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Mechanical Arm to Facilitate Bridge Beam Bottom Detection: Improving the Quality of Bridge Inspections

In order to assist bridge inspectors in safely and effectively performing inspection on the beam bottom components of bridges, the Institute of Transportation, MOTC (IOT) and Tatung University have collaborated to develop a beam bottom detection tool (bridge inspection tool). The detection tool was developed to circumvent hidden, narrow, and potentially hazardous bridges in tidal river sections where it is difficult to approach the beam bottom and other inspected environments. It is provided for detection applications by bridge maintenance and management agencies (henceforth referred to as bridge management agencies).

There are about 23,000 vehicular bridges nationwide, which are periodically inspected by bridge management agencies. Whether or not bridge inspection operations can be implemented concern the passage safety of the general public. A coastal tidal river section is a river area affected by the tide, and the beam bottom components of the bridges at the tidal river sections are repeatedly soaked by high tide and low tide or in an environment of high salt damage, which can easily lead to corrosion and expansion of steel reinforcement as well as concrete spalling. Therefore, this gradually reduces the bearing

capacity and functionality of bridges. The majority of these bridges have dark, water-adjacent beam bottoms. Inspectors must frequently take risks (tidal space shrinks, avoiding obstacles, etc.), utilize rubber boats or put on diving suits to enter the bridge's beam bottom for inspection and testing. Using a multi-section retractable conveying arm, similar to an endoscope used in the medical field to examine inaccessible areas, Tatung University and IOT have been working together since 2017 to create a bridge inspection tool. To avoid potential issues, when inspecting bridges over tidal river sections, bridge inspectors need only use the bridge inspection tool on the bridge surface and real-time images sent back to inspect the bridge's beam bottom. In order to meet the bridge inspection needs, the front end of the detection rod of this bridge inspection tool is equipped with a lens steering module that can photograph the lateral components of the beam bottom (including cap beams, bearings, pier columns, etc.) by rotating the lens, adding light sources, and increasing the camera's resolution to obtain crisp images of the components between the beams. In 2022, image stitching technology was introduced. Photographing a complete image of the baseboard allows bridge inspectors to mark the spots where damaged components are for future repairs and monitoring.

This bridge inspection tool was used to inspect a 20-meter-long, 10-meter-wide bridge. It took approximately 90 minutes to capture an image of the bottom of the beam. Although it takes significantly longer than a manual visual inspection (about 40 minutes), this bridge inspection tool can record a complete image of the beam's bottom components, thereby reducing inspectors' risks during inspection work. The bridge inspection tool’s conception is both technologically advanced and practically useful. It has obtained an invention patent (No. I741701) from the Intellectual Property Office of the Ministry of Economic Affairs.

The bridge inspection tool is still undergoing research and development. It is anticipated that technical transfer will take place by the end of this year following the conclusion of research and development. In 2021 and 2022, IOT held online research results promotion to share bridge inspection tool

research and development results and inspection cases, and demonstrate the tool's operation and functions. The central government (the Construction and Planning Agency, Ministry of the Interior, the Freeway Bureau, MOTC, the Directorate General of Highways, MOTC, etc.) and local authorities (county and city governments, etc.), and personnel from bridge maintenance and management agencies were invited to participate in and promote exchanges to aid in the implementation of bridge inspections and enhance the quality and safety of bridge inspections.

Figure 1 On-the-spot survey using the bridge inspection tool developed by IOT

Figure 2 Image of the beam bottom captured by the detection tool

Figure 3 Lateral view of girders, bearings, and cap beams captured by the detection tool

Figure 4 Image of baseboard stitching on the bridge