Joint Research on the Maintenance of Concrete Deck Bridges

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1. Introduction

The concrete deck bridge is a bridge type that has been built in large numbers due to its advantages such as a lower girder height than other structures, relatively simple structure, and excellent workability. Of the bridges managed by the government, about 12,500 bridges are of this type, and about 60% of them or about 8,000 bridges, are more than 50 years old (**Fig. 1**). NILIM has been conducting joint research with the Public Works Research Institute (PWRI) and the Japan Prestressed Concrete Contractors Association (JPCA) to systematize inspections and countermeasures for the maintenance of concrete deck bridges. This paper reports the status of that joint research, particularly related to the lateral-fastening PC steel protrusion in pretensioned deck bridges.

2. Protrusion of lateral-fastening PC steel bars

In recent years, among the deck bridges managed by the government, there have been cases of fracture or protrusion of the lateral fastening of PC steel due to corrosion in pretensioned deck bridges (**Photo 1**). At present, about 5,900 pretensioned deck bridges have been built, and as shown in the schematic diagram in **Fig. 2**, their structure consists of precast concrete members that were manufactured in factories and constructed on the site, and integrated using lateral-fastening PC steel.

Water infiltrates the joints between precast members and cast-in-place sections from the bridge surface, etc., but the lateral-fastening PC steel is usually protected by grout. However, if the filling is insufficient for some reason, the lateral-fastening PC steel will corrode and, in some cases, break. If the grout does not adhere sufficiently, the prestressing force released by fracturing may lead to protrusion as shown in Photo 1.

Such an accident may reduce the load-bearing capacity of the bridge, and further cause serious damage to passersby and others in the vicinity of the bridge. Moreover, since there are multiple lateral-fastening PC steels in one bridge, there are concerns about protrusion of other steels, which may cause secondary damage during inspection or

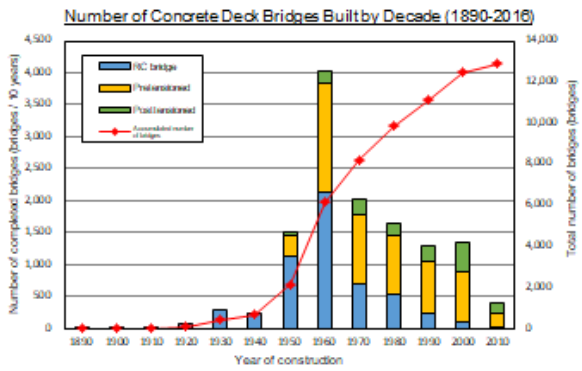

Fig.1: Years of construction of concrete deck bridges

Photo 1: Fracture / protrusion of lateral-fastening PC steel

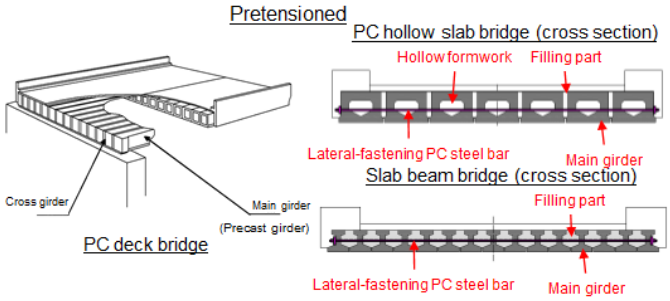

Fig. 2: Outline of pretensioned deck bridge

investigation.
Therefore, it is necessary to organize how to deal with these issues when taking preliminary measures to prevent them or when an emergency response is needed in the event of a protrusion accident.

3. Case collection / analysis and field survey

Although there are several cases in the past where lateral-fastening PC steel broke or protruded, we decided to investigate the cases of protrusion of lateral-fastening PC steel bars in 12 road bridges managed by the government through a literature survey, etc. In addition to collecting design documents and past inspection reports from the administrators, we are conducting field surveys by selecting five bridges. As a result, we found the following.

(1) Bridges with protruding lateral-fastening PC steel do not depend significantly on the environment of the bridge location, such as whether airborne salt was attached or freeze-thaw material was dispersed, but rather tend to depend on factors such as the year of construction, bridge width, and type of steel used. In other words, accidents can occur on any bridge, regardless of environmental conditions.

(2) It was found that the bridges where protrusion occurred were those built before 1980, when the material quality of grout, which plays a role in rust prevention and integration of the PC steel, was inferior.

(3) The bridges where protrusion occurred used PC steel bars as the PC steel. It is assumed that PC steel stranded wire will gradually break and the process of breaking as a stranded wire is progressive, while steel bars will suddenly break if the cross-sectional area of the steel decreases.

(4) It was found that protrusion often occurred to a bridge with a width of more than 8.0 m. This is considered attributable to the high possibility of using couplers as joints for the PC steel bars and the possibility that the presence of the couplers may easily hinder filling during grout injection.

(5) In the bridge where protrusion occurred, water leakage and free lime were observed at the interface between the precast concrete member of the bridge and the cast-in-place section. Even if it is impossible to directly check the lateral-fastening PC steel bar itself, close visual inspection is considered to be effective to a certain extent in early detection of abnormalities.

(6) In the field survey, we also investigated the bridges that were located in the vicinity of the bridges stated above and were expected to have no broken or protruding lateral-fastening PC steel. Although most of the bridges satisfying the conditions (2) to (4) did not have any protrusion of the lateral-fastening steel, we newly confirmed a bridge where protrusion occurred. For this reason, we will continue to investigate other conditions that should be considered. We also investigated the actions taken against the fracture or protrusion of lateral-fastening PC steel. As mentioned above, it is difficult to conduct a detailed survey, etc. in close proximity to the bridges where an accident was observed because of the risk of secondary damage during the survey. Therefore, it is necessary to take measures to prevent secondary damage before conducting a detailed survey. For example, regarding the bridge shown in Photo 1, we installed steel on the sides of the bridge as an emergency measure to reduce the risk of protrusion in the event of fracture (Photo 2a) as a measure to prevent secondary damage before conducting the detailed survey. After that, as a permanent measure, the grout was re-injected into the insufficiently filled areas of all lateral-fastening PC steels, and then preventive measures were taken to prevent protrusion by attaching steel strips and fiber sheets (Photo 2b). In order to systematically summarize the know-how described above, we will continue to conduct surveys, etc.

a. Emergency measure **b. Permanent measure**

Photo 2: Prevent protrusion measure

4. Conclusion

In the joint research, we plan to investigate bridges for which preventive measures were taken to expand our knowledge of their durability, etc. Results of the research will be compiled as a reference material for periodic inspections.