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考察日本
「坡度加曲率對高速公路之影響」

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<tr><td colspan="4">摘要：
考察日本高速公路之大坡度、大曲率相關設施。在十天考察行程中，筆者有機會直接與日本相關人士交換意見。考察心得與建議均於內文中分章提出報告，以供本所後續辦理相關研究及相關改善中山高速公路坡度、曲率路段因應對策之參考。</td></tr>
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ABSTRACT:

This is a report on our visit to Japan's freeway facilities, traffic operating manipulation and future advancement plan of gradient and curve section, etc., During the 10 days of visit, the author exchanged opinions with of Osaka Metropolitan Government, Tokyo Metropolitan Government, Central Japan Railway Company, Traffic Engineering Division, and Engineering Department of Japan directly.

Collected information and suggestions were listed in the report references to future follow-up studies.

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圖 目 錄

考察日本『坡度加曲率對高速公路之影響』

壹、緒論

台灣地區因位處海島，地形條件上和日本島國相似，而在七十年代在中山高速公路（台灣地區第一條高速公路）建設之時，亦和日本從昭和 15 年(1925)起進行的日本高速公路建造時，有著相類似的經驗。其中第二東海自動車道（另稱東名高速公路）之建造，便與台灣地區中山高速公路在林口、苗栗與三義等路段相類似，有著大爬坡與大曲度之配置。因此遇上上下班尖峰時刻或連續假日之車流，這些路段常常造成擁擠一直是高速公路重點疏導的路段。

本次借由日本道路公團對日本有舊有大爬坡、大曲率路段之東京東名高速公路在硬體建設上由原雙向四車道拓寬為雙向有高差之雙向六車道的高速公路，在軟硬體方面則加強坡度、曲率度之明確警告之考察與現地觀察，提供台灣地區對於林口、苗栗與三義坡度路段容量與服務水準提昇之建議。

貳、行程說明

在十天的緊湊行程中除周六、周日外，均安排多處的參訪行程，參訪之單位計有：關西機場、大阪交通局、東京交通局、東京建設局、JR 營運管理單位與日本道路公團等六單位，另並安排至日本東名高速公路現地參訪，行程分述如下：

一、89.9.22 日（五）往程：台北至大阪關西機場。

二、89.9.25 日（一）參訪與拜會：參訪關西機場、大阪市交通局。

三、89.9.26 日（二）往程：東京。

四、89.9.27 日（三）參訪與拜會：東京都廳交通局與 JR 營運管理單位。

五、89.9.28 日（四）參訪與拜會：東京都廳建設局。

六、89.9.29 日（五）參訪與拜會：日本道路公團。

七、89.9.30 日（六）現地參訪：日本東名高速公路。

參、日本高速公路簡介

3.1 日本高速公路路網簡介

日本高速公路自從昭和 15 年起便進行高速公路之籌畫與建造，更在昭和 31 成立日本道路公團專職負責高速公路之興建，在昭和 38 年完成第一條名神高速公路之通車，更於昭和 43 年完成東名高速公路通車等，至今已過一甲子（60 年），其中除北海道、東北、關東、關西、中央、中國、四國、九州外，還有連接新東京國際空港與關西二路段，整體高速公路路網長度約長達 11,520 公里，其各路線資料詳如表 3.1，本次參訪之東名高速公路之首都快速道路端點起至御殿場路段如圖 3-1 所示。基本計畫中之長度約 10,607 公里，各路線分布詳如表 3.2，整備中之長度約 9,342 公里，其各路線之詳如表 3.2，營運中之長度約 6,615 公里，其各路線之分布詳如表 3.2。

在各年度開放通車營運之分布說明如下：

1. 昭和 38 年至昭和 48 年，開放通車營運之路段約達 1,000 公里。路網分佈如圖 3-2 。
2. 昭和 48 年至昭和 51 年，開放通車營運之路段約達 2,000 公里。路網分佈如圖 3-3 。
3. 昭和 51 年至昭和 57 年，開放通車營運之路段約達 3,000

公里。路網分佈如圖 3-4 。

4.昭和 57 年至昭和 62 年，開放通車營運之路段約達 4,000 公里。路網分佈如圖 3-5 。

5.昭和 62 年至平成 3 年，開放通車營運之路段約達 5,000 公里。路網分佈如圖 3-6 。

6. 平成 3 年至平成 8 年，開放通車營運之路段約達 6,000 公里。路網分佈如圖 3-7 。

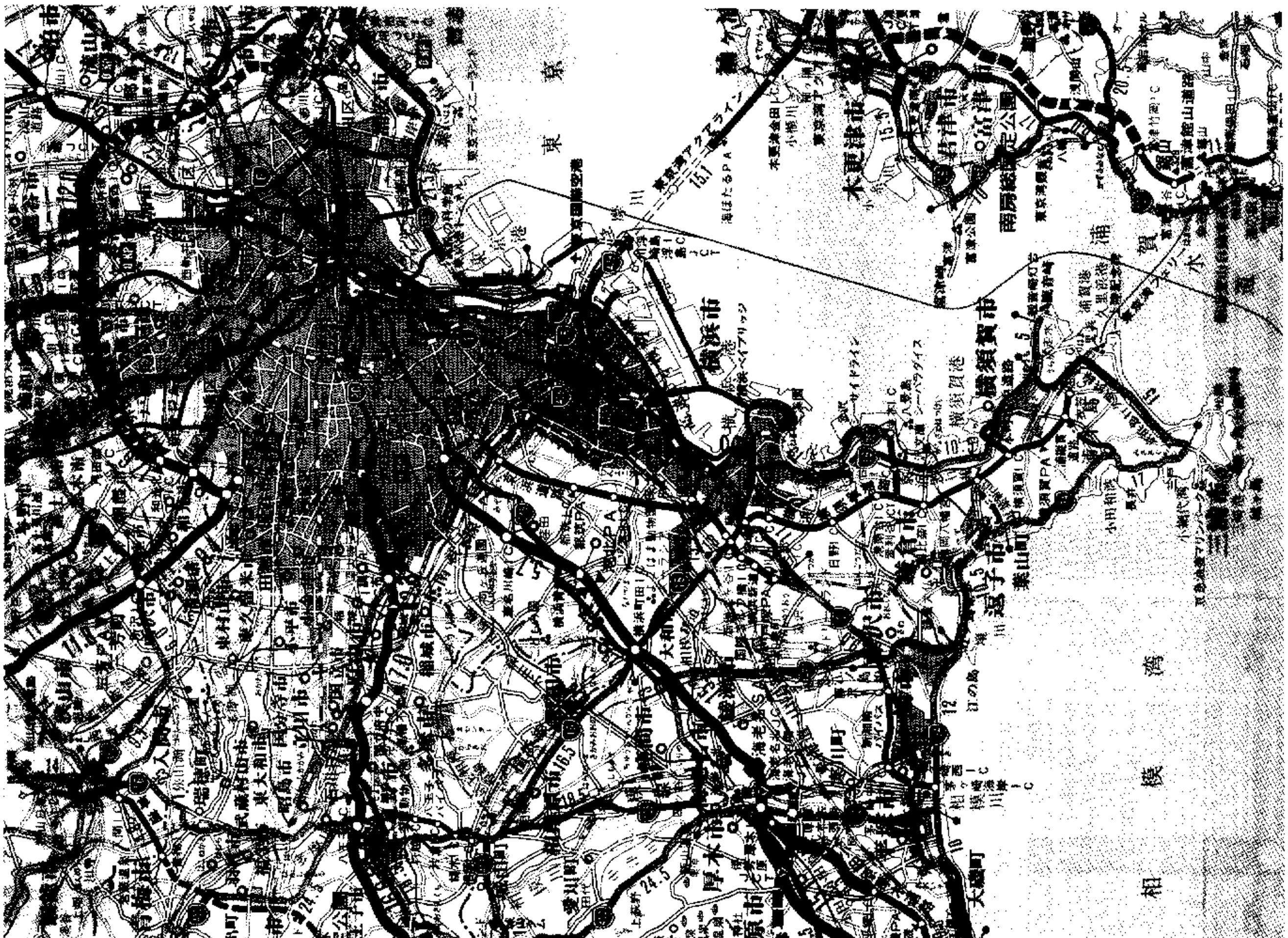


圖 3-1 日本東名高速公路之首都快速道路端點起至御殿場路段圖

（ロ）供用状況図（1,000km、2,000km、3,000km、4,000km、5,000km、6,000km）

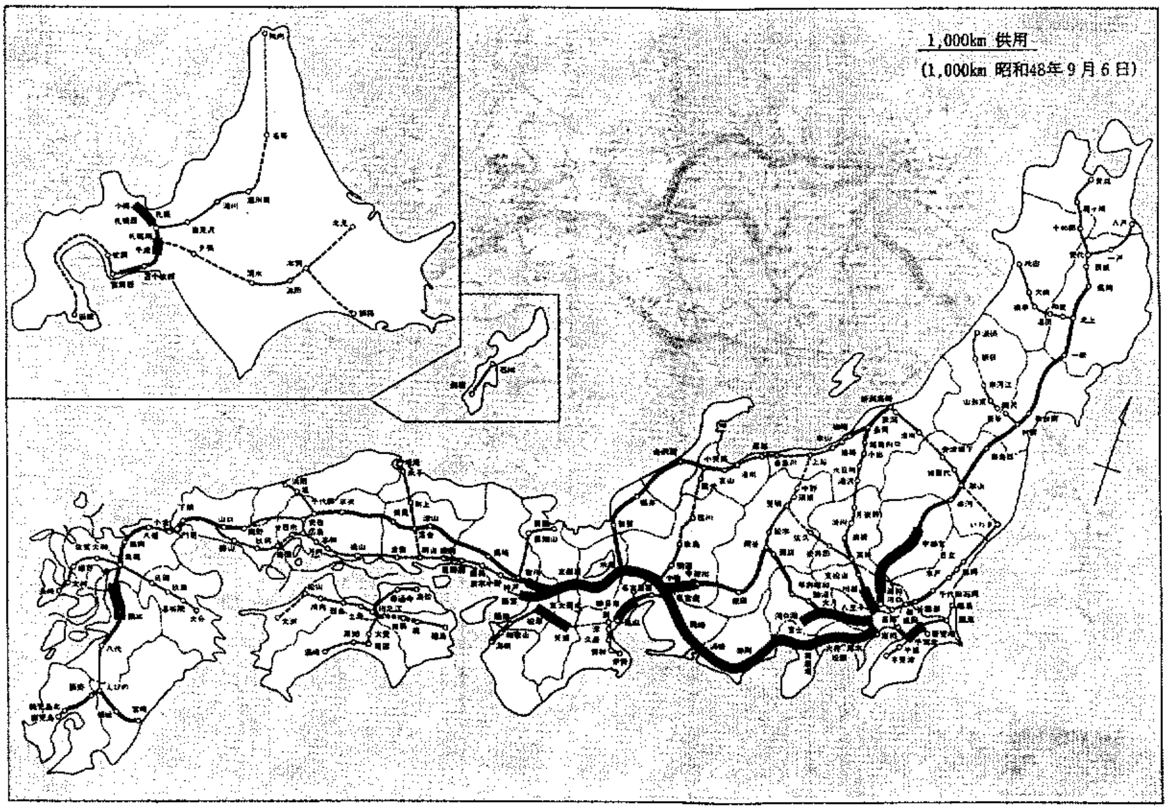


圖 3-2 各年日本高快速公路開放營運路網圖（1,000 公里）

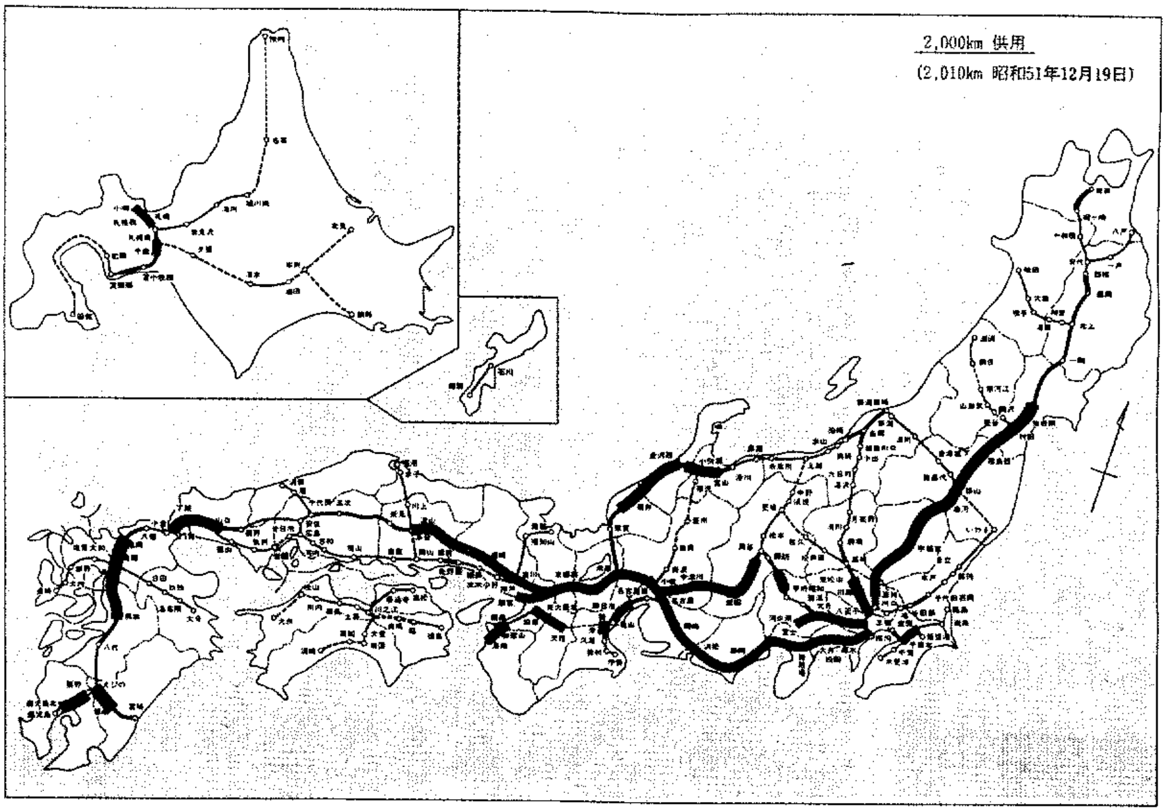


圖 3-3 各年日本高快速公路開放營運路網圖（2,000 公里）

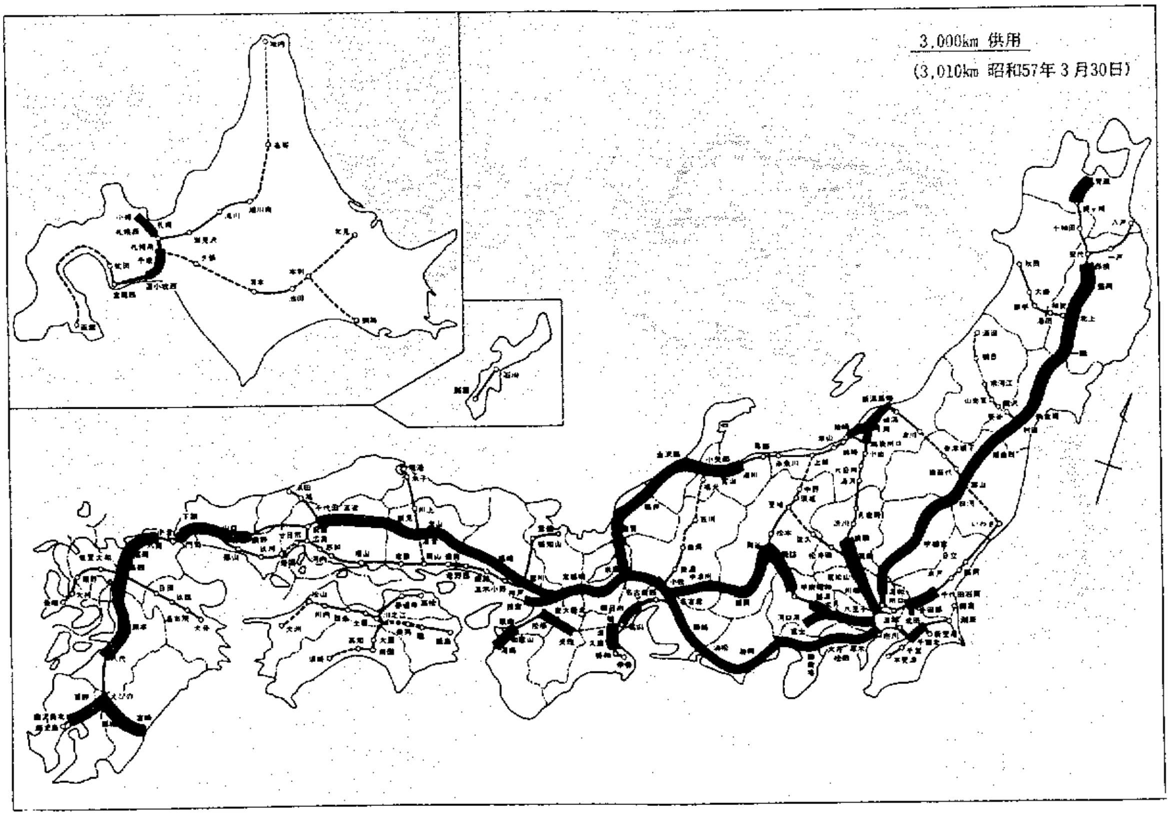


圖 3-4 各年日本高快速公路開放營運路網圖（3,000 公里）

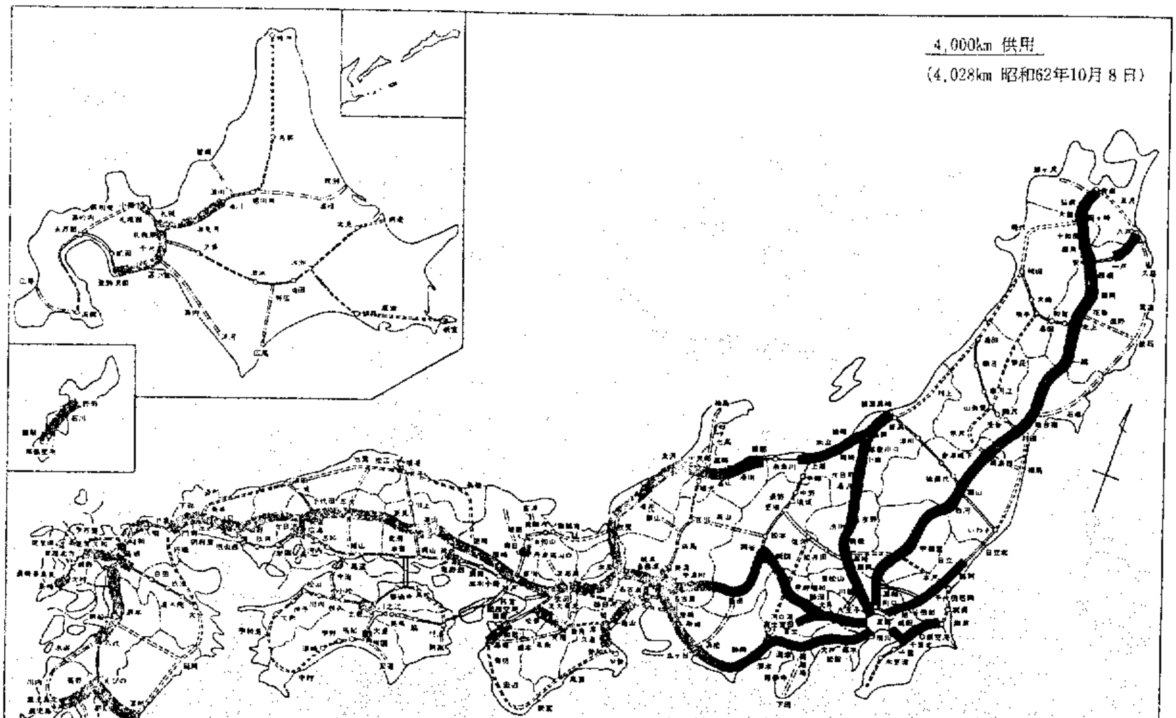


圖 3-5 各年日本高快速公路開放營運路網圖（4,000 公里）

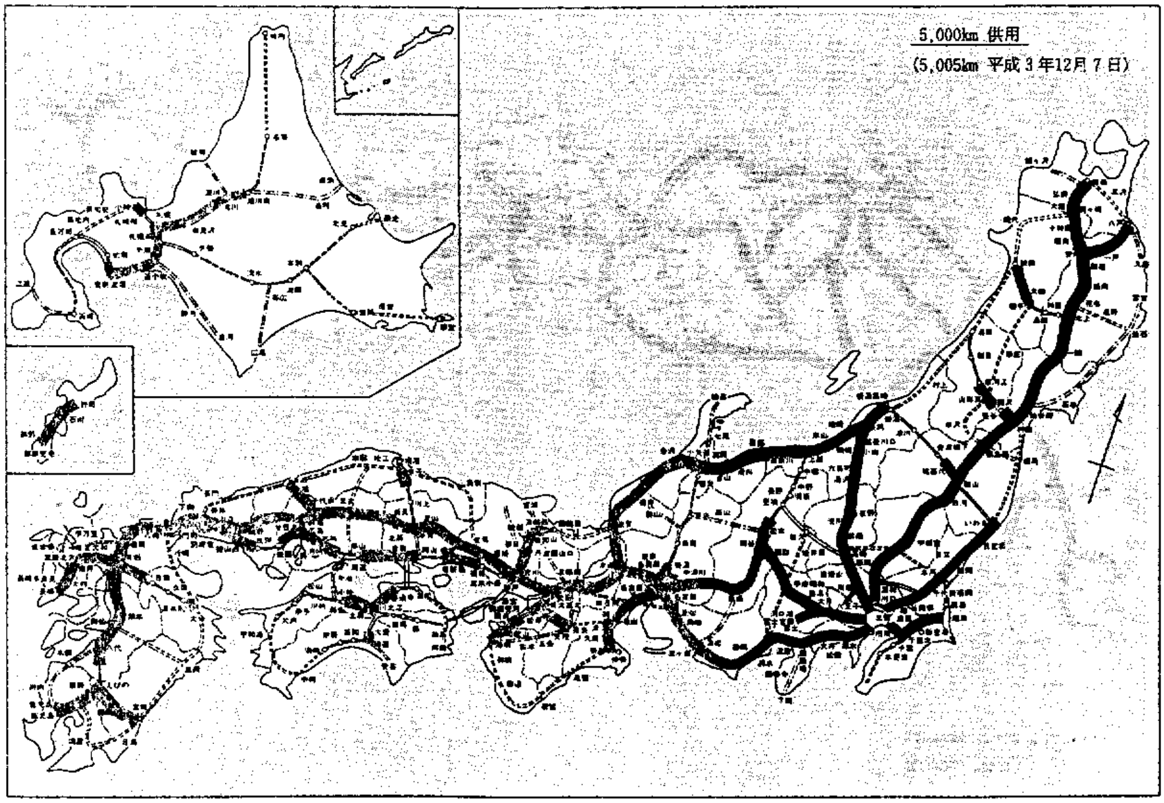


圖 3-6 各年日本高快速公路開放營運路網圖（5,000 公里）

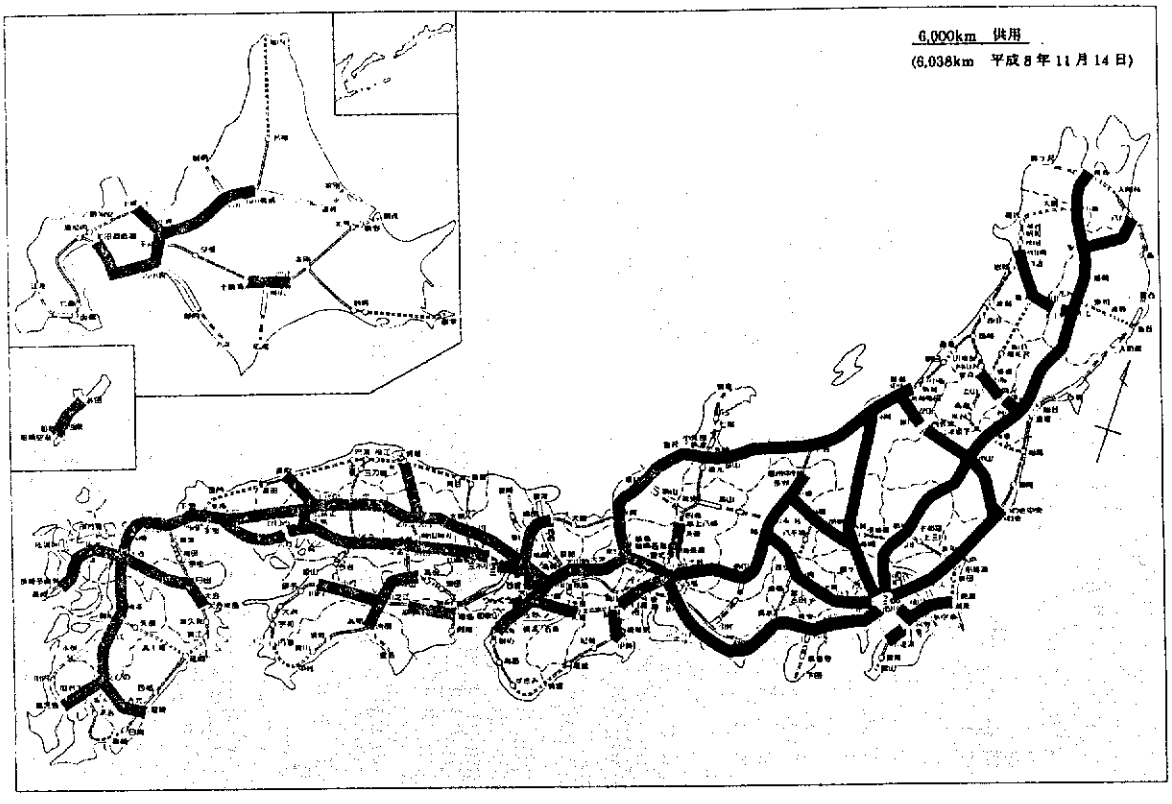


圖 3-7 各年日本高快速公路開放營運路網圖（6,000 公里）

表 3.1 日本高速公路路網之起訖與長度

路線名	起點	終點	長度（KM）
北海道縱貫自動車道	涵館市	稚內市	681
北海道橫斷自動車道（根室線）	壽都郡	根室市	538
北海道橫斷自動車道（網走線）	壽都郡	網走市	156
東北縱貫自動車道（弘前線）	東京都	清森市	698
東北縱貫自動車道（八戶線）	東京都	清森市	167
東北橫斷自動車道（斧石秋田線）	斧石市	秋田市	212
東北橫斷自動車道（酒田線）	仙台市	酒田	158
東北橫斷自動車道（新潟線）		新瀉市	213
日本海沿岸東北自動車道	新瀉市	清森市	322
東北中央自動車道	相馬市	橫手市	268
關越自動車道（新瀉線）	東京都	新瀉市	246
關越自動車道（上越線）	東京都	上越市	203
常盤自動車道	東京都	仙台市	352
東關東自動車道（館山線）	東京都	館山市	95
東關東自動車道（水戶線）	東京都	水戶市	140
北關自動車道	高崎市	那珂湊市	147
第一東海自動車道	東京都	小牧市	347

表 3.1 日本高速公路路網之起訖與長度（續一）

路線名	起點	終點	長度（KM）
中央自動車道（富士吉田線）	東京都	富士吉田市	94
中央自動車道（西宮線）	東京都	西宮市	465
中央自動車道（長野線）	東京都	長野市	76
東海北陸自動車道	一宮市	洿坡市	185
第二東海自動車道	東京都	名古屋市	330
中部橫斷自動車道	清水市	佐久市	136
北陸自動車道	新瀉市	米原市	487
近畿自動車道（伊勢線）	名古屋市	伊勢市	81
近畿自動車道（名古屋大阪線）	名古屋市	吹田市	225
近畿自動車道（名古屋神戶線）	名古屋市	神戶市	174
近畿自動車道（紀勢線）	松原市	勢和村	336
近畿自動車道（敦賀線）	吹田市	敦賀市	162
中國縱貫自動車道	吹田市	下關市	543
山陽自動車道	吹田市	下關市	489
中國橫斷自動車道（姬路鳥取線）	姬路市	鳥取市	86
中國橫斷自動車道（岡山米子線）	岡山市	米子市	128
中國橫斷自動車道（尾道松江線）	尾道市	松江市	137
中國橫斷自動車道（廣島濱田線）	廣島市	濱田市	71

表 3.1 日本高速公路路網之起訖與長度（續二）

路線名	起點	終點	長度（KM）
山陰自動車道	鳥取市	美米市	380
四國縱貫自動車道	德島市	大洲市	222
四國橫斷自動車道	阿南市	大洲市	441
九州縱貫自動車道（鹿兒島線）	北九州市	鹿兒島市	345
九州縱貫自動車道（宮崎線）	北九州市	宮崎市	83
九州橫斷自動車道（長崎大分線）	長崎市	大分市	257
九州橫斷自動車道（延岡線）	御船市	延岡市	95
東九州橫斷自動車道	北九州市	鹿兒島市	436
新東京國際空港線	成田市	新空港	4
關西國際空港線	泉佐野市	關西空港	7
關門自動車道	下關市	北九州市	9
沖繩自動車道	名護市	那霸市	57
其他自動車道			36
合計			11,520

表 3.2 日本高速公路路網之基本計畫、施工中與營運之長度狀況

路線名	總長度（KM）	基本計畫長度（KM）	施工中長度（KM）	營運長度（KM）
北海道縱貫自動車道	681	497	477	319
北海道橫斷自動車道	694	527	412	131
東北縱貫自動車道	865	865	795	766
東北橫斷自動車道	583	583	517	451
日本海沿岸東北自動車道	322	322	157	0
東北中央自動車道	268	167	111	0
關越自動車道	449	449	449	449
常盤自動車道	352	352	313	200
東關東自動車道	235	195	167	110
北關自動車道	147	147	135	14
中央自動車道	635	635	635	632
第一東海自動車道	347	347	347	347
東海北陸自動車道	185	185	185	109
第二東海自動車道	330	300	285	5
中部橫斷自動車道	136	136	98	0
北陸自動車道	487	487	487	487
近畿自動車道	978	833	760	371
中國縱貫自動車道	543	543	543	543
山陽自動車道	489	462	445	417
中國橫斷自動車道	422	406	338	178
山陰自動車道	380	279	18	0
四國縱貫自動車道	222	222	222	190
四國橫斷自動車道	441	375	284	125
九州縱貫自動車道	428	428	428	428
九州橫斷自動車道	352	352	280	245
東九州橫斷自動車道	436	436	327	21
新東京國際空港線	4	4	4	4
關西國際空港線	7	7	7	7
關門自動車道	9	9	9	9
沖繩自動車道	57	57	57	57
其他自動車道	36	0	0	0
合計	11,520	10,607	9,342	6,615

3.2 日本高速公路路網收費簡介

日本的生活水準高、收入高，物價也高，在日本市區快速道路也需收費，每上一段最少 300 日幣，東京市內之首都快速道路更高達 700 日幣。本次現地考察東名高速公路由首都快速道路端點起至御殿場路段約 70 公里，往返共花費 6,400 日幣（單趟 3,200=700+2,500 日幣）約合為一千九百元台幣左右，以台灣中山高速公路收費計算，約只需花費五百元，相差近似四倍之多。兩相比較台灣地區之高速公路收費費率確實較低有調漲之空間。該公路收費表如下圖 3-8 所示。

回数通行券・ハイウェイカード

区分		現金による通行料金	回数通行券 種類	販売金額	割引額（率）	1回の金額
普通車	東京線	700円	9回券	5,700円	600円（約10%）	約 633円
			24回券	14,250円	2,550円（約15%）	約 594円
			100回券	57,100円	12,900円（約18%）	571円
	神奈川線	500円	9回券	4,100円	400円（約 9%）	約 456円
			24回券	10,200円	1,800円　（15%）	425円
			100回券	40,800円	9,200円（約18%）	408円
	埼玉線	400円	14回券	5,000円	600円（約11%）	約 357円
			30回券	10,000円	2,000円（約17%）	約 333円
			100回券	32,650円	7,350円（約18%）	約 327円
	特定料金区間	300円	9回券	2,450円	250円（約 9%）	約 272円
			24回券	6,100円	1,100円（約15%）	約 254円
			100回券	24,450円	5,550円（約19%）	約 245円
大型車	東京線	1,400円	9回券	11,400円	1,200円（約10%）	約 1,267円
			24回券	28,550円	5,050円（約15%）	約 1,190円
			100回券	114,150円	25,850円（約18%）	約 1,142円
	神奈川線	1,000円	9回券	8,150円	850円（約 9%）	約 906円
			24回券	20,400円	3,600円　（15%）	850円
			100回券	81,550円	18,450円（約18%）	約 816円
	埼玉線	800円	14回券	10,000円	1,200円（約11%）	約 714円
			30回券	20,000円	4,000円（約17%）	約 667円
			100回券	65,300円	14,700円（約18%）	653円
	特定料金区間	600円	9回券	4,900円	500円（約 9%）	約 544円
			24回券	12,250円	2,150円（約15%）	約 510円
			100回券	48,950円	11,050円（約18%）	約 490円

東京外環自動車道・首都高速道路東京線セット回数券

種類	車種区分 首都高速	車種区分 東京外環	通行料金 首都高速	通行料金 東京外環	計	販売金額	割引額（率）
30回分	普通車	軽自動車	700円	400円	1,100円	27,550円	5,450円(約17%)
		普通車		500円	1,200円	30,000円	6,000円(約17%)
		中型車		600円	1,300円	32,450円	6,550円(約17%)
	大型車	大型車	1,400円	850円	2,250円	56,350円	11,150円(約17%)
		特大車		1,250円	2,650円	66,150円	13,350円(約17%)

圖 3-8 日本快速公路路網收費概況

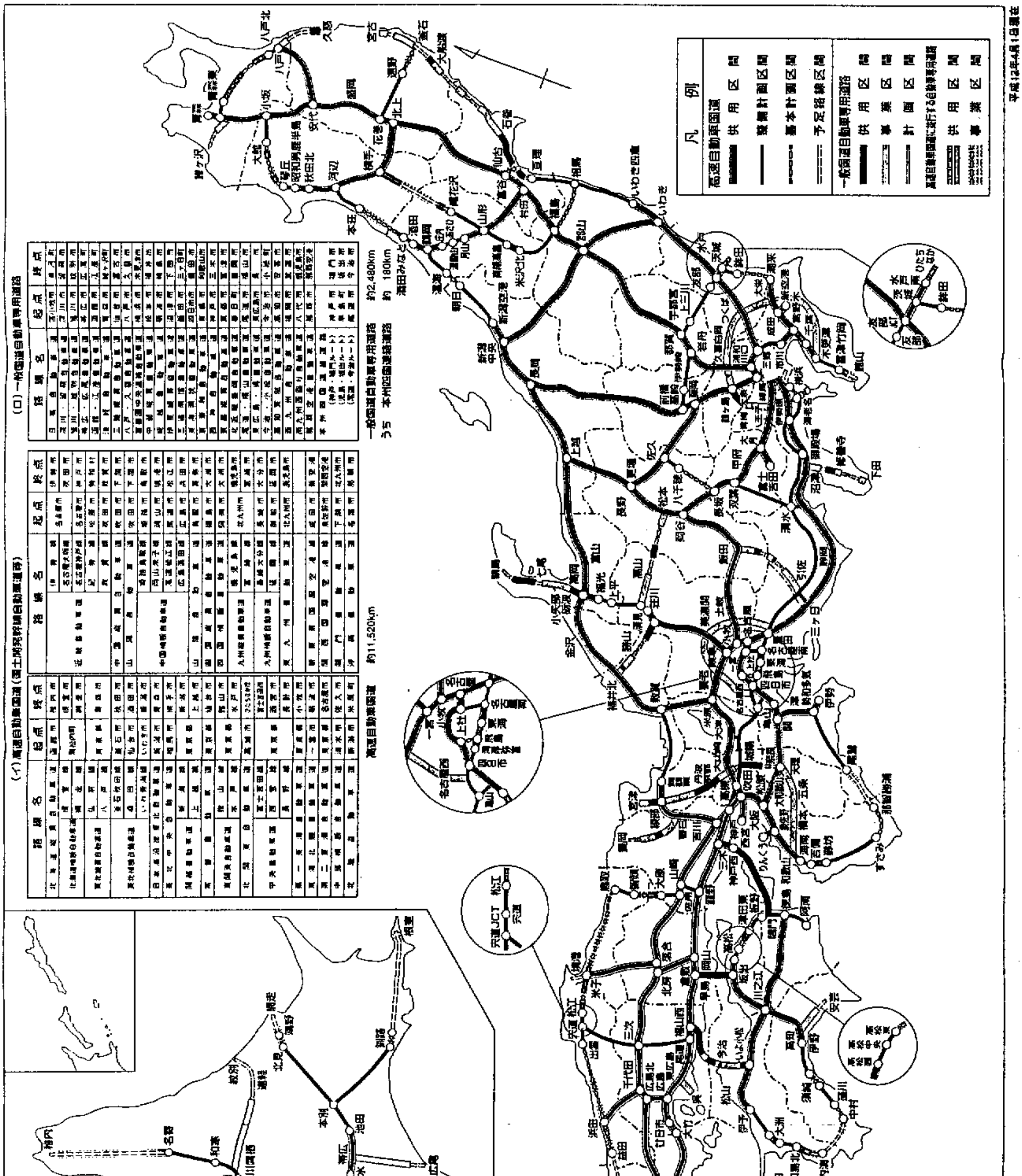


圖 3-9 日本高速公路路網收費概況

3.3 日本高速公路電子收費簡介

日本高速公路自2000年4月24日起進行電子收費之試運行，其試運行之路網中，於平成14年全日本高、快速公路上預計會設置約900個電子收費站，分佈在以下高速公路上：

1. 東關東自動車道。
2. 館山自動車道。
3. 新空港自動車道。
4. 京葉道路。
5. 千業東京道路。
6. 東京灣道路。
7. 東京灣聯絡道路。
8. 首都高速道路。

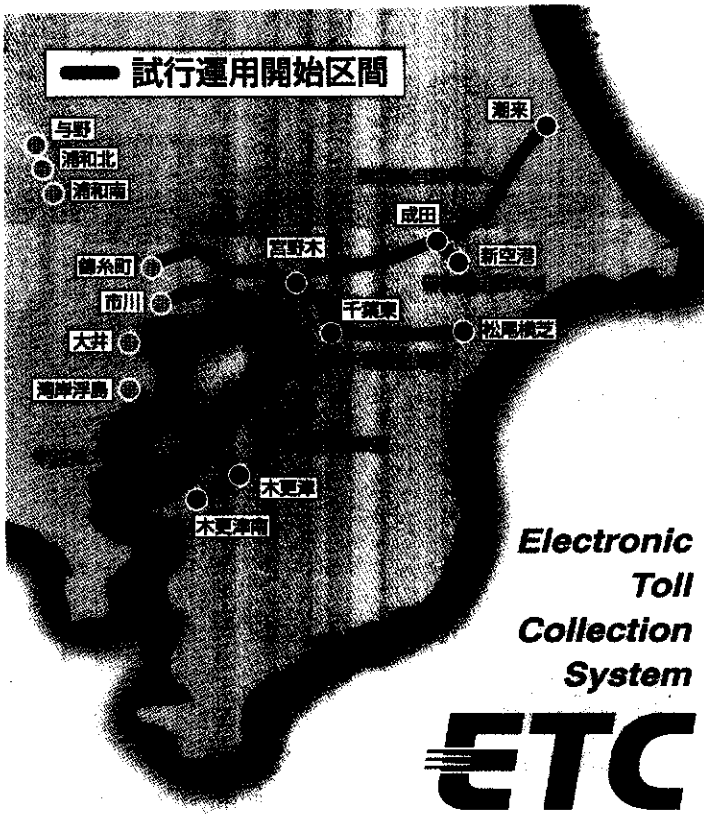
日本高、快速公路上施行電子收費預計會帶來之四大效益：

1.降低因收費繳費所產生之延滯。

2.降低因收費繳費所產生的麻煩。

3.可降低管理費。

4.降低因收費繳費所產生的空氣污染、噪音之環境改善。



下記の路線で試行運用開始

- 東関東自動車道
- 館山自動車道
- 新空港自動車道
- 京葉道路
- 千葉東金道路
- 東京湾アクアライン
- 東京湾アクアライン連絡道
- 首都高速道路の一部料金所

7号線：錦糸町集約料金所
湾岸線：市川集約料金所、大井集約料金所、湾岸浮島料金所
大宮線：浦和南料金所(集約·上り·下り)、浦和北料金所、与野料金所

ETCの詳しい情報はインターネットのホームページにも掲載されています。

建設省道路局ホームページ(ITS) ● http://www.moc.go.jp/road/ITS/j-html/
日本道路公団ホームページ ● http://www.japan-highway.go.jp/
首都高速道路公団ホームページ ● http://www.shuto-kousoku.go.jp/
阪神高速道路公団ホームページ ● http://west.park.or.jp/hanshin-expressway/
本州四国連絡橋公団ホームページ ● http://www.hsba.go.jp/

圖 3-10 日本高快速公路電子收費道路之路網示意圖

肆、日本高速公路之大爬坡、大曲率路段

（東名高速公路）

本次訪察係由日本東京之池袋出發走東京首都高速公路上東名高速公路，東名高速公路之大爬坡、大曲率路段位於60K至67K之大井松田至御殿場路段。

本路段日本道路公團於昭和57年進行大井松田至御殿場路段四線道拓寬為六線道。現就日本行此趟於東京首都高速公路與東名高速公路上之各項設施介紹如后。

4.1 高快速公路上之設施

1. 設置有高低差之雙向車道：

雙向車道設置有高低差以避免對向車產產生嚴重之對撞事在日本東京的市區快速道路上，就如同台北都會區中山高圓山路段，全天幾乎都在塞車。然其中央分隔島係採雙向車道有高低差之設計，以避免對向車產產生嚴重之對撞事故。如圖4-1所示。

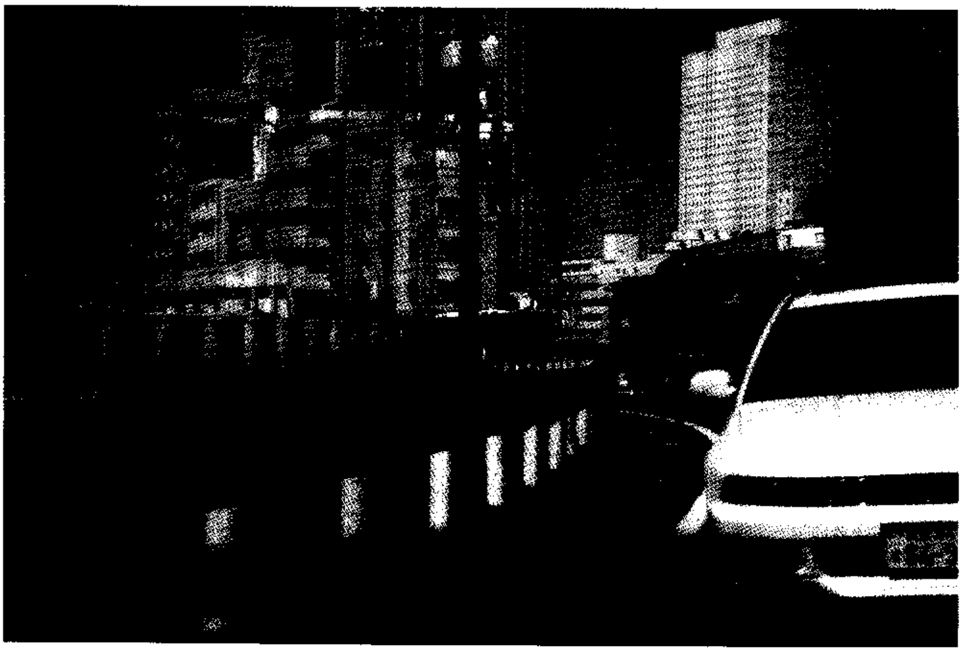


圖 4-1 有高低差之雙向車道設置圖

2. 提供即時資訊之可變標示：

在日本東京的市區快速道路上，就如同中山高速公路上設有可變標示，但其中提供道路延滯長度之資訊，如圖 4-2 所示。另外亦會提供到達不同目的地旅行時間推估值。如圖 4-3 所示。

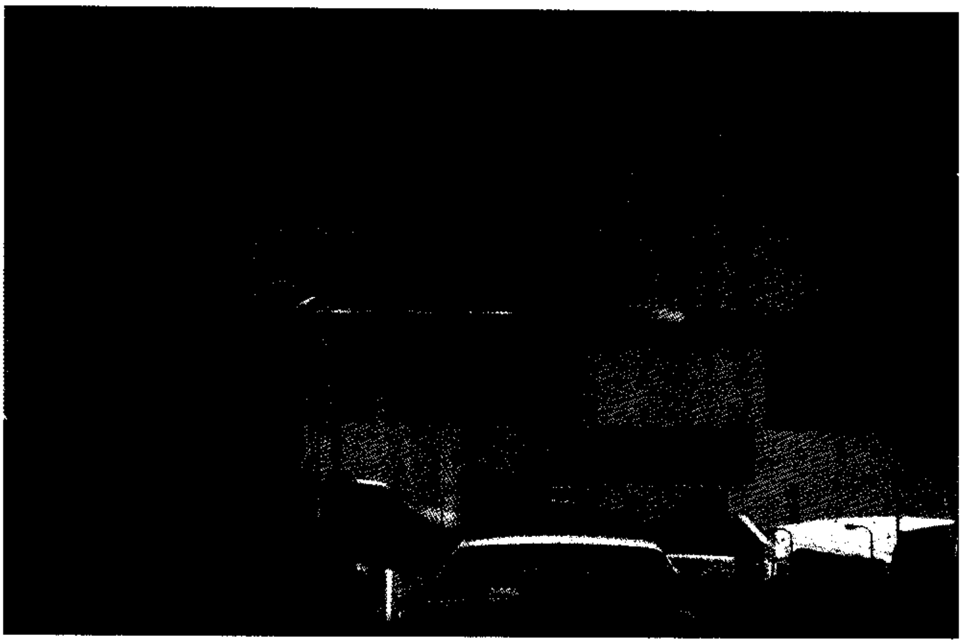


圖 4-2 可變標示（提供延滯長度推估值）

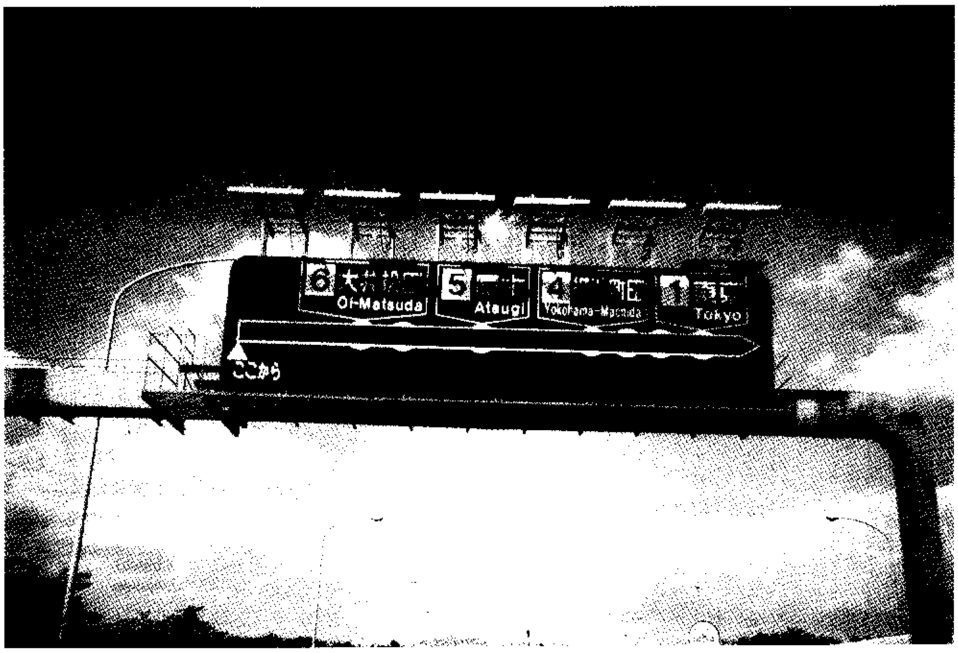


圖 4-3 可變標示（旅行時間推估值）

3. 隧道內有亮度之號誌指標

在日本東京的市區快速道路上，就如同建國南北路之三總地下路段或基隆路之仁愛路車型地下道路段，其指標除有亮度外還設有號誌，以告知用路者前方道路之通暢狀況，如圖 4-4 所示。

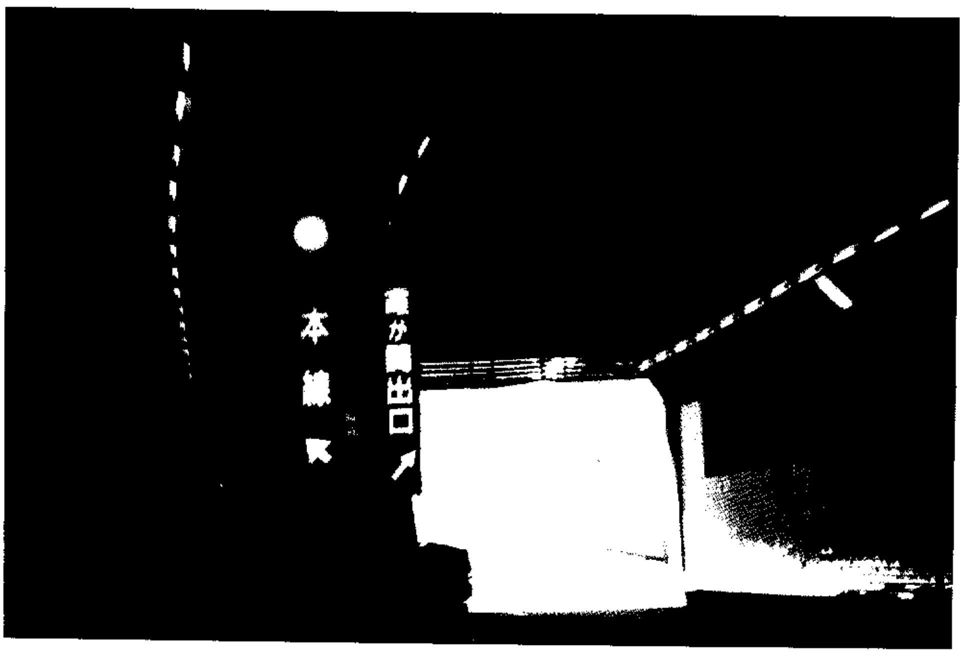


圖 4-4 有號誌之指標（隧道內）

4. 提供即時資訊之可變告示牌：

在日本東京的市區快速道路上，就如同中山高速公路上設有路牌，不一樣的是路牌上道路服務水準之可變的，以提供道路服務水準資訊，如圖 4-5 所示。

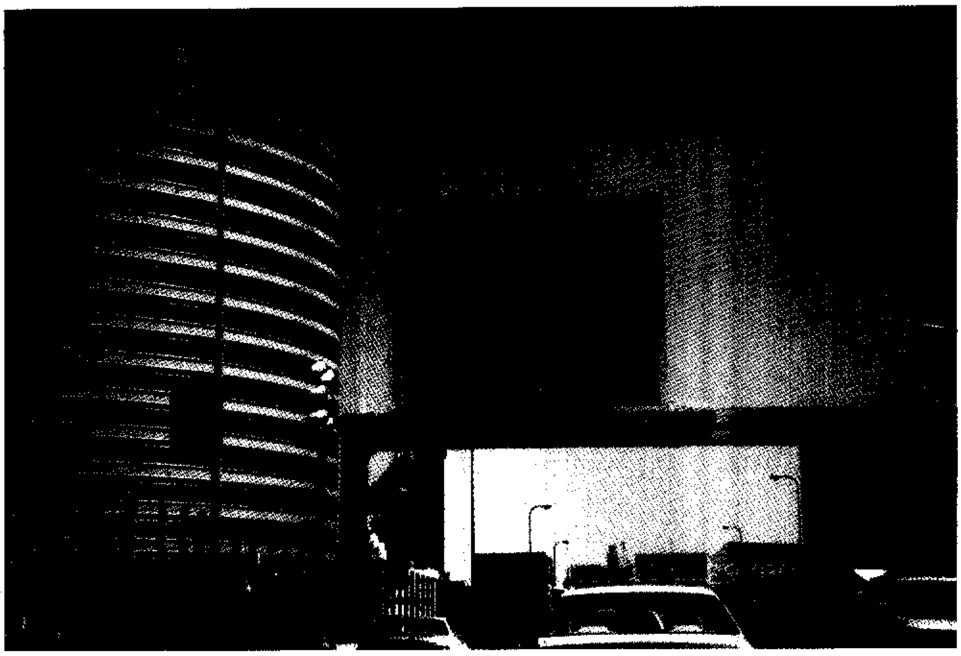


圖 4-4 可變告示牌（提供道路服務水準資訊）

圖 4-5 可變告示牌（提供道路汽車故障資訊）

5.多變化之道路隔音牆：

在日本不論是市區快速道路上或高速公路上都設有隔音牆，樣式繁多如圖 4-6、圖 4-7 至圖 4-8 所示。

圖 4-6 日本高快公路隔音牆（1）

圖 4-7 日本高快公路隔音牆（2）

圖 4-8 日本高快公路隔音牆（3）

4.2 休息站設施

1. 停車休息服務：

在日本東名高速公路海老名休息站，不像中山高之休息站設有很長的匝道與引道，其腹地亦不大，而是一個很簡易但服務卻很齊全的休息站，其中休息站出口匝道路段如圖 4-9 所示，停車服務如圖 4-10 所示。

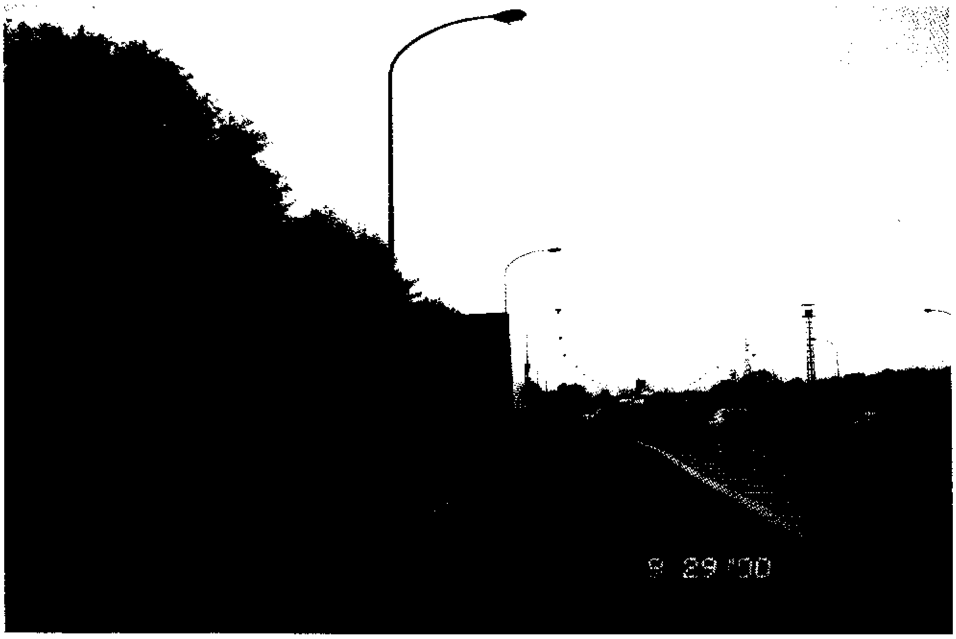


圖 4-10 日本高快公路簡易休息站停車場

2. 停車販賣與洗手間服務：

在日本東名高速公路海老名休息站，亦提供販賣與洗手間服務如圖 4-11 與圖 4-12 所示。

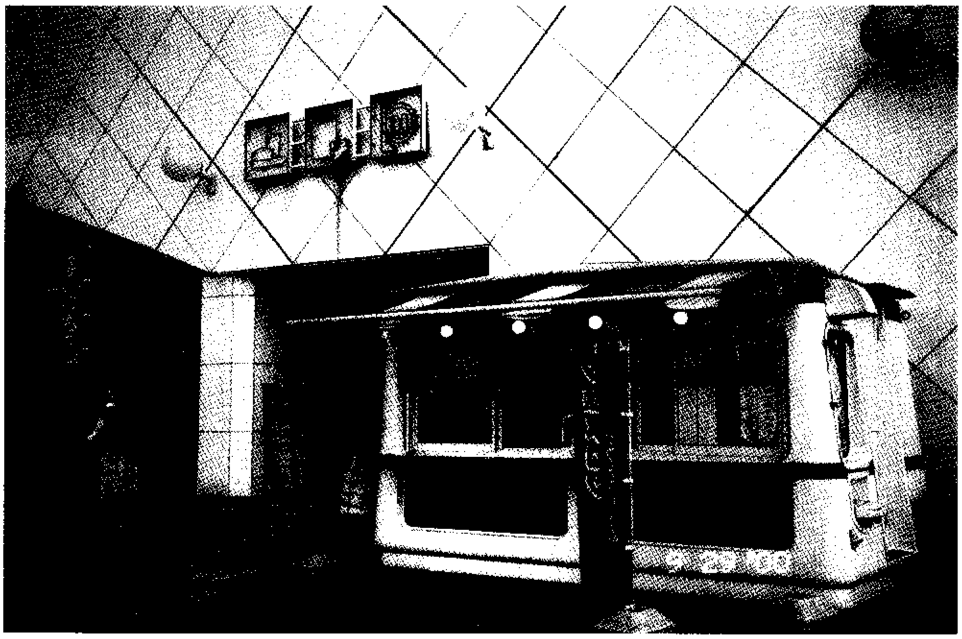


圖 4-11 日本高快公路簡易休息站販賣服務

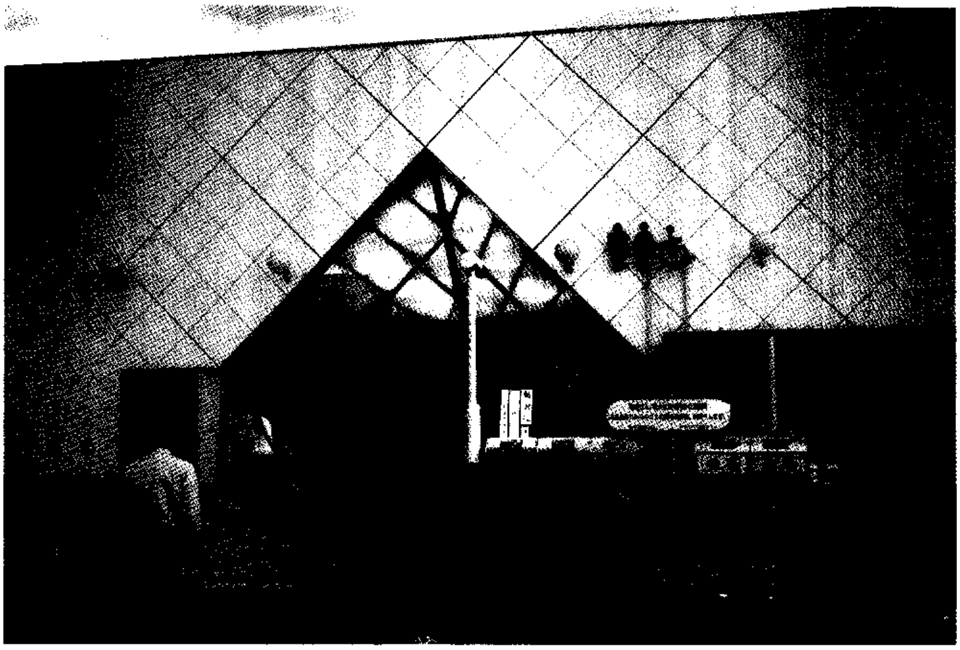


圖 4-12 日本高快公路簡易休息站洗手間服務

3. 道路情報、資訊服務：

在日本東名高速公路海老名休息站，提供道路情報、資訊服務如圖 4-13 與圖 4-14 所示，資訊種類繁多，服務人員齊全，可供我國效法。

圖 4-13 日本高快公路簡易休息站道路情報服務

圖 4-14 日本高快公路簡易休息站道路資訊服務

4.3 大爬坡與大曲率路段

1.大爬坡路段警告標示：

在日本東名高速公路大井松田至御殿場路段（60k 至 67k）處有大爬坡路段。道路公團會明確標示坡度的高度以供駕駛者參考，如圖 4-15 與圖 4-16 所示。

圖 4-15 日本東名高快公路大爬坡路段警告標示（1）

圖 4-16 日本東名高快公路大爬坡路段警告標示（2）

2 大曲率路段警告標示：

在日本東名高速公路大井松田至御殿場路段（60k 至 67k）處有大曲率路段。道路公團會明確標示曲率半徑以供駕駛者參考，如圖 4-17 所示。

圖 4-17 日本東名高快公路大曲率路段警告標示（1）

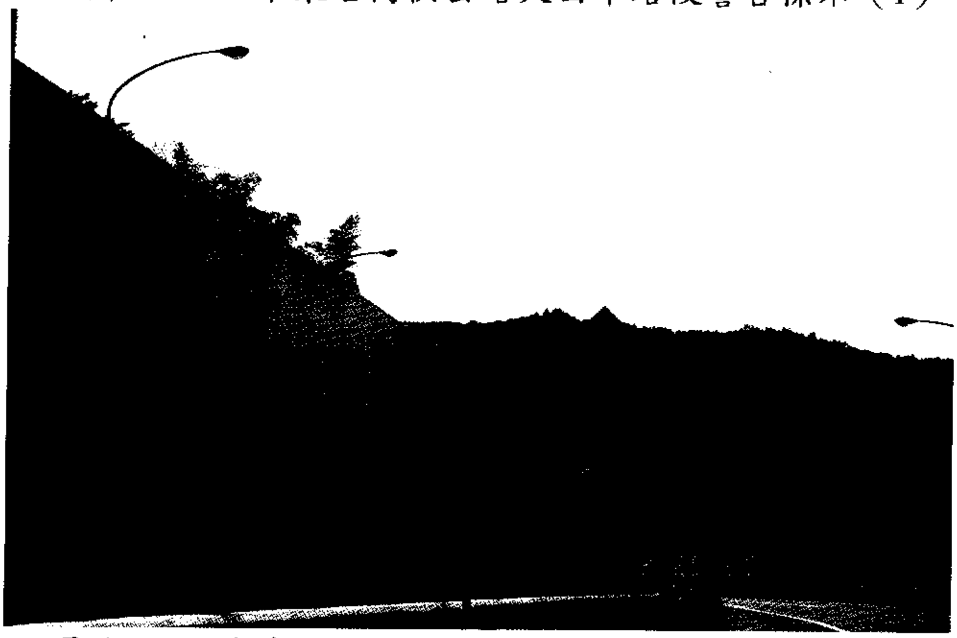
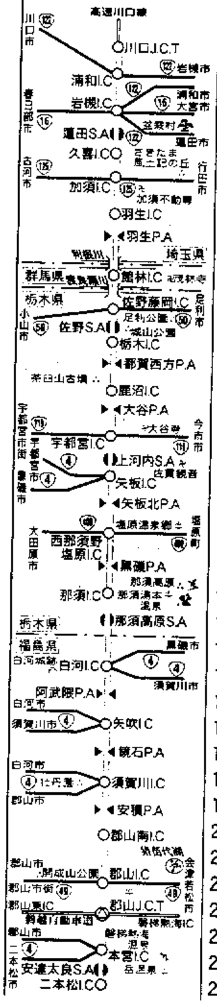


圖 4-18 日本東名高快公路大曲率路段警告標示（2）

4.4 日本公路時間表簡介

在台灣您可能見過台灣鐵路管理局出版之鐵路時刻表，在日本 JR 也有，但在日本高速公路的休息站之道路情報資訊站中，您也可買到『日本公路時間表』，其主要記載日本各道路網之道路路段上之預估旅行時間，您可由此推估您每段旅程的大致時間。現摘錄其中一頁如下。若有需要參考可來電洽詢本報告作者（TEL：2349-6806　E-mail jason@iot.gov.tw）

東北自動車道（その1）　起点　埼玉県川口市～　終点　青森県青森市



川口JCTからの 距離／時間	所要時間	地名	距離	所要時間	青森ICからの 距離／時間	接続案内
0.0/0:00		川口JCT			679.5/6:54	首都圏高速道路連絡ガイド(92頁)
4.8/0:03	0:03	浦和IC	4.8	0:03	674.7/6:51	(122) 川口市、岩槻市方面(198頁)
10.5/0:07	0:04	岩槻IC	5.7	0:04	669.0/6:47	(16) 春日部市、大宮市方面(186頁)　(122) 浦和市、蓮田市方面(198頁)
18.2/0:12	0:05	蓮田SA	7.7	0:05	661.3/6:42	
25.5/0:16	0:04	久喜IC	7.3	0:04	654.0/6:38	
33.4/0:21	0:05	加須IC	7.9	0:05	646.1/6:33	(125) 古河市、行田市方面(196頁)
39.4/0:25	0:04	羽生IC	6.0	0:04	640.1/6:29	
40.6/0:26	0:01	羽生PA	1.2	0:01	638.9/6:28	
46.0/0:29	0:03	館林IC	5.4	0:03	633.5/6:25	
55.0/0:34	0:05	佐野藤岡IC	9.0	0:05	624.5/6:20	(50) 小山市、足利市方面(192頁)
58.0/0:36	0:02	佐野SA	3.0	0:02	621.5/6:18	
72.7/0:45	0:09	栃木IC	14.7	0:09	606.8/6:09	
79.3/0:49	0:04	都賀西方PA	6.6	0:04	600.2/6:05	
91.5/0:57	0:08	鹿沼IC	12.2	0:08	588.0/5:57	
99.3/1:02	0:05	大谷PA	7.8	0:05	580.2/5:52	
103.0/1:04	0:02	宇都宮IC	3.7	0:02	576.5/5:50	(119) 宇都宮市街、今市市方面(195頁)
110.6/1:09	0:05	上河内SA	7.6	0:05	568.9/5:45	
120.2/1:15	0:06	矢板IC	9.6	0:06	559.3/5:39	(4) 宇都宮市、黒磯市方面(181頁)
127.5/1:20	0:05	矢板北PA	7.3	0:05	552.0/5:34	
139.1/1:27	0:07	西那須野塩原IC	11.6	0:07	540.4/5:27	(400) 大田原市、塩原町方面(210頁)
145.5/1:31	0:04	黒磯PA	6.4	0:04	534.0/5:23	
152.5/1:36	0:05	那須IC	7.0	0:05	527.0/5:18	
160.5/1:41	0:05	那須高原SA	8.0	0:05	519.0/5:13	
169.7/1:47	0:06	白河IC	9.2	0:06	509.8/5:07	(4) 黒磯市、須賀川市方面(181頁)
178.7/1:52	0:05	阿武隈PA	9.0	0:05	500.8/5:02	
186.3/1:57	0:05	矢吹IC	7.6	0:05	493.2/4:57	(4) 白河市、須賀川市方面(181頁)
193.9/2:02	0:05	鏡石PA	7.6	0:05	485.6/4:52	
198.2/2:05	0:03	須賀川IC	4.3	0:03	481.3/4:49	(4) 白河市、郡山市方面(181頁)
206.0/2:10	0:05	安積PA	7.8	0:05	473.5/4:44	
207.7/2:11	0:01	郡山南IC	1.7	0:01	471.8/4:43	
216.4/2:16	0:05	郡山IC	8.7	0:05	463.1/4:38	(49) 郡山市、会津若松市方面(161頁)
220.2/2:18	0:02	郡山JCT	3.8	0:02	459.3/4:36	磐越自動車道・郡山東IC、磐梯熱海IC方面(105頁)
223.1/2:20	0:02	本宮IC	2.9	0:02	456.4/4:34	(4) 郡山市、二本松市方面(182頁)
226.3/2:22	0:02	安達太良SA	3.2	0:02	453.2/4:32	
236.0/2:28	0:06	二本松IC	9.7	0:06		

圖 4-19 日本公路時間表

伍、日本國道工團之簡介

本次拜訪日本道路公團，有二大收穫，一是『高速道路便覽』，二是『高速公路之設計標準』。

5.1 高速道路便覽

本次拜訪日本道路公團送給運研所代表之『高速道路便覽』（封面如圖 5-1 所示）其中包括有下列十二章：

1. 高速自動車國道簡介。
2. 整備與推動計畫。
3. 利用現況。
4. 通行費率計算關係。
5. 通行費率。
6. 建設計畫經費來源。
7. 實質建設狀況。
8. 養護管理。
9. 防災、防震對策。
10. 交通安全。
11. 環境對策。
12. 技術準則。

相關研究者若有需要亦可來電洽借。

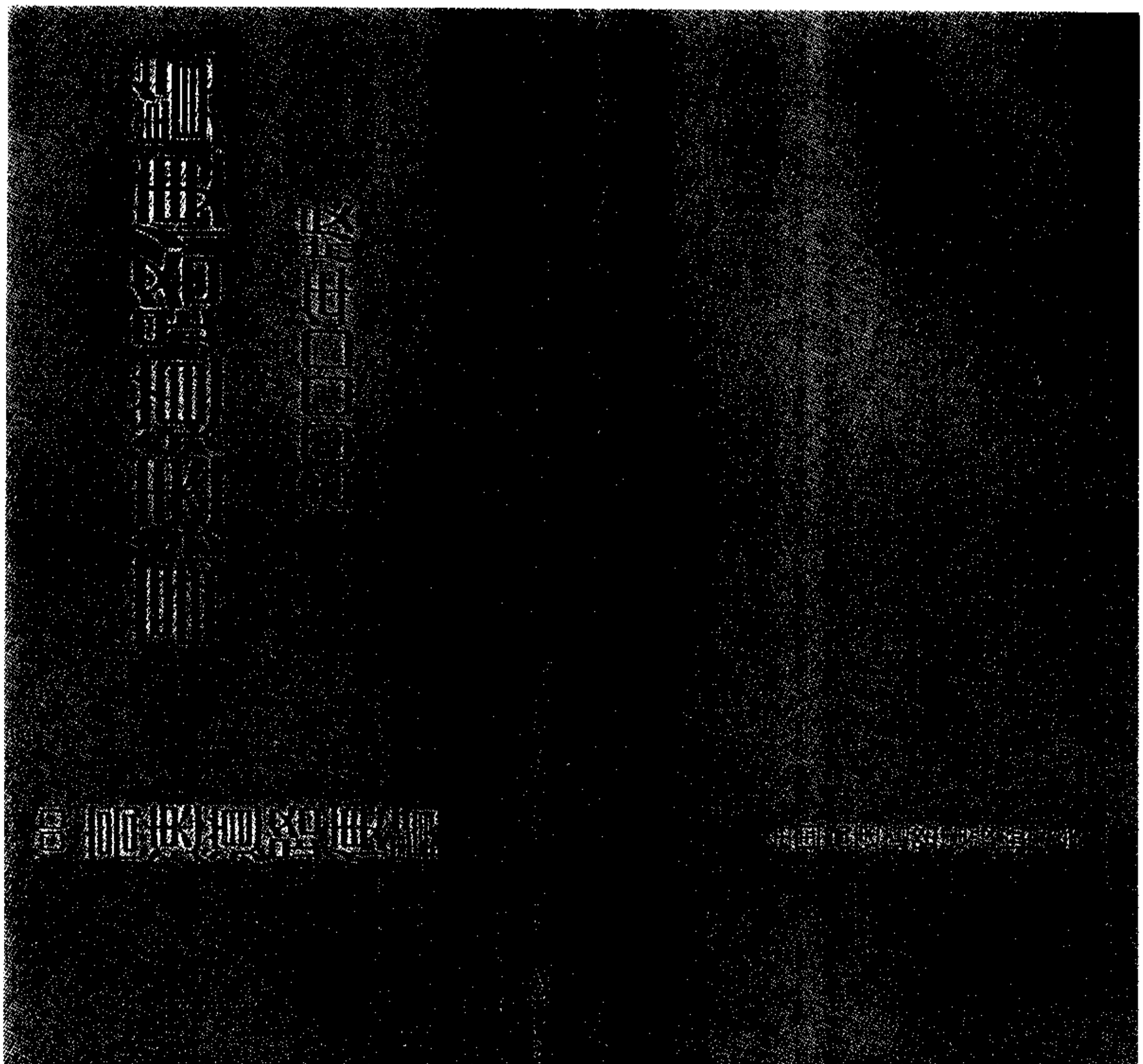


圖 5-1　高速道路便覽封面

5.2 高速公路之建設程序

日本從昭和 15 年起進行高速公路籌畫、建造，並在昭和 31 成立日本道路公團專司高速公路之興建，其高速公路之建設程序分述如下：（另如圖 5-2 所示）

1. 規劃路線。

2. 由國土開發幹線自動車道建設審議會進行基本計畫審查。

   基本計畫包括：

   ①路線起訖。

   ②路線經過地點。

   ③車道數。

   ④設計速率。

   ⑤公路聯絡之縣市鎮。

   ⑥建設計畫主體項目。

3. 環境影響評估。

4. 由國土開發幹線自動車道建設審議會進行建設計畫審查。

   ①路線經過縣市鎮名稱。

   ②車道數。

   ③設計速率。

   ④公路聯絡縣市鎮之區位。

⑤建設經費。

⑥其他配合事項。

5. 由日本道路公團負責施工作業。

6. 計畫實施。

7. 路線公佈。

8. 中心樁設置。

9. 設計協議。

10. 用地取得。

11. 施工。

12. 營運。

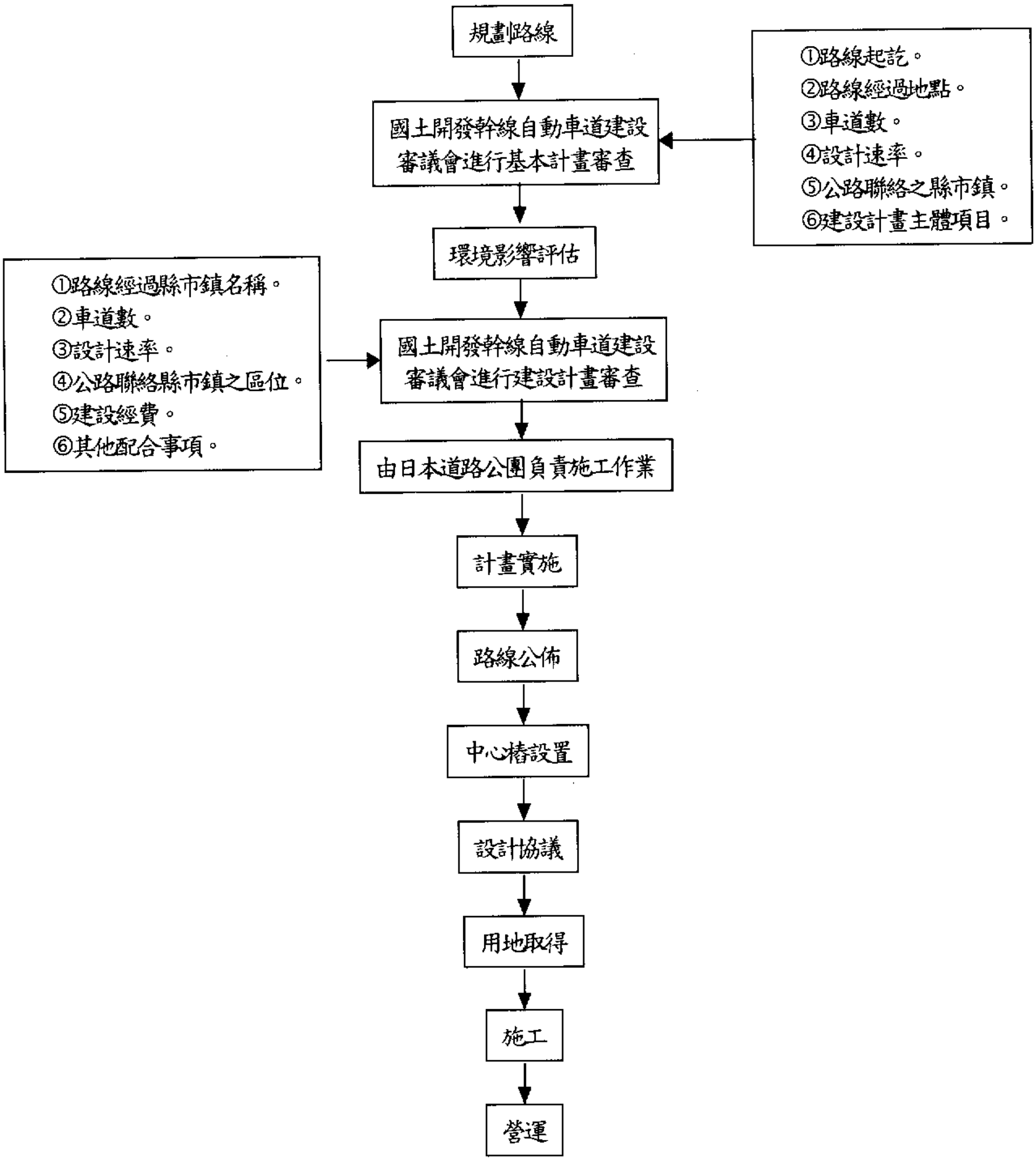


圖 5-2 日本高速公路之建設程序示意圖

5.3 高速公路之設計標準

本次訪查日本道路公團，其對於高速公路之設計有一套之標準。內容分成第一篇緒論、第二篇幾何設計、第三篇交通安全設置與第四篇技術發展等篇。內容分述如下：（詳如附件一）

第一篇緒論。

第二篇幾何設計：

1.日本道路系統。

2. 道路功能分類。

2-1 高速公路之幾何設計

1. 高速公路設計速率。

2. 高速公路縱斷面。

3. 高速公路幾何設計。

4. 寒冷地區高速公路幾何設計。

2-2 交流道、休息區與其他設施

1. 交流道與匝道區。

2. 公車停等區。

3. 休息區。

4. 收費站。

第三篇交通安全設置：

1.柵欄圍牆（Guard fence）。

2.交通號誌（Traffic Signs）。

3.道路標誌（Road Markings）。

4.反光紐（Delineators）

5.距離告示（Distance marks）

6.防撞板/裝置（Glare reduction）

7. 預防掉落物圍牆（Fences against falling objects）

8.邊界圍牆（Boundary Fences）

第四篇技術發展：

1. 電子收費系統（ETC）。

2. 車輛資訊通訊系統（VICS）。

陸、結論與建議

1.高速公路有大爬坡、大曲率路段，一般均發生於歷史悠久的高速公路中，現今已無設置之必要。

於歷史悠久的高速公路如日本東京之東名高速公路與民國七O年代興建的台灣之中山高速公路，當時往往考量其時之隧道施工技術不良，可能造成施工成本高昂與漫長工期，而改採以大爬坡、大曲率路段以節省土方、降低成本。以現今之施工技術，逢山鑿洞，遇河架橋，現今台灣地區之北二高與中南二高已無大爬坡、大曲率路段之設置。

2. 日本東京東名高速公路對大爬坡、大曲率路段在硬體建設方面之經驗。

他山之石可以攻錯，以本次參訪之日本東京東名高速公路在硬體建設方面之經驗，日本國道工團係以拓寬方式將原本雙向四車道的高速公路（60k 至 67k）處拓寬為雙向有高差之雙向六車道的高速公路，以利加減速性能較差之車輛使用，避免造成交通干擾與延滯。

3. 日本東京東名高速公路對大爬坡、大曲率路段在軟體方面之經驗。

在軟體建設方面之經驗，日本國道工團於：

（1）升降坡上之升降坡警告示排上除說明有險坡外，還清楚註明坡度百分比，以讓駕駛者有心理準備。

（2）在有曲率路段則於警告示牌上除說明有危險彎道外，亦清楚註明轉彎半徑大小，以讓駕駛可自行調整車道。

4. 日本高速公路之可變標示上有旅行時間資訊。

在台灣地區之高速公路上設置有跑馬燈式之可變標示，以更新告知駕駛道路資訊，但在日本高速公路上除於固定牌上告知欲到達目的地之相對距離外，其正右側之可變標示上標有欲到達目的地預測之旅行時間資訊。正如臺北市內有多處交叉路口設有標示倒數秒數的紅綠燈一樣方便用路者穿越馬路。此點可供高速公路局日後設置參考。

5. 日本高速公路休息站上提供道路服務水準之行車資訊。

在日本高速公路上除有停車休息、餐飲、加油、旅遊資訊、施工資訊等服務外，另設置有一台道路服務水準之行車資訊，其於畫面上告知欲到達目的地之路網與相對距離外，亦標示欲到達目的地依交通狀況預測之旅行時間資訊，亦可供高速公路局參考。

6. 日本高速公路尚未於網際網路上提供道路服務水準之行車資訊。

在日本大阪交通局、東京交通局、建設局與道路公團的訪問行程中，本所蘇振維工程司均曾提出問及日本高速公路之道路服務水準是否上網際網路提供行車資訊，所得一致的回答均是尚未提供。反觀，本所運輸資訊組早已於本所 www.iot.gov.tw 網際網路上提供台灣北部區域與台中附近國道中山高之道路服務水準之即時平面行車資訊，另亦於八十九年底推出台灣北部區域與台中附近國道中山高之道路服務水準之即時圖形行車資訊，其搶鮮版可在 210.69.172.99/travel/index.cfm 下查詢。

7. 透過電子收費可達成道路使用者付費之理念，並抑制車輛使用、降低空氣污染、減少噪音改善環境等一舉數得。

道路使用者付費的觀念在日本道路使用上可明顯看出，電子收費可帶來 1.降低因收費繳費所產生之延滯、2.降低因收費繳費所產生的麻煩、3.可降低管理費與 4.降低因收費繳費所產生的空氣污染、噪音之環境改善等效益。故日本高速公路自 2000 年 4 月 24 日起進行八條路線電子收費之試運行，到了平成 14 年（2002 年）全日本會設置約 900 個收費站。

8. 台灣地區之高速公路收費費率實有研究調漲之空間。

本次現地考察東名高速公路由首都快速道路端點起至御殿場路段約 70 公里，往返計花費 6,400 日幣(單趟 3,200=700+2,500 日幣）約為一千九百元台幣左右，若以台灣中山高速公路收費計算，約只需花費五百元，相差近似四倍之多。所以台灣地區之高速公路收費費率似仍低廉，可研究有無調漲之空間。

9. 建議交通部高公局或公路局編製公路時間表。

在台灣您可能見過台灣鐵路管理局出版之鐵路時間表，在日本也有，但在日本高速公路的休息站之道路情報資訊站中，您也可買到『日本公路時間表』，其主要記載日本各道路網各道路路段上之預估旅行時間，您可由此推估您每段旅程的大致時間。建議交通部高公局或公路局可參考研究編製『台灣地區公路時間表』以提高台灣地區公路資訊服務水準。

10. 建議台灣地區之交通部高公局或國工局編製『高速道路便覽』與『高速公路之設計標準』。

本次拜訪日本道路公團，有二大收穫，一是『高速道路便覽』，二是『高速公路之設計標準』。這二樣都是交通部高公局或

國工局必備的工具書，建議交通部高公局或國工局以本土化資料，編製類似『高速道路便覽』與『高速公路之設計標準』以供後續建設之參考。

最後，感謝日本大阪交通局、關西空港、東京交通局、建設局與道路公團的訪問行程中之熱忱接待，本所運安組林亨杰哥，在日本訪問時給予之縝密細心安排、免費翻譯，使筆者日本行順利圓滿。另外，本次考察行程以及相關手續等瑣碎事宜，承鼎漢顧問公司石丸、美惠、伯君與智霖給予協助，亦一併表示致謝。

附件

日本高速公路之設計標準

CONTENTS

Ⅰ. GENERAL

Road traffic contributes greatly to the social, economic and cultural development of Japan. Expressways, especially, play important roles as infrastructure to promote balanced development of the whole nation and exchanges among various regions. Japan Highway Public Corporation (JH) has been working to develop road design standards to realize safe, smooth, and comfortable driving on expressways. JH also constructs and manages expressways throughout Japan.

The Topography of Japan is characterized by narrow land with steep mountains, leaving only small plains. Through this land, expressways must organize themselves as a network covering the whole nation. Expressway design standards should be determined, above all, in a way suitable for maintaining a balance between the measures necessary for safe driving and the cost effectiveness for construction and operation. Furthermore, driving smoothness and comfort also need to be considered. These considerations have led to establishment of the minimum geometric design standards necessary for expressways. In addition, traffic safety devices, such as road signs for guiding drivers, guard fences for mitigating traffic accident damage; and visual guidance devices for directing safe driving practices, are essential for desirable road operation.

This booklet introduces geometric design standards and traffic safety device design standards developed by JH, as well as the Vehicle Information and Communications System (VICS) and the Electronic Toll Collection system (ETC) which are among the recent developments in the field of traffic engineering; all these measures aim at safe, smooth and comfortable drive on expressways.

Ⅱ. THE STANDARD OF GEOMETRIC DESIGN

1. The Road System in Japan

Roads are the basic socio-economic asset of great importance, indispensable for the transportation of materials and the movement of people, and regional development and land use along the roads cannot advanced without proper road improvement.

In the consideration of a nation-wide road network, it is desirable that the roads be classified by function and be improved to form an integrated system by connecting the network.

For this purpose, the roads in Japan are classified under the Road Law into the following four categories.

(a) National Expressway
(b) National Highway
(c) Prefectural Road
(d) Municipal Road

These roads have the following functions.

(1) National Expressway

The Expressways form the most important part of the nation-wide motor vehicle traffic network and connect the important areas of political, economic and cultural activity.

(2) National Highway

The national highways form the nation-wide major road network together with the national expressways. They connect the prefectural capitals, the important cities of political, economical and cultural activity, the important ports and airports, significant spots for international sightseeing, and developing areas.

(3) Prefectural Road

The prefectural roads form the major local road network and connect cities, towns with populations over 5,000, ports, airports, major railway stations and sightseeing spots.

(4) Municipal Road

The municipal roads are an important social investment of cities, towns and villages in support of daily life; they connect the area communities with one another. At the same time the municipal road is indispensable to the effective functioning of public property and economic activity.

2. Classification of Roads

The classification of roads is done, in terms of road design standards, by classifying the roads into groups in which the same design standards (speed, geometry, etc.) are used, or by areas of existing roads, topographical conditions and planned traffic volume.

Type and class of road are determined in accordance with planned traffic volume, topography, road category (expressway, national highway, prefectural road, municipal road) and the allowable design speed calculated. As related later, the geometric design and other features are determined by the planned speed. This system of classification is shown in Table Ⅱ-1.

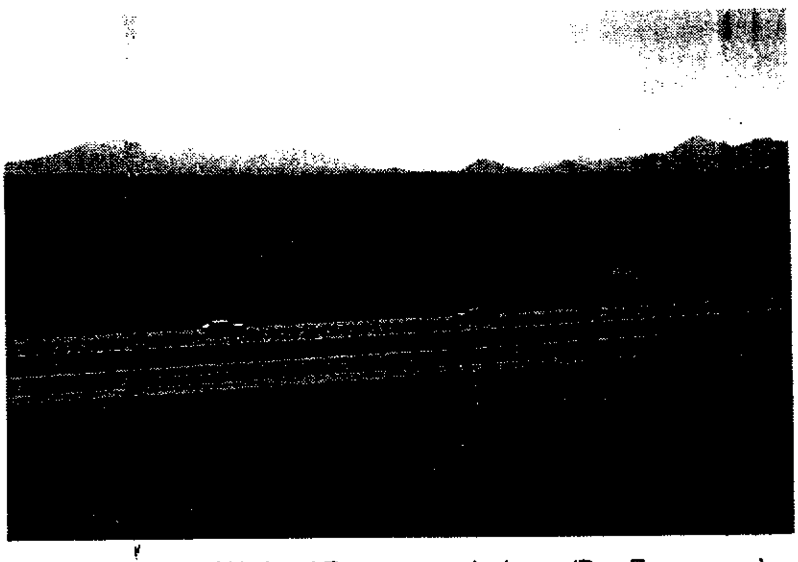


Photo Ⅱ-1 One of National Expressways in Japan (Doo Expressway)

Table II-1 System of Classification

	Type	Class	Design Speed (km/h) Standard	Design Speed (km/h) Allowable	Access Control	Design Traffic Volume (veh./day) Over 30,000	30,000-20,000	20,000-10,000	Less than 10,000	Remarks
Expressway	1	1	120	100	F	N.E. in level terrain				
		2	100	80	F, P	N.E. in mountainous terrain	N.E. in level terrain			
						E. in level terrain				
		3	80	60	F, P		N.E. in mountainous terrain		N.E. in level terrain	
						E. in mountainous terrain		E. in level terrain		
		4	60	50*	F, P			N.E. in mountainous terrain		*Not applicable to N.E.
								E. in mountainous terrain		
	2	1	80	60	F	N.E. in urban area, E. in urban area except the center of metropolis				
		2	60	50 40	F	E. in the center of metropolis				

	Type	Class	Design Speed (km/h) Standard	Design Speed (km/h) Allowable	Access Control	Design Traffic Volume (veh./day) Over 20,000	20,000 -10,000	10,000 -4,000	4,000 -1,500	1,500 -500	Less than 500	Remarks
Roads Other than Expressway	3	1	80	60	P, N	N.H. in level terrain						
		2	60	50 40	N	N.H. in mountainous terrain	N.H. in level terrain					
						P.M. in level terrain						
		3	40 50 60	30	N		N.H. in mountainous terrain		N.H. in level terrain P. in level terrain			
						P.M. in mountainous terrain			M. in level terrain			
		4	30 40 50	20	N				M. in mountainous terrain P.M. road in mountainous terrain			
									M. in level terrain			
		5	20 30 40	-	N						M. in level terrain or mountainous terrain	1-lane road
	4	1	60	50 40	P, N	N.H. in urban area						
						P.M. in urban area						
		2	40 50 60	30	N				N.H. in urban area			
								P.M. in urban area				
		3	30 40 50	20	N				P. in urban area			
									M. in urban area			
		4	20 30 40		N						M. in urban area	1-lane road

Note : N.E.: National Expressway E.: Expressway Other than National Expressway
F.: Full Control of Access P: Partial Control of Access N: Non Control of Access
N.H.: National Highway P.: Prefectural Road P.M.: Prefectural of Municipal Road M.: Municipal Road

II-1 The Standard of Geometric Design of Expressway

1. Design Speed

In road structure, it is the planned speed which defines the relationship between the vehicle and the road to be designed and for moving vehicles, this is the speed which will maintain normal driver comfort.

Design speed is the basic speed for study in the selection of the geometric design of roads. It is determined in Japan by the zone, topography, planning and traffic volume as related in Table II-1.

(1) Distance Restrictions Applicable to Design Speeds

The design speed may vary within a short distance due to the changes in zone, topography, planning and traffic volume for a given section.

Because this disturbs drivers, it is undesirable in terms of traffic safety and driver comfort. Therefore, the minimum distance for which a design speed must be maintained is stipulated.

The following table shows the limits in Japan.

(2) Transition Between Different Design Speeds

The difference in speeds at connection points is kept within 10-20 km/h. The design speed is changed according to variations in topography and zone, or at interchanges.

Table II-1-1

	Standard	Special Case
Minimum distance for one design speed	30-20 km	5km

2. Cross Section

As Fig. II-1-2 shows, the cross section on an expressway consists of lanes, center strip and shoulders, and, if necessary, a buffer zone is also installed.

It is difficult to establish the width of the cross section quantitatively in relation to design speed, but, in general, wider structure elements such as lanes, shoulders and center strips are required for higher design speeds. The wider road structure is also required for a large planned traffic volume. The relationship between the width of each element and the expressway standard is presented in Table II-1-2, and the concepts are related hereafter.

(1) Lane width

This is the most important among the elements of an expressway because vehicles travel on it. The standard lane width for expressways is 3.5m since the vehicles travel at high speed. But for Class 1, the inner lane of two lanes on one

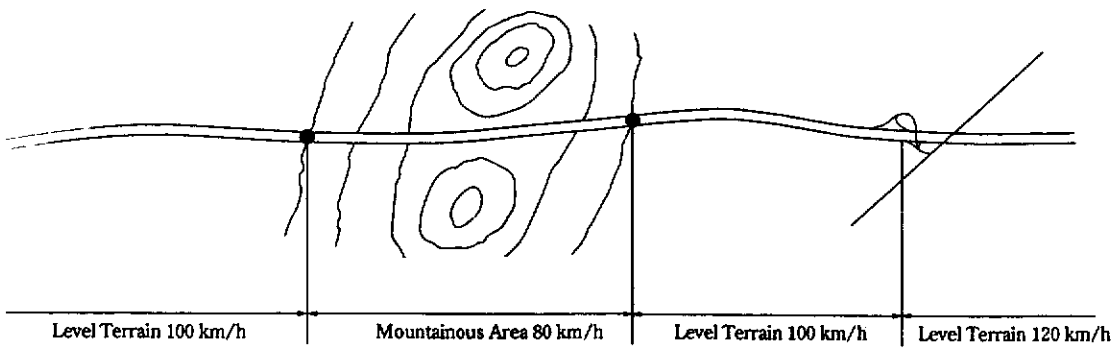


Fig. II-1-1 Continuity Design Speed

Table Ⅱ-1-2 Standard Widths of Type 1 highway

Class	Lane Widths					Medial Strip	Marginal Strip of Median	Shoulder Widths					
	4-Lanes		6-Lanes					Left		Right			Marginal Strip
	Left	Right	Left	Middle	Right			Cut and Embankment	Long Bridge	Cut and Embankment	Long Bridge	Tunnel	
1	3.50	3.75	3.50	3.75	3.50	3.00	0.75	3.00	3.25	1.75	1.25	1.00	0.75
2	3.50	3.75	3.50	3.75	3.50	3.00	0.75	3.00	2.50	1.75	1.25	1.00	0.75
3	3.50	3.50	3.50	3.50	3.50	2.00	0.50	2.50	1.75	1.00	1.00	0.75	0.50
4	3.25	3.25	-	-	-	2.00	0.50	1.75	1.25	1.00	1.00	0.75	0.50

direction and the middle lane of three lanes in one direction is 3.75m wide. These widths are special to routes with heavy traffic and a high proportion of large vehicles in order to permit high speed and comfortable driving. When the first expressway Nagoya-Kobe (Meishin) Expressway was constructed in Japan, a lane width of 3.6m was adopted, following the practice in various foreign countries. Since then, lane studies have been done on the basis of the operation of the Meishin and the Tokyo-Nagoya (Tomei) Expressways, and a lane width of 3.5m was then adopted as being more suitable in Japan.

(2) Center Strip

This consists of a median and a marginal strip. The median separates the two directions of traffic, prevents turns, minimizes disorder in the traffic flow and increases driving safety. The median strip is provided with a guard fence to ensure these functions. The marginal strip has the function of maintaining the lane effect by indicating clearly the external line of the traffic line, guiding the driver's vision, increasing driving safety and providing a lateral clearance.

To increase visibility a white making Line 20 cm wide indicating the outer line of the carriageway is drawn on the marginal strip. The basic width of the median is 3.0m.

This is sufficient to ensure that the lateral clearance will not be affected by the guard fence and the plantings within the median.

The minimum width of a median strip for expressways is 2.0m, which is established because it is sufficient for any safety facilities installed within the median.

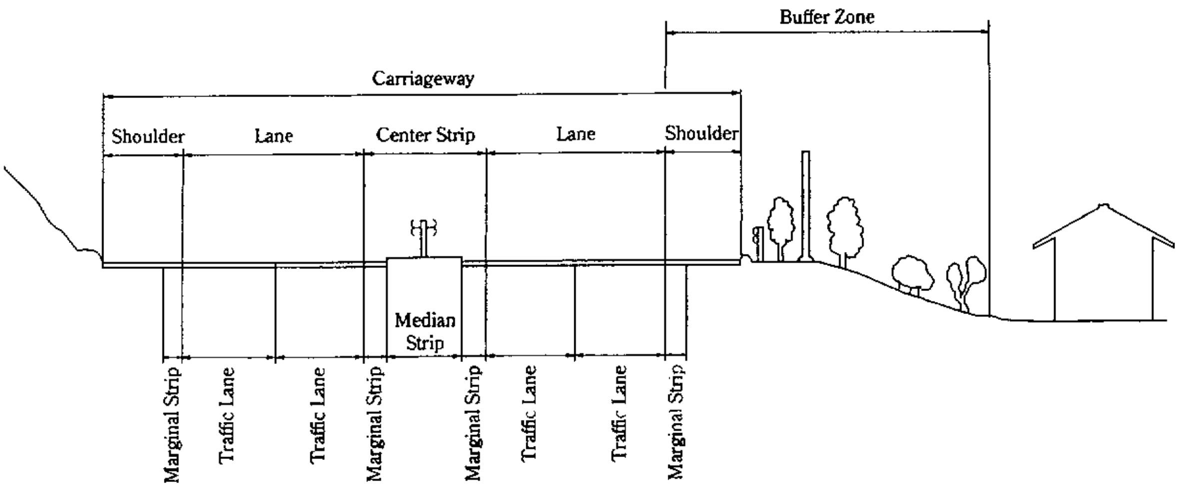
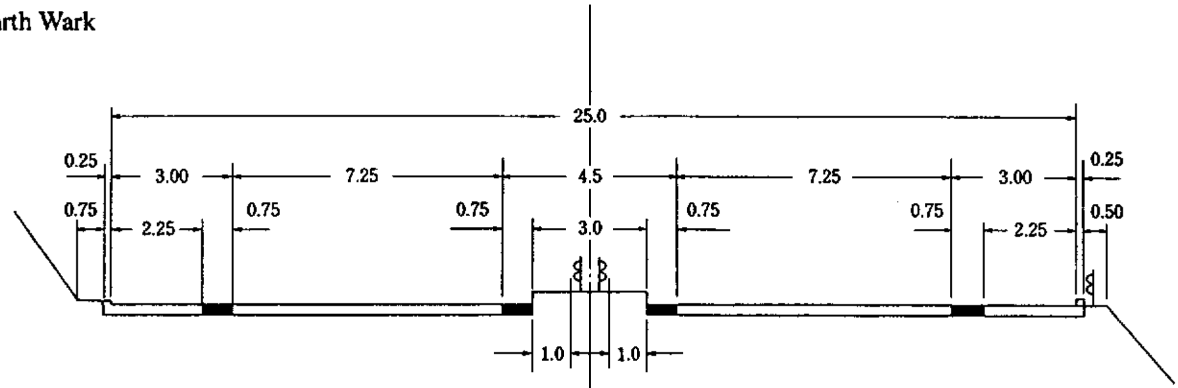
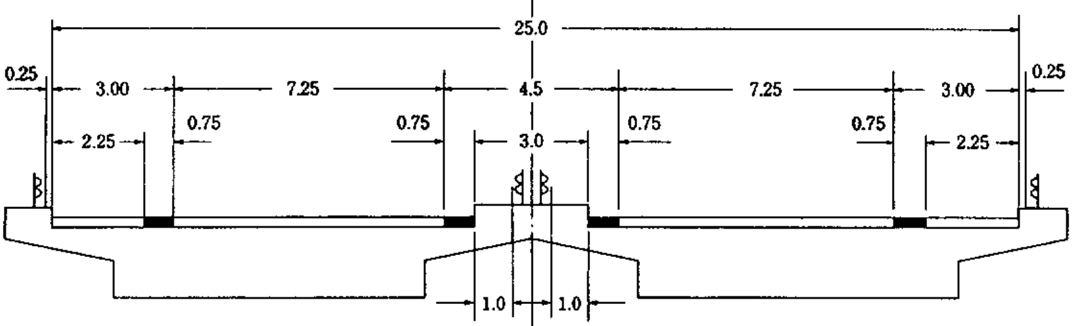


Fig. Ⅱ-1-2 Cross Section of an Expressway

A. Earth Wark



B. Middle-length and Short Bridge



C. Long Bridge

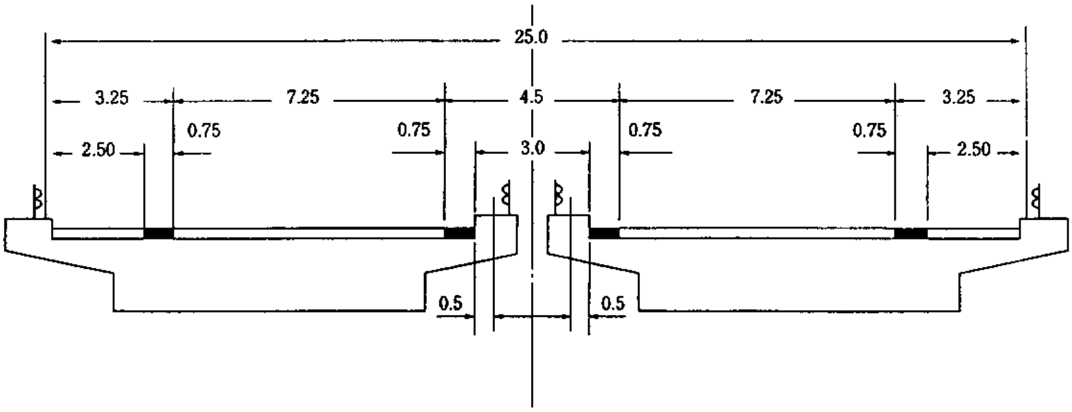


Fig. II-1-3 Standard Cross Section of Expressway for Each Structure

(3) Shoulders

The shoulder for an expressway has the following functions.

(a) It prevents accidents and traffic disturbances because disabled cars can get out of the traffic lane.
(b) It contributes to traffic safety and comfort by providing lateral clearance.
(c) It protects the carriage way

The shoulder width is determined by these functions. In Japan a passenger car is 1.70m wide and a truck is 2.50m side so a width of 2.5m is required to provide adequate space off the traffic lanes for any kind of disable vehicle; the width should be at least 1.70m, assuming only passenger cars. The basic concept is that the shoulder installed to the left of the outer lane should provide space for a disables car.

Variations in the allowable space for kinds and widths of disabled vehicles in accordance with the regulations are shown in the figures of Table II-1-2.

But for sections alongside a climbing lane, since the carriageway is wider than that of other sections, and vehicles travel at a lower speed on the climbing lane, cars can safely pass cars parked on a narrow shoulder (Fig. II-1-4).

The right shoulder is not installed in cases of standard cross section with center strip, but for roads with grade separations and those where the two directions of traffic are separated by a means other than a center strip, the shoulder is installed on the right side of the lanes in that direction. The width is determined by the requirement for lateral clearance on the right side of the outer lane and is as shown in Table II-1-2. The shoulder includes a marginal strip, the function of which is the same as that of the center strip. The thickness of the pavement of the shoulder is the same as that of the roadway itself. (Fig. II-1-5).

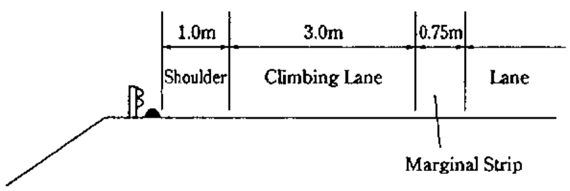


Fig. II-1-4 Shoulder on a Carriageway with a Climbing Lane

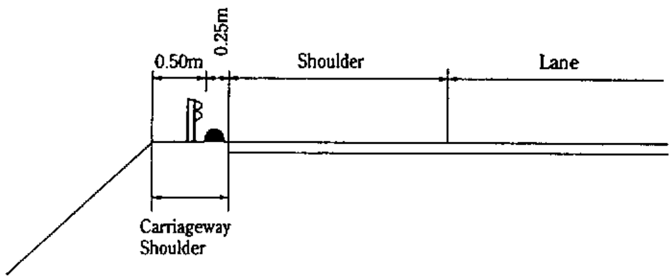


Fig. II-1-5 Standard Shoulder

Table Ⅱ-1-3 Standard Values of Geometric Design

Design Speed (km/h)	Minimum Design Radius for Various Values of Super-elevation: Desirable (m)	Minimum(m): 6%	Minimum(m): 8%	Minimum Curve Length(m): Desirable	Minimum Curve Length(m): Minimum	Minimum Length of Transition Curve (m)	Minimum Radius to Omit Transition Curve (m): Desirable	Maximum Super-elevation Rate: Rotation about Center of Each Pavement	Maximum Super-elevation Rate: Rotation about Median Edge of Each Pavement
120	1000	710	630	1400/ θ	200	100	4000	1/250	1/200
100	700	460	410	1200/ θ	170	85	3000	1/225	1/175
80	400	280	250	1000/ θ	140	70	2000	1/200	1/150
60	200	150	140	700/ θ	100	50	1000	1/175	1/125

Design Speed (km/h)	Minimum sight Distance: Stopping Sight Distance (m)	Maximum Vertical Grade (%): Disirable	Maximum Vertical Grade (%): Minimum	Minimum Vertical Curve Radius: Crest (m) Standard	Crest (m) Absolute	Sag (m) Standard	Sag (m) Absolute	Minimum Length of Vertical Curve (m)	Maximum Compound Grade (%)
120	210	2	5	17,000	11,000	6,000	4,000	100	8.5
100	160	3	6	10,000	6,500	4,500	3,000	85	8.5
80	110	4	7	4,500	3,000	3,000	2,000	70	9.0
60	75	5	8	2,000	1,400	1,500	1,000	50	9.0

Note : Special consideration is given for snowy and cold areas.

3. Geometric Design

Road alignment includes horizontal and vertical alignment; the horizontal alignment is composed of straight lines, circles and transition curves, and the vertical alignment is composed of straight lines and vertical cures. The standard minimum values for these elements are shown in Table Ⅱ-1-3.

(1) Horizontal Alignment

This consists of straight lines, circles and cloth-oid curves to be used as transition curves. The general policy for horizontal alignment design is as follows;

(a) The alignment should be suitable to the topography.
(b) The alignment should be continuous with no rapid changes.
(c) Sufficient curve length should be maintained to prevent an illusion in which the curve looks less sharp than it actually is. this is a particular problem where the radius of the curve is small.

The radius of the circle curve given in Table Ⅱ-1-3 is the minimum for guaranteeing driving safety and comfort and the applicable radius is generally far bigger than this value.

(2) Vertical Alignment

For the vertical alignment, the maximum vertical grade applicable which will ensure driving safe and comfort according to the design speed has been established as shown in Table Ⅱ-1-3. The case of an alignment which is satisfactory in terms of visibility from the driver's lane may occur if the grade vertical follows. The design should be executed to provide a vertical grade that is, in relation with the horizontal alignment, continuous in terms of visibility and smoothness. In cases where the up grade is so long that the climbing speed of large vehicles falls below half the design speed, the regulations require the installation of a special lane for low-speed vehicles. In a flat area, the minimum gradient is specified at 0.5-0.3% to ensure drainage.

(3) Combination of Horizontal and Vertical Alignments

The design of a combination of plane and profile alignments must include a full consideration of the driver's vision and the psychological effect as well as vehicle motion dynamic requirements. In order to execute such a design, it is desirable to make the horizontal curve correspond with the vertical curve at a 1:1 ratio. This has been obtained from various studies and foreign examples. If the combination is not satisfactory perspectives are checked as shown in Fig. Ⅱ-1-3, and further study is done to provide a smooth alignment.

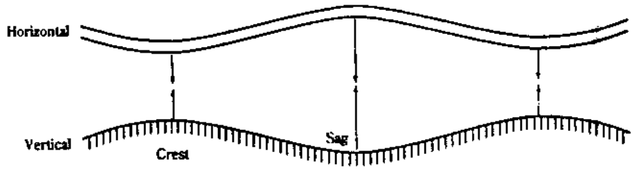
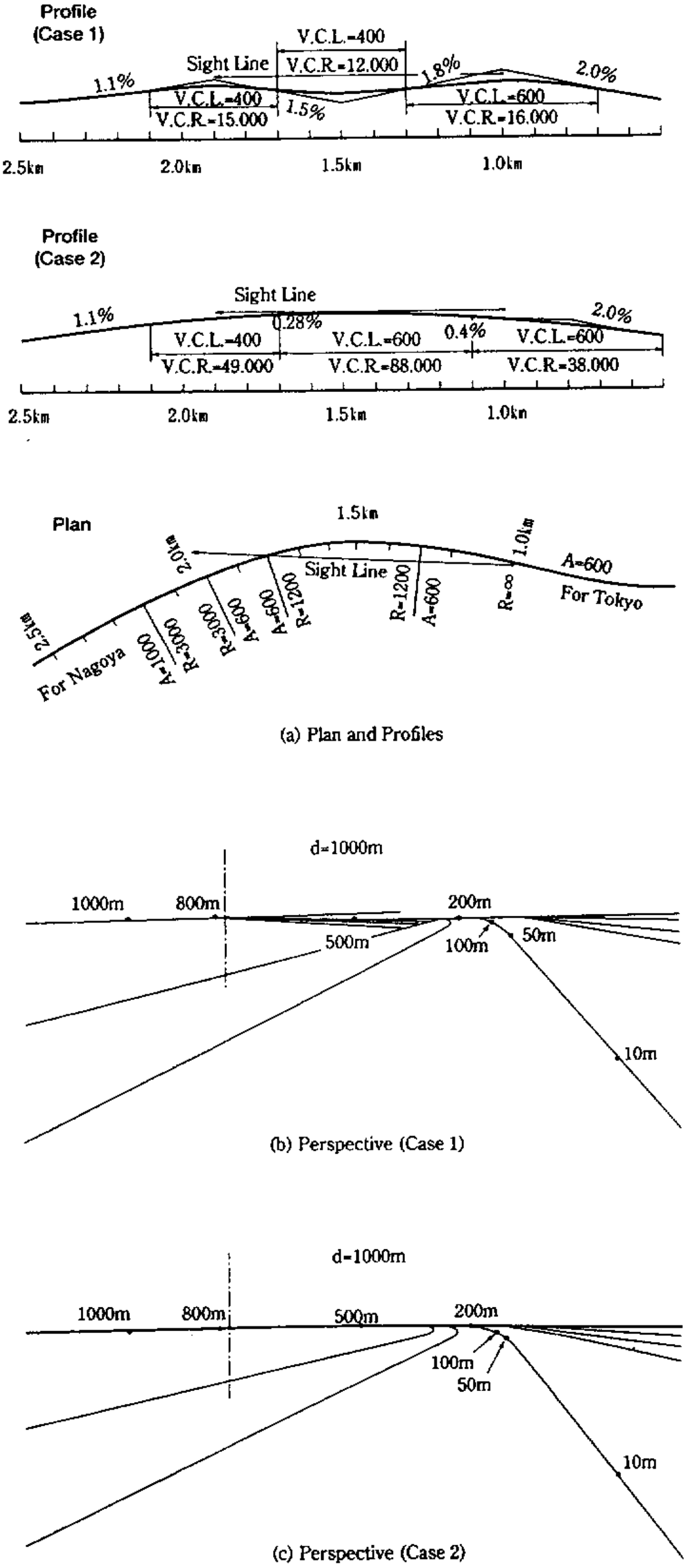


Fig. Ⅱ-1-6 Coordinution of Horizontal and Vertical Alignment



(a) Plan and Profiles

(b) Perspective (Case 1)

(c) Perspective (Case 2)

Fig. II-1-7 Examination of Aligment by Means of Perspective

4. Geometric Design for Cold Areas

Because Japan is a long land extending north and south with many mountains, the weather varies frequently.

The geometric design of the roads must include consideration of the weather. Especially in northern parts, there is heavy snow, and the depth exceeds 3 meters in some areas. In addition, the temperatures are extremely low; there are districts where temperatures below freezing continue for more than 30 days during winter. In such areas a geometric design providing for snowy surface and icy road surface is required to keep traffic moving in winter time. The countermeasures for snow are different from those for ice. For ice only the important measures to be taken in the design are those to provide against a decrease of sliding friction caused by the freezing? for snow the geometric design must ensure clear carriageway and provide against a decrease of the sliding friction drag.

(1) Measures for Securing Traffic Width

As snow removal work in Japan is carried out by snow plow and rotary snow-plow, space for the snow being removed is provided on the shoulder. (Fig. II-1-8)

Usually snow piles are made on the slope in the case of an embankment and on the cut slope in the case of a cut.

The shoulders are widened to accommodate the piles without affecting the lanes. Shoulder widths for snow piles are established according to the maximum depth of likely snowfall once every ten years, and the width is adjusted for the sunshine effect.

These relationships are presented in Table II-1-3.

(2) Horizontal Alignment, Grade, Superelevation and combined Gradient

On roads with snow-fall and freezing, the sliding friction of vehicles decreases and side-slipping occurs when starting, when stopping and when driving on curves, thus creating road conditions quite different from normal.

Accordingly, the minimum radius of a plane curve and the maximum grade, superelevation and combined grade are stipulated separately from those for normal cases. These values are as shown in Table II-1-5.

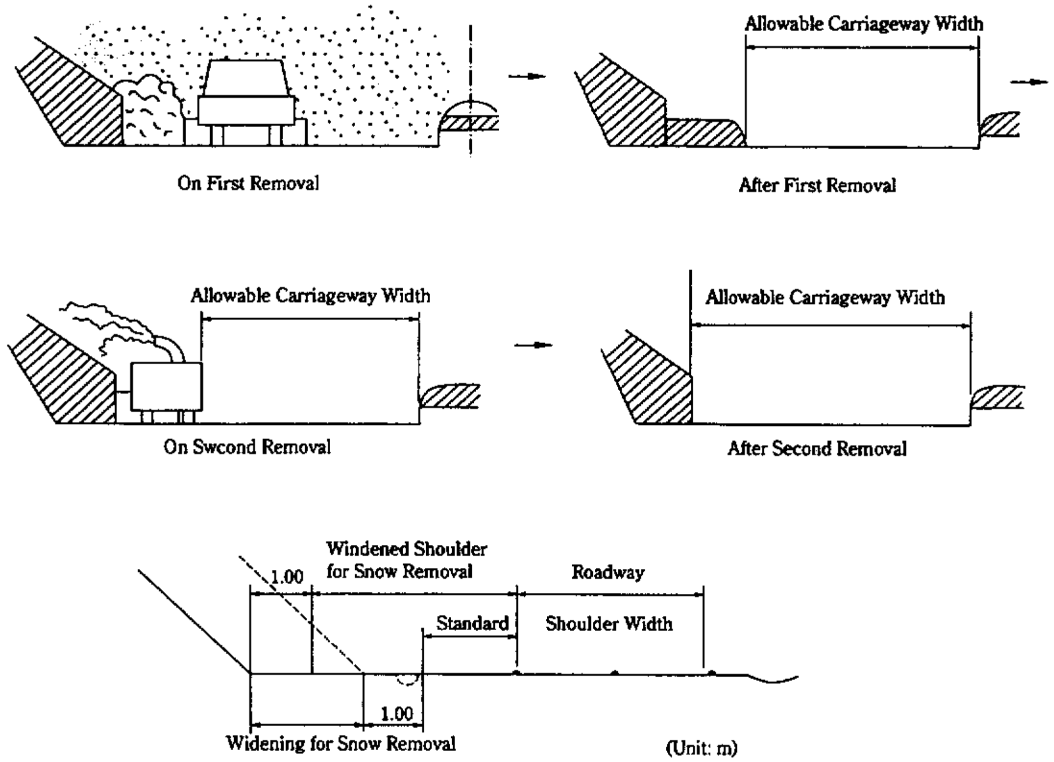


Fig. II-1-8 Space for Snow Piles

Table II-1-4 Widening for Snow Removal on Cut Section

(a) WIDENING FOR PILING REMOVED SNOW

Maximum Snow Depth Probable Once in 10 Years(m)	0~0.5	~1.0	~1.5	~2.0	~3.0	~3.5	>3.5
Widening(m)	0	0.5	1.0	2.0	3.0	4.0	5.0

(b) ADJUSTMENT FOR SUNSHINE

	Amount of Adjustment	
	Snow Depth ≦2.0m	Snow Depth >2.0m
Slope in NW ~NE Direction	+0.5m	+1.0m
Slope in SE ~SW Direction	−0.5m	−1.0m

Note NW : Northwest NE : Northeast
SE : Southeast SW : Southwest

Table Ⅱ-1-5 Curve Radius and Grade in Cold Areas with Snowfall

Design Speed	Minimum Curve Radius			Maximum Superelevation		Maximum Grade		Maximum Combined Grade	
								A	
	Standard	A	B	A	B	Standard	Exception	Standard	Exception
120 km/h	710	710	630	6%	8%	2	4	6%	7%
100 km/h	460	460	410			3	5		
80 km/h	280	280	250			4	6		
60 km/h	150	150	140			5	6		

A : Zone "A"
- (a) There are more than 30 days with snowfall of over 10 cm.
- (b) Annual average temperature in January is below - 4℃

B : Zone "B"
- (a) Maximum snow depth for February in successive years (averages for more than five years) is over 50 cm.
- (b) There are more than 10 days with snowfall of over 10 cm.
- (c) Annual average temperature in January is below 0℃ and there are more than 10 days with rainfall of over 10 mm for the period during December to February.

Ⅱ-2 Interchange, Rest Area and other Facilities

1. Interchange and Junction

(1) Classification

JH classifies the connection of expressway and highway into the following two categories by the class of highway.

(i) Interchange

This means a connection of an expressway with a normal road, not with another expressway, and requires the type of grade separation used for entry and exit from highway to expressway.

(ii) Junction

This is a type of grade separation and is used for the separation and merging of expressways.

(2) Plan of Interchange Location

Expressways are completely closed to entry and exit from the roadside and drivers must pass through interchanges to travel on the expressways.

The plan of interchange locations is a critical factor for drivers' convenience. The function of an expressway is to provide fast, safe and uninterrupted travel but, if many entrances and exits are installed, constant traffic flow will be disturbed and the original function may be impaired.

For this reason it is not desirable to install interchanges too close to one another. However in the surroundings of big cities, if the number of interchanges is insufficient, traffic congestion occurs due to vehcle concentration into one place. As a solution the distance between interchanges is kept short to increase the diversification effect. In consideration of traffic, social and natural conditions, interchanges are generally planned for the following location.

(a) Crossings or nearest points of important arterial roads such as highways.

(b) Surroundings of cities with a population of more than 30,000, or a location to provide an interchange for areas with a populations of 50,000 to 100,000.

(c) Crossings or nearest points of major roads to important ports, airports, material transport facilities and internationally known sightseeing areas.

(d) Locations with more than 30,000 vehicles per day through the interchange

(e) Locations to maintain the distance between interchanges

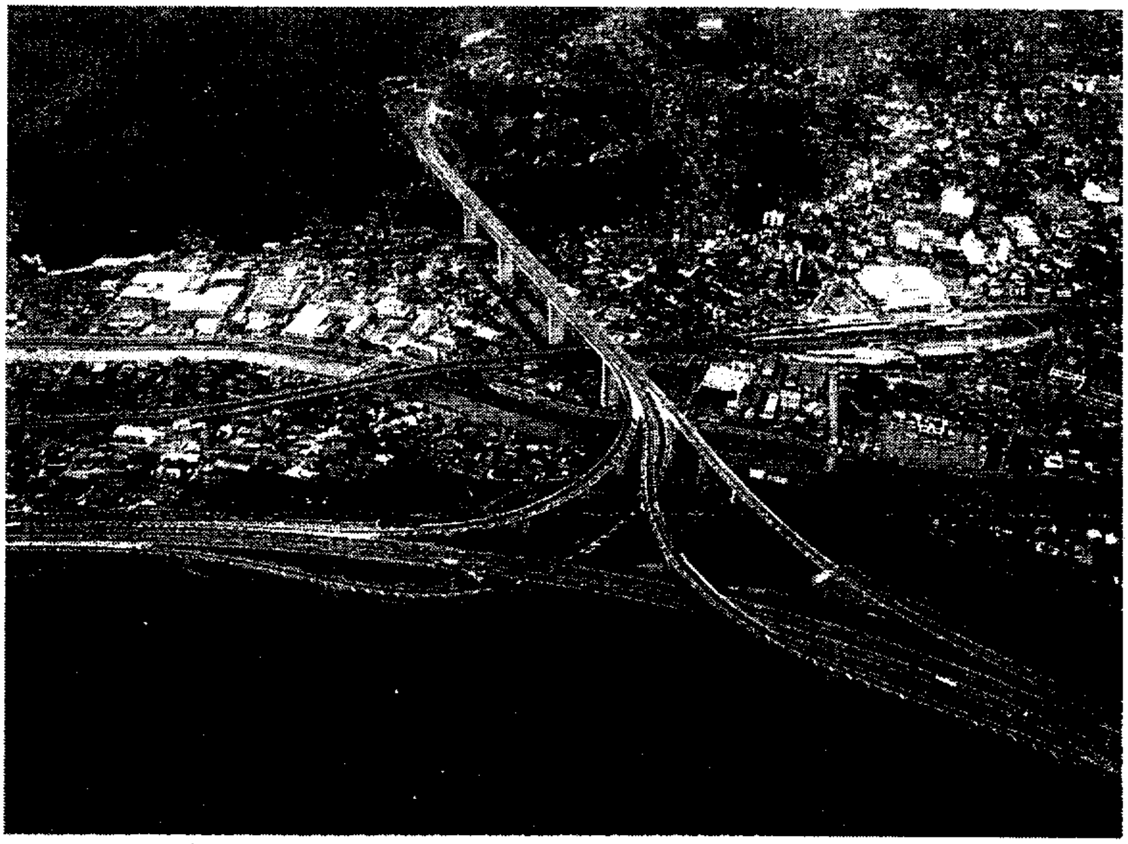


Photo Ⅱ-2-1 OKAYA Junction = Chuo Expresway / Nagano Pref. / 1986

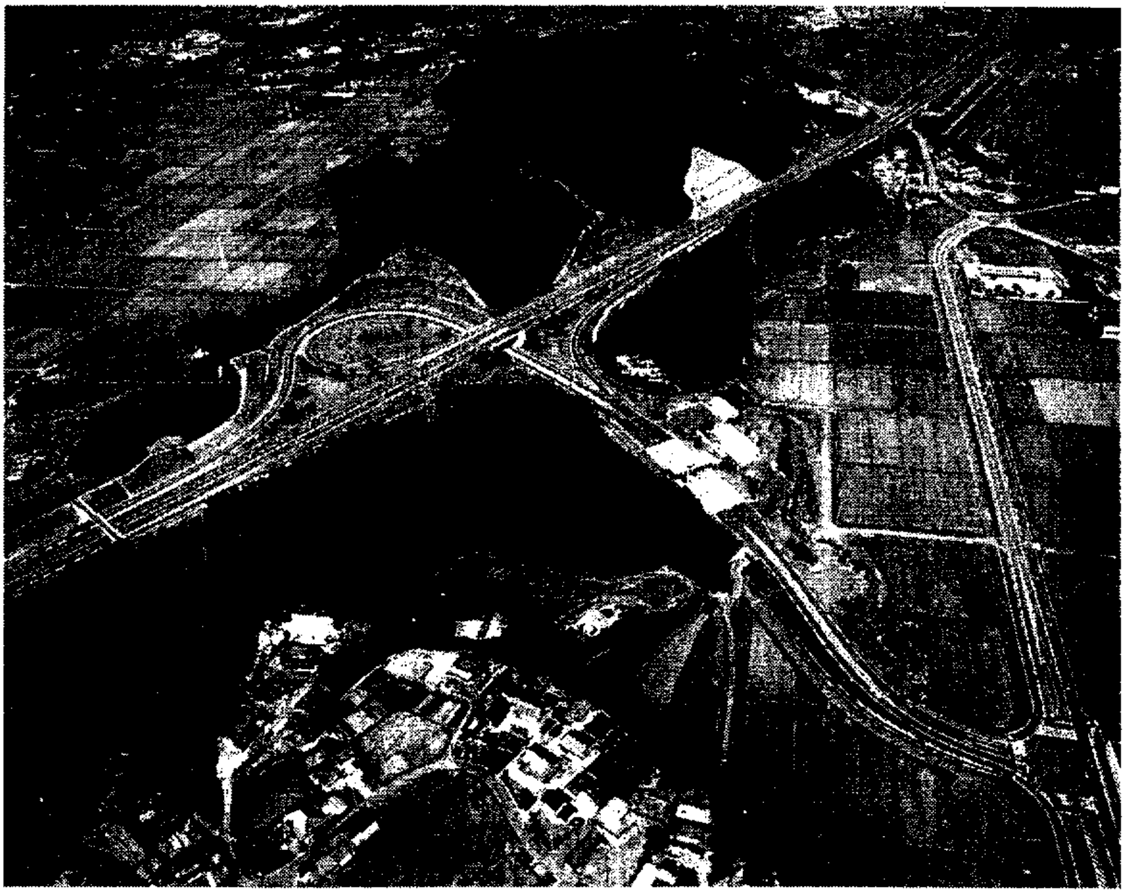


Photo Ⅱ-2-2 KITA IBARAKI Interchange = Joban Expressway / Ibaraki Pref. / 1988 between the minimum 4 km and the maximum 30 km.

The relation between city population and the standard number of interchanges according to the above standard is as shown in the following table.

Population	Standard Number of Interchanges
Less than 100 thousand	1
Less than 100 thousand ~300 thousand	1~2
Less than 300 thousand ~500 thousand	2~3
Over 500 thousand	3

The standard distance between interchanges for each area is listed in the following table.

Area	Standard Distance
Within a city	5Km~10Km
City outskirts	15Km~25Km
Between Cities	20Km~30Km

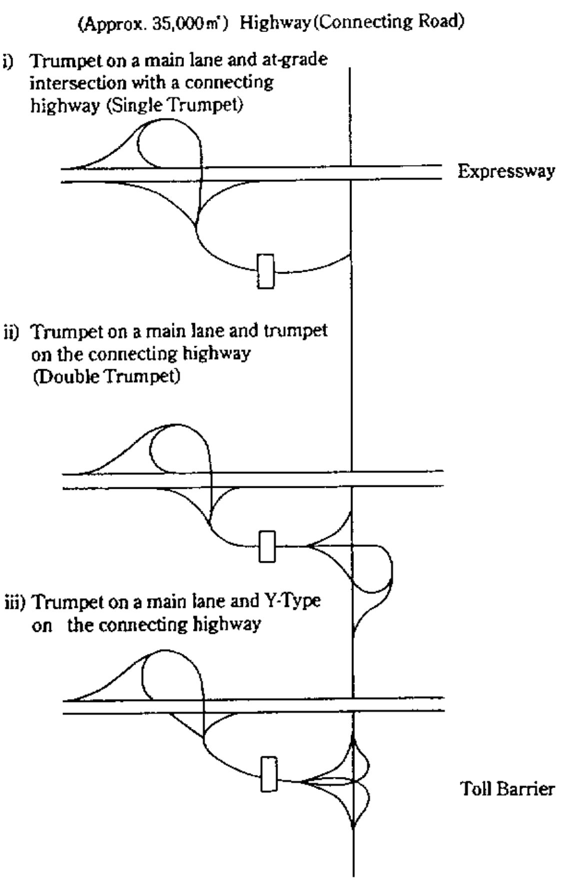
(3) Types and Application of Interchanges

The typical types on expressways are the "Trumpet" and the "Y" because it is easy to install all toll gates in one place.

(a) Trumpet Type

This is the most typical type and is used at the crossings for connecting highways with heavy traffic.

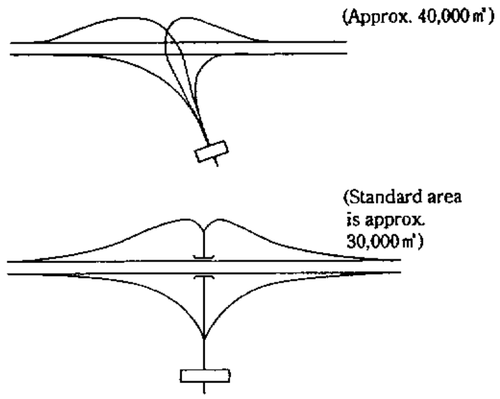
Some examples are illustrated as follows;



(b) Standard Y-Type

This is used in cases where it is difficult to for the loop of a Trumpet-type due tu topographical restrictions.

Large construction space and expense are required because the crossing with main lanes occur at two points.



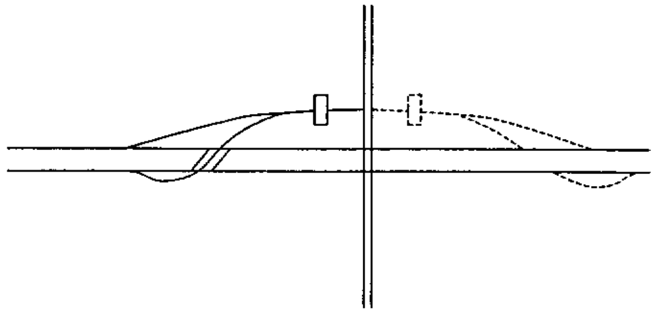
(c) At-Grade Y-Type (including an at-grade intersection between ramps)

This is a variation of the Y-type and is used in cases where traffic is light and no waiting time occurs in crossing an intersection.

Because this type has one intersection with the main lanes, the cost for land and construction is less than for the type described in (b)

(d) Diamond Type

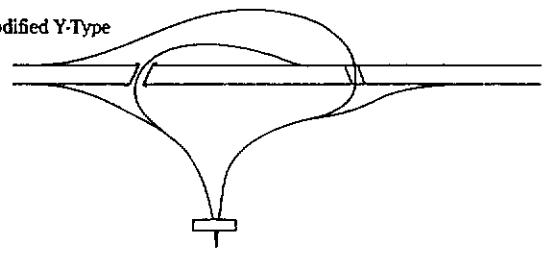
This is applied when the service is mainly for one direction. This is a simple type, and the construction cost is very low. But in cases where service is provides in both directions, toll gates are required at two places and maintenance costs are high.



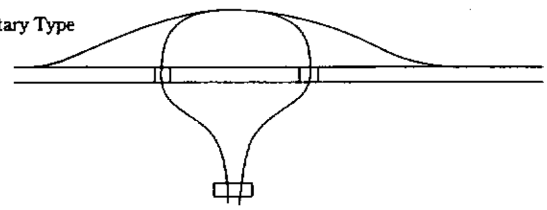
(e) Others

Table II-2-1 shows the number of interchanges of each type installed and in use at present in Japan, and the share of the Trumpet-type is of the total. But in the future, because smaller traffic volume is anticipated on the proposed branch lines and end lines, a study is being made on the application of the at-grade Y-type (with at-grade intersection), which is more economical in construction and land costs.

Modified Y-Type



Rotary Type



Partial Cloverleaf Type

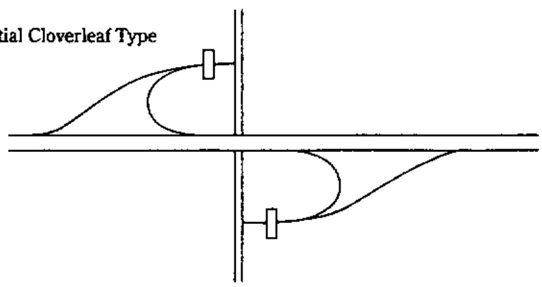


Table II-2-1

	Number	%
Trumpet	397	66
Y-type	113	19
Diamond	59	10
Others	31	5

1998

Table II-2-2

		Design Speed - Main Line (Km/h)			
		120	100	80	60
Radius of plane curve (over m)	Standard	2,000	1,500	1,100	500
	Exception	(1,500)	(1,000)	(700)	(350)
Radius of minimum curve convex type (over m)	Standard	45,000	25,000	12,000	6,000
	Exception	(23,000)	(15,000)	(6,000)	(3,000)
Radius of minimum curve concave type (over m)	Standard	16,000	12,000	8,000	4,000
	Exception	(12,000)	(8,000)	(4,000)	(2,000)
Maximum Grade (%)	Standard	2	2	3	4.5
	Exception	(2)	(3)	(4)	(5.5)

Table II-2-3

Design Speed of Main route / Planned Traffic Volume	120Km/h	100Km/h	80Km/h	60Km/h
More than 10,000 vehicles per day	40Km/h	40Km/h	40Km/h	35Km/h
5,000~10,000 vehicles per day	40Km/h	40Km/h	35Km/h	30Km/h
Less than 5,000 vehicles per day	35Km/h	35Km/h	30Km/h	30Km/h

* Applicable only for connecting side roads with a main road and excepting highway side roads

(4) Geometric Design of Interchanges

The following gives the alignment conditions of the main road for interchange installation, design speed, lane width and geometric design used in interchange design.

(a) Alignment Condition of Main Lane for Interchange Installation

(b) The design speed for interchanges is determined according to the design speed of main road and access traffic volume at the interchange, as per Table II-2-3.

(c) Lane width is of two kinds according to the design speed at the interchange.

(d) Geometric Design

Table II-2-4 shows the radius of the smallest-radius curve, visibility distance, transition curve, grade, vertical curve and combined gradient.

	Standard
40,35Km/h	A Standard
30Km/h	B Standard

* Applicable only for connecting side roads with a main road and excepting highway side roads

(e) Speed Change Lane

A lane is installed with sufficient length for acc4ss vehicles to decrease or increase speed upon entering or leaving the main route.

The two types shown in Fig. II-2-2 are used.

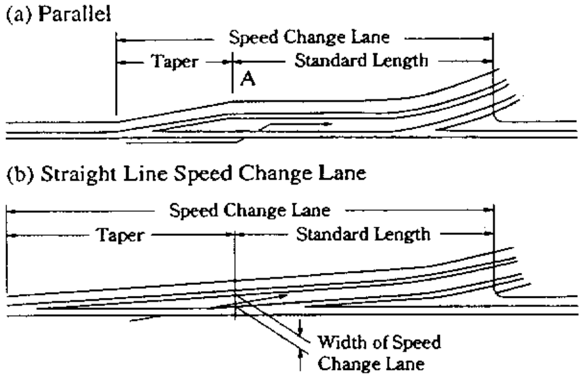
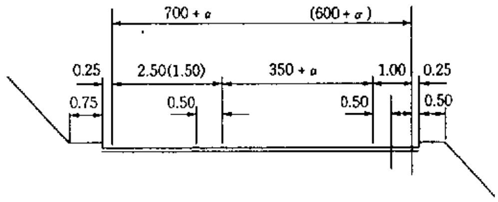


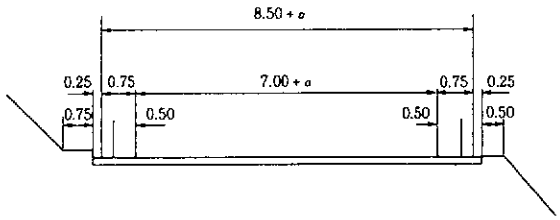
Fig. II-2-2 Shape of Speed Change Lane

One lane in one direction



Two lanes in one direction

Two lanes in two directions without separation



Two lanes in two directions without separation

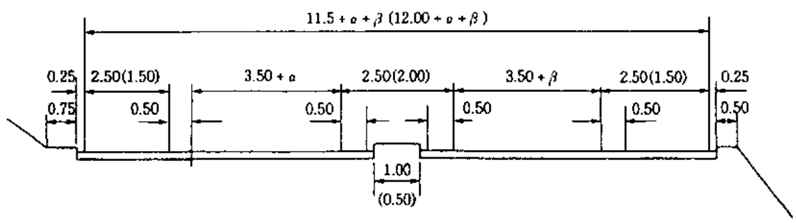


Fig. II-2-1 Cross Section of A-Standard Ramp

Table Ⅱ-2-4 Ramp Design Speed and Standard Value

Design (km/h)	Radius of Minimum		Transition Curve		Maximum Grade		Radius of Minimum Vertical Curve			
							Convex Type		Concave Type	
	Standard (m)	Exception (m)	Minimum Parameter	Radius of Smallest-radius Curve to omit Transition Curve (m)	Standard (%)	Exception (%)	Standard	Exception	Standard	Exception
40	50	40	35	140	6	7	900	450	900	450
35	40	30	30	140	6	7	700	350	700	350
30	30	20	20	140	6	8	500	250	400	300

Design (km/h)	Minimum Length of Vertical Curve (m)		Minimum Combined Gradient (%)	Sight Distance (m)
	Standard	Exception		
40	40	35	11.0	45
35	35	30	11.0	35
30	30	25	11.0	30

(5) Geometric Design and Types of Junctions

An interchange connecting expressways to one another is called a junction and is distinguished from an interchange connecting with highways. This means that a junction is a facility for changing expressways and is an important grade separation with high standards to handle heavy and fast traffic. The design speed applied to junctions is high, at 40 - 80km/h.

Among the types of junction, the Y-type and the Trumpet type are utilized for three-way intersections, and the Y-type is generally adopted in cases of heavy traffic and high lane standards.

A Y-type junction consists of a direct ramp and a semi-direct ramp and can correspond to a high design speed, but it usually has three-way construction whose cost is high due to the many bridges or C-boxes.

In case of small traffic volume and low lane standards, the design speed of a junction is kept low for reasons of economy, and the Trumpet junction is employed. A trumpet junction has a loop as its major feature, and it is generally

Table Ⅱ-2-5 Standard Length of Speed Change Lane

Design Speed(km/h)		120	100	80	60
Length of Deceleration Lane	One lane Two lanes	100 150	90 130	80 110	70 90
Length of Acceleration Lane	One lane Two lanes	200 300	180 260	160 220	10 10
Taper Length	One lane	70	60	50	45
Exit Angle	One lane Two lanes	1/25		1/20	1/15
Entrance Angle	One lane Two lanes	1/40		1/30	1/20

suitable to every topography and economical. It is important to design with sufficient attention to traffic problems which may be caused by a loop ramp, the curve radius of which is necessarily small. It is used for a direction with light traffic.

Sufficient distance from the nose to the minimum curve part is maintained since the vehicles pass through the diverging nose at high speed without speed reduction in a deceleration lane in cases where the loop is on the off-ramp side. Good forward visibility is maintained throughout the loop in order that drivers may see the loop.

A junction with a four-way intersection is often utilized in cities with a large traffic volume. In its construction, while a direct or semi-direct (turbine)type is adopted, a cloverleaf with semi-direct loop on the side with the heavier traffic is used.

In the provinces a full cloverleaf type is also used, but it has the operational deficiency of requiring a detour at the loop and the ramp speed is restricted to about 40 km/h due to space limitations.

It is often appropriate to use a modified cloverleaf, direct or semi-direct.

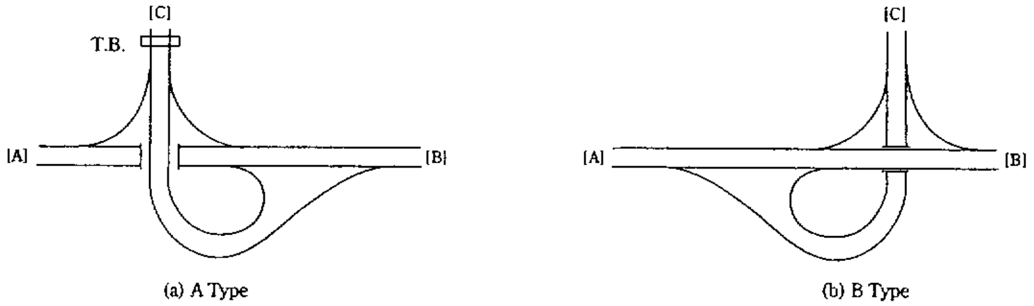


Fig. II-2-3 Trumpet Junction

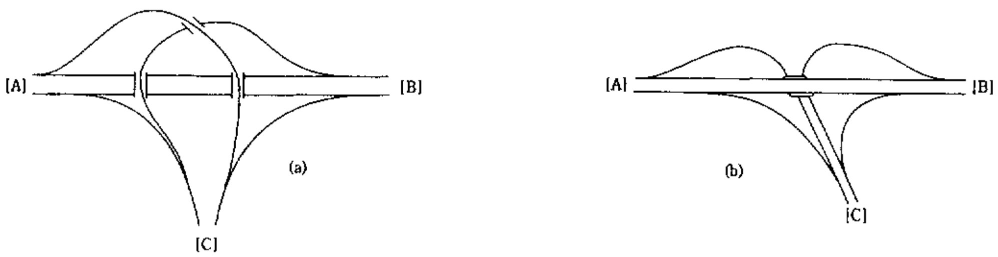


Fig. II-2-4 Semi-direct Y-type Junction

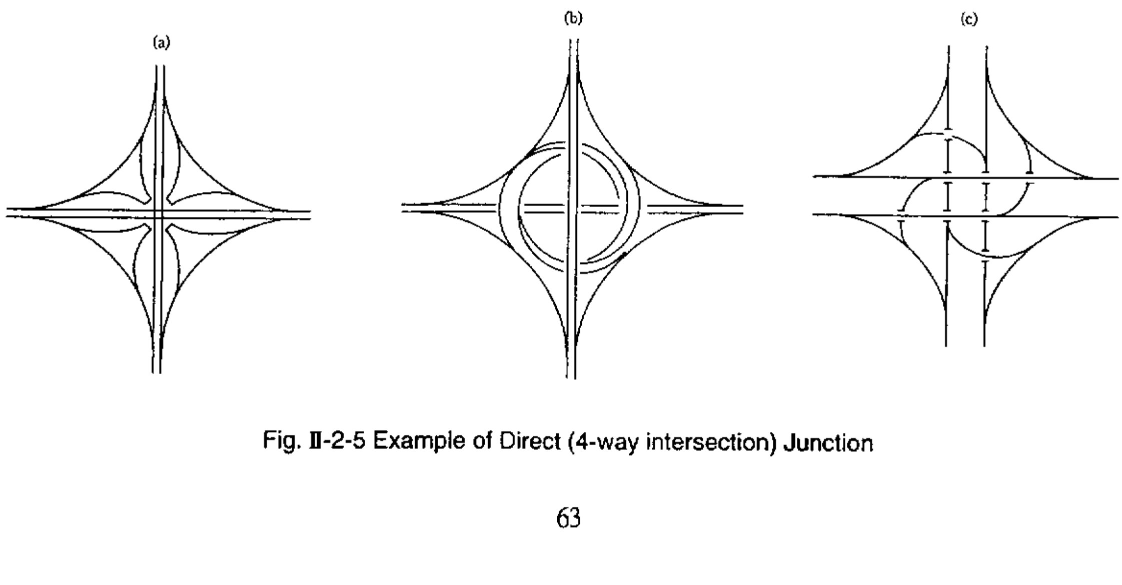


Fig. II-2-5 Example of Direct (4-way intersection) Junction

Table II-2-6 Junction Design Speed (unit:km/h)

Design Speed (sub-route) / Traffic Volume (vehicle/day)	120 km/h	100 km/h	80 km/h	60 km/h
More than 20,000 vehicle/day	80 or 60	80 or 60	60 or 40	60 or 50
Less than 20,000~ more than 10,000 vehicle/day	80 or 60	60 or 50	60 or 50	40
Less than 10,000 vehicle/day	60 or 50	60 or 50	40	40

Table II-2-7 Geometric Design Standard for Junctions

Design (km/h)	Radius of Minimum		Transition Curve		Maximum Grade		Radius of Minimum Vertical Curve			
							Convex Type		Concave Type	
	Standard (m)	Exception (m)	Minimum Parameter	Radius of Minimum Curve to omit Transition Curve	Standard (%)	Exception (%)	Standard	Exception	Standard	Exception
80	280	230	140	800	4	5	4,500	3,000	3,000	2,000
60	150	120	70	350	5	6	2,000	1,400	1,500	1,000
50	100	80	50	220	5.5	6	1,600	800	1,400	700
40	60	50	35	140	6	6	900	450	900	450

Design (km/h)	Minimum Length of Vertical Curve (m)		Minimum Combined Gradient (%)	Sight Distance (m)
	Standard	Exception		
80	100	70	10.5	110
60	70	60	10.5	75
50	60	40	10.5	65
40	40	35	10.5	45

(a) Design Speed of Junction

(b) Lane Width for Junctions

In cases in the design speed category of 80 or 60 km/h Table II-2-7, the lane width is the same as that of the main road, and in other cases, the lane width of standard-A at interchanges is used.

(c) Geometric Design

This is stipulated as shown in the following table.

2. Bus Stop

In order to promote maximum utilization of expressways, bus stops are installed at interchanges and at intermediate points along the route for busses operating between cities. There are, in Japan, many communities with large populations in level terrain and a number of communities with a considerable population in mountanous area.

The bus stops provide on the expressways can offer a high speed transportation system to the communities along these roads by shortening the travelling time for route busses.

The bus stops on expressways are located at sufficient intervals not to interfere with high speed bus operation by requiring too frequent stops and not to unnecessarily disturb the traffic flow in the main lanes by frequent bus entry.

The types are classified into three by location of the bus stop.

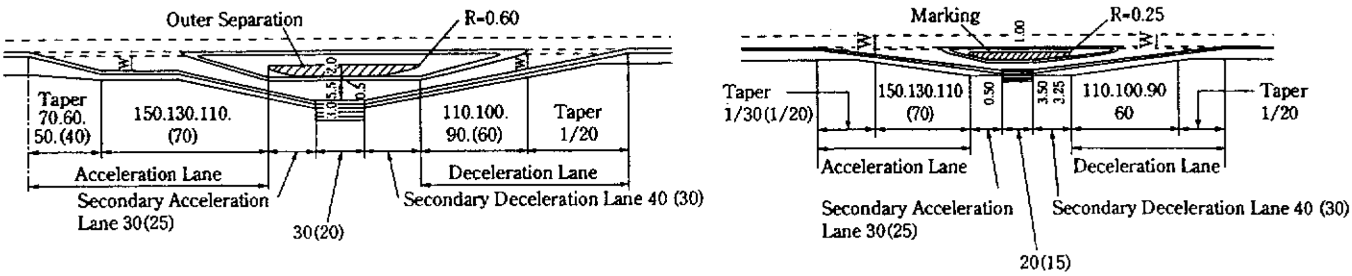
A rough sketch is given below.

3. Rest Area

(1) Objective

The expressways in Japan are fully controlled for entry and exit, and their facilities are not available to outside users. This means that an expressway is a roadway with control of the number of entrances and exits to the main traffic flow, in order to maintain rapid, constant, comfortable and safe driving, the original purpose of the expressway.

The provision of service facilities at proper intervals for comfortable and safe driving is indispensable to expressways users.



W : Width of Speed Change Lane. Figures in parenthesis apply in case that design speed is 60km/h

Fig. II-2-6 Typical Design of Bus Stops Between Interchanges

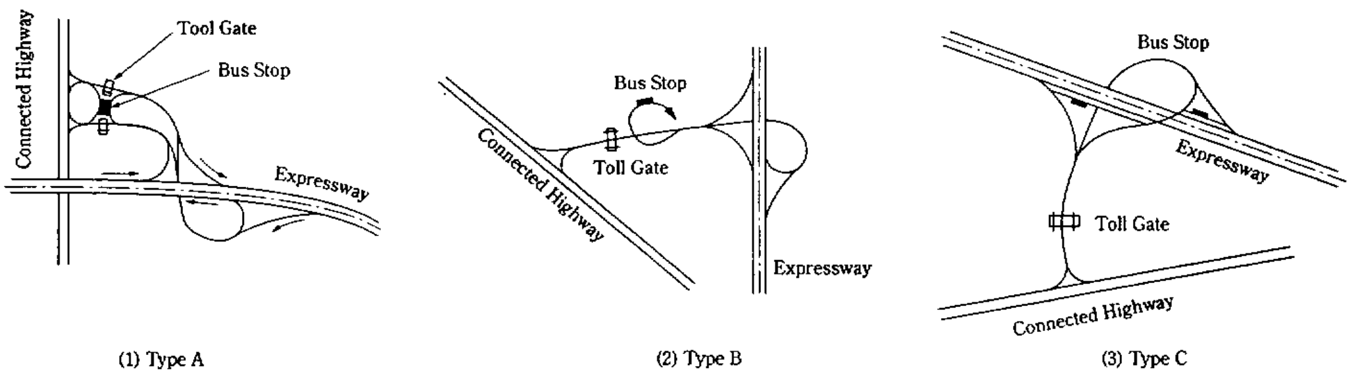


Fig. II-2-7 Typical Design of Bus Stops at Interchanges

(2) Classification

The functions of rest facilities are classified into two categories, and they are installed in appropriate combinations at various location intervals.

(a) Service Area

Restaurant, Parking Area, Public Lavatory, Gas Station, Free Rest Place, Route Information, Repair Shop, Garden

(b) Parking Area

Vending Machines, Parking Area, Public Lavatory, Garden

(3) Plan of Location

In the study of a location, consideration is given to roadside conditions such as topography and geometric design of the route for a systematic combination of service area and parking area and to maintain the proper interval between interchanges.

Suwa Service Area beside Lake Suwa

Oya Parking Area of Tohoku Expressway

· Intervals between interchange and rest facilities
· Roadside conditions

If rest facilities are provided along an expressway, little objection is raised by local residents. A place with a convenient water supply and drainage is suitable.

· Condition for Road Structure

The structure is to adjust the soil volume of the main road and is very economical.

· Alignment condition of route
· Intervals between interchange and rest facilities

	Minimum Interval		Standard Interval	Maximum Interval
	Standard	Exception		
Between Interchange and Facilities	5 Km	3 Km	—	—
Between Rest Facilities			15 Km	25 Km
Between Service Areas			50 Km	100 Km

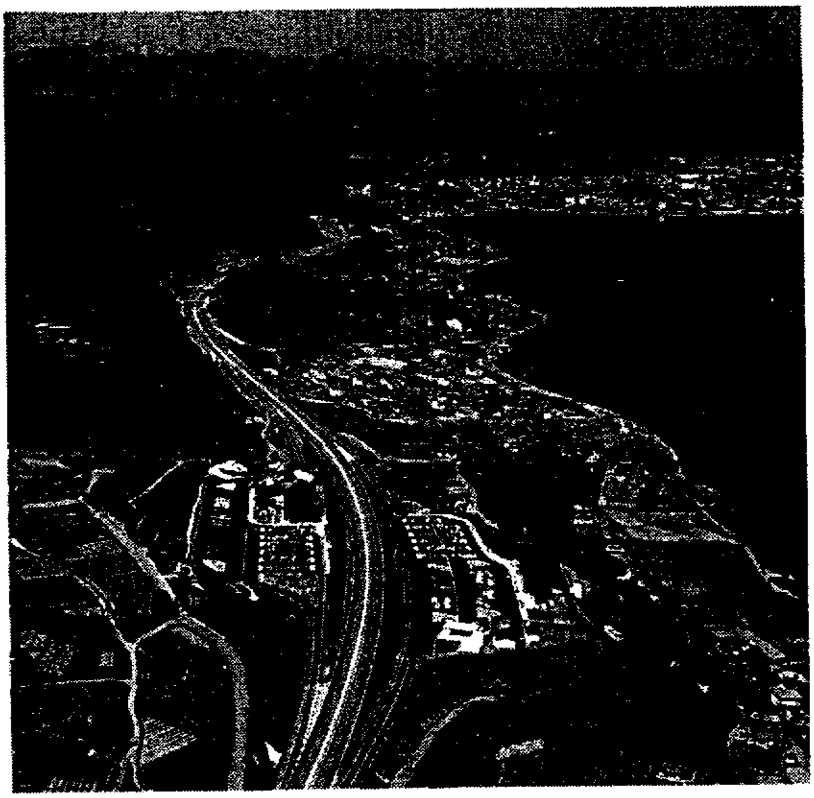


Photo Ⅱ-2-3 Suwa Service Area beside Lake Suwa

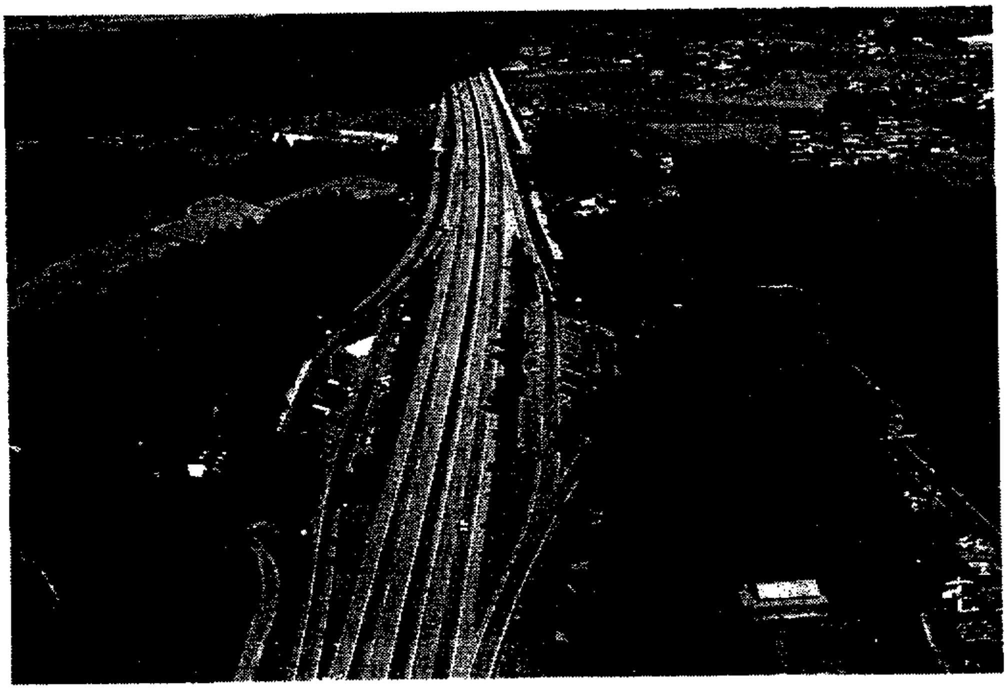


Photo Ⅱ-2-4 Oya Parking Area of Tohoku Expressway

Table II-2-8 Alignment of Main Road at Location Selected for Service Area

Alignment Factor / Design Speed Main Road	Radius of Horizontal Curve(m)		Minimum Radius of Vertical Curve Convex type (m)		Minimum Radius of Vertical Curve Concave type(m)		Maximum Grade (%)	
120	2,000	1,500	45,000	23,000	16,000	12,000	2	2
100	1,500	1,000	25,000	15,000	12,000	8,000	2	3
80	1,000	700	12,000	6,000	8,000	4,000	3	4
60	500	400	5,000	3,000	4,000	2,000	4.5	5.5

Table II-2-9 Alignment of Main Road at Location Selected for Parking Area

Alignment Factor / Design Speed for Main Road	Radius of Horizontal Curve(m)		Minimum Radius of Vertical Curve Convex type (m)		Minimum Radius of Vertical Curve Concave type(m)		Maximum Grade (%)	
120	1,500	1,200	45,000	23,000	15,000	12,000	2	3
100	1,000	850	25,000	15,000	12,000	8,000	3	4
80	700	600	12,000	6,000	8,000	4,000	4	5
60	400	400	6,000	3,000	4,000	2,000	4.5	5.5

(4) Types of Rest Areas

a) Types of Service Area

These are classified by location into the following three categories.

① Classification by the relationship between parking area and main road

- With separation between the two directions traffic parking areas are installed on both sides.
- One side

  A parking area is provided on one side.

② Classification by location of the building, whether it is located outside the through road or inside it

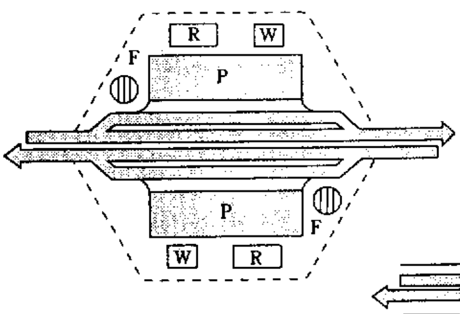
- Outer type

  The restaurant is located outside the through road.
- Inner type

  The restaurant is located inside the through road.

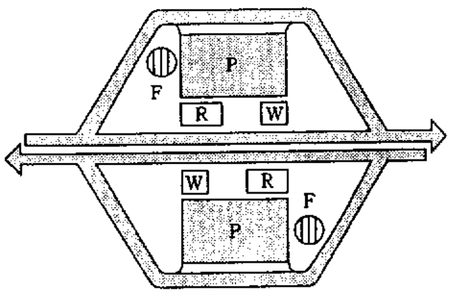
③ Classification by location of the gas station

- Entrance type
- Central type
- Exit type



(a) Outward Type

Fig. II-2-8



(b) Inward Type

Fig. II-2-9

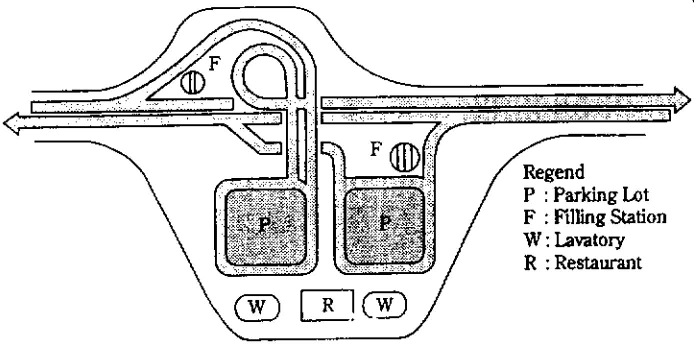


Fig. II-2-10

There are combination of the above types, but in general, a traffic direction separation, external and exit type is used in Japan. Examples of service areas are shown in Figs.II-2-8 to II-2-10.

b) Types of Parking Area
   Different from service areas, a parking area is limited to the minimum required facility and is classified by the relationship between parking area and main road and between building and through road. In principle, traffic direction separation and external type is used. The arrangement of various facilities of the type illustrated in Fig. II-2-11 is common.

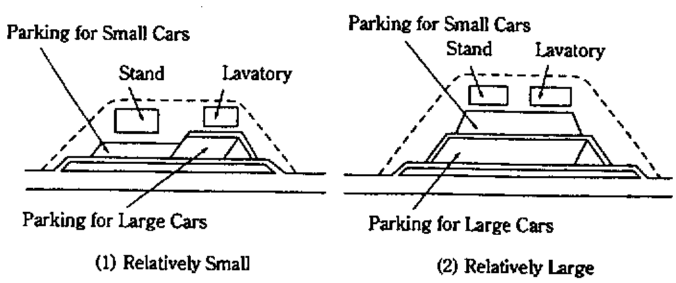
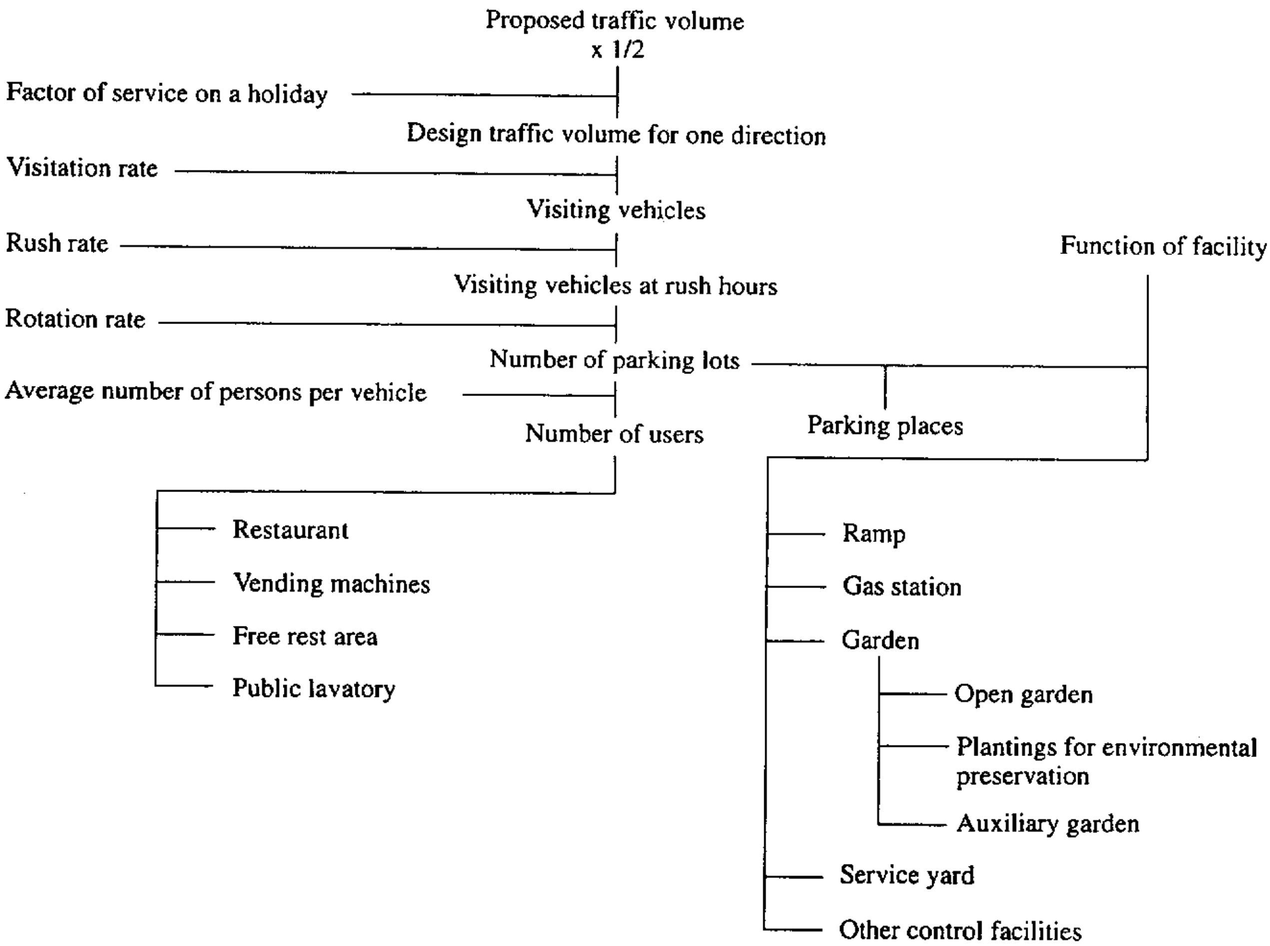


Fig. II-2-11

c) In the case of a combined installation of rest facility and interchange, the line of Traffic of users may become complicated and operation difficult compared with separate installations. But when the interchange and the rest facility are required within a limited area due tu topographical restrictions, this type is used. It is adopted in cases where the traffic line can be handled properly because the interchange access traffic and the number of vehicles using the rest facility are small.



(5) Scale for Rest Areas

The total scale of a rest facility is obtained by adding the scales of each structural factor, which are calculated according to the proposed traffic volume and the established number of parking lots.

a) Parking Lot

Parking Lot = Proposed Traffic Volume × 1/2
× Holiday Service Factor
× Visitation Rate x rush Rate/
rotation

Kind of Facility	Kind of Vehicle	Visitation Rate	Rush Rate	Average Parking Time (minute)
Service Area	Small vehicle	0.175	0.10	25
	Large bus	0.25	0.25	20
	Large truck	0.125	0.075	30
Parking Area	Small vehicle	0.10	0.10	15
	Large bus	0.10	0.25	15
	Large truck	0.125	0.10	20

Average Daily Traffic Volume (vehicle /day in both directions)	Holiday Service Factor
$0 < Q \leqq 25{,}000$	1.40
$25{,}000 < Q \leqq 50{,}000$	$1.65 - Q \times 10^{-5}$
$50{,}000 < Q$	1.15

Holiday Service Factor :
Factor to be used for calculating the traffic volume on the 35th day of a 365 day year, using average daily traffic volume.

Visitation Rate : Number of visiting Vehicle (vehicle/day)/Traffic Volume on Main Road (vehicle/day)

Rush Rate : Visiting Vehicle at Rush Hours (vehicle/day)/Visiting Vehicles (vehicle/day)

Rotation : 1 (hour)/Average Parking Time (hour)

b) Garden Composition

Garden is composed of the elements shown in Fig. II-2-12

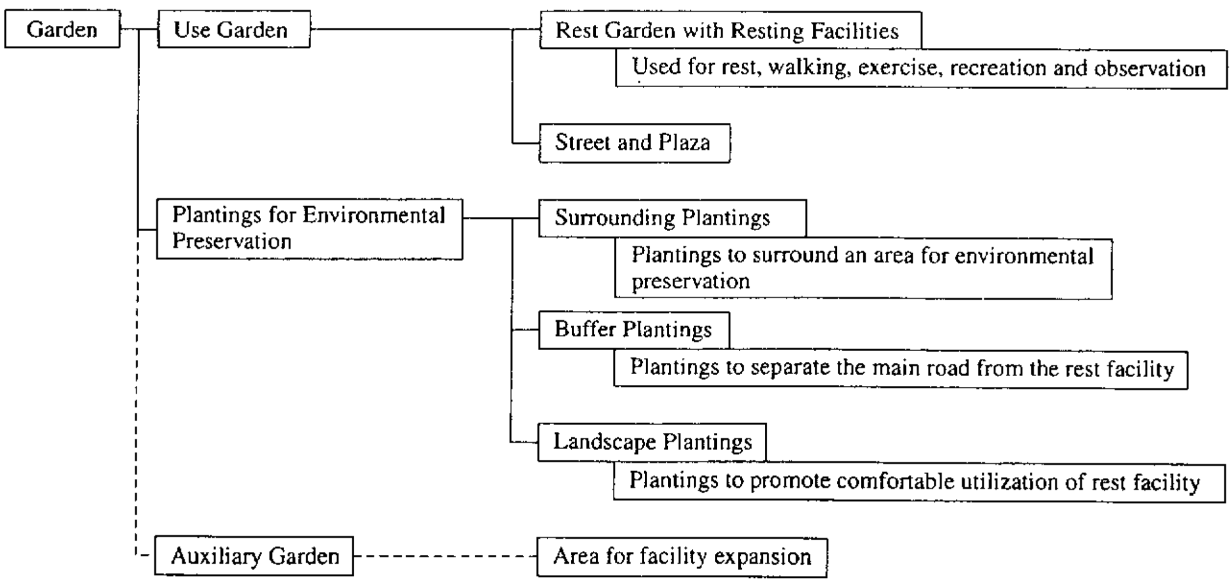


Table Ⅱ-2-10 Standard Number of Parking Spaces

Kind of Rest Facility	Number of Parking Area (one side)					
	Maximum		Standard		Minimum	
Service Area	250	Small vehicle 200 Large vehicle 50	100 to 200	Small vehicle 70 Large vehicle 30 Small vehicle 150 Large vehicle 50	70	Small vehicle 50 Large vehicle 20
Parking Area	60	Small vehicle 40 Large vehicle 20	25 to 40	Small vehicle 20 Large vehicle 5 Small vehicle 30 Large vehicle 10	15	Small vehicle 10 Large vehicle 5

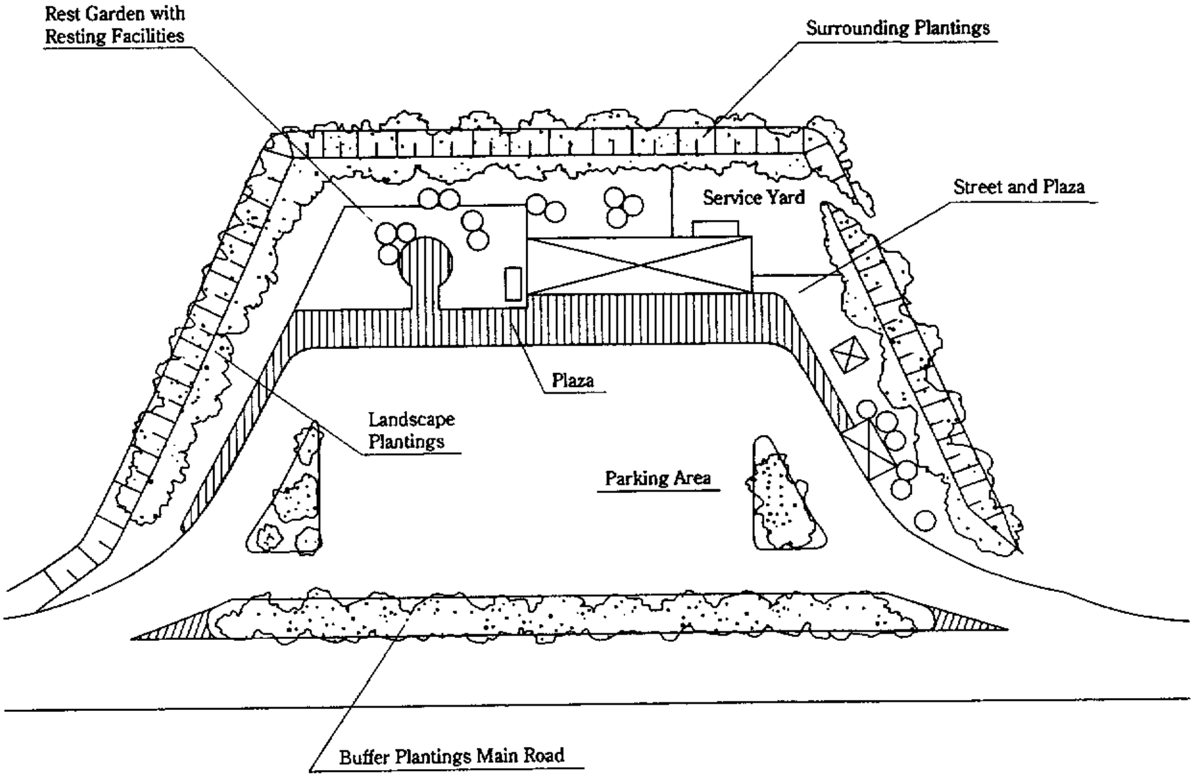


Fig. Ⅱ-2-12 Composition of Garden

c) Total Scale

The Rest facility is composed of parking area, various service facilities and garden. The total area of a rest facility in Japan is 50-80 ha for service area (both sides) and 20-40 ha for parking area. The area parking is 1/2-1/3 of the above area.

4. Toll Gate

Since an expressway is a tool road, it is necessary to install a facility to collect fees from the using vehicles. The toll barrier is the facility for this purpose. The toll barrier is composed of tool office, toll gate (island, booth, gate, building), plaza (toll plaza) and is classified by place of installation into two kinds.

- Toll gate on a main road:
  Toll gate installed on the main road
- Toll gate at an interchange:
  Toll gate installed at an interchange

A general drawing for a toll barrier at an interchange is

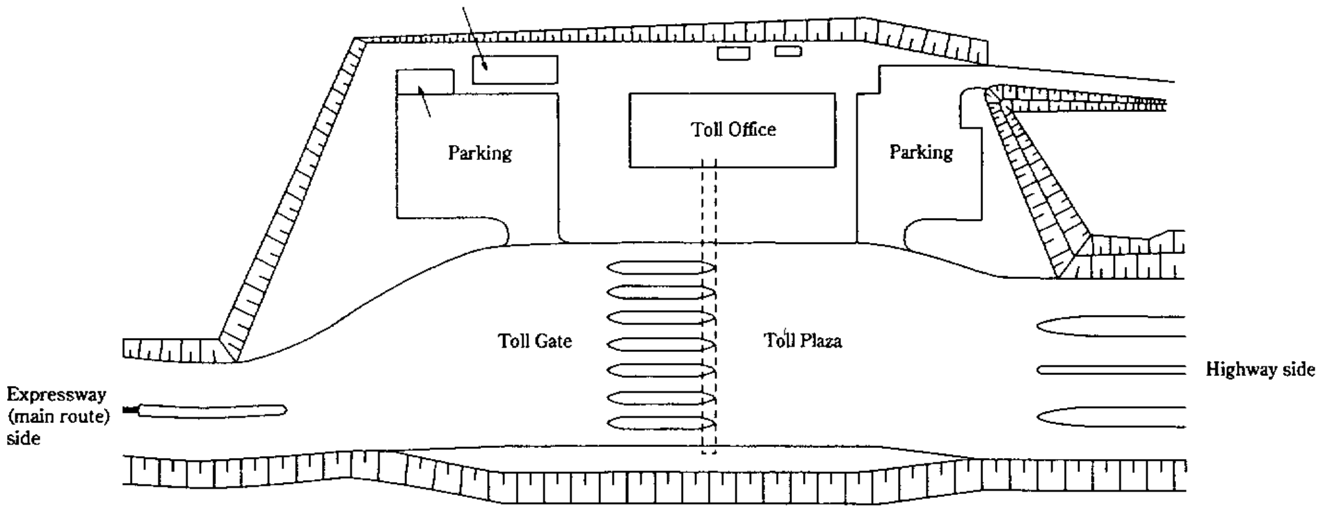


Fig. Ⅱ-2-13 Toll Barrier

illustrated in Fig. Ⅱ-2-13.

a) Toll Office

This is a building in which staff collecting fees rest and conduct business, and its scale varies according to the facilities provided at the interchange. (Overall maintenance or snow removal work)

b) Toll Gate

In this facility toll collecting machines are installed, and the staff perform the collection.

c) Toll Plaza

This is an area created by expansion of the part of the lane provided for installation of a toll gate.

(1) Calculation of the Number of Lanes at a Toll Plaza

The required number of lanes at a toll gate is calculated by the access traffic volume at the interchange, the time required for collection at the toll gate (average service time) and the number of vehicles waiting to pay (service standard).

a) Traffic volume at normal times

This is the 30th time traffic volume calculated according to the estimated access traffic volume at the interchange, adjusted by K-value (ratio of the 30th time traffic volume against ADT) and D-value (ratio of the traffic volume in the direction with more traffic at 30th time traffic volume against that in both directions)

Normal Time Traffic Volume (DHV)=ADT KXD

b) Average Service Time

This is generally 6 sets at the entrance side and 14 secs. at the exit side.

c) Service Standard

The number of waiting vehicles is usually one.

d) Vehicle Handling Capacity at Toll Gate

The maximum number of vehicles at toll gates with lanes are, by service time, as follows;

(2) Geometric Design of Toll Gates

The cross section is as shown below, and the lane width is that required for large vehicles.

A width of 3.0m is required to accommodate the fee collector and a vehicle.

The left most lane is 3.5m wide to accommodate maintenance vehicles. (in cold areas with snow, the width is 4.0m wide to allow snow removal vehicles)

The grade is less than 2% at the front and back slopes of a toll gate, which does not require braking of the vehicles moving through the gate, and the cross slope is less than 2% at the maximum but is enough to provide drainage.

Table Ⅱ-2-11 Vehicle Handling Capacity at Toll Gate

Number of Lanes \ Service Time	6	8	10	14	18
Average No. of Waiting Vehicles	1.0	1.0	1.0	1.0	1.0
1	300	230	180	130	100
2	850	640	510	360	280
3	1,420	1,070	850	610	480
4	2,000	1,500	1,200	860	670
5	2,590	1,940	1,550	1,110	860
6	3,180	2,380	1,910	1,360	1,060
7	3,770	2,830	2,260	1,620	1,260
8	4,360	3,270	2,620	1,870	1,450
9	4,960	3,720	2,980	2,130	1,650
10	5,560	4,170	3,330	2,380	1,850

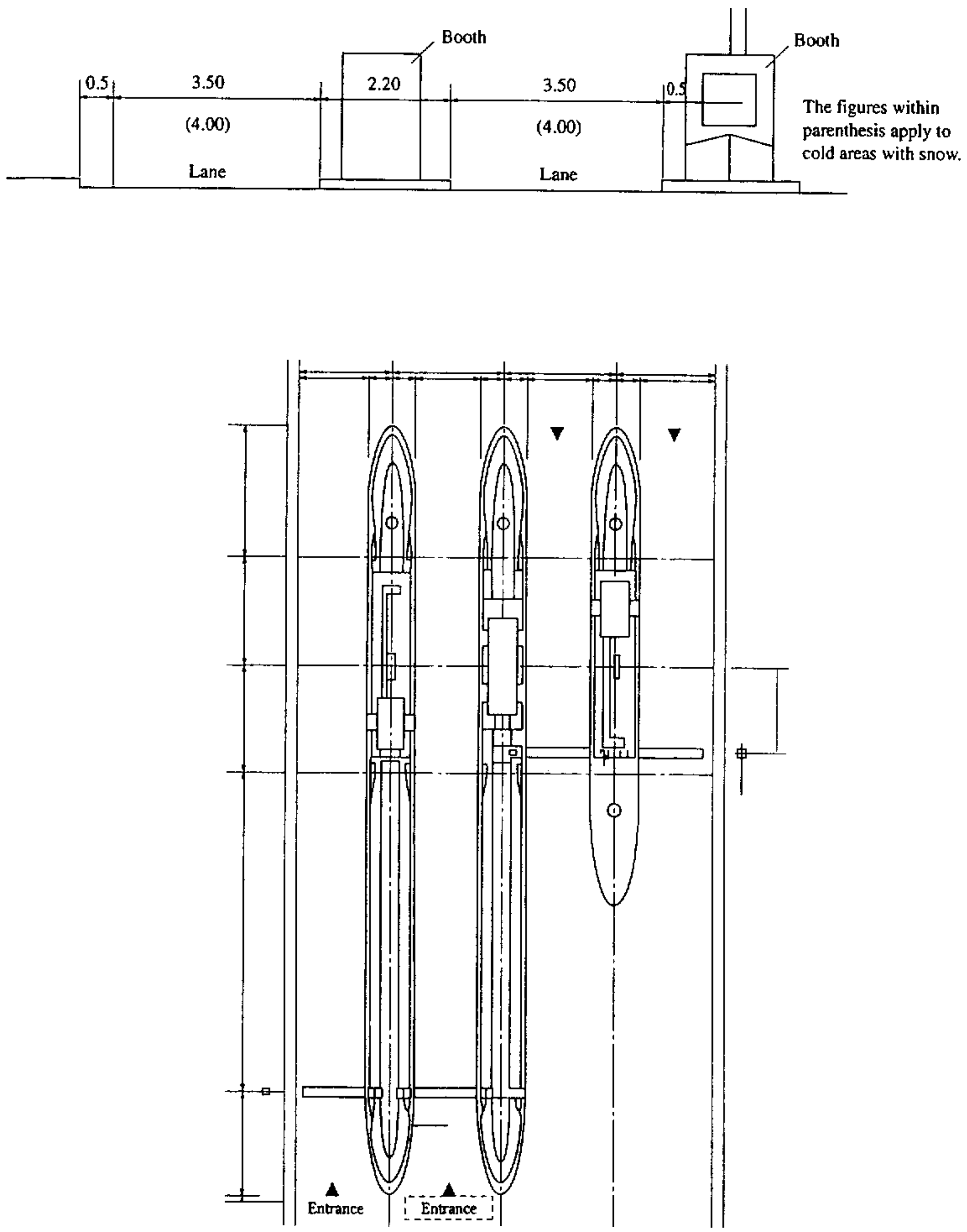


Fig. II-2-14 Figure of a Toll Gate

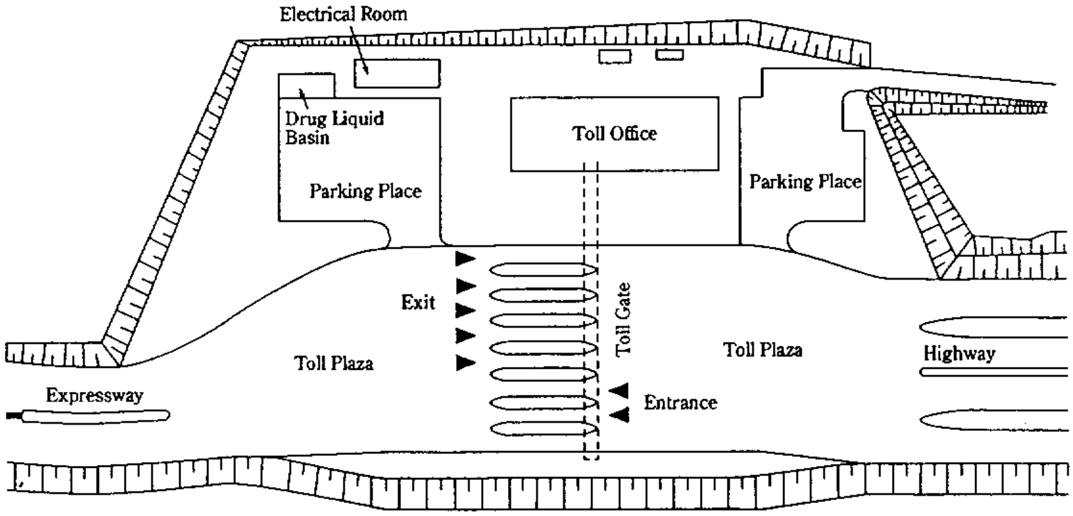


Fig. II-2-15 Location of Toll Gate

Ⅲ. TRAFFIC SAFETY DEVICES

1. Guard Fence

(1) Definition of the Protective Barrier

Protective barriers prevent errant vehicles from leaving the proper lane or encroaching into opposite lanes, and redirect them back to the right course while minimizing damage to the occupants of the vehicles and to the other vehicles. The secondary purpose of protective barriers is visual guidance of drivers.

(2) Types of Protective Barriers

The following types are available.

Table Ⅲ-1 Types of Protective Barriers

Level of rigidity	Type of barrier	Outline
Flexible barriers	Guard rails	Wave rails connected together and supported by posts
	Box beam	Box beam pipes supported by posts
	Cable type	Initially tensioned cables supported by posts
	Beam-type for bridges	Multiple circular or angular beams of closed sections supported by posts
Rigid barriers	Concrete protective barriers	Concrete barriers with vartical or sloped front surface, free from plastic deformation

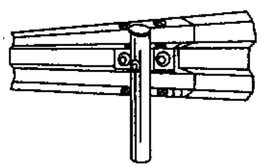


Fig. Ⅲ-1 Guard rail

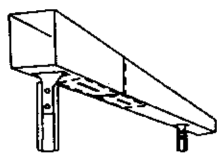


Fig. Ⅲ-2 Box beam

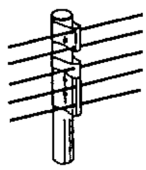


Fig. Ⅲ-3 Cable type

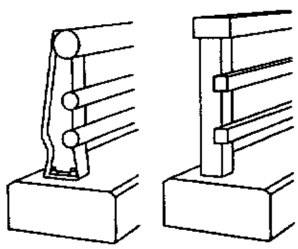
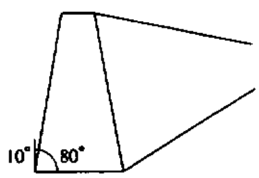
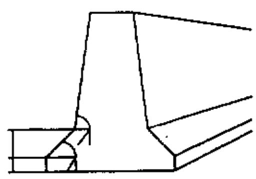


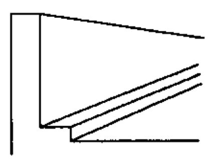
Fig. Ⅲ-4 Beam-type for bridges



Slope Type



Florida Type



Vertical-wall Type

Fig. Ⅲ-5 Concrete Protective Barriers

(3) Classifications of Protective Barriers

Protective barriers are divided into the following classifications according to the strength (impact level).

(4) Places of Installation

(i) Roadside

Protective barriers are basically installed in the following sections.

a) Embankment sections
b) Sections where bridges, overpasses and box culverts are located
c) Sections where piers, abutments, sign posts, emergency telephones, etc. are located
d) Cut sections near tunnel portals
e) Cut sections with a height of 1.5 m or less and cut sections with an 1.5 m-plus height of cut and an length of 40 m or less
f) Traffic islands between service areas or parking areas and main traffic lanes

(ii) Median strip

Median strips are basically equipped with protective barriers throughout the highway.

Table Ⅲ-2 Classitications of Protective Barriers

Classifications		Vehicle weight (t)	At-crash speed (km/h)	At-crash grade (degrees)	Strength (impact level) (kJ)
Roadside barriers	Median barriers				
A	Am	25	45	15	130
SC	SCm		50		160
SB	SBm		65		280
SA	SAm		80		420
SS	SSm		100		650

(5) Application of Protective Barriers by Classification

The classifications of protective barriers applied according to the design speed and section of installation are listed in Table Ⅲ-2.

The sections vulnerable to serious damage include the following.

a) Sections crossing or near to railway lines in the suburbs of big cities or local trunk railway lines
b) Sections crossing or near to high-speed, heavy-traffic-expressways or fully-access-controlled highways
c) High-speed, heavily trafficked sections with median strips
d) Sections where serious secondary damage is expected.
e) Sections where the safety of vehicle occupants is likely to be seriously threatened due to the existence of large off-street drops or other factors

Table Ⅲ-3 Application of Protective Barriers

Classification of highways	Design speed	Ordinary sections	Sections vulnerable to severe damage	Sections crossing or nearing the Shinkansen (bullet train) lines
National expressways Fully-access-controlled highways	100 km/h or higher	A, Am	SB, SBm	SS, SSm
	80 km/h			
	60 km/h		SC, SCm	SA, SAm

2. Traffic Sign

(1) Purpose

Traffic signs are aimed at providing guidance, warnings, notice and regulatory information to road users in certain formats for ensuring safe and smooth traffic.

(2) Classification

Traffic signs are grouped into four classes.

(i) Guide signs

Guide signs inform drivers of their positions by indicating directions and distance to designations, and landmarks including famous points, and provide information on roadside areas for the convenience of travellers.

(ii) Warning signs

Warning signs are installed mainly for notifying drivers of conditions on or adjacent to a street that are potentially hazardous to traffic operations or require particular attention, and for advising drivers to exercise caution.

(iii) Regulatory signs

Regulatory signs are used for traffic control, restriction or specification, and include closed-to-traffic, speed limit and access-control signs.

(iv) Notice signs

Notice signs inform drivers of regulations ahead in the lane, specify areas where parking is allowed and provide other information on the points necessary for traffic operations.

(3) Examples of S igns

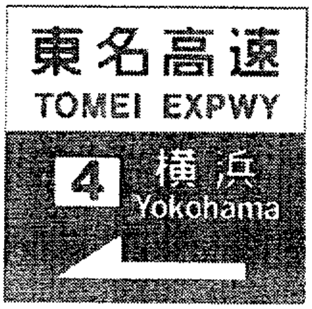
(i) Guide signs

Guide signs are intended mainly to provide information on positions, areas, etc. to drivers for guidance in the speedy and assured travel to the destinations. The pieces of information required by drivers until they reach their destinations and the corresponding signs are listed in Table Ⅲ-4.

Table Ⅲ-4 Information Provided by Guide Signs

Position on the highway			Information required for road users' decision-making	Corresponding information to be provided	Information displayed: Minimum information required for logical route guidance	Information displayed: Other information	Related signs
Entrance ramp guide	National highway		⓪ Entrance ramp which the driver is heading for	· Advance notice of entrance ramp	· Name of entrance ramp · Entrance ramp number · Distance to entrance ramp · Direction	· Destination	· Entrance ramp guide signs
Route guide	Section of uninterrupted flow		① Information on the highway on which the vehicle is currently running ② Information on the area to which the vehicle is currently moving	· Route on which the vehicle is running · Direction in which the vehicle is currently moving · Presence of target exit · Distance to target exit		· Kilometer post	· Guide signs for confirmation (direction and distance)
Route guide	Section of uninterrupted flow		③ Information for confirming approximate current position on the route	· Present position		· Prefecture · Famous point · Route boundary · Junction name	· Roadside guide signs (jurisdictional boundaries, tunnels, rivers, etc.) · Areas and distance signs for confirmation · Junction name guide signs
Route guide	Near the Junction	Immediately before the junction (advance notice of the branch)	④ Information on the direction	· Route to follow · Direction in which to travel · Distance to the junction	· Route number or route name · Direction · Distance to the junction	· Destination	· Advance branch notice signs
Route guide	Near the Junction	Junction (junction guide)	④ Information on the direction	· Route to follow · Direction in which to travel	· Route number or route name · Direction	· Destination	· Junction guide sign
Route guide	Near the Junction	Immediately after the junction (guide for confirmation)	⑤ Information for confirming the direction	· Route selected · Direction selected	· Route number or route name · Direction	· Destination	· Hybrid guide signs which display ⑤ and provide ① and ② as well. Guide signs for confirmation double as guide signs in sections of uninterrupted flow. (Guide signs for confirmation)

Exit ramp guide	Near the exit ramp	⑥ Information for confirming the desired exit ramp	· Advance notice of exit ramp	· Exit ramp name · Exit ramp number · Distance to exit	· Locations accessible from the exit and access roads	· Locations accessible from the exit and access roads are indicated. Signs for confirmation are installed beyond the point of exit sign.
			· Exit ramp	· Exit ramp name · Exit ramp number		· Exit guide signs
	Toll Barrier on the expressway			· Toll plaza name · Distance to toll plaza		· Toll plazas and check barriers
	End of the expressway			· Exit ramp name · Exit ramp number · Distance to exit		· End mark
Guide on auxiliary facilities			Information on the positions of auxiliary facilities on the highway	Note 1) Destination (place to which one is directed displayed on guide signs), encouragement to secure adequate headways, emergency phone signs, emergency parking lanes, automatic ticket dispenser signs, electronic toll collection system signs, climbing lanes, emergency exits and evacuation passages in the tunnel, centerlines, inside lanes, outside lanes, areas for applying or removing tire chains, bus stops, advance notice of outside lanes, highway radios, etc.		
	Rest areas	Information for confirming the desired rest area	· Advance notice of entrance to rest area · Entrance	· Name of entrance		Guide for service areas and rest areas, advance notice of rest area, parking space signs, signs for facilities for the handicapped (guide signs for any facilities)



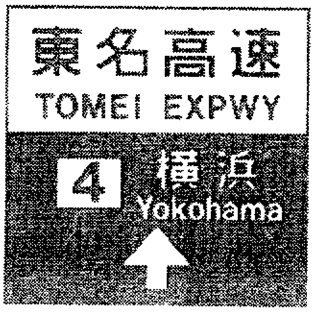


Fig. Ⅲ-6 Direction of entrance (103-A)

Fig. Ⅲ-7 Advance notice of entrance (104)

Fig. Ⅲ-8 Areas and advance notice of exit (100-A)

Fig. Ⅲ-9 Areas and exit (112-A)

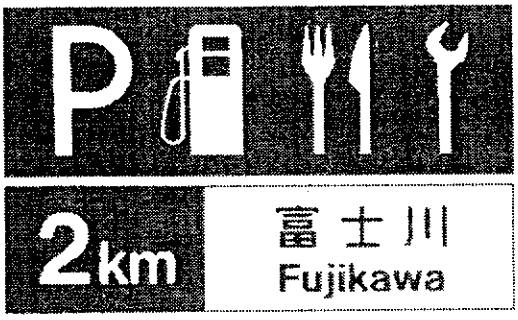


Fig. Ⅲ-10 Services (116-A)

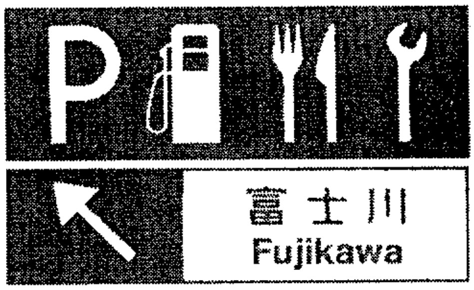


Fig. Ⅲ-11 Services (116-B)

(ii) Warning signs

Table Ⅲ-5 Advance Warnings and Warning Signs

Advance warning		Type of sign	Remarks
Advance warning of changes in road alignment	Advance warning of changes in horizontal alignment	"Bend Ahead", "Turn Ahead", "S-shaped Bend Ahead", "Reverse Turn Ahead"	"S-shaped Bend Ahead", "Reverse Turn Ahead". Only warning lamps are installed for "Reverse Turn Ahead"
	Advance warning of changes in vertical alignment	"Steep Downslope Ahead", "Steep Upslope Ahead"	――――
	Advance warning of changes in traffic flow	"Merging Traffic Ahead", "Lane Decrease", "Two-way traffic", "Opposing Traffic Ahead"	――――
Advance warning of weather-induced changes in road surface and road conditions	Advance warning of changes of road surface	"Freezing"	――――
	Warnings of cross wind and fog	"Cross wind", "Fog"	――――
Other advance warnings	Advance warning of animals crossing the road	"Animals crossing the road"	――――
	Roadside environmental conservation	"No snow disposal"	Bulletin boards for road administrators
	Guidance at steep curvatures in horizontal alignment and at the end of an expressway	"Arrows"	Signs are installed continuously along the outside edge of the road.
	Prevention of slope fires	"No cigarette tossing"	――――
	Prevention of rear-end collisions	"Secure adequate headway"	――――
	Safe traffic in tunnels	"Lighting in the tunnel", "Radio rebroadcast available"	――――

"Right (or left) curve" (202)

"Right (or left) turn" (203)

※ Display of the radius of curvature (R=xx m) with the sign board is also desired on the expressway.

Fig. Ⅲ-12 Bend and turning signs

Fig. Ⅲ-13 Steep slope

Fig. Ⅲ-14 Advance warning of a long downhill

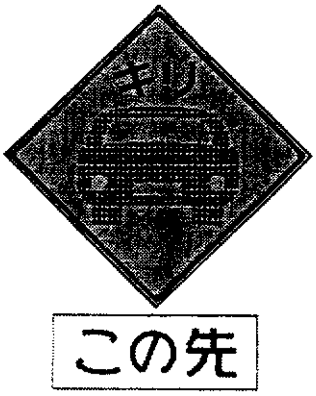


Fig. Ⅲ-15 Advance cautious driving in the fog

Fig. Ⅲ-16 "Slippery" (209)

Fig. Ⅲ-17 "(Warning of) cross wind"

Fig. Ⅲ-18 "Animals crossing the road" (214-2)

Fig. Ⅲ-19 "Animals crossing the road" (monkeys, raccoon dogs and hares)

Fig. Ⅲ-20 Sign board for securing adequate headways (in open sections)

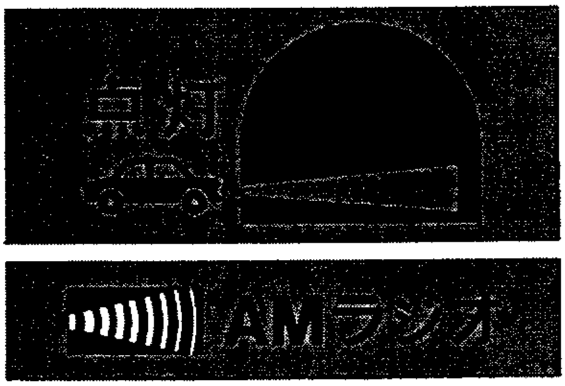


Fig. Ⅲ-21 Lighting in the tunnel and availability of radio broadcast

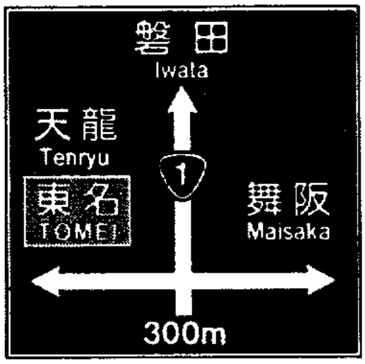


Fig. Ⅲ-22 Example of Displaying Name of Expressway in Sign of 108 Faction

3. Road Markings

This is a traffic control facility installed to supplement the road signs. This is done by painting instructive lines and symbols on the roads.

The purpose is to control the traffic flow, to promote safety and smooth traffic and to protect the road structure.

The markings are classified in the Sign Ordinance into two categories; one is carriageway markings such as lane lines and outer boundary lines set by road administrators and the other is information and instructions set by the Public Safety Commission. Concerning the color of road markings lines are in white, some indications are in yellow.

(1) Lane Line

On a road with more than two lanes in one direction, the lanes are separated from each other by the lane lines provided.

The marking is a dotted line, in white and of the following dimensions.

(2) Outer Boundary Line

The outer boundary is lined to separate the shoulder from the lane. The indication is made by a solid line, in white and of the following dimensions.

i) Type1. (Boundary line between main route and ramp)

Note : $\ell_1 : \ell_2 = 2 : 3$ (Standard values for ℓ_1 are shown below)

Design Speed (km/h)	Under 40 km/h	50 ~ 60	Over 80 km/h
Length Unit (m)	4	6	8

ii) Type2. (Boundary lines between main lane and speed changing lane and slow vehicle lane)

Note : $\ell_1 : \ell_2 = 1 : 4$ (The ℓ_1 is usually 3m)

Photo Ⅲ-1 Boundary Lines

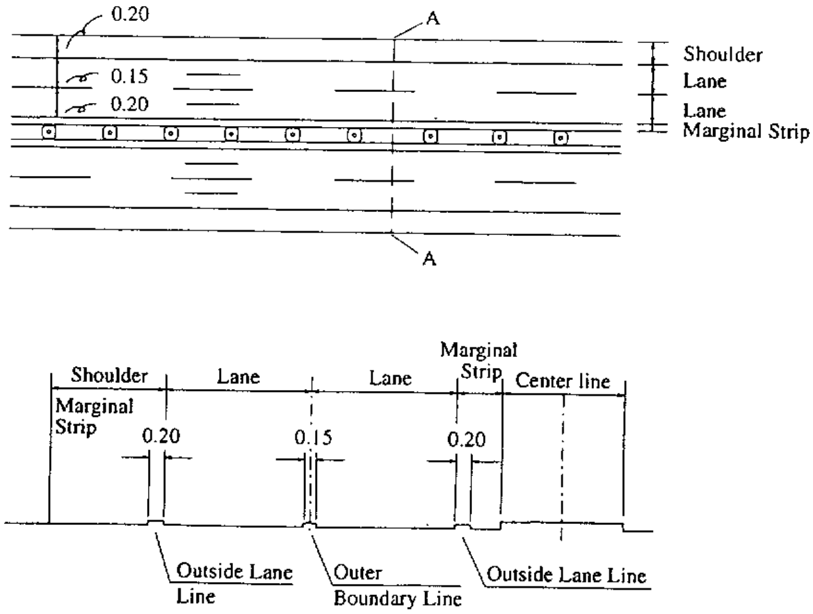


Fig. Ⅲ-23 Example of Standard Separation Lines used with 4 Lanes

Photo Ⅲ-2 Example of Standard Separation Lines (Tohoku Expressway)

4. Delineators

This is erected along the roadsides and indicates the road alignment. It functions mainly at night to guide the eyes of drivers.

The Road Structure Ordinance stipulates that proper sight distance be maintained on the roads, in actual driving, drivers are always seeking for something to guide them.

The delineator is effective in promoting safe driving by providing advance notice of the alignment, which serves to prevent traffic accidents.

The color and number of delineators are determined by the location, as shown in Table Ⅲ-6. The arrangement Horizontal Vertical too is fixed in cases of more than two reflectors on one post to indicate where expressway runs and locatings of interchange and facilities at night. The maximum distance between delineators is 50m on the main roadway and 25m on rampways and the speed-changing lanes of interchanges and tunnels.

The intervals at shown in Table Ⅲ-7 to provide continuous visual guidance.

It is standard practice to locate delineators on the left side of the carriageway, at a distance of 120 cm from road surface to the center of the reflector and with 50 cm clearance.

The delineator is installed 90 cm from the road surface on the median side of the main roadway and on an interchange rampway. It is attached directly on the front surface of guard rails, it is installed 60 cm away from the marginal strip. (Fig.Ⅲ-24).

Table Ⅲ-6 Location and Kind of Delineator

Location	Color	Number	Remarks
Left shoulder of Main Roadway	White	1	
Median of Main Roadway	Orange	1	
Ramp at Interchange and Service Area	Orange	1	
Speed Changeing Lane	Orange	2	Longitudinal Arrangement
Start of Merging lane and End of Acceleration Lane	Orange	3	Longitudinal Arrangement
Start of Separation lane and Start of Deceleration Lane	Orange	3	Parallel Arrangement

Table Ⅲ-7 Standard Location Interval

Radius of Road Curve R (m)	Location interval for Delineator S (m)
~ 50	5
51 ~ 80	7.5
81 ~ 125	10
126 ~ 180	12.5
181 ~ 245	15
246 ~ 320	17.5
321 ~ 405	20
406 ~ 500	22.5
501 ~ 650	25
651 ~ 900	30
901 ~ 1,200	35
1,201 ~ 1,550	40
1,551 ~ 1,950	45
1,951 ~	50

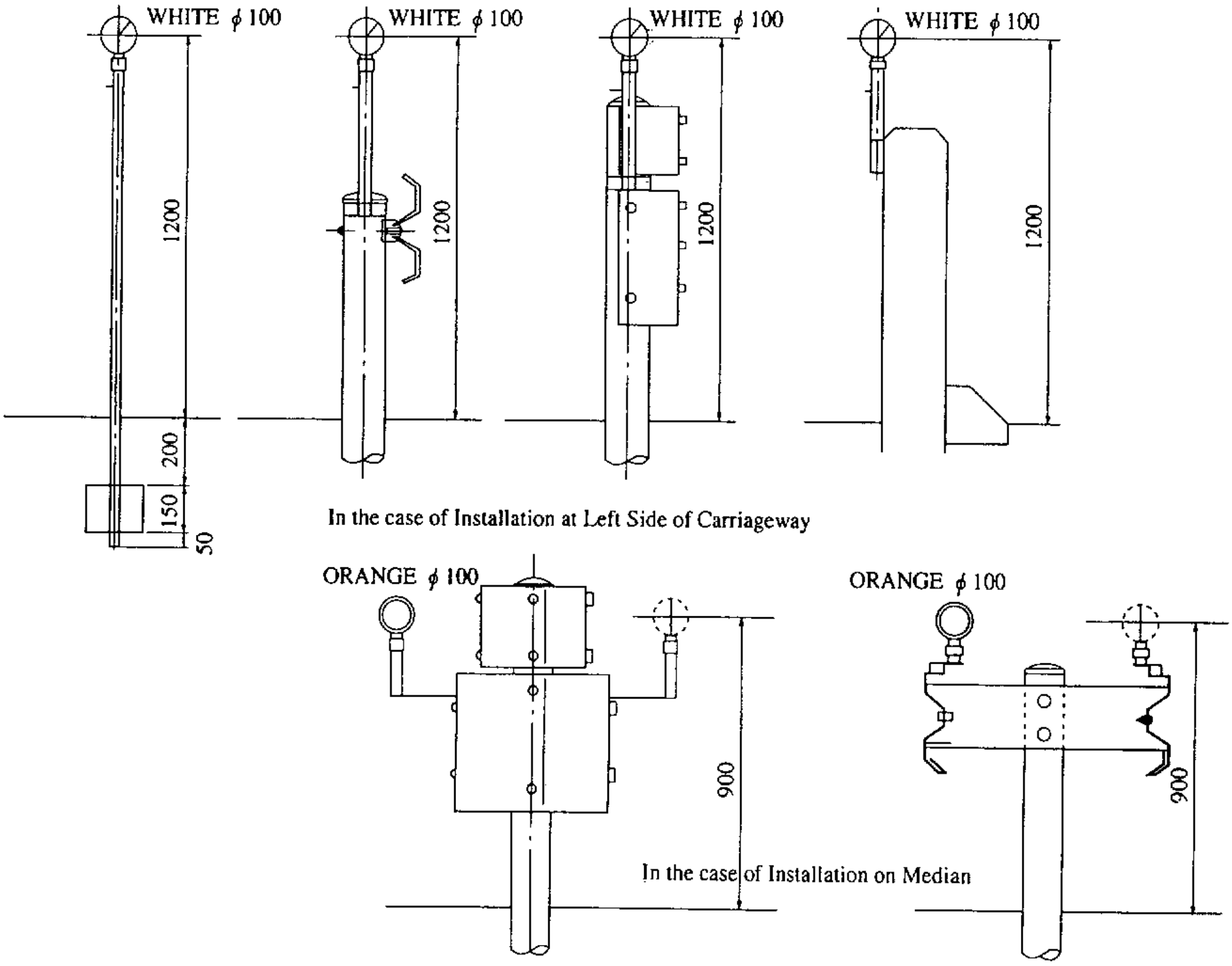


Fig. III-24 Installation Method for Delineator

5. Distance Marks

Distance marks, which identify geographical points, are required for both appropriate and quick maintenance, repair and improvement of expressways and for informing road users of their positions. Their most common use is at the time of traffic accidents or vehicle breakdowns. Communications and reporting for support and handling of vehicles are carried out based on the distance marks. Road improvement work is also based on the marks. They should, therefore, be installed accurately.

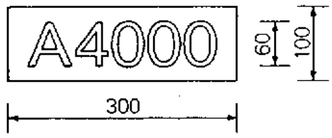
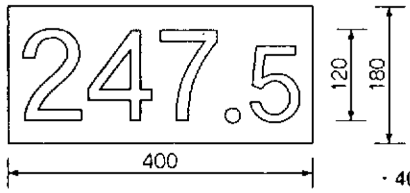
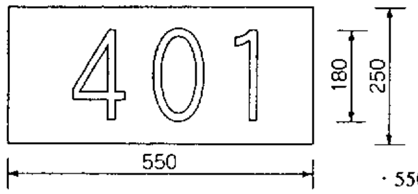
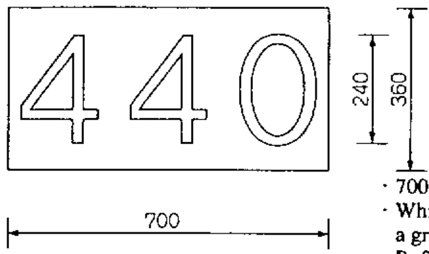
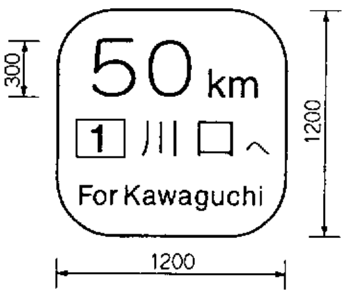
Distance marks also serve as landmarks for general road users.

Table III-8 Types of Distance Marks

(1) 50-kilometer posts:	Installed on the shoulder of the expressway at 50-km spacings
(2) 10-kilometer posts:	Installed on the shoulder of the expressway at 10-km spacings
(3) 1-kilometer posts:	Installed on the shoulder of the expressway at 1-km spacings
(4) 500-meter posts:	Installed on the shoulder of the expressway at 500-m spacings
(5) 100-meter posts:	Installed on the shoulder of the expressway at 100-m spacings
(6) 20-meter posts:	Installed on the shoulders of interchanges, junctions and service area ramps on expressways at 20-m spacings

The following types of distance marks are used.

Table Ⅲ-9 Outline of Distance Mark Installation Procedures

Type of distance mark	Installation height	Installation method	Colors, letters, design and notation
20-meter post (at interchanges and service area ramps)	30 cm from the bottom	Cut and Embankment section: Set on guard fences Bridge or viaduct section: Attached to concrete barrier curbs	 · 300×100 · Green letters on a white background · Non-reflective
100-meter post	1.25 m from the bottom Tunnel sections: Without inspection galleries: 1.25 m from the bottom With inspection galleries: 2.00 m from the bottom	Cut and Embankment sections: Set on guard fences Cut sections: Installed as freestanding posts Bridge or viaduct section: Posts are attached to the outer face Tunnel sections: Installed on the wall parallel to the road centerline	 · 400×180 · Green letters on a white background · Reflective
500-meter post			
1-kilometer post			 · 550×250 · White letters on a green background · Reflective
10-kilometer post		Cut and Embankment section: Installed as freestanding posts Bridge or viaduct section: Kilometer posts are used Posts are attached to the outer face Tunnel sections: Installed on the wall parallel to the road centerline	 · 700×360 · White letters on a green background · Reflective
50-kilometer post	2.00 m from the bottom	Cut and Embankment section: Installed as freestanding posts Bridges, viaduct, tunnels and when the distance marks are installed as part of the guide sign system at interchanges, junctions, service areas and parking areas: 10-kilomete-post types are used. 50-kilomete-post types are used in the earthwork sections at the 40-km or 60-km point.	 · 1200×1200 · Top half: White letters on a green background · Bottom half: Green letters on a white background · Reflective

Installation position : Signs are installed generally on the left protective shoulders.
Where noise barriers are installed, distance marks are installed on median strips.
In snowy cold areas, distance marks except 50-kilometer posts are installed on median strips.

6. Glare Reduction

(1) Purpose

Glare reduction devices are installed for reducing the headlight glare of opposing traffic at night.

(2) Place of Installation

On the primary and secondary national highways among the first-class highways, glare reduction devices are installed on the median strips in bridge and overpass sections and in cut and embankment sections without vegetation. The tertiary national highways are equipped with glare reduction devices only in the sections where such devices are considered necessary in view of,the design speed and alignment. Installation of glare reduction devices can be omitted in the sections with the following characteristics.

a) The median strip has a width of 7 m or larger.
b) The difference in the elevation of centerline in opposing directions is 2 m or greater
c) Lighting devices are installed continuously.

(3) Structural Specifications

(i) Height

The height of a glare reduction device is set at 1.4 m on the assumption of combinations of opposing passenger vehicles and of a passenger car and a large-size vehicle running in the opposite directions.

(ii) Shading angle

The shading angle θ in the case where passenger vehicles passing other vehicles are moving in opposing directions with a 50 m gap between them is calculated by the following equation.

$$\theta = \tan^{-1}\frac{8.5}{50} \fallingdotseq 9^\circ\ 30'$$

In order to reduce the headlight glare of a vehicle passing other vehicles for another vehicle travelling in the opposite direction, greater shading angle is required. Full shading, however, narrows the view of the driver and deteriorates a view of opposing traffic during patrol. Therefore, a shading angle of approximately 10 degrees has been selected to provide partial shading.

7. Fences Against Falling Objects

The purpose of installation of fences against falling objects is the prevention of objects from falling from overbridges down to expressways or the prevention of objects from jumping beyond the vehicles on expressways to areas out of the expressways, to ensure traffic safety.

(1) Types

Fences to prevent falling objects are grouped into the following two types according to their purposes.

(i) Fences to prevent objects dropping from overbridges: Installed on overbridges

(ii) Fences to prevent objects falling off expressways: Installed along roadsides of expressways

(2) Places of Installation

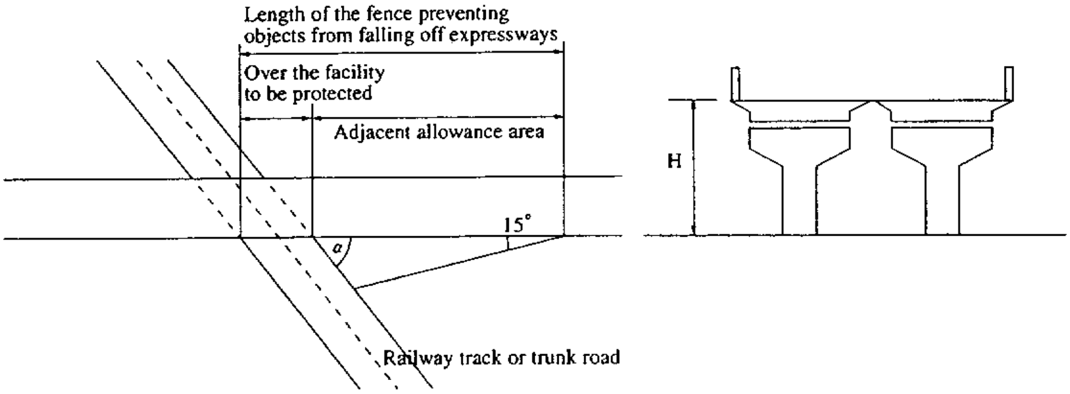
(i) Fences to prevent objects dropping from overbridges
- a) National highways and major prefectural roads
- b) Overbridges in densely populated areas used by a large number of people and vehicles
- c) Overbridges designated as school-commuting roads
- d) Other sections where installation of fences is deemed necessary

(ii) Fences to prevent objects falling off expressways
- a) Sections crossing or nearing railway tracks
- b) Sections crossing or nearing heavily trafficked trunk roads
- c) Sections in the vicinity of housing areas
- d) Other sections where installation of fences is deemed necessary

(3) Area of installation

The area of installation of fences to prevent objects falling off expressways include the area crossing the facility to be protected and the adjacent allowance area. The adjacent allowance area is shown below.

The adjacent allowance area is represented by the following equation.



Length of adjacent allowance area

$$L = V_0 \sqrt{\frac{2(H+3)}{g}} \left(\cos 15^\circ + \frac{\sin 15^\circ}{\tan \alpha} \right)$$

where, V_0 = Speed of object jumping out of the expressway (m/s)

H = Height from the base of the facility to be protected to the road surface of the expressway (m)

α = Crossing angle between the facility and the expressway (between 0 and 180 degrees) (α = 90 degrees is assumed in the case of proximity)

g = Gravity acceleration = 9.8 m/s^2

8. Boundary Fences

(1) Purposes

Boundary Fences are installed to prevent unauthorized people or animals from entering the expressway and to prevent illegal occupation of the road site.

(2) Installation Sections

○ Boundary Fences are installed in the following places

① Sections where other roads are constructed adjacent to the expressway

② Sections with houses adjacent to the expressway and with a possibility of people entering the expressway

③ Sections with a less-than-3-m difference in elevation between the expressway and the land outside the road area or sections with a difference in elevation of 3 m or larger where the possibility of entrance is assumed

④ Around such facilities as interchanges, service areas and parking areas

⑤ Remaining land

⑥ Under viaducts

⑦ Sections where adjacent land is expected to be developed for housing and there is a danger of illegal occupation

⑧ Other sections where installation of fences is deemed necessary

○ Despite the above conditions, boundary fences can be omitted in the following sections.

① Sections with channels or ponds where neither entry nor illegal occupation is expected in the future

② Sections with retaining walls of a height of 1.5 m or greater, concrete masonry walls or other types of walls, which are structurally considered free from future entry or illegal occupation.

③ Sections which are structurally considered free from future entry or illegal occupation e. g. points of connection with national highways

④ Sections which are topographically considered free from future entry or illegal occupation e. g. under viaducts in extremely steep mountainous areas

⑤ Sections where noise barriers, snow fences and landslide control devices are installed and there is no danger of people's access or future illegal occupation

⑥ Sections where occupation is allowed under the overpass

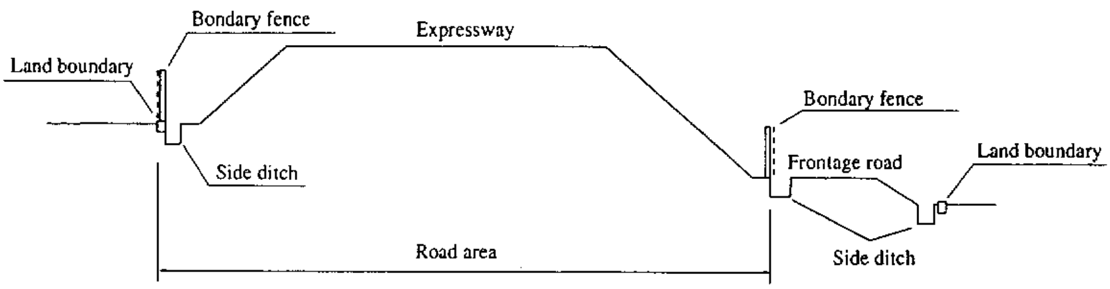
○ Other

In exceptional cases such as the development that integrates embankment slope and roadside facilities, separate studies are made.

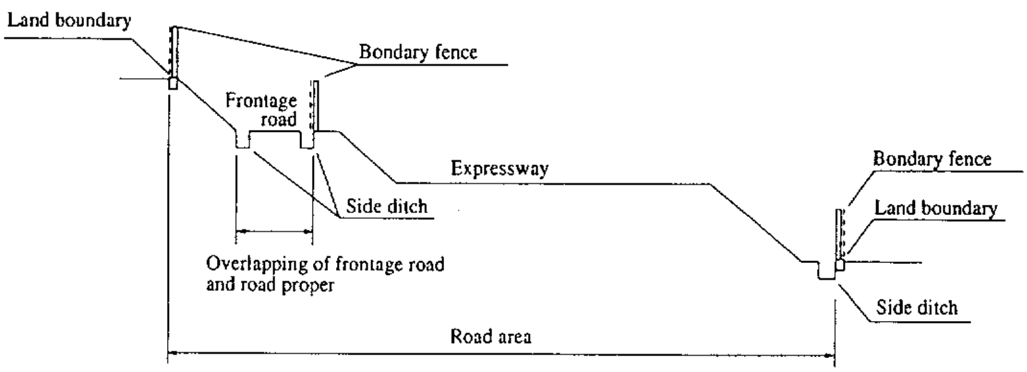
(3) Places of Installation

Boundary fences in the road areas are installed at boundaries of the road areas, and those in the remaining land are installed at boundaries of the land.

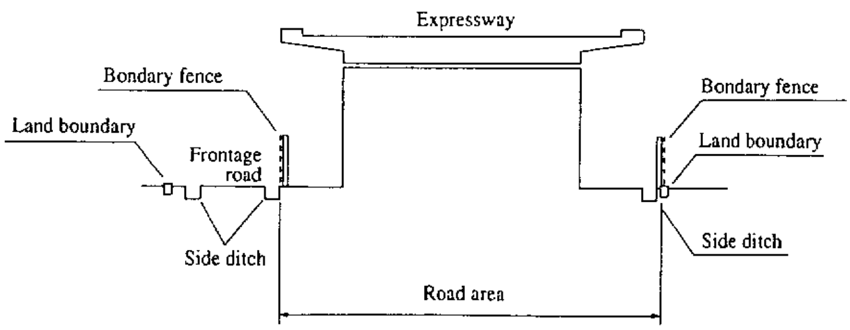
<Reference drawings>



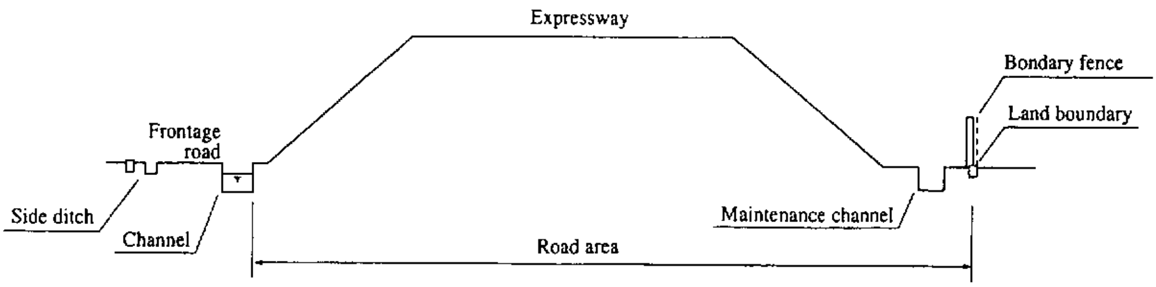
(a)



(b)



(c)



(d)

(4) Types and Use

(i) Wire netting

(a) Sections adjacent to national highways and frontage roads

(b) Sections adjacent to buildings

(c) Sections recognized as urban areas other than (a) and (b) above

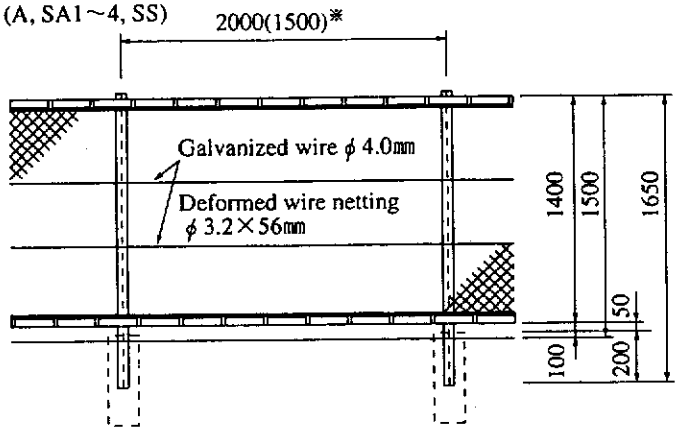
(ii) Barbed wires

Hilly and mountainous areas

(iii) Wire mesh

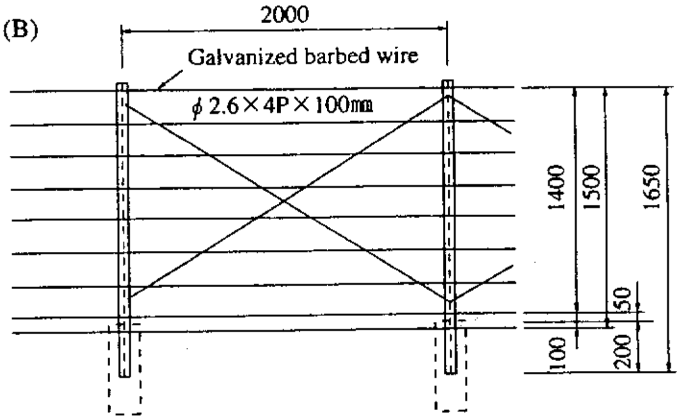
Sections in hilly and mountainous areas adjacent to agricultural land

· Wire netting (A, SA1～4, SS)

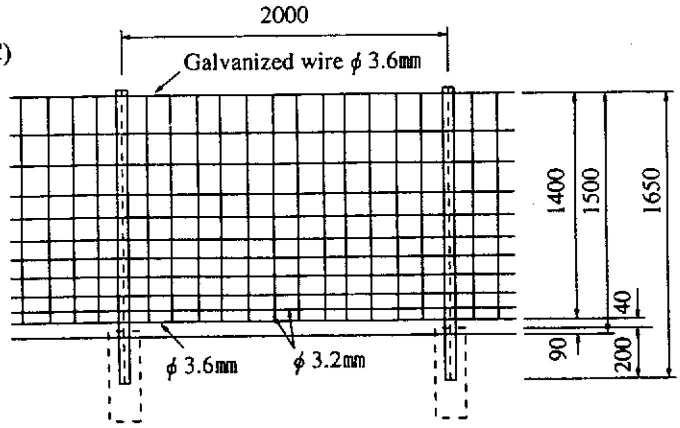


※ For snowy areas

· Barbed wires (B)



· Wire mesh (C)



V. TECHNOLOGICAL DEVELOPMENTS

1. ETC (Electronic Toll Collection System)

(1) Outline

ETC is a new toll collection system currently under development for the mitigation of traffic congestion at toll plazas on expressways, the increase of efficiency through cashless operation and for the reduction of overhead costs. Radio communication between antennas installed at toll plazas and in-vehicle equipment enables automatic toll payment without stopping at toll plazas.

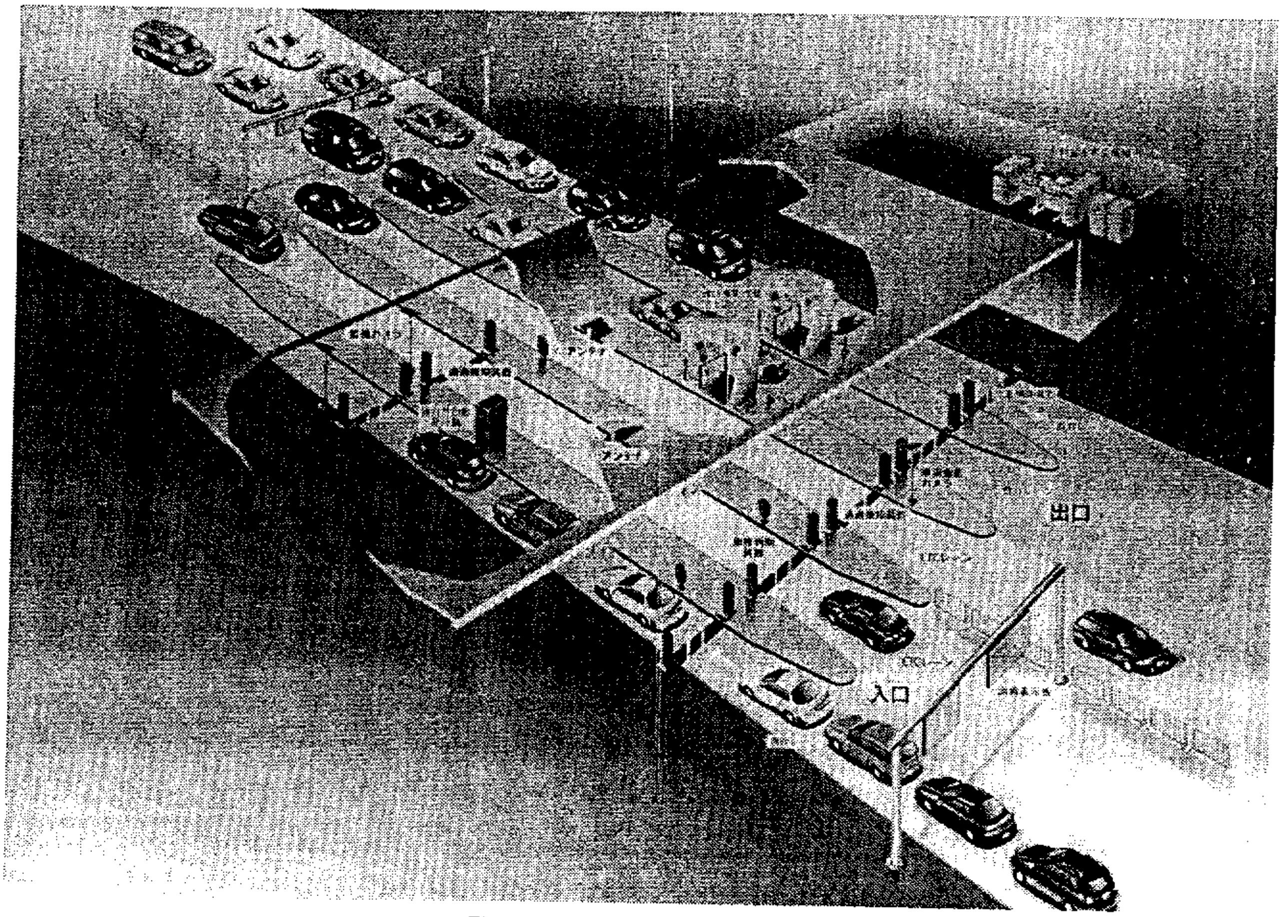
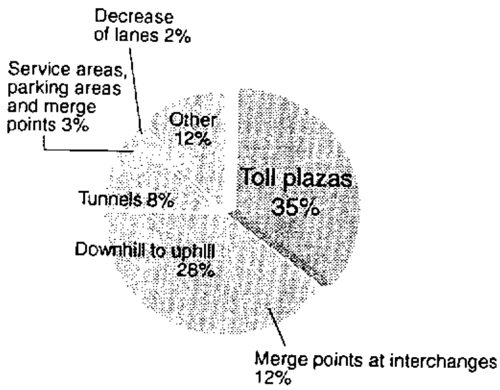


Fig. IV-1 An Illustration of ETC

(2) Objective

Reduction of traffic congestion at toll plazas is one of the major objectives of ETC. At present, the most serious congestion on expressways is found at toll plazas, where 35% of congestion is detected. If all the vehicles passing toll plazas are equipped with the ETC, the capacity is expected to become three to four times as large as at present. Thus a great contribution to the mitigation of congestion.



Source:
Japan Highway Public Corporation

Fig. IV-2 Condition of Traffic Congestion

(3) Toll Payment Procedure Under ETC

On expressways where per-distance rate system is applied, vehicles equipped with appropriate ETC equipment (ETC vehicles) entering the toll plaza receive entrance information via an antenna installed on the toll plaza.

This means the vehicles receive an invisible ticket. The ETC vehicles, as they reach a desired exit, send entrance data from the on-board equipment to an antenna, and the toll is calculated and charged based on the data received.

a) Entrance information is sent to the on-board equipment via an antenna at the toll plaza.
b) Entrance information is sent to an antenna at the toll plaza from the on-board equipment.
c) Toll is calculated and conveyed to the on-board equipment via an antenna at the toll plaza.

2. VICS (Vehicle Information and Communications System)

(1) Outline

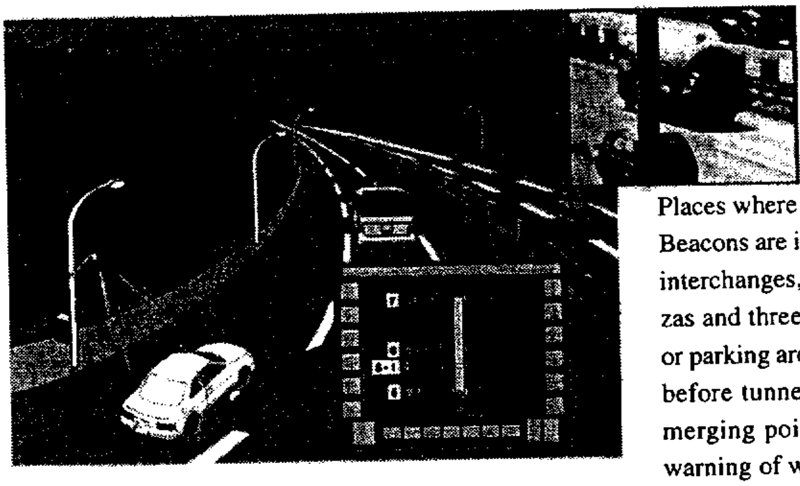
Quick collection and processing of information on ever-changing road conditions and real-time provision of as much accurate and detailed information as possible are critical to safe, smooth and comfortable traffic.

JH has been developing VICS, an advanced information dissemination system which enables drivers to obtain traffic information real-time.

(2) Mechanism of Information Dissemination

VICS conveys traffic information to drivers real-time to ensure safe and comfortable travel.

Radio-transmitting beacons installed on the shoulders of expressways or national highways use semi-micro waves to send various messages direct to the equipment in the vehicles on the highway. Such messages include information on congestion, travel time, traffic disruption, traffic regulations, traffic control and parking spaces.



Places where radio-transmitting beacons are installed: Beacons are installed three to four kilometers short of interchanges, one to two kilometers short of toll plazas and three to four kilometers before service areas or parking areas. They are also scheduled to be placed before tunnel portals, at interchanges, junctions or merging points, at congestion points, at points of warning of weather changes and at other points.

Fig. IV-4 An image of information dissemination by VICS