ]
    add.chnl  xydp
    plot.lab
  else
    gd                                                                  191
    up
    horizontal
      axis.fit.off
      x.min.p  1 =
      if                                                                196
        0   x.min  :=
        x.min          x.max  x.min -  2. /  x.min +    world.set
      else
        x.min          x.max  x.min -  2. /  x.min +    world.set
      then                                                              201
    vertical
      axis.fit.off
      y.min    y.max      world.set
    xy.axis.plot
    x.min.p  1  =                                                       206
    if
      x.min.p     x.max.p  x.min.p - 2 /   1 +  ramp          +
    else
```

```
      x.min.p     x.max.p  x.min.p - 2 /   1 +  ramp  1 -    +
    then                                                              211
    s.freq  float  /
    a.token  sub[ x.min.p  ,   x.max.p  x.min.p - 2 /  1 +  ]
    add.chnl  xydp
    plot.lab
                                                                      216
    dp
    horizontal
      axis.fit.off
      x.max  x.min -  2. /  x.min   +    x.max     world.set
    xy.axis.plot                                                      221
    x.min.p  1  =
    if
      0  x.min.p  :=
    then
    x.max.p  x.min.p - 2 / floor  x.min.p +                           226
    x.max.p  x.min.p - 2 / floor 1 +  ramp         +
    s.freq  float  /
    a.token
    sub[ x.max.p x.min.p - 2 / floor x.min.p + ,
         x.max.p x.min.p - 2 / floor 1 + ]                            231
    add.chnl  xydp
    plot.lab
  then
  hp
  \  my.outline                                                       236
  \  dir.lee.asc  datafile.dat.p2  "cat
  h.c.str  " y"  "=
  if
  \  datafile.dat.p2 " .t" "cat add.chnl 0 n>s "cat  defer>  hp
     dump.p.o.stack
  then                                                                241
;

cr cr  cr ."   DATA manipulation, please wait ....."
\  \ load c:\per\asy\Armo.Typ       \  armor.type
\ ================================================================   246
: creat.datafile.asc       \ create ASCII file of filtered raw data
  cr mycase       s.type
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    48  mytime  "len  -  spaces            "drop
  ." Sampling frequency    :"   s.freq            .   ."   Hz"      251
  cr specifics    "type    48  specifics  "len  - spaces           "drop
  ." Sampling time length  :"   s.length s.freq /   .   ."  Sec"

  cr  " Unit conversion (1) or Not (0): "  s.type  0  get.val
  0  =                                                                256
  if
    10  0 fix.format
    s.length 1 +  1
    DO cr
      s.chnls 1 +   1                                                 261
      DO
                        db0   [ j  ,  i ]
```



```
                                .
      loop
    loop                                                              266
  else
    11   4  sci.format
    s.length 1 +  1
    DO cr
      s.chnls 1 +   1                                                 271
      DO
                        i  channel.const
                        i  smooth.spe
                        db0   [ j  ,  i ]
                        conv.formula                                  276
                        ."    "
                        .
      loop
    loop
  then                                                                281
;

: make.ascii
  cr  " Unit conversion (1) or Not (0): "  s.type  0  get.val
                                                                      286
  cr ."   Storing ASCII data to hard disk, please wait ....."
  datafile.asc   defer>  delete
  datafile.asc   defer>  out>file  console.off  echo.off

  cr mycase       s.type                                              291
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    48  mytime  "len  -  spaces            "drop
  ." Sampling frequency    :"   s.freq            .   ."   Hz"
  cr specifics    "type    48  specifics  "len  - spaces           "drop
  ." Sampling time length  :"   s.length s.freq /   .   ."  Sec"   296

  0  =
  if
    10  0 fix.format
    s.length 1 +  1                                                   301
    DO cr
      s.chnls 1 +   1
      DO
                        db0   [ j  ,  i ]
                        .                                             306
    loop
  loop
  else
    11   4  sci.format
    s.length 1 +  1                                                   311
    DO cr
      s.chnls 1 +   1
      DO
                        i  channel.const
                    \   i  smooth.spe                                 316
                        db0   [ j  ,  i ]
                        conv.formula
```

```
                        ."     "
                        .
      loop                                                          321
    loop
  then
\  creat.datafile.asc
  my.out>file.close
  cr   ."                ASCII data file created    :   " datafile.asc      326
     "type  cr
;
\ make.ascii
\ ================================================================

\ !--------------------------------------------------------------------     331
   Simulated spectrum
real scalar Amp.i.s
     scalar Amp.r.s
     scalar x.pos.1
     scalar x.pos.2
     scalar phase                                                       336

\ 2000.      g.depth       :=
\ g.depth    depth.1       :=
\ 1          b.p.1         :=
\ 2 10 **    fft.points    :=                                          341

: compute.wave.length             \  You should provide: w.l.o g.depth
   tmp.period
                                  \  Accelerated Newton Method
  {  2pid      := 2 * pi * g.depth                              }
  {  gtt/2pi   := gravity * tmp.period ** 2 / 2 / pi    }              346
  {  gttd      := gravity * tmp.period ** 2 *  g.depth  }
  {  w.l.o     := gtt/2pi     }     \  place outside to improve efficiency
     for FFT
  begin
    {  2pid/l := 2pid / w.l.o
                                                          }
    {  w.l.n   := w.l.o - ( w.l.o - gtt/2pi * tanh ( 2pid/l ) ) /       351
                          ( 1 + gttd / w.l.o ** 2 * sech ( 2pid/l ) ** 2
                             )  }
    w.l.n  w.l.o  -  abs  w.l.o /   epslon  <
    w.l.n  w.l.o  :=
  until
;                                                                     356

: c.standing.w.amp  \  [ position of gauge ]  -> amp
  2  pi  *  w.l.n  /    tmp.v  :=
  real   s.length  ramp  neg  s.freq  /
         2 * pi * tmp.period  /                                       361
         tmp.v   w.l.n  *  +
         sin
         tmp.v   x.pos  w.l.n  -  *
         cos  *
         2  *  750  *                                                366
;
```



```
: com.std
  1      tmp.period  :=
  120    w.l.o       :=                                               371
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *
      x.pos  :=  c.standing.w.amp  2048  +  db0   xsect[ ! , 1 ]  :=
  8.  8.  /  w.l.n  2.  /  *
      x.pos  :=  c.standing.w.amp  2048  +  db0   xsect[ ! , 2 ]  :=    376
  2.  16.  /  w.l.n  *  del.l  :=
;
real scalar tmp.v.sp
: p.s.w.amp.ind  \  [ x.pos , amp.i , amp.r , T , phase ] -> amp
  phase        :=                                                     381
  tmp.period   :=
  amp.r.s      :=
  amp.i.s      :=
  x.pos        :=
                                                                      386
  120.  w.l.o  :=
  compute.wave.length
  2.  pi  *  w.l.n  /    tmp.v.sp  :=
  real      s.length  float  ramp  s.freq  /
  dp>sp                                                               391
            2.  *  pi  *  tmp.period  /
            dup
            tmp.v.sp  x.pos  * swap  -  phase  +  sin    amp.i.s  *
            swap
            tmp.v.sp  x.pos  *       +  phase  +  sin    amp.r.s  *     396
            -
;

: par.std.spec.0  \ kr=0
  1     tmp.period  :=    \  ---> del.l = 19.50                        401
  120   w.l.o       :=
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *                                          406
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1    1024      0    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
  db0   xsect[ ! , 1 ]  :=
    x.pos.2    1024      0    1.0    0    p.s.w.amp.ind  dp>sp  2048  +  411
  db0   xsect[ ! , 2 ]  :=
;

: spec.show
  1     tmp.period  :=    \  ---> del.l = 19.50                        416
  120   w.l.o       :=
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *                                          421
  x.pos.2  :=
```

```
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1     750    500    1.00   0    p.s.w.amp.ind  dp>sp  2048  +
    x.pos.1     800    400    1.10   0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     600    500    1.20   0    p.s.w.amp.ind  dp>sp  2048  +  426
        +
    x.pos.1     400    250    1.05   0    p.s.w.amp.ind  dp>sp  2048  +
        +
\   x.pos.1     400    250    0.98   0    p.s.w.amp.ind  dp>sp  2048  +
    +
  db0   xsect[ ! , 1 ]  :=
    x.pos.2     750    500    1.00   0    p.s.w.amp.ind  dp>sp  2048  +
    x.pos.2     800    400    1.10   0    p.s.w.amp.ind  dp>sp  2048  +  431
        +
    x.pos.2     600    500    1.20   0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.2     400    250    1.05   0    p.s.w.amp.ind  dp>sp  2048  +
        +
\   x.pos.2     400    250    0.98   0    p.s.w.amp.ind  dp>sp  2048  +
    +
  db0   xsect[ ! , 2 ]  :=
    x.pos.1     750      0    1.00   0    p.s.w.amp.ind  dp>sp  2048  +  436
    x.pos.1     800      0    1.10   0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     600      0    1.20   0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     400      0    1.05   0    p.s.w.amp.ind  dp>sp  2048  +
        +
\   x.pos.1     400      0    0.98   0    p.s.w.amp.ind  dp>sp  2048  +
    +
  db0   xsect[ ! , 3 ]  :=                                              441
;
: par.std.spe  \ kr=0.5
  1     tmp.period  :=    \  ---> del.l = 19.50
  120   w.l.o       :=
  compute.wave.length                                                   446
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=                                     451
    x.pos.1     500    250    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     300    150    1.15   0    p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.1     400    200    1.1    0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     500    250    0.9    0    p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 1 ]  :=                                              456
    x.pos.2     500    250    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     300    150    1.15   0    p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.2     400    200    1.1    0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.2     500    250    0.9    0    p.s.w.amp.ind  dp>sp  2048  +
```



```
        +
  db0   xsect[ ! , 2 ]  :=                                              461
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1     500      0    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     300      0    1.15   0    p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.1     400      0    1.1    0    p.s.w.amp.ind  dp>sp  2048  +
        +
    x.pos.1     500      0    0.9    0    p.s.w.amp.ind  dp>sp  2048  +  466
        +
  db0   xsect[ ! , 3 ]  :=

;
: par.std.spec.1  \ kr=1
  1     tmp.period  :=    \  ---> del.l = 19.50                         471
  120   w.l.o       :=
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *                                            476
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1    1024    512    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     500    250    1.15   0    p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.1     400    200    1.1    0    p.s.w.amp.ind  dp>sp  2048  +  481
        +
    x.pos.1     124     62    1.2    0    p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 1 ]  :=
    x.pos.2    1024    512    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     500    250    1.15   0    p.s.w.amp.ind  dp>sp  2048  +
     +
    x.pos.2     400    200    1.1    0    p.s.w.amp.ind  dp>sp  2048  +  486
        +
    x.pos.2     124     62    1.2    0    p.s.w.amp.ind  dp>sp  2048  +
        +
  db0   xsect[ ! , 2 ]  :=
;
: par.std.spec.1.RES  \ kr=1
  1     tmp.period  :=    \  ---> del.l = 19.50                         491
  120   w.l.o       :=
  compute.wave.length
  6.  8.  /  w.l.n  2.  /  *
  x.pos.1  :=
  8.  8.  /  w.l.n  2.  /  *                                            496
  x.pos.2  :=
  2.  16.  /  w.l.n  *    del.l  :=
    x.pos.1    1024   1024    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     500    500    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.1     400    400    1.1    0    p.s.w.amp.ind  dp>sp  2048  +  501
     +
\    x.pos.1     124    124    1.2    0    p.s.w.amp.ind  dp>sp  2048  +
     +
  db0   xsect[ ! , 1 ]  :=
```

```
    x.pos.2    1024   1024    1.0    0    p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     500    500    1.0    0     p.s.w.amp.ind  dp>sp  2048  +
\    x.pos.2     400    400    1.1    0     p.s.w.amp.ind  dp>sp  2048  +  506
     +
\    x.pos.2     124    124    1.2    0     p.s.w.amp.ind  dp>sp  2048  +
     +
  db0   xsect[ ! , 2 ]  :=
;

: create.spec.DATAFILE.dat                                                 511

  regular.datafile
     file.template
     8 comments
     integer  dim[ 6 ]  subfile                                            516
     integer  dim[ s.length , s.chnls ]  subfile
  end

  cr
  datafile.dat  " !!!!"  "cat  get.str datafile.dat  ":=                   521
  datafile.dat  defer>  file.create
  datafile.dat  defer>  file.open
           mycase           1  >comment
           mydate           2  >comment
           mytime           3  >comment                                    526
           specifics        4  >comment
           datafile.dat.p23 5  >comment
  1  subfile  acq.input   array>file
  2  subfile  db0   array>file
  file.close                                                               531
  cr  ."     Data file created   : "   datafile.dat  "type
;
\ \\ Now you only need to use this to specify any Kr (0 -- 1)
\ spec.show
\ create.spec.DATAFILE.dat                                                 536
\ ^-------------------------------------------------------------------
   Simulated spectrum
\ ===================================================================

\ \datafile.asc defer> delete
\ \datafile.prn defer> delete                                              541

\ token a.token
token w.h.ary
token w.p.ary
\ | real   dim[ n.of.w ] array  w.h.ary                                    546
\ | real   dim[ n.of.w ] array  w.p.ary
\ exp.mem>  a.token
exp.mem>  w.h.ary
exp.mem>  w.p.ary
                                                                           551
: out.of.index
  index 1 + array.size >
;
```



```
: H.s.c    \ H.scale.conversion   \  [ Int-val  ,  Real-practical-val ]   556
  dig.to.h  *
;

: T.s.c    \ T.scale.conversion   \  [ Int-val  ,  Real-practical-val ]
  float     s.freq float    /                                              561
;

: index.p.1
    index  1 +  index   :=
;                                                                          566

\  dir.lee.txt  " lcri.cri"  "cat  defer>  load
\ ======================================
: raw.exp.ana    \
   1-----------------------------------------------------------------1
  tmp.v.i  :=                                                              571
  tmp.v.i  channel.const
  tmp.v.i  smooth.spe
  get.forced.spe.ref
  \  1. *  becomes> a.token            \ real
  \  1  * 1. *  becomes> a.token     \ dp.real                             576
  \  equiv> a.token                  \ integer
  real n.of.w  ramp  0 over :=  becomes>   w.h.ary
           w.h.ary              becomes>   w.p.ary

\  conv.formula  becomes>   a.token                                        581
\  smooth.xeq

  shift.raw.data
  smooth.xeq
  conv.formula  becomes>   a.token                                         586
\  a.token
\  drop

\  smooth.xeq
\  conv.formula  becomes>   a.token                                        591
\  a.token
\  shift.raw.data
\  drop

   \ gd hp                                                                 596
   \ up  a.token 1 yap
   \ my.pause

  0 index :=
  0 i.count :=                                                             601

  begin
   index.p.1
   a.token [ index ]  sgn    0  >          \   set to zero down crossing
   index  array.size           >=    or                                   606
  until

  index  array.size  <
```

```
if
  a.token [ index ]  sgn                                              611
  begin
      index.p.1
      a.token [ index ]  sgn  dup rot  <>
      dup                     0        <>    and
      index  array.size                >=    or                       616
  until
      index  left.index        :=
      dup    zero.up.or.down   :=
then
\  cr  ." left.index"    left.index .                                  621

begin    \
   !2-------------------------------------------------------------!2

index  array.size  <
  if
    begin                                                             626
      index.p.1
      a.token [ index ]  sgn  dup rot  <>
      dup                     0        <>    and
      dup    zero.up.or.down           =     and
      index  array.size                >=    or                       631
    until
    index       right.index :=
  then

  index  array.size  <                                                636
  if
    i.count  1 +   i.count :=
    \ cr ." right.index=  "    right.index .
    \ cr ." i.count=  "        i.count     .
    right.index left.index -                    w.p.ary [ i.count ] :=  641
    a.token sub[ left.index ,   right.index left.index -  ]
    []min/max  swap -                            w.h.ary [ i.count ] :=

    right.index left.index  :=
  then                                                                646

index array.size  >=
until   \
   ^2-------------------------------------------------------------^2


i.count  0  >                                                         651
if
   drop
then
\ cr ." i.count ="   i.count  .   ."              ch = "  i  .
                                                                      656
i.count 0 >
if
  \  i.count     n.of.w.ary  [ 1 , i ]  :=
  w.p.ary    t.s.c    w.p.ary   :=  \ pratical unit
```



```
  then                                                                661
  \  dp w.h.ary sub[ 1 , 50 ] 1 yap  hp i.count .   my.pause
; \
   ^1-------------------------------------------------------------^1

: w.h.sort&index   \
   !3-------------------------------------------------------------!3
  i.count 10 /          1/10.index          := \  cr 1/10.index  .    666
  i.count 3  /          1/3.index           := \  cr 1/3.index   .
  i.count 2  /          1/2.index           := \  cr 1/2.index   .

  1/10.index 0 >
  if                                                                  671
    1  tmp.v.i  :=
    real  i.count  ramp    becomes>  a.token

    w.h.ary  sub[ 1 , i.count ]    sort&index
                                                                      676
    rev[ 1 ]
      begin  \  w.p stored in accordance with w.h in descent order
        dup  [ tmp.v.i ]     tmp.v.i.2  :=
        w.p.ary [ tmp.v.i.2 ]     a.token [ tmp.v.i ]  :=
        tmp.v.i  i.count  >=                                          681
        tmp.v.i  1 +   tmp.v.i  :=
      until
    drop
    a.token  ^sum
      dup  [ 1/10.index ]       1/10.index  /  1/10.w.p :=            686
      dup  [ 1/3.index  ]       1/3.index   /  1/3.w.p  :=
      dup  [ 1/2.index  ]       1/2.index   /  1/2.w.p  :=
           [ i.count    ]       i.count     /  ave.w.p  :=

    rev[ 1 ]   \ dup   w.h.token  :=                                  691
    ^sum
      dup  [ 1/10.index ]       1/10.index  /  1/10.w.h :=
      dup  [ 1/3.index  ]       1/3.index   /  1/3.w.h  :=
      dup  [ 1/2.index  ]       1/2.index   /  1/2.w.h  :=
           [ i.count    ]       i.count     /  ave.w.h  :=            696

    1  tmp.v.i  :=
    0. tmp.v    :=
    0. tmp.v.2  :=
    begin                                                             701
      tmp.v     w.h.ary   [ tmp.v.i ]  2. **  +       tmp.v   :=
      tmp.v.2   w.p.ary   [ tmp.v.i ]  2. **  +       tmp.v.2 :=
      tmp.v.i   1 +    tmp.v.i   :=
      tmp.v.i   i.count >
    until                                                             706
    tmp.v     i.count / sqrt                rms.w.h  :=
    tmp.v.2   i.count / sqrt                rms.w.p  :=

  then
;  \                                                                  711
   ^3-------------------------------------------------------------^3
```

```
\ ================================================================
token  wha  exp.mem>  wha
token  wpa  exp.mem>  wpa
: wh.wp                                                          716
  dup  1  +   swap
  \ s.chnls 1 +   1
  DO
         db0     xsect[ ! , i ]
                                                                 721
         i  raw.exp.ana
         \ cr  i .   ." *********    ok    raw.exp.ana   *********"
            cr
               i.count 0 <=
               if
               4 0 fix.format  i  float . 5 0 fix.format i.count      726
                  n.type
         \     ."    ------- No complete wave cycle  --------"
               ."    ------- Not enough wave cycles --------"
               then

         i.count 0 >                                             731
         if
           w.h.sort&index
           \ cr i .  ." *********    ok w.h.sort&index   *********"
              cr
           1/10.index 0 <=
           if                                                    736
                 4 0 fix.format i  float  .  5 0 fix.format i.count
                    n.type
                 ."    ------- Too small number of waves ------"
           then

           1/10.index 0 >                                        741
           if
                 4 0 fix.format i  float  .  5 0 fix.format i.count
                    n.type
                 \ =w.h.token  sort  rev[ 1 ]
                 w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]
                                                                 746
                 wh.format
                                  dup  [ 1 ]                  .
                                  dup  [ 2 ]                  .
                                       [ 3 ]                  .  2
                                     spaces
                 1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .      751
                    rms.w.h  .
                 3 spaces
                 6 2 fix.format
                 1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .
                    rms.w.p  .
           then
                                                                 756
         then
         cr
  loop
```



```
  w.h.ary  sub[ 1 , i.count ]  becomes>  wha                     761
  w.p.ary  sub[ 1 , i.count ]  becomes>  wpa
;

: creat.datafile.prn       \ on site print out of wave statistics
  get.forced.spe.ref                                             766
  \ \  cr case       slope  "cat         "type
  cr mycase       s.type
  1 0 fix.format
  \  ."   ( f"    smo.flag 0 n>s s.type    ."  p"  smo.p 0 n>s s.type
  \  ."  c" conv.flag 0 n>s s.type    ."  s" shif.flag 0 n>s s.type ."   771
     )"
  get.spe.str    s.type
  cr mydate       "type    5 0 fix.format
  cr mytime       "type    68  mytime  "len  -  spaces            "drop
  ." Sampling  frequency  :"  s.freq              .   ."  Hz"
  cr specifics    "type    68  specifics  "len  - spaces           "drop  776
  ." Sampling time length  :"  s.length s.freq /   .   ."  Sec"
  cr      cr  \     cr

  ."  Ch   #_W"  ."    "
  "  H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms" s.type      781
   3 spaces
                                        "  T1/10  T1/3  T1/2 T.ave T.rms"
                                           s.type
  cr  cr
        s.chnls 1 +   1
        do                                                       786
          i  wh.wp
        loop
;

\ datafile.prn  defer>  out>file      echo.off  \   console.off      791

\ creat.datafile.prn
\ my.out>file.close
\ {29.line}
\ cr  ."                PRN   data file created    :  " datafile.prn    796
   "type  cr
\ datafile.prn defer> print
-1 4 fix.format

\ ================================================================
\ !--------------------------------------------------------------!   801

real    scalar  a.ch1        scalar  cos.k.dl
        scalar  a.ch2        scalar  sin.k.dl
        scalar  b.ch1        scalar  kr
        scalar  b.ch2                                            806

integer scalar  m.max
        scalar  m.min
dp.real scalar  sum.ai.sq
        scalar  sum.ar.sq                                        811
```

```
real     scalar  l.max
         scalar  l.min
         scalar  t.max
         scalar  t.min
                                                                          816
token  Re.fft.ary
token  Im.fft.ary
token  ifft.ary.inc
token  ifft.ary.ref
                                                                          821
exp.mem>  Re.fft.ary
exp.mem>  Im.fft.ary
exp.mem>  ifft.ary.inc
exp.mem>  ifft.ary.ref
                                                                          826
\ !4-------------------------------------------------------------------!4
dp.real scalar amp.i               scalar apha.max            scalar
   apha.min
        scalar amp.r               scalar apha.ran            scalar
           apha.old
        scalar apha                scalar acos.sn1            scalar
           acos.sn2
        scalar out.s               scalar out.o                        831
        scalar apha.max.sec        scalar apha.min.sec
        scalar as1      scalar as2        scalar theta       scalar beta
        scalar apha.1   scalar apha.2     scalar beta.1      scalar
           beta.2

: f.as1.as2                                                               836
  a.ch1 2 **   b.ch1 2 **  +   amp.i 2 **  +   amp.r 2 **   -
  2 /   amp.i /   a.ch1 2 **   b.ch1 2 **  +  sqrt   /
  dup   abs  1  >
  if
      cr  ."  ----- Modified ----  As1 is out of bound  -----  "  dup  . 841
      sgn  1.  *
  then
  asin    as1   :=

  a.ch1 2 **   b.ch1 2 **  +    amp.r 2 **  +   amp.i 2 **   -            846
  2 /   amp.r /   a.ch1 2 **   b.ch1 2 **  +  sqrt   /
  dup   abs  1  >
  if
      cr  ."  ----- Modified ----  As2 is out of bound  -----  "  dup  .
      sgn  1.  *                                                          851
  then
  asin    as2   :=
;

: f.theta                                                                 856
  a.ch1    a.ch1 2 **    b.ch1 2 **    +  sqrt  /   asin
  b.ch1    0    <
  if
     neg  pi   +
  then                                                                    861
  theta   :=
```



```
;

: chk.apha.beta.agn
  a.ch1  amp.i apha cos  *  amp.r beta cos  *   +  - a.ch1 /  abs dup    866
     epslon  >
  b.ch1  amp.i apha sin  *  amp.r beta sin  *   -  - b.ch1 /  abs dup
     epslon  >
  OR
  if
    cr   ."    Need to be modified  ( > epslon ) ------  "        swap
       .  .
  else                                                                    871
  2 *drop
  then
;

: chk.apha.beta                                                           876
  a.ch1  amp.i apha cos  *  amp.r beta cos  *   +  - a.ch1 /  abs
     epslon  >
  b.ch1  amp.i apha sin  *  amp.r beta sin  *   -  - b.ch1 /  abs
     epslon  >
  OR
;                                                                         881

: f.apha.beta
  f.as1.as2       f.theta
  as1   theta   -               apha.1   :=
  pi    theta   -     as1   -   apha.2   :=
  theta   as2   -               beta.1   :=                               886
  as2     pi    -   theta   +   beta.2   :=
  apha.1                        apha     :=
  beta.1                        beta     :=
  chk.apha.beta
  if apha.2                     apha     :=                               891
     chk.apha.beta
     if beta.2                  beta     :=
        chk.apha.beta
        if apha.1               apha     :=
        then                                                              896
     then
   then
  chk.apha.beta.agn
;
\                                                                         901
   ^4-------------------------------------------------------------------


integer scalar s.min  integer scalar s.max
   \      scalar chnl.#1
   \      scalar chnl.#2
                                                                          906
: s.min.max  \ shifts of integration limits
  \  normal.display screen.clear
  cr   ."         shifts of integration limits :  "
  cr   ."                                        s.min = " #input  s.min
```

```
      :=
  cr    ." s.max = " #input   s.max   911
      :=
;
0 s.min :=    0 s.max :=
\ s.min.max

\ | real  dim[ fft.points ,       2 ]  array  Re.fft.ary                916
\ |       dim[ fft.points ,       2 ]  array  Im.fft.ary
  real
: FFT.ref.coe

  get.forced.spe.ref                                                     921
  db0   sub[ 1 , fft.points  ;  1 , 2 ]  1.  *        becomes>
     Re.fft.ary
                                        re.fft.ary   becomes>
                                           Im.fft.ary
  dp.real
  fft.points  complex  ramp                          becomes>
     ifft.ary.inc
                                        ifft.ary.inc becomes>            926
                                           ifft.ary.ref
  0.    0.   z=x+iy      ifft.ary.inc   :=
  0.    0.   z=x+iy      ifft.ary.ref   :=
  real

 \   3.884826    del.l    :=  \ for spectrum test                       931

   db0   xsect[ ! , r.ch1 ]
   \        sub[ 1 , #.fft.pts ]
            shift.raw.data
            r.ch1  smooth.spe                                          936
            smooth.xeq   \  smooth
            sub[ b.fft.p , fft.points ]
                        r.ch1  channel.const   conv.formula
            fft  dup   \ not xsect[ ! , i ]
            Zreal     Re.fft.ary   xsect[ ! , 1 ]   :=                 941
            Zimag     Im.fft.ary   xsect[ ! , 1 ]   :=
   db0   xsect[ ! , r.ch2 ]
            shift.raw.data
            r.ch2  smooth.spe
            smooth.xeq   \   smooth                                    946
            sub[ b.fft.p , fft.points ]
                        r.ch2  channel.const   conv.formula
            fft  dup   \ not xsect[ ! , i ]
            Zreal     Re.fft.ary   xsect[ ! , 2 ]   :=
            Zimag     Im.fft.ary   xsect[ ! , 2 ]   :=                 951

   del.l   20  *    l.max  :=
   l.max   9   /    l.min  :=
   { tmp.v := 2 * pi  }
                                                                       956
   { t.max := tmp.v /
        ( gravity * tmp.v / l.max * tanh ( tmp.v * g.depth / l.max ) )
           ** .5 }
```



```
   { t.min := tmp.v /
        ( gravity * tmp.v / l.min * tanh ( tmp.v * g.depth / l.min ) )
           ** .5 }
   \   t.max  s.freq *    fix   M.max  :=                               961
   \   t.min  s.freq *    fix   M.min  :=
   fft.points    t.max /   s.freq /    fix   M.min  :=
   fft.points    t.min /   s.freq /    fix   M.max  :=
   0.  sum.ai.sq  :=
   0.  sum.ar.sq  :=                                                   966

   \   m.max 0 -  m.max  :=   m.min 10 -  m.min :=        \  extended
      limits
   fft.points  2  +  tmp.v.i  :=

   m.max 1 + s.min -     m.min s.max +                                 971
   do
     \ fft.points i /    s.freq /   float  tmp.period  :=   \ T=N/m
        points/cycle
     fft.points float   i /    s.freq /    tmp.period  :=   \ T=N/m
        points/cycle
     compute.wave.length
     2  pi *   w.l.n /   del.l *    dup                   \ k * del.l   976
     cos     cos.k.dl  :=
     sin     sin.k.dl  :=

     re.fft.ary [ i ,     1 ]                        a.ch1  :=
     im.fft.ary [ i ,     1 ]    neg                 b.ch1  :=          981
     re.fft.ary [ i ,     2 ]                        a.ch2  :=
     im.fft.ary [ i ,     2 ]    neg                 b.ch2  :=
\     chnl.#1  channel.const
\     re.fft.ary [ i ,     1 ]         conv.formula   a.ch1  :=
\     im.fft.ary [ i ,     1 ]    neg  conv.formula   b.ch1  :=          986
\     chnl.#2  channel.const
\     re.fft.ary [ i ,     2 ]         conv.formula   a.ch2  :=
\     im.fft.ary [ i ,     2 ]    neg  conv.formula   b.ch2  :=

            {  ( ( a.ch2 - a.ch1 * cos.k.dl - b.ch1 * sin.k.dl ) ** 2 +  991
                 ( b.ch2 + a.ch1 * sin.k.dl - b.ch1 * cos.k.dl ) ** 2 )
                     sqrt
                   / 2. / sin.k.dl  abs }
            dup    neg
                 z=x+iy         ifft.ary.inc [ i ]  :=
                                                                        996
            {  ( ( a.ch2 - a.ch1 * cos.k.dl + b.ch1 * sin.k.dl ) ** 2 +
                 ( b.ch2 - a.ch1 * sin.k.dl - b.ch1 * cos.k.dl ) ** 2 )
                     sqrt
                   / 2. / sin.k.dl  abs }
            dup   \ neg
                 z=x+iy         ifft.ary.ref [ i ]  :=                 1001

    ifft.ary.inc [ i ] zimag  neg    amp.i  :=
    ifft.ary.ref [ i ] zimag         amp.r  :=

    { sum.ai.sq  :=  sum.ai.sq  +    amp.i ** 2 }                      1006
    { sum.ar.sq  :=  sum.ar.sq  +    amp.r ** 2 }
```

```
\
   !5-------------------------------------------------------------------------

  rad
  1  r.ch1  =
  if                                                                      1011

\  { ( ( a.ch1  + amp.r ) / amp.i ) }   1    min   acos  \  apha.min  :=
\  { ( ( b.ch1  - amp.r ) / amp.i ) }  -1    max   acos neg
\             pi  2. /  +                     max      apha.min  :=
\  { ( ( a.ch1  - amp.r ) / amp.i ) }  -1    max   acos  \  apha.max  :=  1016
\  { ( ( b.ch1  - amp.r ) / amp.i ) }  -1    max   acos  \  neg
\             pi  2. /  +                     min      apha.max  :=

  { ( ( a.ch1  + amp.r ) / amp.i ) }   1    min   acos    apha.min  :=
  { ( ( a.ch1  - amp.r ) / amp.i ) }  -1    max   acos    apha.max  :=    1021

  apha.max  apha.min  -      apha.ran :=
  apha.max  apha.min  +  2  /   apha  :=
  pi  2. /   { ( ( b.ch1  + amp.r ) / amp.i ) } 1 min acos  +
     apha.max.sec  :=
  pi  2. /   { ( ( b.ch1  + amp.r ) / amp.i ) } 1 min acos  -             1026
     apha.min.sec  :=

\ -1 4 fix.format
\ cr  i .
f.apha.beta
  0  tmp.v.i.2  <>                                                       1031
  if
    -1 4 fix.format
    cr  i .
    11 4 fix.format
    cr 3 spaces                                                           1036
    a.ch1 . b.ch1 . amp.i . amp.r . apha . beta . theta . apha.min .
       apha.max .
    cr                                80 spaces  apha.min.sec .
       apha.max.sec .
  then

apha  dup                                                                 1041
\             rand.unif   6.283185307  *   dup  dup  dup
              cos         ifft.ary.inc  [ i ]  zreal  *        swap
              sin         ifft.ary.inc  [ i ]  zimag  *
              z=x+iy  dup ifft.ary.inc  [ i ]         :=
              conj        ifft.ary.inc [ tmp.v.i  i  - ]  :=            1046
beta  dup
              cos         ifft.ary.ref  [ i ]  zreal  *        swap
              sin  neg       ifft.ary.ref  [ i ]  zimag  *
              z=x+iy  dup ifft.ary.ref  [ i ]         :=
              conj        ifft.ary.ref [ tmp.v.i  i  - ]  :=            1051

then
\
   ^5-------------------------------------------------------------------------
```



```
   loop                                                                   1056
   sum.ar.sq    sum.ai.sq /  sqrt    kr   :=
;
\ ================================================================

: App.datafile.prn            \ append FFT parameters to .prn file      1061
  get.forced.spe.ref
  cr
  9   4  fix.format
  cr  cr
  ." Energy reflection level (%): " kr 2. ** 100. *    .                 1066
  cr
  ." Program parameters, etc. :: "              cr
  ."                 Kr       : " kr  n.type   ."      r.ch1  : "  r.ch1
      n.type
                                                  ."      r.ch2  : "  r.ch2
                                                                .  cr
\ ."                 H.eng    : "           .  ."      depth  : "          1071
    g.depth .
  ."                                          "      ."      depth  : "
     g.depth .
  \                                           ."      w.l.n  : "  w.l.n
       .  cr
                                              ."      del.L  : "  del.l
                                                                .  cr
  \ ."               del.L    : " del.l     .  ."      depth  : "
     g.depth .
  ."                 L.min    : " l.min     .  ."      T.min  : "  t.min  1076
       .
                                              ."      M.max  : "  m.max
                                                                .  cr
  ."                 L.max    : " l.max     .  ."      T.max  : "  t.max
       .
                                              ."      M.min  : "  m.min
                                                                .  cr
  ."                 smo.flag : " smo.flag  .  ."      f.cut  : "
                                                       s.freq smo.p / .   1081
       12  4   sci.format                     ."      aR.sq  : "
          sum.ar.sq    .
  cr   9  4   fix.format
  ."                 fft.point : " fft.points . ."     b.pnt  : "
     b.fft.p      .
       12  4   sci.format                     ."      aI.sq  : "
          sum.ai.sq    .
;                                                                        1086

\
   -------------------------------------------------------------------------

\ dir.lee.txt  " wav-anai.iff"  "cat  defer>  load    \ -->  sep.wave

: raw.exp.ana.fft  \ 1                                                   1091
   ..........................................................1
  tmp.v.i  :=
```

```
tmp.v.i  channel.const
tmp.v.i  smooth.spe
\  1. *  becomes> a.token            \ real
real n.of.w  ramp   becomes>   w.h.ary                                  1096
          w.h.ary   becomes>   w.p.ary

1. * becomes> a.token
a.token []size array.size :=  drop
                                                                        1101
0 index :=
0 i.count :=

begin
 index.p.1                                                              1106
 a.token [ index ]  sgn    0  >          \   set to zero down crossing
 index  array.size           >=    or
until

index  array.size  <                                                    1111
if
  a.token [ index ]  sgn
  begin
      index.p.1
      a.token [ index ]  sgn  dup rot  <>                               1116
      dup                     0        <>    and
      index  array.size                >=    or
  until
      index  left.index        :=
      dup    zero.up.or.down   :=                                       1121
then
\  cr  ." left.index"    left.index .

begin    \
   !2-------------------------------------------------------------!2
index  array.size  <                                                    1126
  if
    begin
      index.p.1
      a.token [ index ]  sgn  dup rot  <>
      dup                     0        <>    and                        1131
      dup    zero.up.or.down           =     and
      index  array.size                >=    or
    until
    index       right.index :=
  then                                                                  1136

  index  array.size  <
  if
    i.count  1 +   i.count :=
    \ cr ." right.index=  "    right.index .                            1141
    \ cr ." i.count=  "        i.count     .
    right.index left.index -                    w.p.ary [ i.count ] :=
    a.token sub[ left.index ,   right.index left.index -  ]
    []min/max  swap -                            w.h.ary [ i.count ] :=
                                                                        1146
```



```
     right.index left.index  :=
   then

  index array.size  >=
  until    \                                                            1151
     ^2-------------------------------------------------------------^2


  i.count  0  >
  if
    drop
  then                                                                  1156
  \ cr ." i.count ="   i.count  .   ."              ch = "  i  .

  i.count 0 >
  if
    \  i.count     n.of.w.ary  [ 1 , i ]  :=                           1161
    w.p.ary    t.s.c    w.p.ary   :=   \ pratical unit
  then
; \ ^1
   ..........................................................................
    ^1

\ ================================================================      1166

: sep.wave        \ on site print out of wave statistics
  cr.str.sep   " x"  "=  not if else exit then
  r.ch1
  dup                                                                   1171

  cr      cr
  ." Reconstructed incident and reflected waves : "  cr cr
  ."  Ch    #_w"   ."     "
   "  H.1    H.2    H.3    H1/10   H1/3   H1/2  H.ave  H.rms"  s.type   1176
  3 spaces
   "  T1/10  T1/3  T1/2 T.ave T.rms"  s.type
   cr  cr

    \    s.chnls 1 +   1                                                1181
    \    \     2 1 +   1
    \    DO
    \    data.buf.0    xsect[ ! , i ]

  ifft.ary.inc  ifft  Zreal                                             1186
  swap
         \ raw.exp.ana
         raw.exp.ana.fft
         \ cr  i .   ." *********    ok    raw.exp.ana   *********"
            cr
                i.count 0 <=                                            1191
                if
                4 0 fix.format   r.ch1  . 5 0 fix.format i.count
                   n.type
                ."    ------- Not enough wave cycles --------"
         \      ."    ------- No complete wave cycle  --------"
```

```
                then                                                    1196

          i.count 0 >
          if
            w.h.sort&index
            \ cr i .  ." *********     ok w.h.sort&index    *********"   1201
               cr
            1/10.index 0 <=
            if
                  4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                     n.type
                  ."     ------- Too small number of waves ------"
            then                                                        1206

            1/10.index 0 >
            if
                  4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                     n.type
                  \ =w.h.token  sort  rev[ 1 ]                          1211
                  w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]

                  wh.format
                                dup  [ 1 ]                      .
                                dup  [ 2 ]                      .     1216
                                     [ 3 ]                      .  2
                                        spaces
                  1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .
                     rms.w.h  .
                  3 spaces
                  6 2 fix.format
                  1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .      1221
                     rms.w.p  .
            then

          then
          cr
                                                                        1226
    1/3.w.p  1/3.w.p.sep.i  :=
    1/3.w.h  1/3.w.h.sep.i  :=

ifft.ary.ref  ifft  Zreal
swap                                                                    1231
       raw.exp.ana.fft
          \ cr  i .   ." *********     ok     raw.exp.ana    *********"
             cr
                  i.count 0 <=
                  if
                  4 0 fix.format   r.ch1  . 5 0 fix.format i.count      1236
                     n.type
          \       ."     ------- No complete wave cycle  --------"
                  ."     ------- Not enough wave cycles --------"
                  then

          i.count 0 >                                                   1241
          if
```



```
            w.h.sort&index
            \ cr i .  ." *********     ok w.h.sort&index    *********"
               cr
            1/10.index 0 <=
            if                                                          1246
                  4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                     n.type
                  ."     ------- Too small number of waves ------"
            then

            1/10.index 0 >                                              1251
            if
                  4 0 fix.format  r.ch1   .  5 0 fix.format i.count
                     n.type
                  \ =w.h.token  sort  rev[ 1 ]
                  w.h.ary  sub[ 1 , i.count ]  sort  rev[ 1 ]
                  wh.format                                             1256
                                dup  [ 1 ]                      .
                                dup  [ 2 ]                      .
                                     [ 3 ]                      .  2
                                        spaces
                  1/10.w.h  .   1/3.w.h  .  1/2.w.h  .  ave.w.h  .
                     rms.w.h  .
                  3 spaces                                              1261
                  6 2 fix.format
                  1/10.w.p  .   1/3.w.p  .  1/2.w.p  .  ave.w.p  .
                     rms.w.p  .
            then

          then                                                          1266
          cr

    1/3.w.p  1/3.w.p.sep.r  :=
    1/3.w.h  1/3.w.h.sep.r  :=
;                                                                       1271

\
   ------------------------------------------------------------------------


\
   ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

\  datafile.prn defer> print
\                                                                       1276
   ------------------------------------------------------------------------

: Add.chnl.prn
  add.chnl  :=
  add.chnl  0  =  if  exit  then
  db0 xsect[ ! , add.chnl ]
  add.chnl  channel.const                                               1281
  add.chnl  smooth.spe
  shift.raw.data
  smooth.xeq
  conv.formula
```

```
  becomes>  a.token                                                    1286

  12  tmp.v.i.1  :=
  cr
  ." Histroy of Cummulated Overtopping : "
  cr                                                                   1291
  4 0 fix.format
  add.chnl  float  n.type
  "  Time" s.type
  7 2 fix.format
  0  tmp.v.i  :=                                                       1296
  tmp.v.i  s.freq  float  *   .
  begin
    tmp.v.i 1 +  tmp.v.i  :=
    array.size  tmp.v.i.1 float / tmp.v.i float *   s.freq float /    .
    tmp.v.i   tmp.v.i.1  =                                             1301
  until

  cr
  4 0 fix.format
  add.chnl  float  n.type                                              1306
  "  Load" s.type
  7 2 fix.format
  a.token [ 1          ]    a.token [ 1 ] -  .
  0  tmp.v.i  :=
  begin                                                                1311
    tmp.v.i 1 +  tmp.v.i  :=
  \ tmp.v.i  3 =     tmp.v.i  8 = or
  \ if
  \   ."  "
  \ then                                                               1316
    a.token [ array.size  tmp.v.i.1 float / tmp.v.i float *  floor ]
    a.token [ 1 ] -  .
    tmp.v.i   tmp.v.i.1  =
  until
;                                                                      1321
\
   ------------------------------------------------------------------------


real    scalar  Kr.r    scalar Kr.L    scalar Hd1/3.R scalar Hd1/3.L
        scalar  H.eng.R scalar H.eng.L scalar Ho1/3
        scalar horms                                                   1326

normal.display

: fft.sta.p1   \  [ r.ch1,  r.ch2,   del.l,  depth,   b.fft.p  -- ]
  \   get.forced.spe.ref                                              1331
              b.fft.p  :=
              g.depth  :=
              del.l    :=
              r.ch2    :=
              r.ch1    :=                                              1336
  \  nd    ." -----"  r.ch1  .  cr     cr.str.sep  s.type  my.pause
  get.forced.spe.ref  \  update  cr.str
```



```
  \   r.ch1  .  cr     cr.str.sep  s.type  my.pause
\ ============================
  0  tmp.v.i.2       :=                                                1341
  fft.ref.coe
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *  conv.formula  Ho1/3
      :=
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *                Ho1/3
      :=
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *                  Horms
      :=
  \ sum.ai.sq  float sqrt  2 *  fft.points /  2 *                H.eng.r  1346
      :=
  \ kr  kr.r  :=
  \  sum.ai.sq  float sqrt  2 *  fft.points /  2 *    h.s.c    H.eng.l
    :=
  \ kr  kr.l  :=
  \ ho1/3 = 1.4116 horms                \ assuming Rayleigh
    Distribution
  \ ho1/3                                                              1351
  \ 1/3.w.h.sep.i       Hd1/3.R    :=
  \ 1/3.w.h.sep.i       Hd1/3.L    :=
  app.datafile.prn
  sep.wave
;                                                                      1356

: fft.sta.1
  get.forced.spe.ref
  r.ch1.1  r.ch1.1  1 +   del.l.1  depth.1   b.p.1
  fft.sta.p1                                                           1361
;
: fft.sta.2
  get.forced.spe.ref
  r.ch1.2  r.ch1.2  1 +   del.l.2  depth.2   b.p.2
  fft.sta.p1                                                           1366
;
: fft.sta.3
  get.forced.spe.ref
  5        6              del.l.3  depth.3   b.p.3
  fft.sta.p1                                                           1371
;
: Kr.xeq
  \  nd cr.str.sep  s.type  my.pause
  datafile.prn  defer>  out>file   1 out>file.flag :=   echo.off
  sc                                                                   1376
  creat.datafile.prn
  add.chnl  add.chnl.prn
  r.ch1.2  0 <>
  if
    fft.sta.2                                                          1381
  then
  r.ch1.1  0 <>
  if
    fft.sta.1
  then                                                                 1386
  my.out>file.close
```

Pre-File.nam


```
22 35 23 78 window file.wnd                                                    1
: pre.file.name
  dir.lee.txt   " filepass.asy"   "cat    filepass.asy    ":=
  filepass.asy   defer>  file.open

  \  1 comment>   mycase             ":=                                       6
  \  2 comment>   mydate             ":=
  \  3 comment>   mytime             ":=
  \  4 comment>   specifics        ":=
  \  5 comment>   datafile.dat.p23     ":=
  5 comment>   tmp.s     ":=                                                   11
  file.close

  \  datafile.dat    datafile.dat  ":=

  file.wnd                                                                     16
  screen.clear
  my.def.colors
  ." Previous file name :  "
  \  int.on
  tmp.s  s.type.2                                                              21
  \  int.of
;
```

BELL.TXT

A01801-20161220-A004 ❖ December 20, 2016 ❖ [Page count: 1]

```
                                                                          1
: bell.1ll
  bell.flag 1 =
  if
    3  dup  ramp  300  over :=  swap    ramp  50 *               400 +
       tune
  then                                                                    6
;
: bell.3dn
  bell.flag 1 =
  if
    3  dup  ramp  300  over :=  swap    ramp  50 *               400 +    11
                                                    rev[ 1 ]
                                                       tune
  then
;

\  2  dup  ramp  300  over :=  swap    ramp  1200 *  rev[ 1 ]   400 -     16
   tune
: bell.2sl
  bell.flag 1 =
  if
    2  dup  ramp  100  over :=  swap    ramp  900  *  rev[ 1 ]    10 -
       tune
  then                                                                    21
;
: bell.1sl
  bell.flag 1 =
  if
    1  dup  ramp  100  over :=  swap    ramp  900  *  rev[ 1 ]    10 -    26
       tune
  then
;
```

Def-WinN.nam


```
: Def-WinN.nam ; \ %----- Asyst Prog                                          1
\  sc  .date  ." /"  "time  s.type ."   Lee"   {29.line}
.date  ." /"  "time  s.type ."   Lee"
18 10 19 70  window lower.inner.wnd
1  2  13 78  window upper.wnd
\ 14 6  20 74  window lower.wnd                                              6
13 6  19 74  window lower.wnd
1  6  8  74  window {mes.wnd}
\ echo.off
```

Def-AcqN.nam

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```
: Def-AcqN.nam ; \ %----- Asyst Prog                                        1
\ ------------------------------ Def-AcqN.nam
   -------------------------------
\ 02/20/94
\ ---------------------------------------------------------------------
token                       db0         exp.mem>   db0
token                       a.token     exp.mem>   a.token                 6
token                       token.0     exp.mem>   token.0

\ INTEGER
real    SCALAR T.RATE
        scalar s.dura                                                      11
integer SCALAR low.f.modulo
        SCALAR s.length
      \  SCALAR s.freq
        SCALAR s.chnls
        SCALAR #.times                                                     16
        SCALAR p.chnl
        SCALAR chan.beg.#
        SCALAR chan.end.#
        SCALAR p.points
      \ scalar s.dura                                                      21
        scalar pass.id
        scalar Mid.v
        scalar mid.flag
        scalar del.str.pos
        scalar del.time.1                                                  26
        scalar del.time.2
        scalar del.time.3
        scalar del.time.4
        scalar chan.now
                                                                           31
integer scalar dig.lim
real    scalar gain
        scalar v.to.h
        scalar gra.lower.lim
        scalar gra.upper.lim                                               36
        scalar vol.lower.lim
        scalar vol.upper.lim
        scalar dig.to.h
        scalar dig.to.v
\       scalar Mid.v                                                       41
        scalar dig.mid

dp.integer  scalar acq.del

40 string acq.del.s                                                        46
40 string datafile.da2
64 string reserved
64 string spe.str
1  string prn.str
1  string chk.file.str                                                     51
```



```
1  string dma.align.str
1  string dma.or.sync
3  string del.str.1
3  string del.str.2
3  string del.str.3                                                        56
3  string del.str.4
```

Def-AcqS.Spe

A01804-20161220-A007 ❖ December 20, 2016 ❖ [Page count: 3]

```
: Def-AcqS.spe ; \ %----- Asyst Prog                                    1
\ ------------------------- Def-AcqS.spe
   ------------------------------------
\ 02/20/94
\ ------------------------------------------------------------------

    1.      v.to.h            :=    \ linear factor                    6
   -5.      gra.lower.lim     :=
    5.      gra.upper.lim     :=
\    10.     v.to.h           :=    \ linear factor
\   -25.     gra.lower.lim    :=
\    25.     gra.upper.lim    :=                                        11
\    gra.lower.lim   v.to.h /  vol.lower.lim  :=    \ h =  v.to.h * v
\    gra.upper.lim   v.to.h /  vol.upper.lim  :=
\    4095    dig.lim          :=
\    10.     gain             :=    \ range of board <-> 4095
\    dig.mid  2. /  Mid.v     :=   \  2048  =>    0 V                  16
\    dig.mid  2. /  dig.mid   :=   \  2048  =>    0 V

\    gain  float  v.to.h *  dig.lim float /  dig.to.h  :=
\    gain  float            dig.lim float /  dig.to.v  :=
                                                                        21
: re.or.ir.tes
  1   2  =
\  datafile.dat.p2  1 "left      " r"  "=
\  datafile.dat.p2  1 "left      " R"  "=  or
  if                                                                    26
    40  s.freq            := \  #input s.freq :=
   200  dup    s.dura     := \  #input s.freq * s.length :=
         s.freq * s.length :=
     3   s.chnls           := \  #input s.chnls :=
     1   p.chnl            := \  #input p.chnl :=                       31
    320   s.freq            := \  #input s.freq :=
    15    dup    s.dura     := \  #input s.freq * s.length :=
          s.freq * s.length :=
     6    s.chnls           := \  #input s.chnls :=
     6    p.chnl            := \  #input p.chnl :=                       36
  else
\    300   s.freq             := \  #input s.freq :=
\    12    dup    s.dura      := \  #input s.freq * s.length :=
\    160   s.freq             := \  #input s.freq :=
\    32    dup    s.dura      := \  #input s.freq * s.length :=          41
\    200   s.freq             := \  #input s.freq :=
\    26    dup    s.dura      := \  #input s.freq * s.length :=
    200   s.freq            := \  #input s.freq :=
    26    dup    s.dura     := \  #input s.freq * s.length :=
          s.freq * s.length :=                                          46
    5     s.chnls           := \  #input s.chnls :=
    2     p.chnl            := \  #input p.chnl :=

    200   s.freq            := \  #input s.freq :=
    26    dup    s.dura     := \  #input s.freq * s.length :=          51
```



```
          s.freq * s.length :=
    2     s.chnls           := \  #input s.chnls :=
    1     p.chnl            := \  #input p.chnl :=
  then
;                                                                       56
\ re.or.ir.tes       \
   inv.of

\
   ------------------------------------------------------------------------


: acq.del.def                                                           61
  4   1000 *   acq.del   :=
  datafile.dat   3  "right    2 "left    acq.del.s   ":=

  " 12"  acq.del.s  "=
  if                                                                    66
        81   1000 *   acq.del  :=
  then
  " 13"  acq.del.s  "=
  if
        76  1000 *   acq.del  :=                                        71
  then
  " 16"  acq.del.s  "=
  if
        62  1000 *   acq.del  :=
  then                                                                  76
  " 19"  acq.del.s  "=
  if
        55  1000 *   acq.del  :=
  then
  " 20"  acq.del.s  "=                                                  81
  if
        53  1000 *   acq.del  :=
  then
  " 22"  acq.del.s  "=
  if                                                                    86
        51  1000 *   acq.del  :=
  then
  " 24"  acq.del.s  "=
  if
        49  1000 *   acq.del  :=                                        91
  then
;

: get.acq.spe
  \  dir.lee.txt  " lspe-1.dat"  "cat  defer> file.open                 96
  dir.lee.txt  " lSPE-ACQ.dat"  "cat  defer> file.open
  1  subfile  file>unnamed.array
  dup  [ 1 ]  s.freq     :=
  dup  [ 2 ]  s.dura     :=
  dup  [ 3 ]  chan.beg.#    :=                                          101
  dup  [ 4 ]  chan.end.#    :=
  dup  [ 5 ]  p.chnl        :=
```

```
    chan.end.#  chan.beg.# -  1 +   s.chnls :=

  dup  [ 6  ]  del.time.1    :=                                          106
  dup  [ 7  ]  del.time.2    :=
  dup  [ 8  ]  del.time.3    :=
  dup  [ 9  ]  del.time.4    :=
  dup  [ 10 ]  v.to.h        :=
  dup  [ 11 ]  gra.upper.lim :=                                          111
  dup  [ 12 ]  gra.lower.lim :=
  dup  [ 13 ]  del.str.pos   :=
  drop

  41  comment>  del.str.1  ":=                                           116
  42  comment>  del.str.2  ":=
  43  comment>  del.str.3  ":=
  44  comment>  del.str.4  ":=
  45  comment>  chk.file.str ":=
  \ chk.file.str  s.type my.pause                                        121
  46  comment>  dma.align.str ":=
  47  comment>  dma.or.sync  ":=
  file.close

    s.freq  s.dura *  s.length  :=                                       126
    gra.lower.lim   v.to.h /  vol.lower.lim  :=    \ h =  v.to.h * v
    gra.upper.lim   v.to.h /  vol.upper.lim  :=
    4095   dig.lim          :=
    10.    gain            :=   \ range of board <-> 4095
    dig.mid  2. /  Mid.v    :=  \  2048  =>   0 V                        131
    dig.mid  2. /  dig.mid  :=  \  2048  =>   0 V

    gain  float  v.to.h *  dig.lim float /  dig.to.h  :=
    gain  float            dig.lim float /  dig.to.v  :=
                                                                         136
  50    acq.del   :=
;
get.acq.spe
```

Def-AnaN.nam

A01805-20161220-A008 ❖ December 20, 2016 ❖ [Page count: 5]

```
: Def-AnaN.nam ; \ %----- Asyst Prog                                          1
\ Asyst text file    ------------------ Def-AnaN.nam
   --------------------------
\
\
\ Note             : 1. name list for overall uses
\                      2. 03/25/91, 02/20/94                                  6
\ ---------------------------------------------------------------------

echo.off

Integer             scalar array.size                                       11
                    scalar index
                    scalar i.count
                    scalar left.index
                    scalar right.index
                    scalar #.iter                                           16
                    scalar Mid.v.cutoff
                    scalar n.of.w
                    scalar zero.up.or.down
                    scalar aut.plo.fla
                    scalar t.fmt.width                                      21
                    scalar #.groups
                    scalar add.chnl
                    scalar shift.first.flag
\                   scalar lc.flag  \ line colors
                    scalar font.size.L                                      26
                    scalar font.size.N
                    scalar font.size.S
                    scalar int.flag
                    scalar 2in1.flag
                                                                            31
integer  scalar #.ysum
         scalar #.nsum
integer  scalar step.size  scalar tmp.v.ii
1        step.size :=
                                                                            36
integer  dim[ 3 ]  array  group.ele
real dim[ 3 ]  array  ysum
real dim[ 5 ]  array  nsum
real dim[ 3 ]  array  bcoe
                                                                            41
integer scalar drif.flag

integer           scalar chnl.no
                  scalar case.no
                  scalar item.no                                            46

integer scalar 1/10.index              INTEGER scalar r.ch1
        scalar 1/3.index                       scalar r.ch2
        scalar 1/2.index                       scalar fft.points
        scalar 1/10.w.p.i                      scalar i.smt                 51
```



```
        scalar 1/3.w.p.i                       scalar r.ch1.1
        scalar 1/2.w.p.i                       scalar r.ch1.2
        scalar b.fft.p                         scalar b.p.1
        scalar b.p.2                           scalar b.p.3
                                                                            56
real    scalar g.depth
        scalar gravity
        scalar tmp.period
        scalar w.l.o
        scalar w.l.n                                                        61
        scalar epslon

dp.real scalar 2pid
        scalar gttd
        scalar gtt/2pi                                                      66

real    scalar 1/10.w.h
        scalar 1/3.w.h
        scalar 1/2.w.h
        scalar ave.w.h                                                      71
        scalar rms.w.h
        scalar 1/10.w.p
        scalar 1/3.w.p
        scalar 1/2.w.p
        scalar ave.w.p                                                      76
        scalar rms.w.p
        scalar del.l
        scalar del.l.1
        scalar del.l.2
        scalar del.l.3                                                      81
        \ scalar gain
dp.real scalar 2pid/l
real    scalar cutoff.freq
        scalar x.pos
        \ scalar v.to.h                                                     86
        scalar depth.1
        scalar depth.2
        scalar depth.3

     40 string d&t                                                          91
      8 string file.ext
     30 string font.type.n

real scalar 1/3.w.p.sep.i
real scalar 1/3.w.h.sep.i                                                   96
real scalar 1/3.w.p.sep.r
real scalar 1/3.w.h.sep.r

\ ---------------------------------------------------------------------
                                                                            101
integer  scalar #w
         scalar #r
         scalar #.case
         scalar #.chnl
         scalar #.item                                                      106
```

```
         scalar #.elem
         scalar coef.flag
         scalar cali.flag
         scalar smo.flag
         scalar shif.flag                                          111
         scalar kr.flag
         scalar smo.p
         scalar conv.flag
         scalar #.tmp.array
                                                                   116
real     scalar std.mea
         scalar std.dev
         scalar std.err
         scalar conf.int
         scalar conf.l.u                                           121
         scalar conf.l.l
         scalar deg.fre
         scalar coef.1.sp
         scalar coef.0.sp
         scalar f.beg   scalar f.end                               126

30       string item.name
40       string tmp.s.2
 5       string case.flag
 5       string cnst.flag                                          131
 5       string whwp.flag
 1       string bat.flag

\ ================================================================
token    el.a              exp.mem> el.a                          136
token    5d.a              exp.mem> 5d.a
token    3d.a              exp.mem> 3d.a
token    r.ba              exp.mem> r.ba
token    token.1           exp.mem> token.1
token    token.2           exp.mem> token.2                       141
token    token.3           exp.mem> token.3
token    token.4           exp.mem> token.4
token    token.5           exp.mem> token.5
token    token.6           exp.mem> token.6
token    token.7           exp.mem> token.7                       146
token    token.8           exp.mem> token.8
token    token.9           exp.mem> token.9
token    token.10          exp.mem> token.10
token    token.11          exp.mem> token.11
token    token.12          exp.mem> token.12                      151
token    token.13          exp.mem> token.13
token    token.14          exp.mem> token.14
token    token.15          exp.mem> token.15
token    token.16          exp.mem> token.16
token    t1                exp.mem> t1                            156
token    t2                exp.mem> t2
token    t3                exp.mem> t3
token    t4                exp.mem> t4
token    t5                exp.mem> t5
token    t6                exp.mem> t6                            161
```



```
token    t7                exp.mem> t7
token    t8                exp.mem> t8
token    t9                exp.mem> t9
token    t10               exp.mem> t10
                                                                   166
1        string nor.type
3        string ope.type
3        string h&v.flag

integer  scalar #.elem                                             171
         scalar #.las.loop
         scalar #.inn.loop
         scalar #.out.loop
         scalar #.col
         scalar #.col.ini                                          176
         scalar t.fmt.width
         scalar case.no
         scalar chnl.no
         scalar item.no
         scalar elem.no                                            181
         scalar #.fft.pts
         scalar #.plt.pts
         scalar pt.beg  scalar pt.end
2 string xy.axis.str
1 string h.c.str                                                   186
1 string asc.str
1 string view.str
1 string non.stop.str
1 string forced.spe.str
1 string lc.str                                                    191
1 string grid.str

3 string now.gp
1 string cr.str
1 string cr.str.sep                                                196
1 string scr.str
32  string y.label
32  string x.label
64  string misce.str
14  string  d&t.string                                             201

integer  scalar col.1.pos  scalar col.2.pos
         scalar col.1.w    scalar col.2.w
         scalar #.#spe
         scalar lin.#                                              206
         scalar f.no.c

17 1 +  #.#spe     :=
12      col.1.pos  :=
47      col.2.pos  :=                                              211
13      col.1.w    :=
13      col.2.w    :=
real dim[ #.#spe ]             array  #spe
dim[ #.#spe , col.1.w ] string.array  #spe.str
dim[ #.#spe ,       3 ] string.array  "spe                         216
```

```
dim[ #.#spe , col.1.w ] string.array  "spe.str
Dim[ 7 , 12 ]           string.array  file.name.ary
```

Def-Ana1.1sp

A01806-20161220-A009 ❖ December 20, 2016 ❖ [Page count: 10]

```
: Def-Ana1.1sp ; \ %----- Asyst Prog                                          1
\ ------------------------------- Def-Ana1.1sp
   --------------------------
\
\
\ 02/22/94 by Y.R. Lee
\ ------------------------------------------------------------------------   6

\ ========================================================================
\
\ Keywords       :  1. def-anas.spe 1 2 3
\                   2. for all specifications with minimized                 11
   modification.
\
\ Note :
\
\ Written        :  Nov. 1993 by  Y-R Lee  ( 02/20/94)
\ ========================================================================   16

\ nd

fg.color   foreground
bg.color   background                                                        21

: def.values.ana
  \ --------------------------
  " gen"  cnst.flag           ":= \ for IND case flag
  " wha"  whwp.flag           ":= \ for wha or wpa                           26
  1       coef.flag            := \ 1(yes) unit conversion
  1       conv.flag            := \ 0 for calibration  else  for
     practical units
  9       cali.flag            := \ 1 for calibration
\ 0       asc.flag             := \ 1(yes) create ascii file with
    coef.flag
  xeq.flag   " r"  "=                                                        31
  xeq.flag   " w"  "=    or
  xeq.flag   " p"  "=    or
  if
    1     smo.flag             := \ 1(yes) smooth
    0     smo.flag             := \ 1(yes) smooth                            36
  else
    0     smo.flag             :=
\   1     smo.flag             :=
  then
  3       smo.p                :=                                            41
  0       Kr.flag              := \ 1(yes)
  9       shif.flag            := \ 0(No) 1(linear) , 2(parabolic) , 3(
     mean)
  1       mid.flag             := \ 0(0.) 1(2048.) 2(256.)
  0.      f.beg                :=
  200.    f.end                :=                                            46
          \ ------------------------------------
```



```
          mid.flag  0  =   if   0.      dig.mid :=   then
          mid.flag  1  =   if   2048.   dig.mid :=   then
          mid.flag  2  =   if   256.    dig.mid :=   then
  \ --------------------------                                               51
  3       #.tmp.array          := \ for # of columns in prn file
  \ 4     #.chnl               := \ for column added  ( > s.chnls )
  14      #.item               :=
  70      #.case               := \ for case file name strings
  2000    n.of.w               := \ max. number of waves per channel         56
  0.95    conf.int             := \ confidence interval
  10      em.color             := \ confidence interval
  \ --------------------------
  29.5    del.l.2              :=
  29.5    del.l.3              :=                                            61
  32.5    del.l.1              :=
  48.0    depth.2              :=  \  g.depth at point of reflection
     measurement
  48.0    depth.3              :=  \  g.depth at point of reflection
     measurement
  82.0    depth.1              :=  \  g.depth at point of reflection
     measurement
  0.005   epslon               :=  \  convergence criterion for Acc-         66
     Newton Method
  980     gravity              :=  \  unit : cm
  500     #.iter               :=
  2 10    ** fft.points        :=  \  -> 2048
  441     b.p.1                :=
  1       b.p.2                :=                                            71
  1       b.p.3                :=
  \ --------------------------
  0       mid.v.cutoff         :=
  30.0    g.depth              :=  \  g.depth at point of reflection
     measurement
  0       i.smt                :=  \  0 : no  ;  1 : yes                     76
;
def.values.ana

dim[ #.case , 8 ] string.array  run.c.n
                                                                             81
\ dir.asy.sys  " spfn.sov"  "cat  defer> load.overlay

: smooth.spe
    case
    1   of  1.  smo.p  /   set.cutoff.freq                                   86
        endof
    2   of  1.  smo.p  /   set.cutoff.freq
        endof
    3   of  1.  smo.p  /   set.cutoff.freq
        endof
    4   of  1.  smo.p  /   set.cutoff.freq
        endof
    5   of  1.  smo.p  /   set.cutoff.freq
        endof
    6   of  1.  smo.p  /   set.cutoff.freq                                   91
        endof
```

```
    7   of  1.  smo.p  /   set.cutoff.freq
        endof
    8   of  1.  smo.p  /   set.cutoff.freq
        endof
    endcase
;                                                                    96

: item.title
    case
    1   of   "  1 ---- MEAN                          "   item.name ":=
        endof
    2   of   "  2 ---- STANDARD DEVIATION            "   item.name ":=
        endof
    3   of   "  3 ---- STANDARD ERROR                "   item.name ":=   101
        endof
    4   of   "  4 ---- UPPER CONFIDENCE LEVEL        "   item.name ":=
        endof
    5   of   "  5 ---- LOWER CONFIDENCE LEVEL        "   item.name ":=
        endof
    6   of   "  6 ---- SIZE                          "   item.name ":=
        endof
    7   of   "  7 ---- TOTAL                         "   item.name ":=
        endof
    8   of   "  8 ---- MAX                           "   item.name ":=   106
        endof
    9   of   "  9 ---- MIN                           "   item.name ":=
        endof
    10  of   " 10 --- RANGE OF CONFIDENCE           "   item.name ":=
        endof
    11  of   " 11 --- MEAN SQUARE                    "   item.name ":=
        endof
    12  of   " 12 --- SPECTRUM INTEGRAL              "   item.name ":=
        endof
    endcase                                                          111
;

: item.format
    case
    1   of  10 5      fix.format                                     116
        endof
    2   of  10 5      fix.format
        endof
    3   of  10 5      fix.format
        endof
    4   of  10 5      fix.format
        endof
    5   of  10 5      fix.format
        endof
    6   of  10 0      fix.format                                     121
        endof
    7   of             coef.flag  0  =
                       conv.flag  0  =   and
                       if
                          10 1 fix.format
                       else                                         126
```



```
                          10 3 fix.format
                       then
                          endof
    8   of             coef.flag  0  =
                       conv.flag  0  =   and
                       if                                           131
                          10 1 fix.format
                       else
                          10 4 fix.format
                       then
                          endof
    9   of             coef.flag  0  =                              136
                       conv.flag  0  =   and
                       if
                          10 1 fix.format
                       else
                          10 4 fix.format                           141
                       then
                          endof
    10  of  10 5       fix.format
        endof
    11  of             coef.flag  0  =
                       conv.flag  0  =   and
                       if                                           146
                          10 1 fix.format
                       else
                          10 5 fix.format
                       then
                          endof
    12  of             coef.flag  0  =                              151
                       conv.flag  0  =   and
                       if
                          10 1 fix.format
                       else
                          10 5 fix.format                           156
                       then
                          endof
    endcase
;

: wh.format                                                         161
  coef.flag  0  =
  conv.flag  0  =   and
  if
     7 1 fix.format
  else                                                              166
     7 2 fix.format
  then
;

\ ------------------------------------------------------------------  171
\ ==================================================================
: post.shift
  \ shift by mean
  \  dup
```

```
  dup       []size array.size :=      \   drop                          176
            []sum   array.size  /
            -
;
integer scalar  out>file.flag
: my.out>file.cont                                                      181
  out>file.flag 1 =
  if
    out>file.cont
  then
;                                                                       186

real scalar pre.datum
1    string pre.flag
\ : pos.or.neg
  " p" pre.flag ":=                                                     191
  " -" pre.flag ":=
: pre.xeq
  pre.flag " p" "= not
  pre.flag " n" "= not  and  if exit then
  pre.flag " p" "=                                                      196
  if
    \   sc cr cr " ----------- PPP" s.type pause
    2046 pre.datum        :=
    []size tmp.v.i  :=
    becomes> a.token                                                    201
    tmp.v.i 1 +    1
    do
      a.token [ i ]  pre.datum <=  if   pre.datum  a.token [ i ]  :=
          then
    loop
  then                                                                  206
  pre.flag " n" "=
  if
    2049 pre.datum        :=
    []size tmp.v.i  :=
    becomes> a.token                                                    211
    tmp.v.i 1 +    1
    do
      a.token [ i ]  pre.datum >=  if   pre.datum  a.token [ i ]  :=
          then
    loop
  then                                                                  216
  a.token
;

: shift.raw.data
  console                                                               221

  pre.xeq

  shif.flag  0  =   not
  if                                                                    226
\    console
    {29.line}
```



```
    70  29  goto.xy  b.t  " SHF-ing"  s.type
     2  0    fix.format   shif.flag  n.type   b.t
\    my.out>file.cont                                                   231
    \ out>file.cont
  then

  \ shif.flag  -->  0 : no operation
  \            -->  1 : linear                                          236
  \            -->  2 : palabolic
  \            -->  5 : mean
  \            -->  9 : dig.mid
  \  by drift
  \  dig.mid  dp>sp  -                                                  241
  1. *  becomes>  a.token  \ <-- added
  shif.flag
  case
     1  of  2 #.ysum  :=     3 #.nsum    :=  endof
     2  of  3 #.ysum  :=     5 #.nsum    :=  endof                     246
  endcase

  real
  shif.flag   dup  1 =   2 =  or
  if                                                                    251
    \ " SFT"  s.type
    0  ysum  :=
    0  nsum  :=
    a.token  []size  swap drop  array.size  :=
    #.nsum  1 +  1                                                      256
    do
      array.size  1 +  1
      do
        i  j  1 -  float  **    nsum [ j ] +                   nsum [ j ]
           :=
      loop                                                              261
    loop
    #.ysum 1 +   1
    do
      array.size  1 +  1
      do                                                                266
        i j 1 -  float  **   a.token  [ i ] *   ysum [ j ] +   ysum [ j
          ] :=
      loop
    loop

    shif.flag  2  =                                                     271
    if
      nsum [ 1 ]  nsum [ 3 ]  nsum [ 5 ]  * *
      nsum [ 2 ]  nsum [ 3 ]  nsum [ 4 ]  * *  2. *   +
      nsum [ 3 ]  nsum [ 3 ]  nsum [ 3 ]  * *  -
      nsum [ 1 ]  nsum [ 4 ]  nsum [ 4 ]  * *  -                        276
      nsum [ 2 ]  nsum [ 2 ]  nsum [ 5 ]  * *  -
      tmp.v  :=  \ delta
      ysum [ 1 ]  nsum [ 3 ] nsum [ 5 ] *  nsum [ 4 ] nsum [ 4 ] *  -  *
      ysum [ 2 ]  nsum [ 3 ] nsum [ 4 ] *  nsum [ 2 ] nsum [ 5 ] *  -  *
           +
```

```
      ysum [ 3 ]  nsum [ 2 ] nsum [ 4 ] *  nsum [ 3 ] nsum [ 3 ] *  -  *
           +
      tmp.v  /  bcoe [ 1 ]  :=
      ysum [ 1 ]  nsum [ 3 ] nsum [ 4 ] *  nsum [ 2 ] nsum [ 5 ] *  -  *
      ysum [ 2 ]  nsum [ 1 ] nsum [ 5 ] *  nsum [ 3 ] nsum [ 3 ] *  -  *
           +
      ysum [ 3 ]  nsum [ 2 ] nsum [ 3 ] *  nsum [ 1 ] nsum [ 4 ] *  -  *
           +
      tmp.v  /  bcoe [ 2 ]  :=
      ysum [ 1 ]  nsum [ 2 ] nsum [ 4 ] *  nsum [ 3 ] nsum [ 3 ] *  -  *
      ysum [ 2 ]  nsum [ 2 ] nsum [ 3 ] *  nsum [ 1 ] nsum [ 4 ] *  -  *
           +
      ysum [ 3 ]  nsum [ 1 ] nsum [ 3 ] *  nsum [ 2 ] nsum [ 2 ] *  -  *
           +
      tmp.v  /  bcoe [ 3 ]  :=
      array.size   ramp
      dup  dup *  bcoe [ 3 ] *
      swap  bcoe [ 2 ] *  +
      bcoe [ 1 ] +
    then

    shif.flag  1  =
    if
        nsum [ 3 ] ysum [ 1 ] *  nsum [ 2 ] ysum [ 2 ] *  -
        nsum [ 1 ] nsum [ 3 ] *  nsum [ 2 ] nsum [ 2 ] *  -
        /  bcoe [ 1 ]  :=
        nsum [ 1 ] ysum [ 2 ] *  nsum [ 2 ] ysum [ 1 ] *  -
        nsum [ 1 ] nsum [ 3 ] *  nsum [ 2 ] nsum [ 2 ] *  -
        /  bcoe [ 2 ]  :=
        bcoe [ 2 ]   array.size   ramp  *   bcoe [ 1 ] +
    then

    a.token  swap  -  a.token  :=
    a.token  ^sum  [ array.size ]  array.size /   mid.v   :=
  then

  shif.flag  5  =
  if
    a.token
    dup
                []size array.size :=
      mean      -        a.token  :=
\  \\980930    a.token
\  \\980930    dup      []size array.size :=
\  \\980930             []sum   array.size  /
\  \\980930             -       a.token  :=
    \       ^sum  [ array.size ]  array.size /   mid.v   :=
  then
  shif.flag  9  =
  if
    a.token  []size array.size  :=
    dig.mid  float  -   a.token :=
  then

  a.token  \  <-- added
```



```
  shif.flag  0  =  not
  if
    console
    70  29  goto.xy       ."           "
    previous.window
    " p"  xeq.flag  "=  not
    " r"  xeq.flag  "=  not  and
    " w"  xeq.flag  "=  not  and
    if
      " OK"  s.type
    then
\    my.out>file.cont
    \ out>file.cont
  then
    my.out>file.cont
;

: shift.raw.data.mean  \  by mean
  1.  *  \  <---- important
  dup  []size  tmp.v.i  :=
       []sum   tmp.v.i  /
  -
;

\   ~~~
```

```
  1 subfile      #spe        file>array
  cr

  0  tmp.v.i :=                                                    381
  begin
    tmp.v.i 1 +  tmp.v.i  :=
    tmp.v.i   get.comment
    tmp.v.i   #.#spe  =
  until                                                           386
  1  subfile   #spe  file>array
  file.close

  \  " y" my.pause.flag ":=
  \  my.pause                                                     391
  {29.line}
;
: recover.par.acq
  1  #spe swap [ ]  s.freq     :=
  2  #spe swap [ ]  s.dura     :=                                 396
     s.dura  s.freq *  s.length   :=
  3  #spe swap [ ]  chan.beg.#    :=
  4  #spe swap [ ]  chan.end.#    :=
     chan.end.#  chan.beg.# -  1 +   s.chnls :=
\ 3  #spe swap [ ]  s.chnls    :=                                 401
  5  #spe swap [ ]  p.chnl     :=
  6  #spe swap [ ]  del.time.1 :=
  7  #spe swap [ ]  del.time.2 :=
  8  #spe swap [ ]  del.time.3 :=
  9  #spe swap [ ]  del.time.4 :=                                 406
  10 #spe swap [ ]  v.to.h     :=
  11 #spe swap [ ]  gra.upper.lim :=
  12 #spe swap [ ]  gra.lower.lim :=
  13 #spe swap [ ]  del.str.pos   :=
\  13 #spe swap [ ]  group.ele [ 2 ]  :=                          411

  1  "spe     "[ ]  del.str.1    ":=
  2  "spe     "[ ]  del.str.2    ":=
  3  "spe     "[ ]  del.str.3    ":=
  4  "spe     "[ ]  del.str.4    ":=                              416
  5  "spe     "[ ]  chk.file.str ":=
  6  "spe     "[ ]  dma.align.str ":=
  7  "spe     "[ ]  dma.or.sync  ":=
;
\ dir.lee.txt  " lspe-acq.dat"  "cat                              421
\ get.par.file
\ recover.par.acq
: recover.par
  1  #spe swap [ ]  r.ch1.1    :=
  2  #spe swap [ ]  del.l.1    :=                                 426
  3  #spe swap [ ]  depth.1    :=
  4  #spe swap [ ]  b.p.1      :=
  5  #spe swap [ ]  r.ch1.2    :=
  6  #spe swap [ ]  del.l.2    :=
  7  #spe swap [ ]  depth.2    :=                                 431
  8  #spe swap [ ]  b.p.2      :=
```



```
\ 9  #spe swap [ ]  FFT.POINTS :=
  9  #spe swap [ ]  #.fft.pts  :=
  10 #spe swap [ ]  f.beg      :=
  11 #spe swap [ ]  f.end      :=                                 436
  12 #spe swap [ ]  #.groups   :=
  13 #spe swap [ ]  group.ele [ 1 ]  :=
  14 #spe swap [ ]  group.ele [ 2 ]  :=
  15 #spe swap [ ]  Add.chnl   :=
                                                                  441
\ 15 #spe swap [ ]  my.pause.flag    :=

  1  "spe     "[ ]  xy.axis.str  ":=
  2  "spe     "[ ]  wnd.str      ":=
  3  "spe     "[ ]  offset.str   ":=                             446
  4  "spe     "[ ]  y.lab.str    ":=
  5  "spe     "[ ]  h.c.str      ":=
  6  "spe     "[ ]  asc.str      ":=
  7  "spe     "[ ]  view.str     ":=
  8  "spe     "[ ]  prn.str      ":=                             451
  9  "spe     "[ ]  forced.spe.str  ":=
  10 "spe     "[ ]  my.pause.flag   ":=
  11 "spe     "[ ]  lc.str          ":=
  12 "spe     "[ ]  grid.str        ":=
                                                                  456
  lc.str "upper " Y" "=
  if    1
  else  0
  then  lc.flag :=
  grid.str "upper " Y" "=                                         461
  if    1
  else  0
  then  grid.flag :=

  h.c.str   pcx.h.c.str    ":=                                    466
;
\ get.par.file  \ can be placed in Def-AnaT.tsp
\ recover.par   \ can be placed in Def-AnaT.tsp
: my.out>file
  out>file                                                        471
  1  out>file.flag :=
;
: my.out>file.close
  out>file.close  0  out>file.flag :=
;                                                                 476
```

LAcq-Spe.men

A01813-20161220-A016 ❖ December 20, 2016 ❖ [Page count: 12]

```
\ ------------------------------ Lee.men                                    1
   ----------------------------------
\ 02/20/94
\ ------------------------------------------------------------------
\ ---  Asyst Menu for real time experiments sys clear  (c) Lee, Yueon-
   Ron -- \
\
\ Requirements :  1.  Memory allocation sensitive                         6
\                 2.  Overlay files included
\                 3.  Confirm device parameters
\                 4.  Configure system properly
\                 5.  Follow subprogram restrictions
\                                                                        11
\ Keywords     :  1.  Acquisition plus analysis
\                 2.  Acquisition
\                 3.  Analysis
\                 4.  Calibration
\                 5.  Scrolling of data                                  16
\                 6.  Real time foreground and background multitasking
   system
\
\ Copyright    :      By Lee,  Oct, 1990.

echo.off                                                                 21
: lacq-spe ;
sc  ."   --  Y.R. Lee --    "   .date   ." ---------   "    .time
1  29.flag :=   {29.line}
0  bell.flag :=
1  menu.flag  :=                                                         26
" y"  my.pause.flag ":=
  forget.all
  my.def.colors
\  dir.lee.txt  " bell.txt"      "cat   defer> load
  dir.lee.txt  " def-winn.nam"  "cat   defer> load                       31
  dir.lee.txt  " def-acqn.nam"  "cat   defer> load
  \ nd
  dir.lee.txt  " def-acqs.spe"  "cat   defer> load
  dir.lee.txt  " def-anan.nam"  "cat   defer> load
  \ dir.lee.txt  " def-ana1.1sp"  "cat   defer> load                     36
\ dir.lee.txt  " def-ana9.9sp"  "cat   defer> load  \ for recover.par
\ dir.lee.txt  " def-ana1.1s2"  "cat   defer> load  \ for recover.par
  dir.lee.txt  " def-ana1.1sp"  "cat   defer> load  \ for recover.par

  dir.lee.txt  " lspe-acq.dat"  "cat                                    41
  get.par.file
  recover.par.acq

echo.off
stack.reset                                                              46
\ 7 set.file.parse
\ def.vuport line.edit
integer scalar row.beg
```



```
1  row.beg  :=
\ ------------------------ Words for resetting parameter                 51
   --------------------
\ ------------------------------------------------------------------
: reset.par.str
   \  Numbeer specifications
   \         " 1234567890123"
   1         " Samp Rate    ="     #spe.str "[   ]  ":=                 56
   2         " Samp Duratio="      #spe.str "[   ]  ":=
   3         " Chan begin   ="     #spe.str "[   ]  ":=
   4         " Chan end     ="     #spe.str "[   ]  ":=
   5         " Monitored Ch="      #spe.str "[   ]  ":=
   6         " Delay Time 1="      #spe.str "[   ]  ":=                 61
   7         " Delay Time 2="      #spe.str "[   ]  ":=
   8         " Delay Time 3="      #spe.str "[   ]  ":=
   9         " Delay Time 4="      #spe.str "[   ]  ":=
   10        " V.to.H       ="     #spe.str "[   ]  ":=
   11        " Upper H Limi="      #spe.str "[   ]  ":=                 66
   12        " Lower H Limi="      #spe.str "[   ]  ":=
   13        " del.str.pos ="      #spe.str "[   ]  ":=
\  14        " Chan start #="      #spe.str "[   ]  ":=
\  11        " #.group      ="     #spe.str "[   ]  ":=
\  12        " group.ele.1 ="      #spe.str "[   ]  ":=                 71
\  13        " group.ele.2 ="      #spe.str "[   ]  ":=
\  14        " Add Chnl     ="     #spe.str "[   ]  ":=
\  15        " Reserved      "     #spe.str "[   ]  ":=
   \  String specifications
   1         " Delay Str 1 ="      "spe.str "[   ]  ":=                 76
   2         " Delay Str 2 ="      "spe.str "[   ]  ":=
   3         " Delay Str 3 ="      "spe.str "[   ]  ":=
   4         " Delay Str 4 ="      "spe.str "[   ]  ":=
   5         " Check file  ="      "spe.str "[   ]  ":=
   6         " DMA Align   ="      "spe.str "[   ]  ":=                 81
   7         " DMA or Sync ="      "spe.str "[   ]  ":=
\  9         "null                 "spe.str "[   ]  ":=
\  10        "null                 "spe.str "[   ]  ":=
;
                                                                         86
: reset.par.str.0
   \  Numbeer specifications
   \         " 1234567890123"
   1         " r.Station.1 ="      #spe.str "[   ]  ":=
   2         " r.Spacing.1 ="      #spe.str "[   ]  ":=                 91
   3         " r.Depth.1   ="      #spe.str "[   ]  ":=
   4         " r.Beg.pnt.1 ="      #spe.str "[   ]  ":=
   5         " r.Station.2 ="      #spe.str "[   ]  ":=
   6         " r.Spacing.2 ="      #spe.str "[   ]  ":=
   7         " r.Depth.2   ="      #spe.str "[   ]  ":=                 96
   8         " r.beg.pnt.2 ="      #spe.str "[   ]  ":=
   9         " r.fft points="      #spe.str "[   ]  ":=
   10        " PS.#.fft.pts="      #spe.str "[   ]  ":=
   11        " #.group     ="      #spe.str "[   ]  ":=
   12        " group.ele.1 ="      #spe.str "[   ]  ":=                 101
   13        " group.ele.2 ="      #spe.str "[   ]  ":=
   14        " Add Chnl    ="      #spe.str "[   ]  ":=
```

```
   15        " Reserved      "      #spe.str "[   ]   ":=
   \  String specifications
   1         " xy.axis(l/o)="      "spe.str "[   ]   ":=
   2         " wnd.str      ="     "spe.str "[   ]   ":=
   3         " offset (y/n)="      "spe.str "[   ]   ":=
   4         " y.lab  (n/e)="      "spe.str "[   ]   ":=
   5         " H.copy (y/n)="      "spe.str "[   ]   ":=
   6         " Make ASCII  ="      "spe.str "[   ]   ":=
   7         " View data   ="      "spe.str "[   ]   ":=
   8         " Print OnSite="      "spe.str "[   ]   ":=
   9         "null                 "spe.str "[   ]   ":=
   10        "null                 "spe.str "[   ]   ":=
;

: c>"a   \  [ "ele , array ]
  \  1  #spe.str "[ ]  ":=
  "[ ]  ":=
;
: "a>c     \  [ ele.# , "array , offset ]  "array>comment
  \ function    \  #spe.str "[  1 ]                1 >comment
                \  1  #spe.str "[ ]  ":=
  swap
  dup
  "[ ]
  +
  >comment
;
: create.ini.par.file
  regular.datafile
  file.template
    60 comments
    real dim[ #.#spe ] subfile
  end
  \  dir.lee.txt  " lspe-acq.dat" "cat  defer>  file.create
  \  dir.lee.txt  " lspe-acq.dat" "cat  defer>  file.open
    spe.str                          defer>  file.create
    spe.str                          defer>  file.open
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  #spe.str  0  "a>c
      tmp.v.i  #.#spe  =
    until
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe.str  20 "a>c
      tmp.v.i  #.#spe  =
    until
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe      40 "a>c
      tmp.v.i  #.#spe  =
    until
```



```
  1 subfile  #spe    array>file
  file.close
;
dir.lee.txt  " lspe-acq.dat" "cat  \ spe.str
get.par.file  my.pause
reset.par.str          \ needed when first change
create.ini.par.file    \ needed when first change
\ ------------------------------------------------------------------
\ ------------------------------------ Colon Defs FOR MENU
   --------------------
integer  scalar  ana.flag
: run.acq
  dir.lee.txt     " acq.men"     "cat defer> load
  stack.clear
;
: run.a+a
  nd
  2 0 fix.format
  "  Use ANA menu (1, 2, 3, ..., 9:all) when analyzed? "
  s.type   2  get.val  ana.flag :=
  {29.line}

  \  dir.lee.txt     " acq.men"     "cat defer> load

  " y"  non.stop.str  ":=
  ana.flag
  case
    1  of  dir.lee.txt     " lsta-0.txt"     "cat defer> load   endof
    2  of  dir.lee.txt     " lref-0.txt"     "cat defer> load   endof
    9  of  dir.lee.txt     " lsta-0.txt"     "cat defer> load
           dir.lee.txt     " lref-0.txt"     "cat defer> load   endof
  endcase
  " n" non.stop.str  ":=
  stack.clear
;
: run.ref
  {29.line}
  dir.lee.txt     " lref-0.txt"     "cat defer> load
  nd
  stack.clear
;
: run.sta
  {29.line}
  " n"  non.stop.str  ":=
  dir.lee.txt     " lsta-0.txt"     "cat defer> load
  stack.clear
;
: run.whp
  {29.line}
  dir.lee.txt     " lwhp-0.txt"     "cat defer> load
  nd
  stack.clear
;
: run.scr
  {29.line}
```

```
  dir.lee.txt      " scr.men"      "cat defer> load
  stack.clear
;
: run.mon                                                              216
  {29.line}
  dir.lee.txt      " mon.men"      "cat defer> load
  stack.clear
;
: run.cal                                                              221
  {29.line}
  dir.lee.txt      " cal.men"      "cat defer> load
  cr .time
  stack.clear
;                                                                      226
\ ^--------------------------------------------------------------------^
: sta.hlp
  dir.lee.txt   " lsta.hlp"  "cat  defer> load
;
: ref.hlp                                                              231
  dir.lee.txt   " lref.hlp"  "cat  defer> load
;
: kr.hlp
  dir.lee.txt   " lref.hlp"  "cat  defer> load
;                                                                      236
: par.hlp
  dir.lee.txt   " lpar.hlp"  "cat  defer> load
;
: let.hlp
  dir.lee.txt   " llet.hlp"  "cat  defer> load                         241
;
: cal.hlp
  dir.lee.txt   " lcal.hlp"  "cat  defer> load
;
: acq.hlp                                                              246
  dir.lee.txt   " lacq.hlp"  "cat  defer> load
;
: a&a.hlp
  dir.lee.txt   " LAnA.hlp"  "cat  defer> load
;                                                                      251
: mon.hlp
  dir.lee.txt   " lmon.hlp"  "cat  defer> load
;

\ ----------------------- Words for resetting parameter                256
   --------------------
: get.#spe.ini
  10  3 fix.format
  0  tmp.v.i  :=
  begin
    tmp.v.i  1 +   tmp.v.i :=                                          261
    tmp.v.i  col.1.pos  col.1.w 1 + + over  row.beg +  goto.xy #spe swap
        [ ] .
    #spe.str  "[ tmp.v.i 1 + ]  "null   "=
  until
  \  21  3  goto.xy  #spe [ 1 ]  .
```



```
;                                                                      266
: get."spe.ini
  0  tmp.v.i  :=
  begin
    tmp.v.i  1 +   tmp.v.i :=
    tmp.v.i  col.2.pos  col.2.w 1 + + over row.beg + goto.xy "spe "[ ]   271
       "type
    "spe.str "[ tmp.v.i 1 + ]  "null  "=
  until
;
: get."spe.p1   \  [ ele.# - ]
  10  foreground                                                       276
  10 3 fix.format
  tmp.v.i.2  :=
  tmp.v.i.2
  16  col.2.pos +  tmp.v.i.2 row.beg +  goto.xy  "spe "[ tmp.v.i.2 ]
     get.str
                                                 "spe "[ tmp.v.i.2 ] ":= 281
  my.def.colors
;
: get.#spe.p1   \  [ ele.# - ]
  10  foreground
  10 3 fix.format                                                      286
  tmp.v.i.2  :=
  tmp.v.i.2
\ 28  tmp.v.i.2 row.beg +  goto.xy  #spe [ tmp.v.i.2 ] get.val
\                                   #spe [ tmp.v.i.2 ] :=
  28  tmp.v.i.2 row.beg +  goto.xy                                     291
  tmp.v.i.2  1  =  if  32000  #spe [ 2 ] /   #spe [ 3 ] /          then
  tmp.v.i.2  2  =  if  32000  #spe [ 1 ] /   #spe [ 3 ] /          then
  tmp.v.i.2  3  =  if  32000  #spe [ 1 ] /   #spe [ 2 ] /  trunc   then
  tmp.v.i.2  4  >= if  32000  #spe [   tmp.v.i.2        ]          then
     get.val                  #spe [ tmp.v.i.2 ] :=                  296
                              my.def.colors
;
: get.#spe.1     1  get.#spe.p1  ;
: get.#spe.2     2  get.#spe.p1  ;
: get.#spe.3     3  get.#spe.p1  ;                                     301
: get.#spe.4     4  get.#spe.p1  ;
: get.#spe.5     5  get.#spe.p1  ;
: get.#spe.6     6  get.#spe.p1  ;
: get.#spe.7     7  get.#spe.p1  ;
: get.#spe.8     8  get.#spe.p1  ;                                     306
: get.#spe.9     9  get.#spe.p1  ;
: get.#spe.10    10 get.#spe.p1  ;
: get.#spe.11    11 get.#spe.p1  ;
: get.#spe.12    12 get.#spe.p1  ;
: get.#spe.13    13 get.#spe.p1  ;                                     311
: get.#spe.14    14 get.#spe.p1  ;
: get.#spe.15    15 get.#spe.p1  ;

: get."spe.1     1  get."spe.p1  ;
: get."spe.2     2  get."spe.p1  ;                                     316
: get."spe.3     3  get."spe.p1  ;
: get."spe.4     4  get."spe.p1  ;
```

```
: get."spe.5      5  get."spe.p1  ;
: get."spe.6      6  get."spe.p1  ;
: get."spe.7      7  get."spe.p1  ;                                    321
: get."spe.8      8  get."spe.p1  ;
: get."spe.9      9  get."spe.p1  ;
: get."spe.10     10 get."spe.p1  ;
: get."spe.11     11 get."spe.p1  ;
                                                                       326
\ ================================================================
: create.lspe.dat
  regular.datafile
  file.template
    60 comments                                                        331
    real dim[ #.#spe ] subfile
  end
  spe.str                              defer>  file.create
  spe.str                              defer>  file.open
\  dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.create              336
\  dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.open
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  #spe.str  0  "a>c                                       341
      tmp.v.i  #.#spe  =
    until
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=                                         346
      tmp.v.i  "spe.str  20 "a>c
      tmp.v.i  #.#spe  =
    until
    0  tmp.v.i  :=
    begin                                                              351
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe      40 "a>c
      tmp.v.i  #.#spe  =
    until
  1 subfile  #spe    array>file                                        356
  file.close
;
: done
    create.lspe.dat
    \    #.#spe 2 + 1 +    col.1.pos  7 + goto.xy                    361
    \    ."   lspe-ana data file created : "
    \ ."  OK?"  spe.str       get.str   spe.str  ":=
    spe.str       get.str   spe.str  ":=
    stack.clear
;                                                                      366
\ ------------------------- Declaration of Menus
   ------------------------------!
Menu main.Menu
\ ------------------------- Declaration of Menus
   ------------------------------!
Menu par.menu
Menu hlp.Menu                                                          371
```



```
Menu acq.Menu
Menu ana.Menu
Menu a+a.Menu
Menu cal.Menu
Menu scr.Menu                                                          376

\ ------------------------- Declaration of Vuports
   ----------------------------!
Vuport Bottom
\ ------------------------- MENU STATUS WORDS
   ---------------------------------!
: main.status             \ For menu.status on Main.menu               381
    0  background
    3  foreground
    2  11 goto.xy ." Press"  b.t  ."  <F10> "  b.t  ." for help"
    2  12 goto.xy ." Press"  b.t  ."  ARROW "  b.t  ." key to choose an
       item"
    2  13 goto.xy ." Press"  b.t  ."   ESC  "  b.t  ." key to  exit any  386
       menu"
    43 12 goto.xy ."          " ." Log in Time : "  .time
    43 13 goto.xy ."          "  " Y.R. Lee"  s.type ."  / 1990, 94, 96"
\   55 11 goto.xy ." Y.R. Lee / Oct. 22 1990"
\   43 11 goto.xy " Developed : Y.R. Lee"  s.type ."  / Oct. 22 1990"
    0  background         \ menu.color                                391
    10 foreground
;
: par.status              \ For menu.status on Main.menu
    1  background
    3  foreground                                                      396
    get.#spe.ini
    get."spe.ini
    \  #.#spe row.beg + 2 -
    col.1.pos  7 +     #.#spe  row.beg + 2 -    goto.xy
    \    ."   lspe-ana data file created : "                          401
    \  " Resetting  " dir.lee.txt " lspe-ana.dat" "cat  "cat  "type
    spe.str                                                 "type
    2  19 goto.xy ." Press"  b.t  ."  <F10> "  b.t  ." for help"
    2  20 goto.xy ." Press"  b.t  ."  ARROW "  b.t  ." key to choose an
       item"
    2  21 goto.xy ." Press"  b.t  ."   ESC  "  b.t  ." key to  exit any  406
       menu"
    43 21 goto.xy ."          " " Y.R. Lee"  s.type ."  / 1990, 94"
    1  background
    13 foreground
;
: hlp.status                                                           411
    5   background
    3   foreground
    1 0 goto.xy   ." <Enter> key to choose an item"
    1 1 goto.xy   ." <Esc> key to escape current menu"
    1 2 goto.xy   ." Choose an item: "                                 416
    5   background
    0   foreground
;
\
```

```
    ------------------------------------------------------------------------------
par.menu                                                                        421
    Menu.Store.Disk
    Menu.status par.status
    " Reset Parameters ---  " "date  "cat    MENU.TITLE
    \    Menu.Pull.Down
    Menu.blow.up                                                                426
    1 1 23 79                                   MENU.SHAPE
    1  13                                       MENU.COLOR
    14                                          Menu.Prompt.Color
    \ 4                                           Menu.Prompt.Color
    1  row.beg + col.1.pos  #spe.str  "[  1 ]   MENU.ITEM{ get.#spe.1  }  431
    2  row.beg + col.1.pos  #spe.str  "[  2 ]   MENU.ITEM{ get.#spe.2  }
    3  row.beg + col.1.pos  #spe.str  "[  3 ]   MENU.ITEM{ get.#spe.3  }
    4  row.beg + col.1.pos  #spe.str  "[  4 ]   MENU.ITEM{ get.#spe.4  }
    5  row.beg + col.1.pos  #spe.str  "[  5 ]   MENU.ITEM{ get.#spe.5  }
    6  row.beg + col.1.pos  #spe.str  "[  6 ]   MENU.ITEM{ get.#spe.6  }  436
    7  row.beg + col.1.pos  #spe.str  "[  7 ]   MENU.ITEM{ get.#spe.7  }
    8  row.beg + col.1.pos  #spe.str  "[  8 ]   MENU.ITEM{ get.#spe.8  }
    9  row.beg + col.1.pos  #spe.str  "[  9 ]   MENU.ITEM{ get.#spe.9  }
    10 row.beg + col.1.pos  #spe.str  "[ 10 ]   MENU.ITEM{ get.#spe.10 }
    11 row.beg + col.1.pos  #spe.str  "[ 11 ]   MENU.ITEM{ get.#spe.11 }  441
    12 row.beg + col.1.pos  #spe.str  "[ 12 ]   MENU.ITEM{ get.#spe.12 }
    13 row.beg + col.1.pos  #spe.str  "[ 13 ]   MENU.ITEM{ get.#spe.13 }
\     14 row.beg + col.1.pos  #spe.str  "[ 14 ]   MENU.ITEM{ get.#spe.14
    }
\    15 row.beg + col.1.pos  #spe.str  "[ 15 ]   MENU.ITEM{ get.#spe.15 }
                                                                            446
    1  row.beg + col.2.pos  "spe.str  "[  1 ]   MENU.ITEM{ get."spe.1  }
    2  row.beg + col.2.pos  "spe.str  "[  2 ]   MENU.ITEM{ get."spe.2  }
    3  row.beg + col.2.pos  "spe.str  "[  3 ]   MENU.ITEM{ get."spe.3  }
    4  row.beg + col.2.pos  "spe.str  "[  4 ]   MENU.ITEM{ get."spe.4  }
    5  row.beg + col.2.pos  "spe.str  "[  5 ]   MENU.ITEM{ get."spe.5  }  451
    6  row.beg + col.2.pos  "spe.str  "[  6 ]   MENU.ITEM{ get."spe.6  }
    7  row.beg + col.2.pos  "spe.str  "[  7 ]   MENU.ITEM{ get."spe.7  }
\     8  row.beg + col.2.pos  "spe.str  "[  8 ]   MENU.ITEM{ get."spe.8
    }
\    9  row.beg + col.2.pos  "spe.str  "[  9 ]   MENU.ITEM{ get."spe.9  }
\    10 row.beg + col.2.pos  "spe.str  "[ 10 ]   MENU.ITEM{ get."spe.10 }  456

\    #.#spe row.beg + 1 +    col.1.pos  3 -  " Done?"   menu.item{ done }
    #.#spe row.beg + 2 -    col.1.pos  3 -  " Done?"   menu.item{ done }
\           row.beg   1 -    col.1.pos  3 -  " Done?"   menu.item{ done }
                                                                            461
MENU.END

: ana.status            \ For menu.status on Main.menu
    0   background
    3   foreground                                                          466
    1  10 goto.xy ." Press" b.t ."  F10 " b.t ." for help"
    3   background
    4   foreground
;
                                                                            471
```



```
\ ---------------------------------- MENUS
    ---------------------------------------!
ana.MENU
    Menu.Store.Disk

    \    " ANALYSIS MENU"                                  Menu.Title       476
    "  ANA "                                Menu.Title
    menu.status ana.status
    \ Menu.Pop.UP
    Menu.blow.UP
    7  16  16  46                                          Menu.Shape       481
    3  4                                                   Menu.Color
    14                                                     Menu.Prompt.Color
\   1 1 " Spectra & Statisitcs"                            Menu.Item{ run.sta }
\   2 1 " Wave Form Analysis (Kr)"                         Menu.Item{ run.ref }
\   3 1 " Distibution Curves"                              Menu.Item{ run.whp }  486
    4 1 " == Reset ACQ Parameters =="                      Menu.Item{ par.menu }
\   5 1 " [Wavelet Analysis]"                              Menu.Item{ nop     }
\   6 1 " [Wavelet & Spectral Coherence]"                  Menu.Item{ nop     }
    \ Make prompt color same as foreground because no items are chosen
       here
MENU.END                                                                    491

\ ------------------------- Designing The Main Menu
    ---------------------------!
main.menu
    Menu.Store.Disk
    \ Menu.Store.memory                                                     496
    Menu.status main.status
    " REAL TIME SYSTEM   ---  " "date  "cat    MENU.TITLE
    Menu.Pull.Down
    1 1 14 79                                          MENU.SHAPE
    0  10                                              MENU.COLOR           501
    14                                                 Menu.Prompt.Color
\   3  3  " ---ACQ---"                                 MENU.ITEM{ run.acq }
\   3  19 " ---A+A---"                                 MENU.ITEM{ ana.menu }
    3  19 " --- reset ACQ parameters ---"              MENU.ITEM{ par.menu }
\   3  35 " -ACQ+ANA-"                                 MENU.ITEM{ run.a+a }  506
\   3  50 " ---CAL---"                                 MENU.ITEM{ run.cal }
\   3  65 " ---MON---"                                 MENU.ITEM{ run.mon }
MENU.END

Hlp.MENU                                                                    511
    " HELP"                                        Menu.Title
    Menu.status hlp.status
    Menu.Pop.UP
\   10 43 22 78                                    Menu.Shape
    10  3 22 39                                    Menu.Shape               516
    5  0                                           Menu.color
    14                                             Menu.Prompt.Color
\   0 1 " <Enter> key to choose an item"           Menu.Item{ NOP }
\   1 1 " <Esc> key to escape current menu"        Menu.Item{ NOP }
\   2 1 " Choose an item: "                        Menu.Item{ NOP }         521
    3 3 " -- ACQ --"                               Menu.Item{ acq.hlp }
    4 3 " -- ANA & A+A --"                         Menu.Item{ a&a.hlp }
```

```
    5 6 " Spectra & Statisitcs"                  Menu.Item{ sta.hlp }
    6 6 " Wave Form Analysis"                    Menu.Item{ ref.hlp }
    7 6 " Kr computation"                        Menu.Item{ kr.hlp  }      526
    8 6 " == Reset Parameters =="                Menu.Item{ par.hlp }
    9 6 " [Wavelet Analysis]"                    Menu.Item{ let.hlp }
   10 6 " [Wavelet & Spectral Coherence]"        Menu.Item{ let.hlp }
   11 3 " -- CAL --"                             Menu.Item{ cal.hlp }
   12 3 " -- MON --"                             Menu.Item{ mon.hlp }      531
    0 foreground
\   \ Make prompt color same as foreground because no items are chosen
   here
MENU.END

\ ------------- Assigning Menus & Colon Defs To Function Keys              536
   -----------------!
    F5   Menu.key.does run.mon
    F4   Menu.key.does run.cal
    F3   Menu.key.does run.a+a
    F2   Menu.key.does run.sta
    F1   Menu.key.does run.acq                                             541
    F10  Menu.key.does hlp.menu

\ -------------------- Initializing and starting program
   ----------------------!
: Start
    echo.off                                                               546
    Stack.clear
    \ Menu.stack.clear            \ Clears all active menus
    Normal.display
    main.menu
    bell.1LL                                                               551
    menu.execute
    \    0 menu.flag :=  \ restore
    \    Normal.display
;
bell.1ll                                                                   556
start
17 1 +  #.#spe :=
real dim[ #.#spe ] array #spe
: create.comment
    0  tmp.v.i  :=                                                         561
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  #spe.str  0  "a>c
      tmp.v.i  #.#spe  =
    until                                                                  566
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
      tmp.v.i  "spe.str  20 "a>c
      tmp.v.i  #.#spe  =                                                   571
    until
    0  tmp.v.i  :=
    begin
      tmp.v.i 1 +  tmp.v.i  :=
```



```
      tmp.v.i  "spe       40 "a>c                                          576
      tmp.v.i  #.#spe  =
    until
;
: create.blank.file
  regular.datafile                                                         581
  file.template
    60 comments
    real dim[ #.#spe ] subfile
  end
\ dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.create                    586
\ dir.lee.txt  " lspe-ana.dat" "cat  defer>  file.open
\  dir.lee.txt  " lspe-acq.dat" "cat  defer>  file.create
\  dir.lee.txt  " lspe-acq.dat" "cat  defer>  file.open
  tmp.s.2  defer>  file.create
  tmp.s.2  defer>  file.open                                               591
  1 subfile  #spe    array>file
  file.close
;
\ create.blank.file
```

APPENDIX 2：　A Few Pages from the Slide

In memory of a desire that lasted for more than 30 years
— the publishing of the English version

（磁失紙存、檔毀箱在、二十多年的開箱懸念、圖書室息燈）

室空人去，館藏賽斤兩，青史盡成灰。
數拾載算計，唯獨此箱形，不忍一箱滅，萬般皆成空。
字抵金痕比魂，更有手漬蠹斑。
跡失味散卻必然，但留檔號，且會雲端。

Fig 1： The cover pages from a previous slide in Chinese (a revision created in 2017).

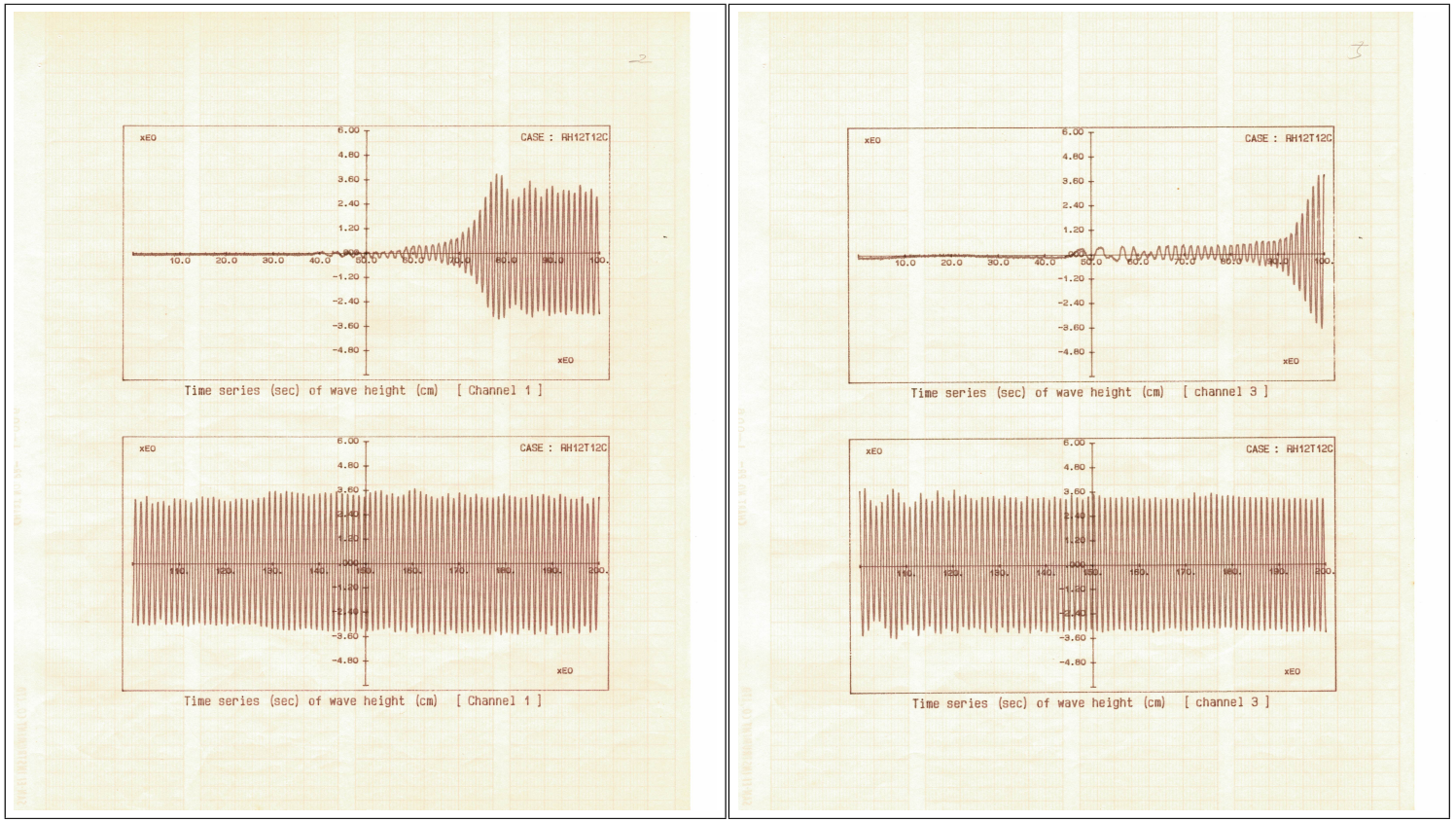


Fig 2： Floppies corrupted, papers survived · · · Plots like these on the backs of high quality semi transparent papers belonged to the initial stage of preparation. They were mainly used to understand preliminarily the characteristics of the wave maker and the wave phenomena in the tank, and to help in the selection of various parameters, such as the instrument parameters of the waves. From the drawings like these, it was decided that the instrument wave period parameters would be 1.3, 1.6, 1.9 and 2.2 second, rather than 1.2, 1.6, 、2.0 、and 2.4, as originally planned. It was observed from these charts that a short wave period puts a lot of stress upon the wave-maker. On the one hand, the wave matures relatively slowly, on the other hand, the wave may not be very pure (with long wave components, at least for the initial stage).

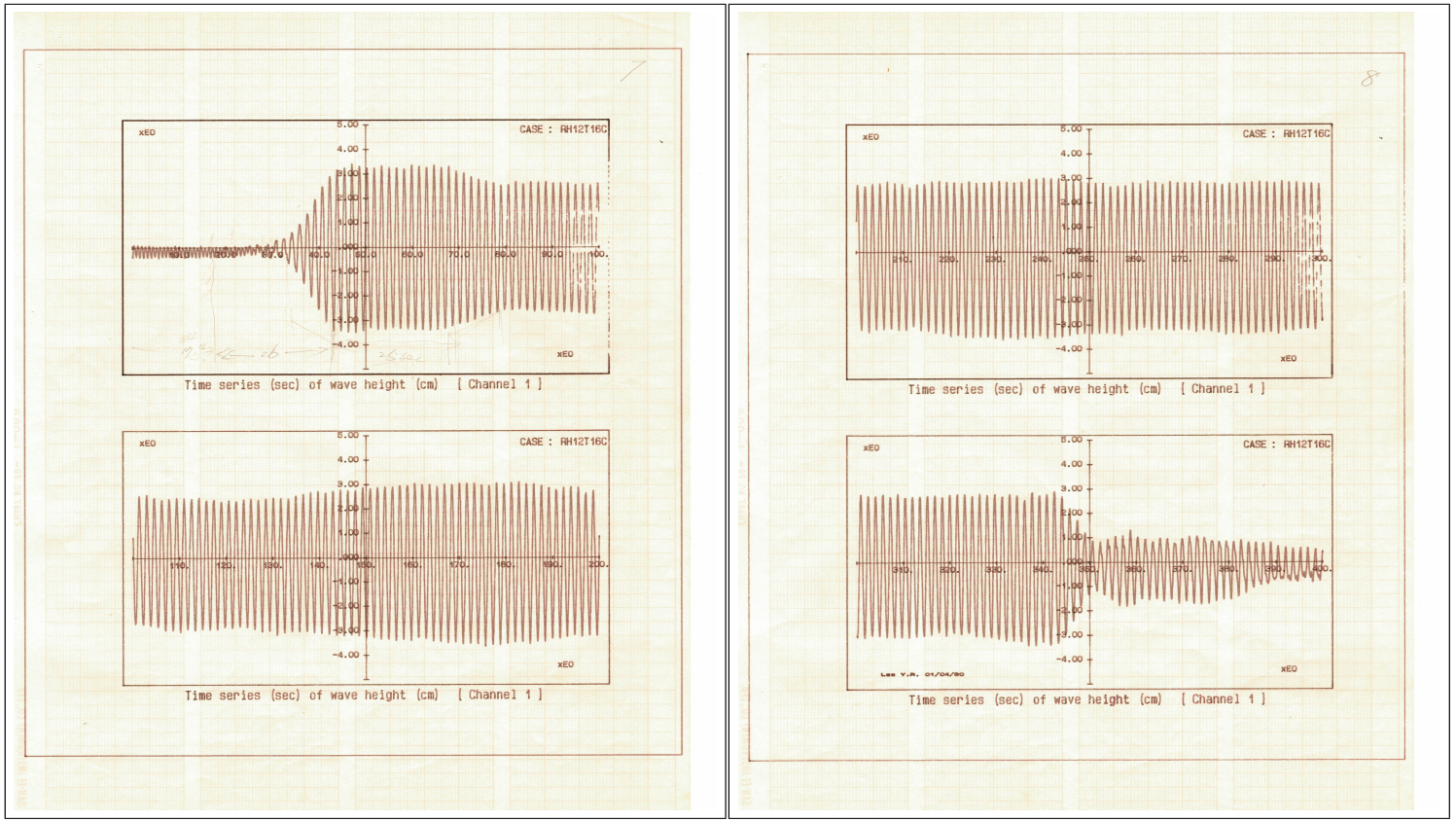


Fig 3： Floppies corrupted, papers survived ··· The curves here are of 1.6 second and gauge 1. Such plots were the earliest rudimentary drawings and belonged to the preceding works of the formal tests. Without these records on papers, a lot of extra information would had been lost and long forgotten. It is noted that this study was done in the era of 286 and 386 PC with the maximum hard disk capacity of 40 MB. At that time dot-matrix printer ruled the world; color monitor and laser printer were high end products and extremely expensive and rare, and plots were mostly drawn by pen plotter (the electronic format of plot was basically unavailable). By the way, these graphs were drawn by Roland DXY-1300 A3.

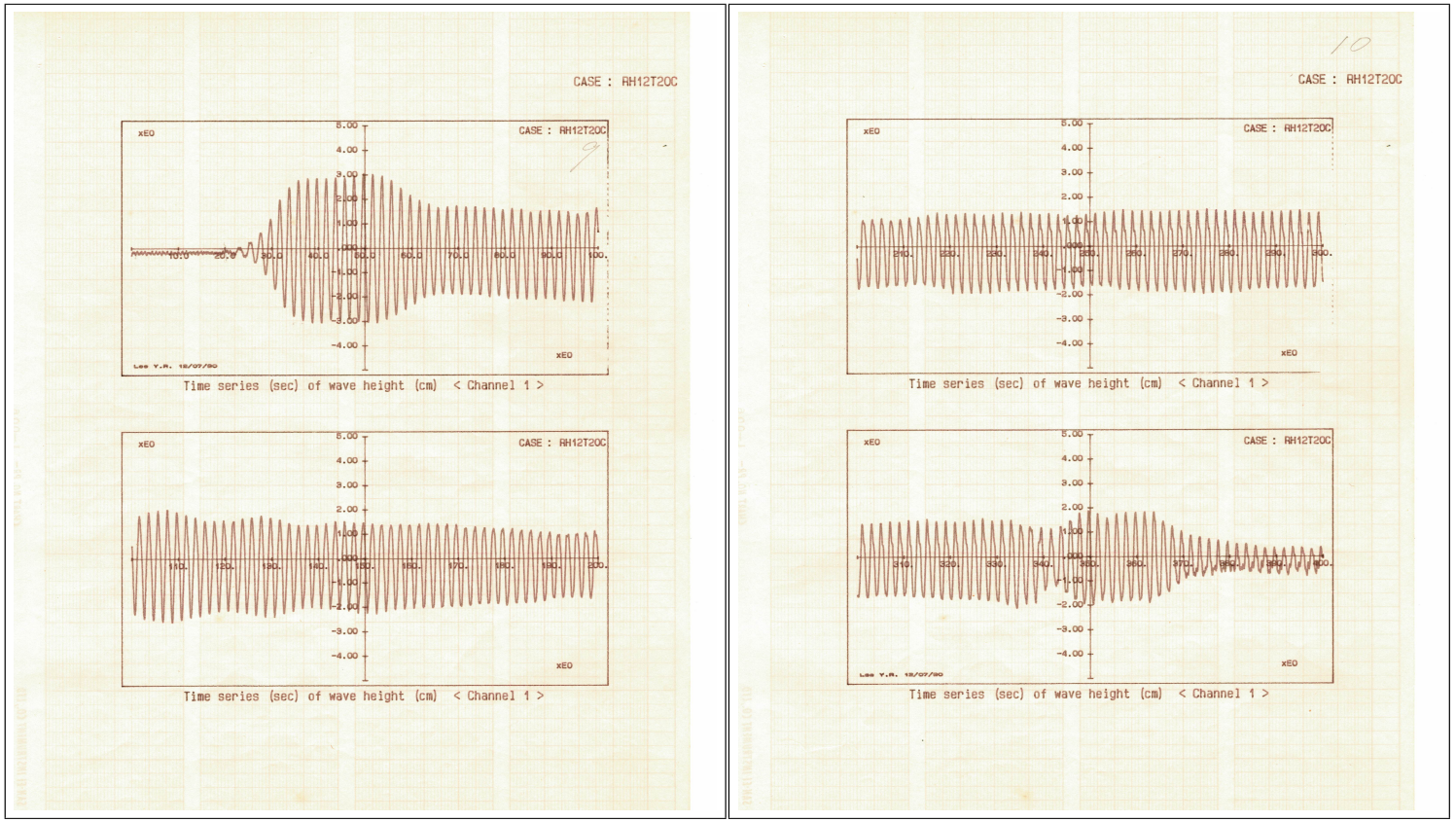


Fig 4： Floppies corrupted, papers survived ··· The wave period instrument parameter here is 2.0 second, and the gauge position is 1. A significant indication from this is the importance of the proper timing of data acquisition and analyses. All these preliminary graphs were drawn in an interactive way (i.e., employing pieces of codes step by step, rather than a complete code in a single step) using the stack style Asyst language, and the interactive way had a higher possibility of inconsistency and input errors. Without the use of papers these graphs would surely had been discarded if they were in the electronic format, and there would be no such retrospection.

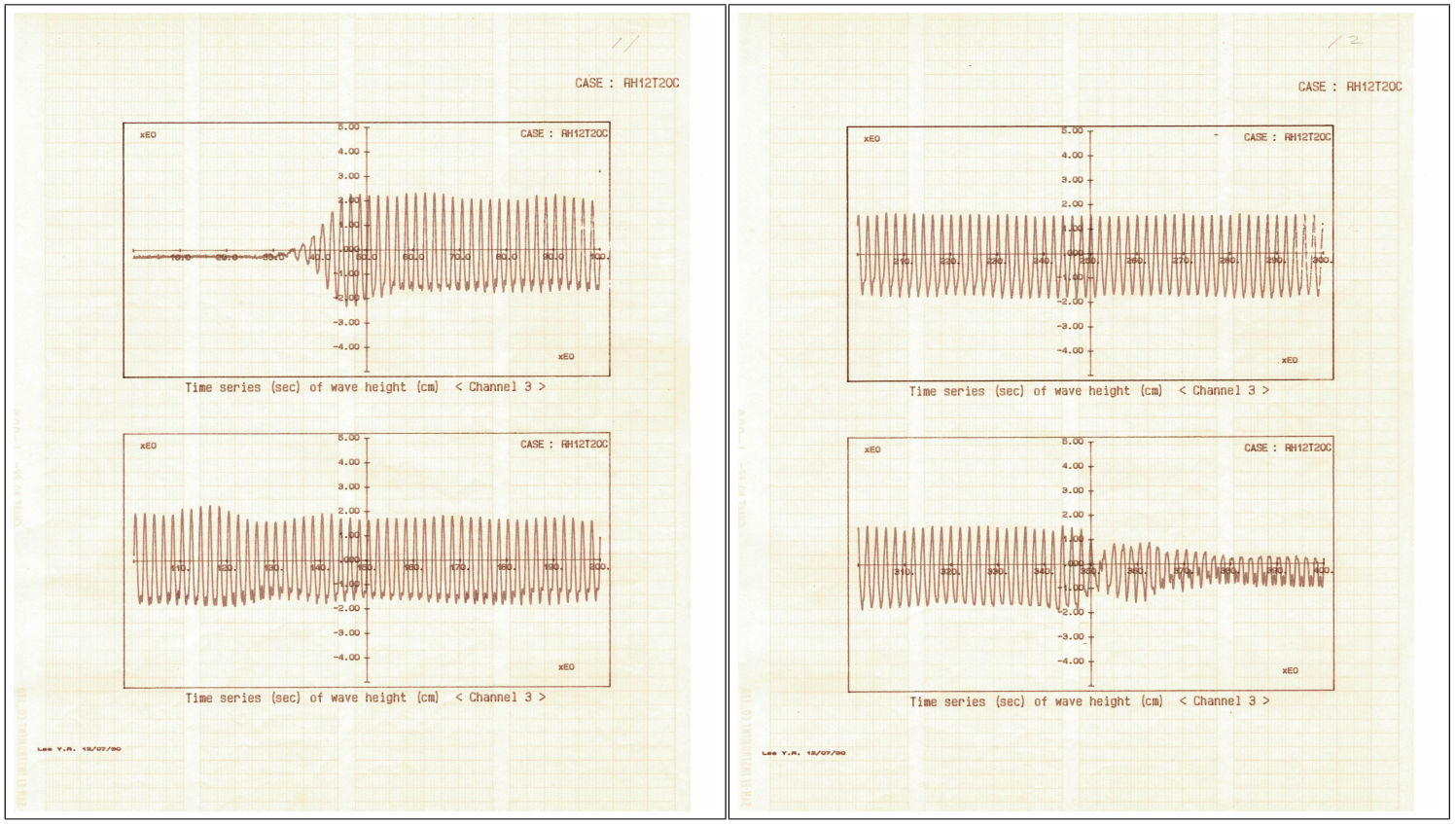
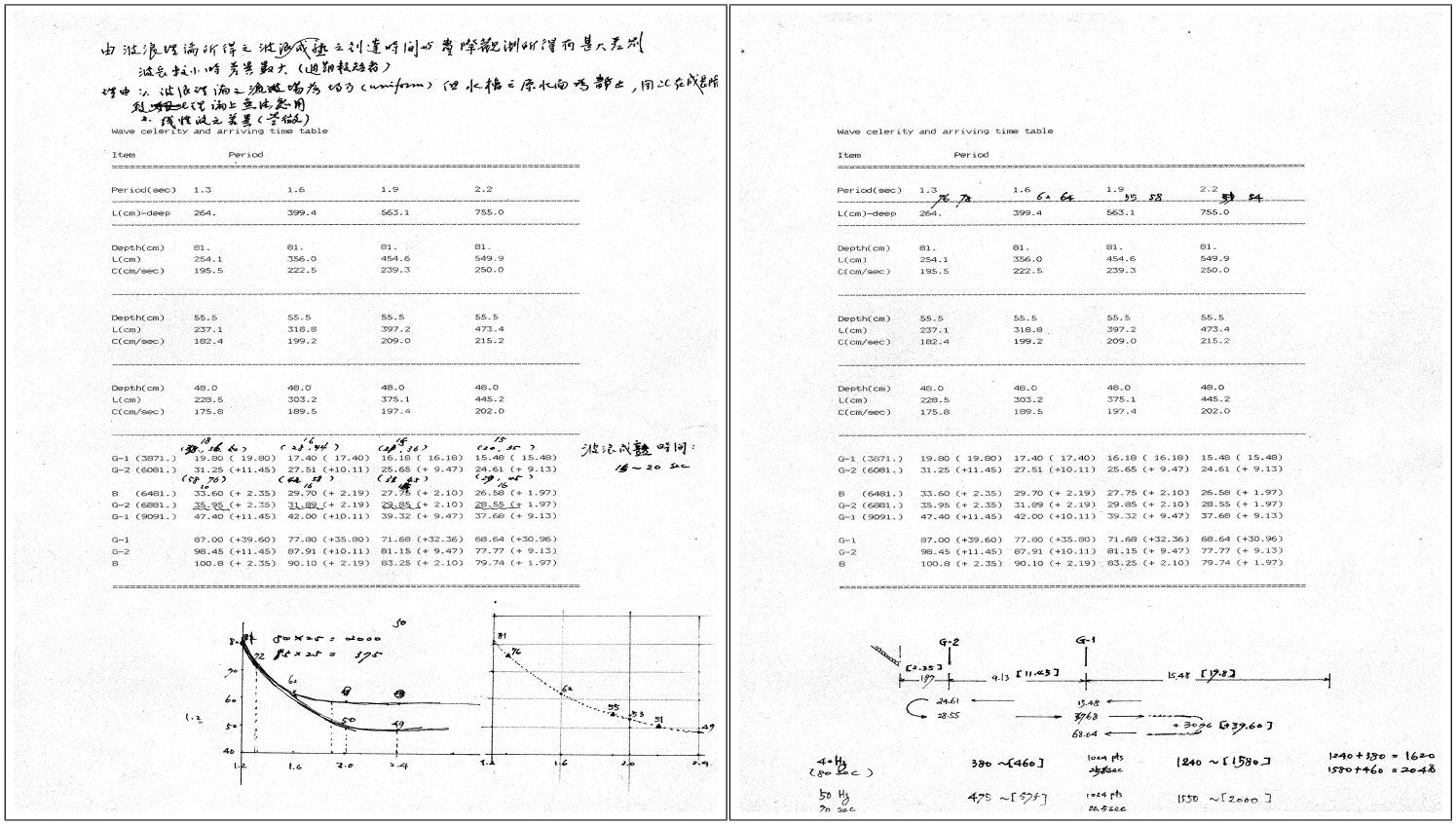


Fig 5： Floppies corrupted, papers survived · · · The concurrent measurement at gauge 3 associated with the figure right before (gauge 1). Together, we can have a grasp of the complexity of interaction between the wave and its environment, as well as the importance of the use of wave separation. Retrospection often uncovers what were previously missed and sets off new ideas.



由波浪理論所得之波浪成型之到達時間與實際觀測所得有甚大差別
波長較小時差異最大（週期較短者）
理由：1. 波浪理論之流場為均勻（uniform）但水槽之原水面為靜止，同此在成型所
到達此波浪論上無此影響
2. 線性波之差異（等級）

Wave celerity and arriving time table

Item	Period			
Period(sec)	1.3	1.6	1.9	2.2
L(cm)-deep	264.	399.4	563.1	755.0
Depth(cm)	81.	81.	81.	81.
L(cm)	254.1	356.0	454.6	549.9
C(cm/sec)	195.5	222.5	239.3	250.0
Depth(cm)	55.5	55.5	55.5	55.5
L(cm)	237.1	318.8	397.2	473.4
C(cm/sec)	182.4	199.2	209.0	215.2
Depth(cm)	48.0	48.0	48.0	48.0
L(cm)	228.5	303.2	375.1	445.2
C(cm/sec)	175.8	189.5	197.4	202.0
G-1 (3871.)	19.80 (19.80)	17.40 (17.40)	16.18 (16.18)	15.48 (15.48)
G-2 (6081.)	31.25 (+11.45)	27.51 (+10.11)	25.65 (+ 9.47)	24.61 (+ 9.13)
B (6481.)	33.60 (+ 2.35)	29.70 (+ 2.19)	27.75 (+ 2.10)	26.58 (+ 1.97)
G-2 (6881.)	35.95 (+ 2.35)	31.89 (+ 2.19)	29.85 (+ 2.10)	28.55 (+ 1.97)
G-1 (9091.)	47.40 (+11.45)	42.00 (+10.11)	39.32 (+ 9.47)	37.68 (+ 9.13)
G-1	87.00 (+39.60)	77.80 (+35.80)	71.68 (+32.36)	68.64 (+30.96)
G-2	98.45 (+11.45)	87.91 (+10.11)	81.15 (+ 9.47)	77.77 (+ 9.13)
B	100.8 (+ 2.35)	90.10 (+ 2.19)	83.25 (+ 2.10)	79.74 (+ 1.97)

波浪成型時間：
15～20 sec

Wave celerity and arriving time table

Item	Period			
Period(sec)	1.3	1.6	1.9	2.2
L(cm)-deep	264.	399.4	563.1	755.0
Depth(cm)	81.	81.	81.	81.
L(cm)	254.1	356.0	454.6	549.9
C(cm/sec)	195.5	222.5	239.3	250.0
Depth(cm)	55.5	55.5	55.5	55.5
L(cm)	237.1	318.8	397.2	473.4
C(cm/sec)	182.4	199.2	209.0	215.2
Depth(cm)	48.0	48.0	48.0	48.0
L(cm)	228.5	303.2	375.1	445.2
C(cm/sec)	175.8	189.5	197.4	202.0
G-1 (3871.)	19.80 (19.80)	17.40 (17.40)	16.18 (16.18)	15.48 (15.48)
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G-1	87.00 (+39.60)	77.80 (+35.80)	71.68 (+32.36)	68.64 (+30.96)
G-2	98.45 (+11.45)	87.91 (+10.11)	81.15 (+ 9.47)	77.77 (+ 9.13)
B	100.8 (+ 2.35)	90.10 (+ 2.19)	83.25 (+ 2.10)	79.74 (+ 1.97)

Fig 6： The planing of data acquisition ··· The estimation of wave propagation and the various arrival times at different wave gauges.

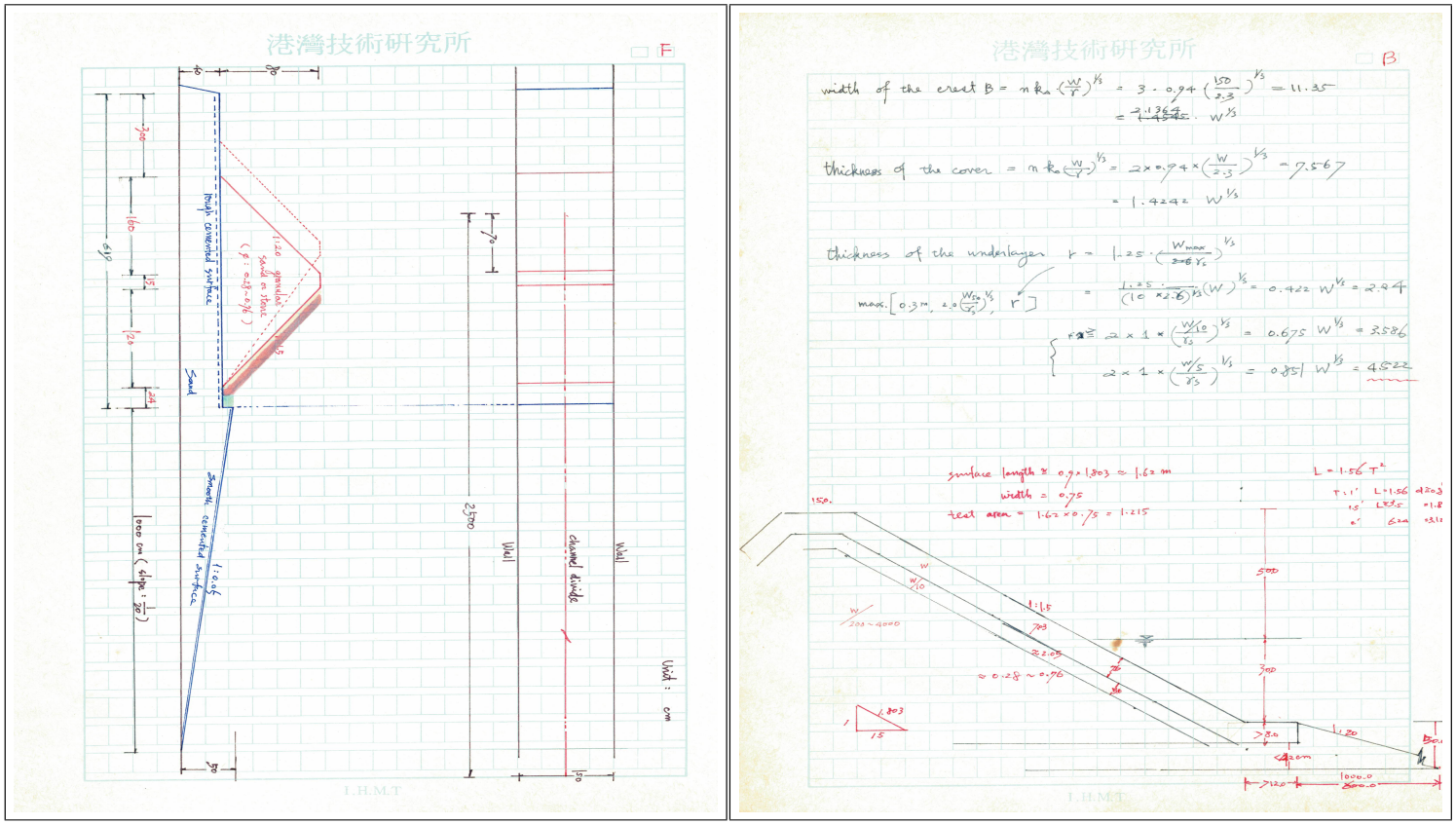


Fig 7： Hand sketch of the layout and some calculations at the initial stage of planning. It seems that the second preselected slope of the breakwater was 1:2.0 (more practical) rather than the adopted 1:1.2 (unrealistic, but easier to work with, most importantly, the higher possibility of damage observations).

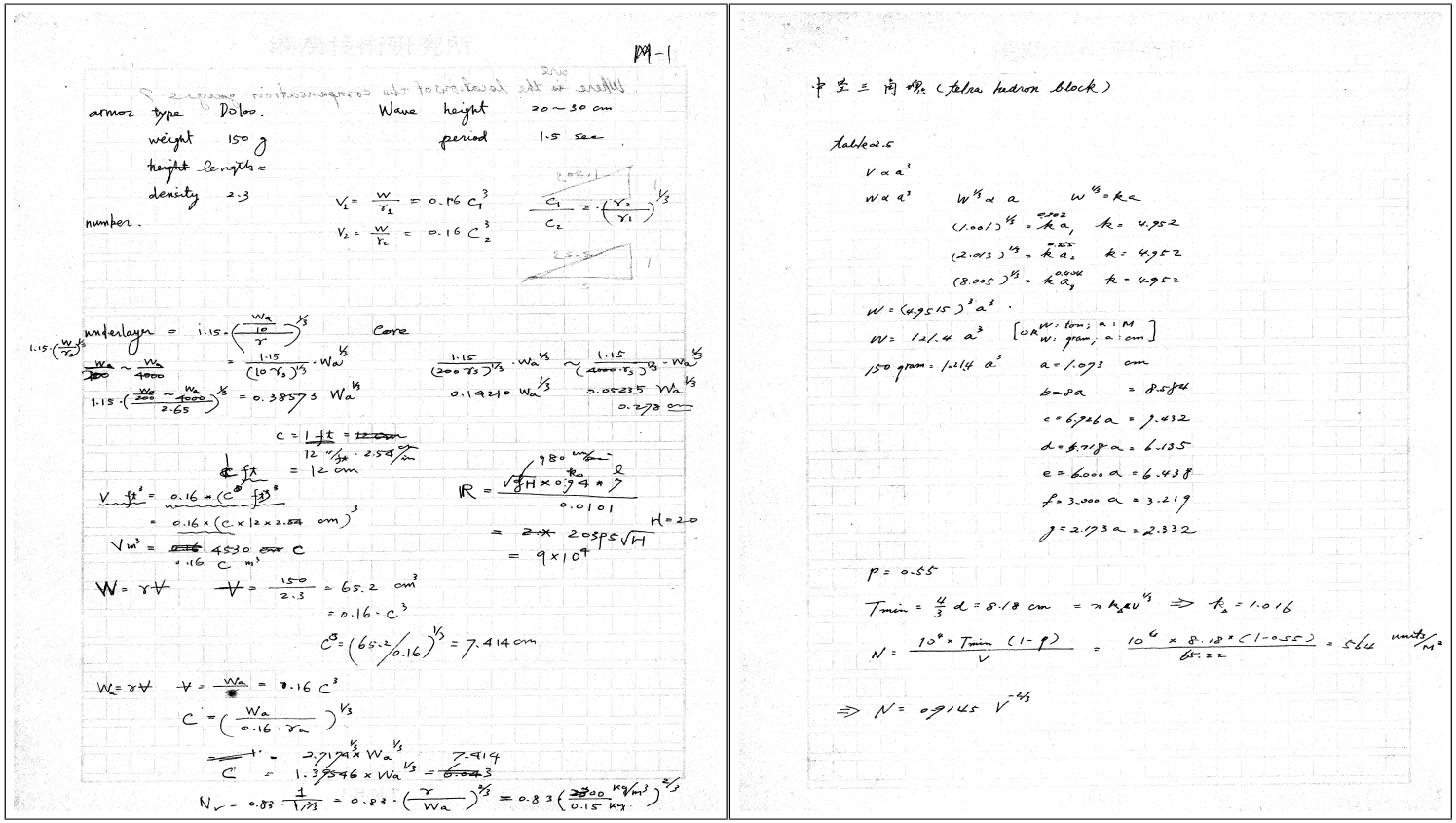


Fig 8： Some drafts of the calculation of armor parameters.

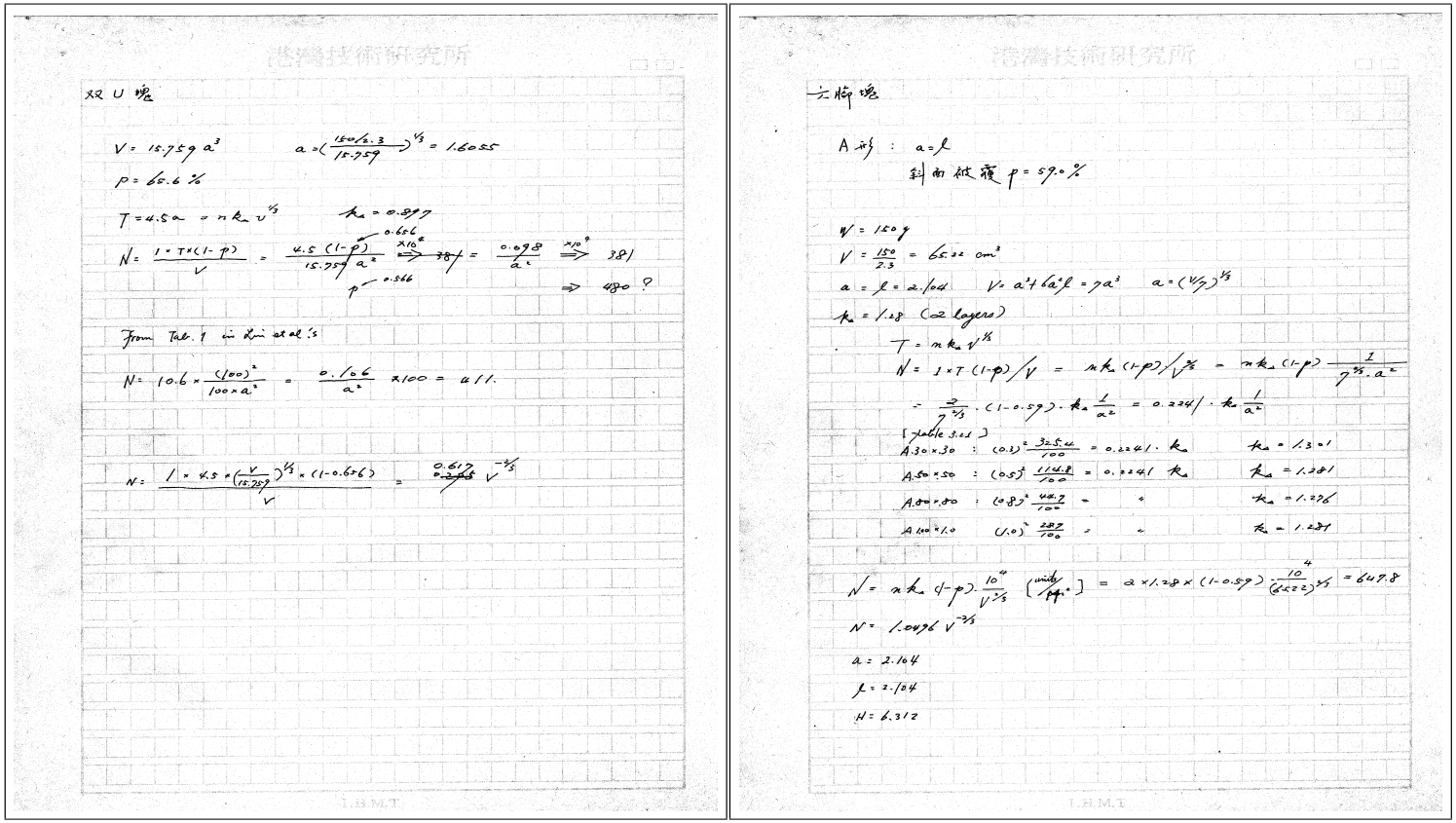


Fig 9： Some drafts of the calculation of armor parameters.

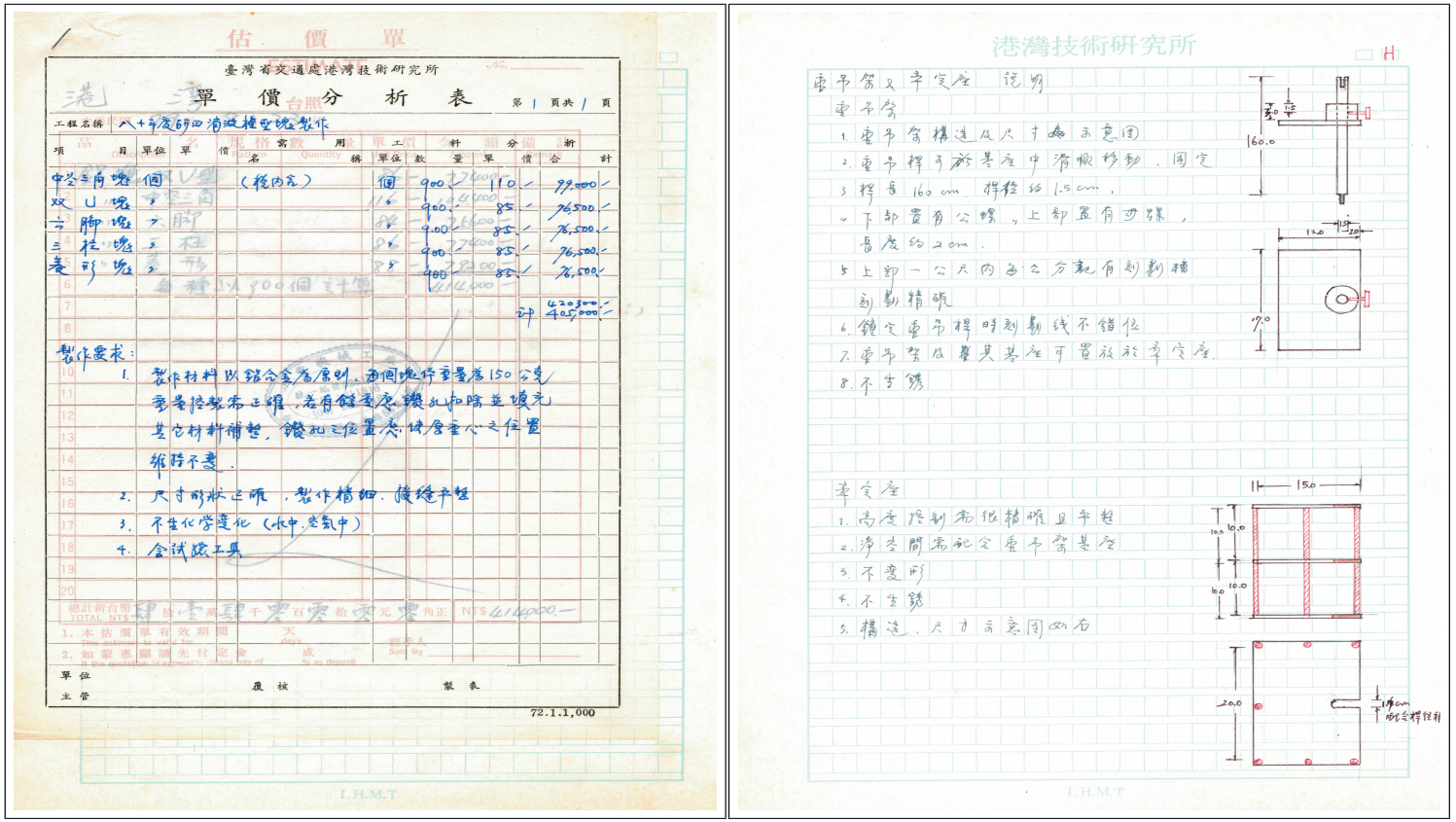
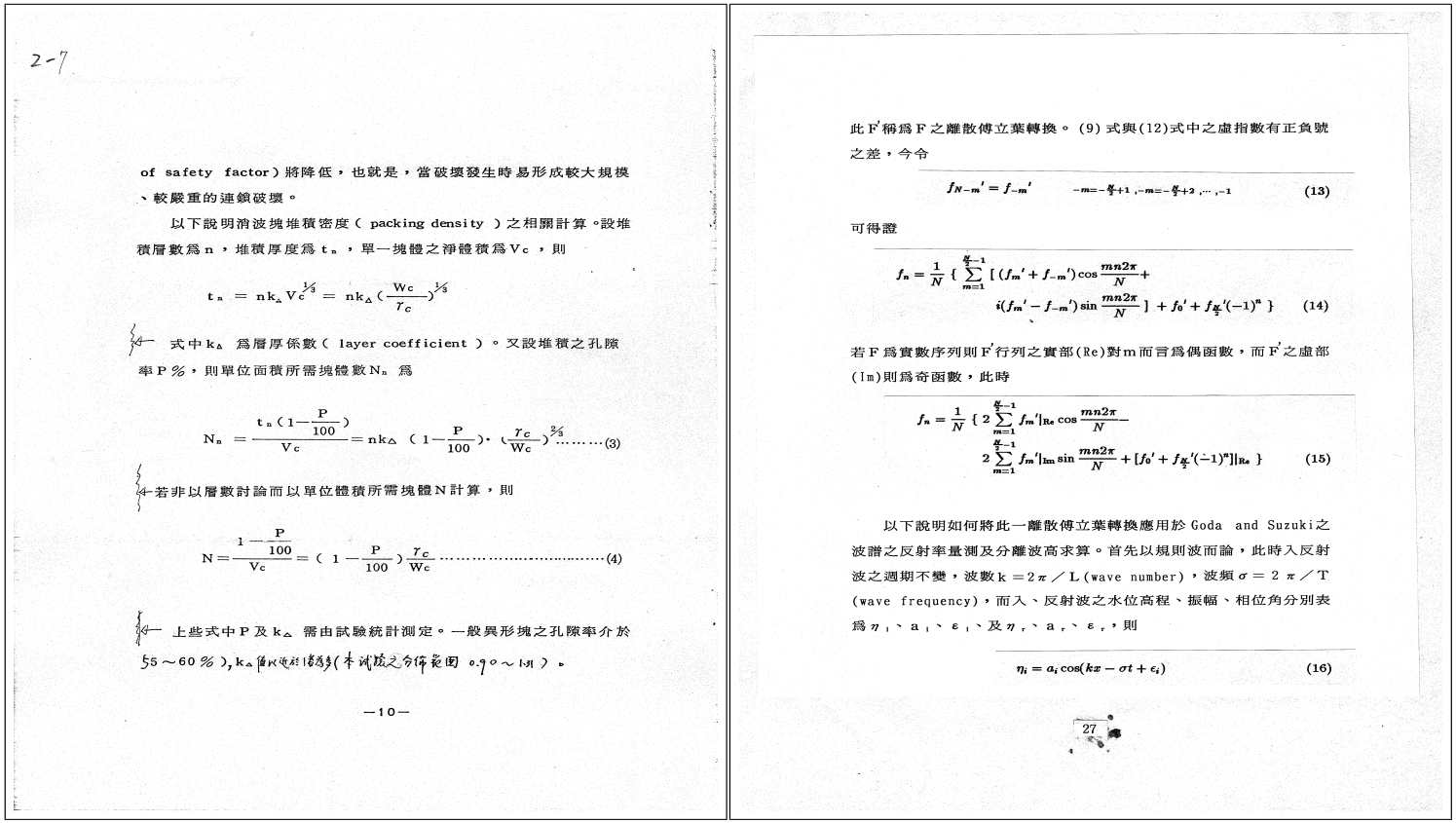


Fig 10： A sheet of rudimentary unit price analysis and a drawing of a calibration stand for the wave gauges. The final version of the analysis sheet was not kept. In the author's memory, all the ten armor types (rather then the eleven types) were placed in one contract awarding. The messages related to the odd number eleven types were: One armor type owner got the news a bit late but wanted to join the tests (and therefore, the right owner was asked to supply the armors, but the armors were still made by the same manufacturer); The only repeated test was of the armor type double-U under slope 1:1.5 (the armor type was not intentional chosen, incidentally, it was placed at the fifth batch of experiment); And the missing part was related to the natural blocks, which was instantly destroyed under slope 1:1.2.



2-7

of safety factor）將降低，也就是，當破壞發生時易形成較大規模、較嚴重的連鎖破壞。

以下說明消波塊堆積密度（ packing density ）之相關計算。設堆積層數爲 n ，堆積厚度爲 t_a ，單一塊體之淨體積爲 V_c ，則

$$t_a = nk_\Delta V_c^{1/3} = nk_\Delta \left(\frac{W_c}{\gamma_c}\right)^{1/3}$$

式中 k_Δ 爲層厚係數（ layer coefficient ）。又設堆積之孔隙率 P %，則單位面積所需塊體數 N_a 爲

$$N_a = \frac{t_a\left(1-\frac{P}{100}\right)}{V_c} = nk_\Delta\left(1-\frac{P}{100}\right)\cdot\left(\frac{\gamma_c}{W_c}\right)^{2/3} \quad \cdots\cdots(3)$$

若非以層數討論而以單位體積所需塊體 N 計算，則

$$N = \frac{1-\frac{P}{100}}{V_c} = \left(1-\frac{P}{100}\right)\frac{\gamma_c}{W_c} \quad \cdots\cdots(4)$$

上些式中 P 及 k_Δ 需由試驗統計測定。一般異形塊之孔隙率介於 55～60 %），k_Δ 值以近於 [illegible]（本試驗之分佈範圍 0.90～1.01）。

—10—

此 F′稱爲 F 之離散傅立葉轉換。（9）式與(12)式中之虛指數有正負號之差，今令

$$f_{N-m}' = f_{-m}' \qquad -m=-\tfrac{N}{2}+1,-m=-\tfrac{N}{2}+2,\cdots,-1 \qquad (13)$$

可得證

$$f_n = \frac{1}{N}\left\{\sum_{m=1}^{\frac{N}{2}-1}\left[(f_m'+f_{-m}')\cos\frac{mn2\pi}{N} + i(f_m'-f_{-m}')\sin\frac{mn2\pi}{N}\right] + f_0' + f_{\frac{N}{2}}'(-1)^n\right\} \qquad (14)$$

若 F 爲實數序列則 F′行列之實部(Re)對 m 而言爲偶函數，而 F′之虛部(Im)則爲奇函數，此時

$$f_n = \frac{1}{N}\left\{2\sum_{m=1}^{\frac{N}{2}-1} f_m'|_{Re}\cos\frac{mn2\pi}{N} - 2\sum_{m=1}^{\frac{N}{2}-1} f_m'|_{Im}\sin\frac{mn2\pi}{N} + [f_0' + f_{\frac{N}{2}}'(-1)^n]|_{Re}\right\} \qquad (15)$$

以下說明如何將此一離散傅立葉轉換應用於 Goda and Suzuki之波譜之反射率量測及分離波高求算。首先以規則波而論，此時入反射波之週期不變，波數 $k = 2\pi / L$ (wave number)，波頻 $\sigma = 2\pi / T$ (wave frequency)，而入、反射波之水位高程、振幅、相位角分別表爲 η_i、a_i、ε_i、及 η_r、a_r、ε_r，則

$$\eta_i = a_i\cos(kx - \sigma t + \epsilon_i) \qquad (16)$$

27

Fig 11： This study is a two-year project (July 1989 – June 1991). The left is a page of the interim report (1990) and it was completely typed in papers by professional Chinese typist. The right is a page of the final report (1991), in which the Chinese was still typed by professional typist, while the mathematical formulas were done by the author using latex (an era when the Chinese latex was unavailable) and then pasted (note the trace of border lines and marks around the page number of the “cut and paste” pieces, and the lines were eliminated when making photographic plates). And yes, all those page numbers in the original final report (1991, in Chinese) were pasted by the author.

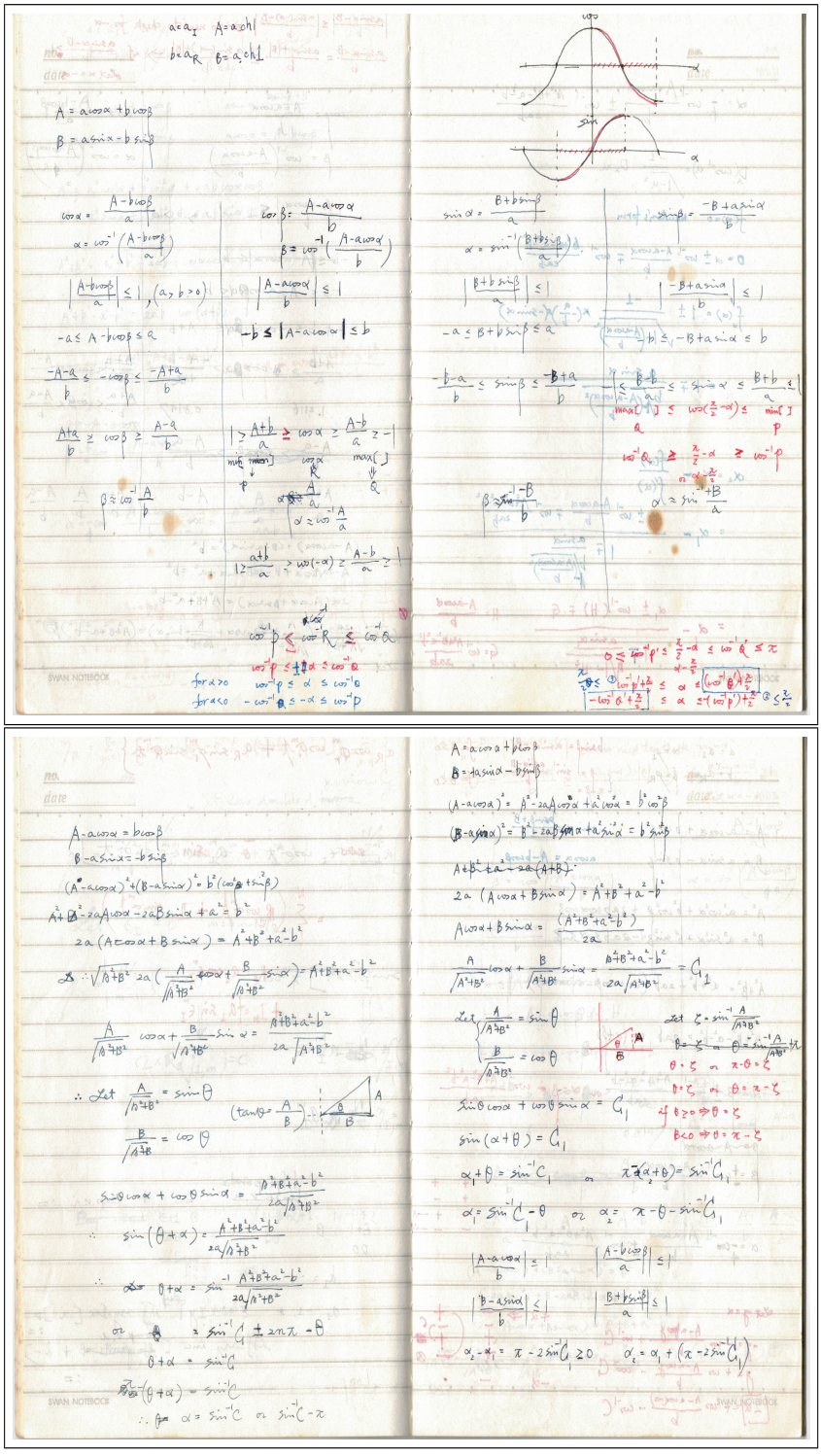


Fig 12 : A few pages related to the coding of wave separation · · · It is like living in another life when reviewing these details and the codes.

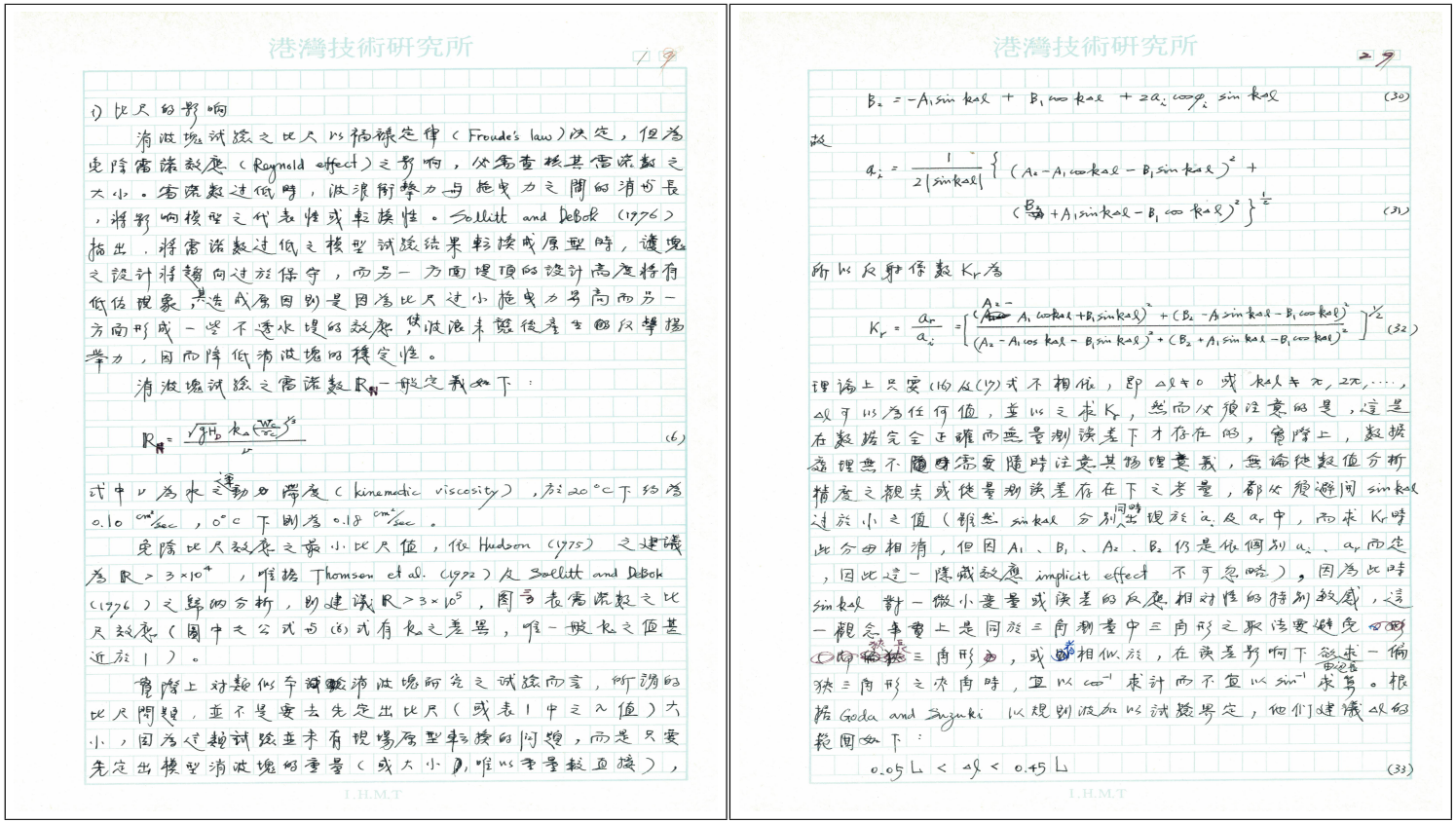


Fig 13： A few pages of the manuscripts ··· For all the published works by the author, this is the only report that has a complete manuscript neatly hand handwritten and to be sent to the publishing house. All the other reports have been self made in digital form, and their existing paper records and handwriting materials combined barely sum up to the volume of this study.

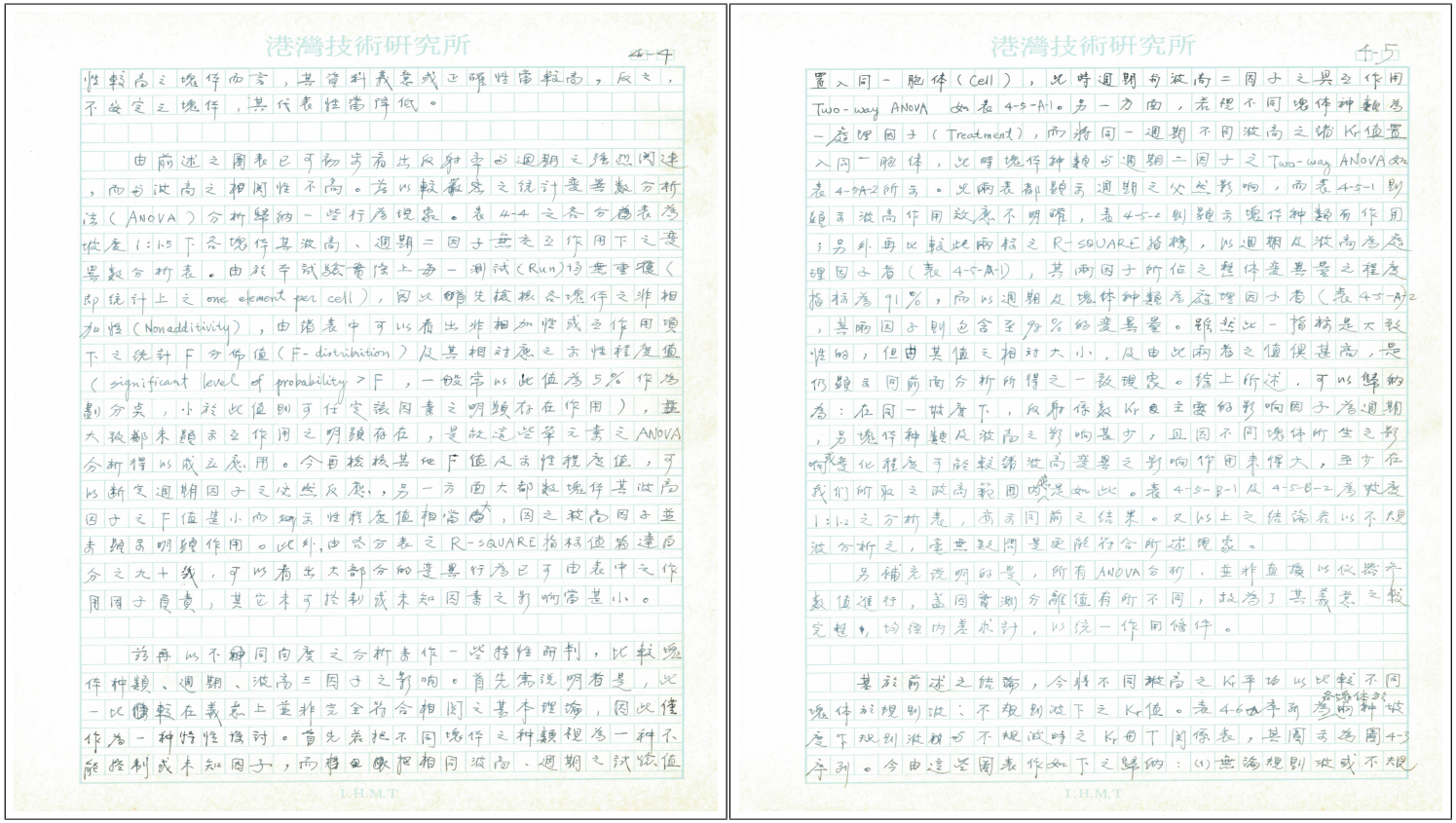


Fig 14： A few pages of the manuscripts ··· These were prepared for the professional Chinese typist.

Fig 15： A few pages of the manuscripts ··· Prepared for the professional Chinese typist.

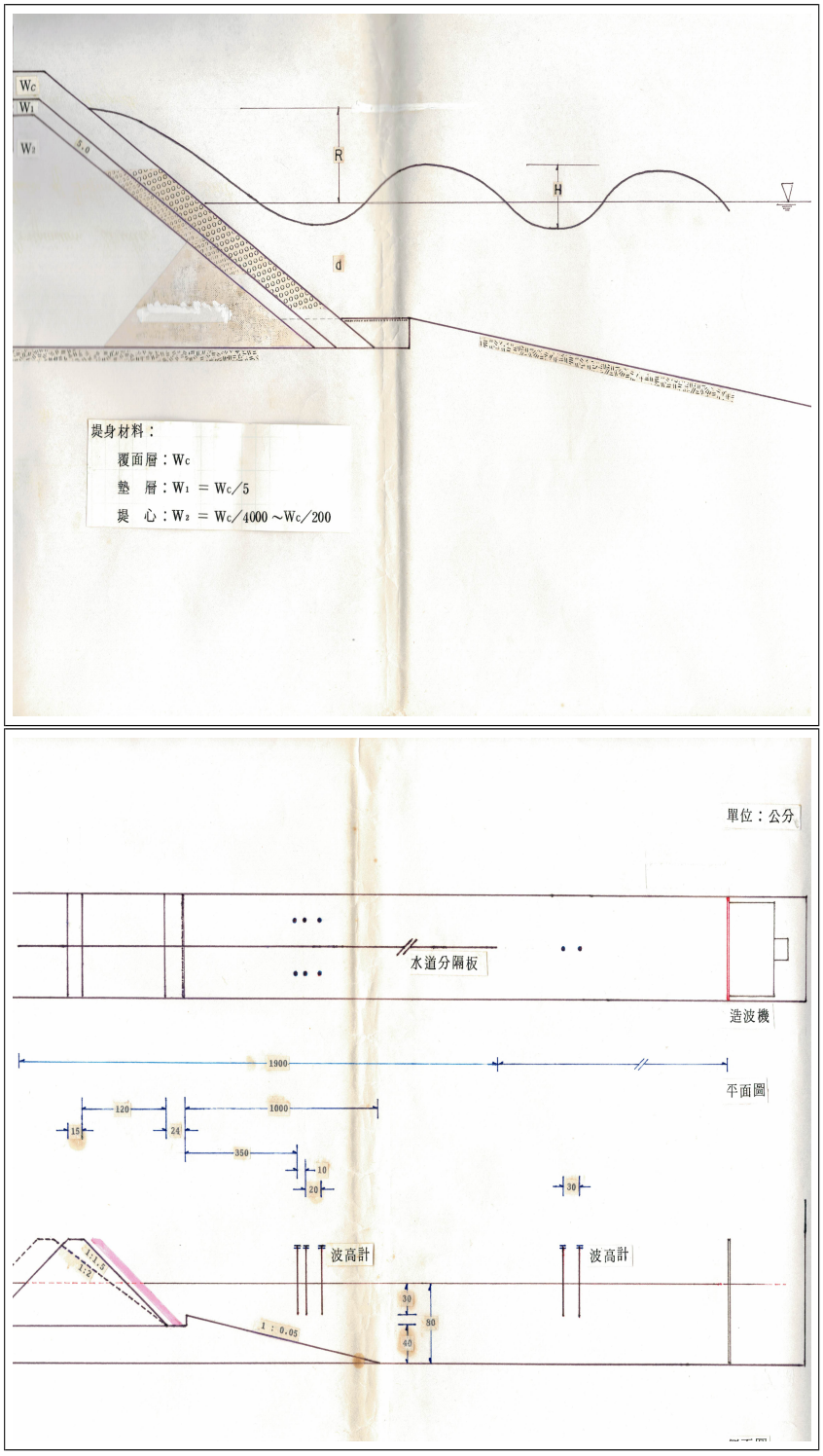
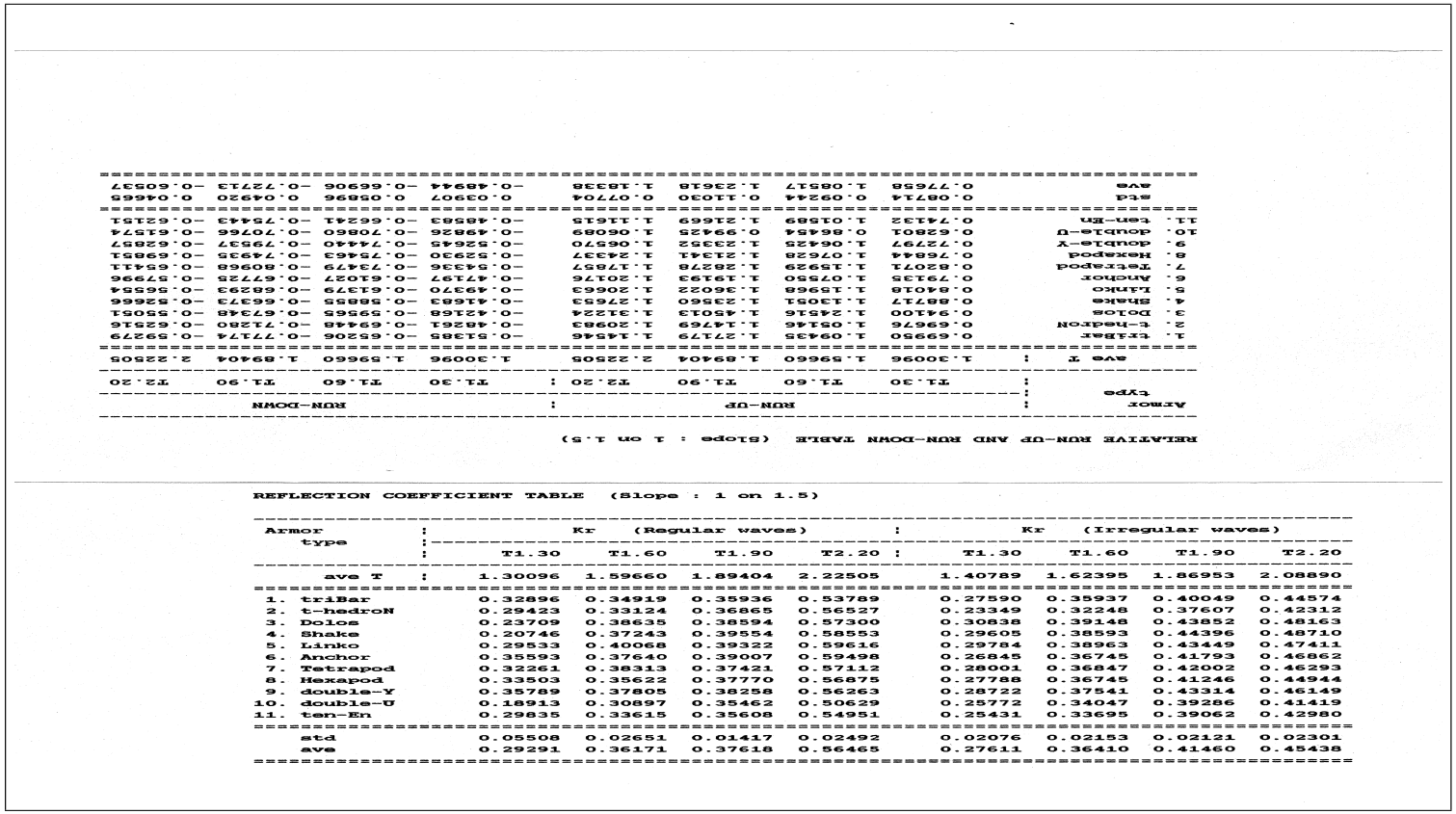


Fig 16： Two long forgotten hand works by the author and now imprinted with history marks · · · These original hand works (prepared for the photographic plate) with a lot of "cut and paste" appeared in the interim report of 1990. Those in the final report of 1991 were drawn by Autocad. And the current figure corresponding to the left was a further revision (with more details) and was prepared immediately after the final report had been printed.



RELATIVE RUN-UP AND RUN-DOWN TABLE (Slope : 1 on 1.5)

Armor type	RUN-DOWN T1.30	RUN-DOWN T1.60	RUN-DOWN T1.90	RUN-DOWN T2.20	RUN-UP T1.30	RUN-UP T1.60	RUN-UP T1.90	RUN-UP T2.20
ave T	1.30096	1.59660	1.89404	2.22505	1.30096	1.59660	1.89404	2.22505
1. triBar	0.51385	0.65206	0.77174	0.92279	0.69950	1.09435	1.27179	1.54646
2. t-hedroN	0.48261	0.69448	0.71280	0.82516	0.69676	1.05146	1.14769	1.20983
3. Dolos	0.42168	0.59565	0.67348	0.75051	0.94100	1.24516	1.45013	1.31224
4. Shake	0.41683	0.58855	0.66373	0.75666	0.88717	1.13051	1.23560	1.27653
5. Linko	0.49370	0.61379	0.68293	0.76554	0.84018	1.15968	1.36022	1.20663
6. Anchor	0.47197	0.61027	0.67725	0.75996	0.79135	1.07550	1.19153	1.20176
7. Tetrapod	0.54336	0.73479	0.80968	0.65411	0.82071	1.15929	1.28278	1.17857
8. Hexapod	0.52930	0.75463	0.74935	0.69851	0.76844	1.07628	1.21341	1.24337
9. double-Y	0.52645	0.74440	0.79537	0.62857	0.72797	1.06425	1.23352	1.06570
10. double-U	0.48583	0.70860	0.70766	0.61574	0.62801	0.86454	0.99425	1.06089
11. ten-En	0.48583	0.66241	0.75443	0.62151	0.74132	1.01589	1.21669	1.11615
std	0.03907	0.05896	0.04920	0.04665	0.08714	0.09244	0.11030	0.07704
ave	0.48944	0.66906	0.72713	0.60537	0.77658	1.08517	1.23618	1.18338

REFLECTION COEFFICIENT TABLE (Slope : 1 on 1.5)

Armor type	Kr (Regular waves) T1.30	Kr (Regular waves) T1.60	Kr (Regular waves) T1.90	Kr (Regular waves) T2.20	Kr (Irregular waves) T1.30	Kr (Irregular waves) T1.60	Kr (Irregular waves) T1.90	Kr (Irregular waves) T2.20
ave T	1.30096	1.59660	1.89404	2.22505	1.40789	1.62395	1.86953	2.08890
1. triBar	0.32896	0.34919	0.35936	0.53789	0.27590	0.35937	0.40049	0.44574
2. t-hedroN	0.29423	0.33124	0.36865	0.56527	0.23349	0.32248	0.37607	0.42312
3. Dolos	0.23709	0.38635	0.38594	0.57300	0.30838	0.39148	0.43852	0.48163
4. Shake	0.20746	0.37243	0.39554	0.58553	0.29605	0.38593	0.44396	0.48710
5. Linko	0.29533	0.40068	0.39322	0.59616	0.29784	0.38963	0.43449	0.47411
6. Anchor	0.35593	0.37640	0.39007	0.59498	0.26845	0.36745	0.41793	0.46862
7. Tetrapod	0.32261	0.38313	0.37421	0.57112	0.28001	0.36847	0.42002	0.46293
8. Hexapod	0.33503	0.35622	0.37770	0.56875	0.27788	0.36745	0.41246	0.44944
9. double-Y	0.35789	0.37805	0.38258	0.56263	0.28722	0.37541	0.43314	0.46149
10. double-U	0.18913	0.30897	0.35462	0.50629	0.25772	0.34047	0.39286	0.41419
11. ten-En	0.29835	0.33615	0.35608	0.54951	0.25431	0.33695	0.39062	0.42980
std	0.05508	0.02651	0.01417	0.02492	0.02076	0.02153	0.02121	0.02301
ave	0.29291	0.36171	0.37618	0.56465	0.27611	0.36410	0.41460	0.45438

Fig 17： Another two forgotten pieces of paper cuts ··· These two small cuts were tucked into the kraft paper bag filled with various paper works, and they were unintentionally folded several times. It was quite baffling when they were dug up more then 25 years later, but there must be a reason to not throw it away. It was finally found out that they had also been prepared for the next revision soon after the final report had come out (due to the “ave T” of the two slopes being marked as the same, and in fact, the difference is very small).

What does it mean? --- **Too small number of waves** ch.4, 8 (2)

```
..
Case            :    c:\lyl\asy\expdat\RH18T19T.dat    [slope = 1:1.5]
Date            :    01/18/91
Time            :    11:40:57.82                                   Sampling    frequency   :    40  Hz
Specifics       :    R-T-27 ; Tetrapod(3,4,7) & H-pod(5,6,8)       Sampling time length    :    80  Sec

 Ch    #_W     H.1     H.2     H.3     H1/10    H1/3    H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms

  1.    42   19.09   18.73   18.41    18.65   17.92   17.30   15.24   15.42      1.89   1.89   1.89   1.89   1.89
  2.    42   21.12   21.09   20.87    20.94   20.38   19.82   18.30   18.39      1.91   1.90   1.90   1.89   1.89
  3.    42   16.97   16.46   15.80    16.13   15.24   15.02   13.95   14.07      1.86   1.88   1.88   1.85   1.86
  4.     4    -------- Too small number of waves -------
  5.    41   14.36   14.09   13.53    13.87   13.28   13.10   12.49   12.51      1.89   1.90   1.89   1.90   1.90
  6.    41   14.23   14.09   13.92    14.01   13.56   13.36   12.74   12.77      1.89   1.90   1.90   1.89   1.89
  7.    48   13.87   13.79   13.70    13.56   13.11   12.88   10.83   11.20      1.88   1.89   1.86   1.62   1.68
  8.     5    -------- Too small number of waves -------
 .....
FFT parameters                :
                    Kr        :       .3421      r.ch1   :          3      r.ch2   :          4
                    del.L     :      28.8000      depth   :    48.0000      w.l.n   :    63.8759
                    L.min     :      64.0000      T.min   :      .6406      M.max   :         80
                    L.max     :     576.0000      T.max   :     2.7724      M.min   :         18
                    Sum.aR.sq :  .01197E   12
                    Sum.aI.sq :  .01023E   13                             b.pnt   :          1
                    fft.point :        2048      i.smt   :          0      f.cut   :      .3333
 .....
Reconstructed incident and reflected waves :
 Ch    #_W     H.1     H.2     H.3     H1/10    H1/3    H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms
  3.    26   17.73   16.65   15.28    16.55   14.04   12.74   10.19   10.68      1.90   1.90   1.90   1.90   1.90
  3.    26    7.91    6.14    5.73     6.59    5.12    4.54    3.72    3.93      1.91   1.89   1.88   1.90   1.90
 .....
FFT parameters                :
                    Kr        :       .3519      r.ch1   :          5      r.ch2   :          6
                    del.L     :      28.8000      depth   :    48.0000      w.l.n   :    63.8759
                    L.min     :      64.0000      T.min   :      .6406      M.max   :         80
                    L.max     :     576.0000      T.max   :     2.7724      M.min   :         18
                    Sum.aR.sq :  .01034E   12
                    Sum.aI.sq :  .08349E   12                             b.pnt   :          1
                    fft.point :        2048      i.smt   :          0      f.cut   :      .3333
 .....
FFT parameters                :
                    Kr        :       .4072      r.ch1   :          1      r.ch2   :          2
                    del.L     :      32.0000      depth   :    82.0000      w.l.n   :    70.7878
                    L.min     :      71.1111      T.min   :      .6752      M.max   :         76
                    L.max     :     640.0000      T.max   :     2.4806      M.min   :         21
                    Sum.aR.sq :  .01469E   12
                    Sum.aI.sq :  .08858E   12                             b.pnt   :        441
                    fft.point :        2048      i.smt   :          0      f.cut   :      .3333
 .....
Reconstructed incident and reflected waves :
 Ch    #_W     H.1     H.2     H.3     H1/10    H1/3    H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms
  1.    26   17.58   17.30   16.81    17.23   16.74   16.37   14.20   14.41      1.89   1.89   1.89   1.89   1.89
  1.    26    8.66    8.62    8.53     8.60    7.81    7.29    6.15    6.31      1.86   1.90   1.88   1.90   1.90
 .....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Tab 6 (TooSNW-2)： "Too small number of waves" — what is the inspiration? ··· Wave data without proper processing are basically useless — the main cause of the scattering outcomes of existing studies.

回舊
回新
再見

What does it mean? --- **No complete wave cycle** ch.2 (4)

```
Case            :    c:\1y1\asy\expdat\RH08T22B.dat    [slope = 1:1.5]
Date            :    01/22/91
Time            :    10:12:04.55                                        Sampling    frequency   :    40   Hz
Specifica       :    R-B-S : triBar(3,4,7) & t-hetroN(5,6,8)            Sampling time length    :    80  Sec

 Ch    #_W     H.1      H.2      H.3     H1/10    H1/3     H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms
  1.    35   10.01     9.99     9.62      9.78    9.27     9.07    8.63    8.65      2.18   2.19   2.19   2.19   2.20
  2.     0   ---------- No complete wave cycle ----------
  3.    35    9.25     9.06     9.03      9.08    8.71     8.54    8.20    8.21      2.19   2.19   2.19   2.19   2.19
  4.    35   12.45    12.30    12.13     12.15   11.48    11.23   10.85   10.87      2.19   2.20   2.19   2.19   2.19
  5.    35    9.45     9.30     9.23      9.30    8.84     8.64    8.25    8.27      2.18   2.19   2.19   2.19   2.19
  6.    35   12.99    12.70    12.57     12.61   11.86    11.60   11.11   11.13      2.18   2.19   2.19   2.19   2.19
  7.    35   10.74    10.62    10.50     10.55    9.98     9.74    9.36    9.37      2.19   2.19   2.19   2.19   2.19
  8.    35   10.40    10.38    10.38     10.35    9.83     9.61    9.23    9.24      2.19   2.19   2.19   2.19   2.19

FFT parameters      :
                Kr  :      .5293      r.ch1  :         3      r.ch2  :         4
             del.L  :   28.8000      depth  :   48.0000      i.smt  :         0
          fft.point :      2048      b.pnt  :         1      f.cut  :     .3333
Reconstructed incident and reflected waves :
 Ch    #_W     H.1      H.2      H.3     H1/10    H1/3     H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms
  3.    22    9.82     9.52     7.11      9.67    6.76     5.71    4.16    4.69      2.24   2.21   2.21   2.23   2.23
  5.    22    5.84     4.42     3.97      5.13    3.64     3.05    2.20    2.51      2.19   2.20   2.20   2.23   2.23
- - - - - - - - - - - - - - - -

FFT parameters      :
                Kr  :      .5222      r.ch1  :         5      r.ch2  :         6
             del.L  :   28.8000      depth  :   48.0000      i.smt  :         0
          fft.point :      2048      b.pnt  :         1      f.cut  :     .3333
Reconstructed incident and reflected waves :
 Ch    #_W     H.1      H.2      H.3     H1/10    H1/3     H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms
  5.    22   10.15     9.91     7.41     10.03    7.05     5.95    4.32    4.88      2.24   2.21   2.21   2.23   2.23
  5.    23    6.19     4.89     3.95      5.44    3.71     3.18    2.29    2.63      2.20   2.20   2.20   2.13   2.16
- - - - - - - - - - - - - - - -

FFT parameters      :
                Kr  :      .4608      r.ch1  :         1      r.ch2  :         2
             del.L  :   31.6000      depth  :   82.0000      i.smt  :         0
          fft.point :      2048      b.pnt  :       441      f.cut  :     .3333
Reconstructed incident and reflected waves :
 Ch    #_W     H.1      H.2      H.3     H1/10    H1/3     H1/2   H.ave   H.rms     T1/10   T1/3   T1/2 T.ave T.rms
  1.    23    8.58     8.25     8.03      8.42    8.02     7.92    7.38    7.45      2.24   2.26   2.23   2.15   2.17
  1.    23    4.72     4.60     4.21      4.66    4.06     3.92    3.58    3.62      2.25   2.21   2.20   2.18   2.18
- - -

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Tab 8 (TooSNW-4) : "No complete wave cycle" — what is the inspiration? ··· The cogent evidence of the results of "uniformization and signification", as well as the necessity of the right tool of wave separation. Pages like these did not appear in the 1991 final report, but they were rediscovered from the paper archive in 2017. In a digital world these pages may be lost forever or have little chance to be rediscovered or retrieved.

ACKNOWLEDGEMENTS

I would like to thank Dr. Hsu Tai-Wen, my colleague Mr. Liu Wen-Hsiung, relevant persons of various armor-right owners, etc. for providing various valuable study materials. I am also grateful to Miss Dai Yi-Ping for her dedicated help in the laboratory. In my memory, there was not a single miss of the file sent to the wave-maker. Finally, the preciousness of the public money should be acknowledged and its usefulness be wished.

誌　　謝

本研究之得順利進行必須感謝戴逸萍小姐於試驗之細心幫忙，記憶中，對講機的響鈴，總能有精準的回饋，送來的造波檔也總是所要的。另蒙許泰文老師、同事劉文雄先生、各塊體相關人士、等，惠予提供各資料，謹此誌謝。最後當感公帑之可貴，願其爲用之無失。

and to *Leo*