Construction of durable RC bridge decks in Tohoku region

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Outstanding Civil Engineering Achievement Award

Four reinforced concrete (RC) bridge decks completed as part of the infrastructure for 'Reconstruction Roads' in the earthquake-devastated Tohoku region of Japan (Fig. 1) won a JSCE Outstanding Civil Engineering Achievement Award 2016 for their contribution to the life cycle management of road bridges. This article describes the background to the project and gives an outline of the work.

Fig. 1 RC bridge decks for which the JSCE Outstanding Civil Engineering Achievement Award 2016 was received

Reconstruction Roads

'Reconstruction Roads' are highways constructed to accelerate recovery from the Great East Japan earthquake of 2011. These special roads have a total length of approximately 360 km and include more than 250 bridges (Fig. 2). They are located in a cold region of Japan, so the concrete components of the structures must be durable against frost attack. In addition to freezing and thawing effects, the bridges will also be prone to the alkali silica reaction (ASR) and chloride attack from the use of deicing salt. The complex interaction of these modes of deterioration combined with heavy traffic can degrade road bridge decks resulting in erosion of concrete, as shown in Fig. 3.

Given the importance of the Reconstruction Roads, any concrete structures used should be sufficiently durable against these complex deteriorations.

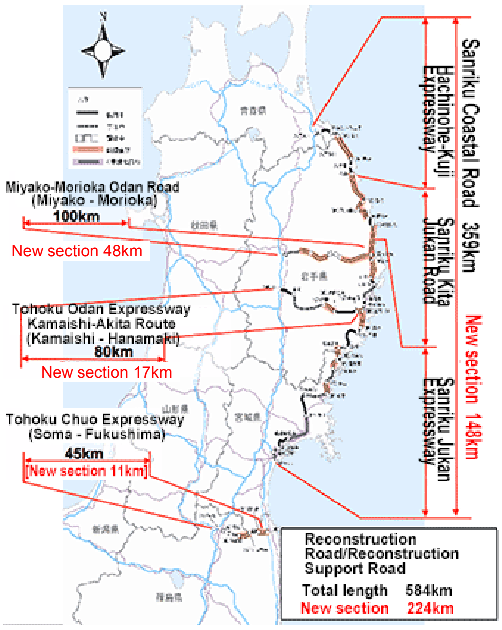

Fig. 2 Map of Reconstruction Roads

Fig. 3 Erosion on RC slab

Multiple defense strategy

In order to develop countermeasures against deterioration within the limited period available for construction, an industry-government-academia investigation group was established. To reliably achieve the required level of durability, the multiple defense concept was adopted with at least two countermeasures put in place for each mode of deterioration. Through this approach, even if one countermeasure is inadequate to protect against the target mode of deterioration, there is another in place to reduce the risk.

Fly ash and blast furnace slag were used in the concrete mixes as countermeasures against chloride attack and the ASR. Other countermeasures were also applied to create a multiple defense network that would protect against every assumed deterioration mode. Ultimately, six countermeasures were selected to form an effective multiple defense network, as shown in Fig. 4.

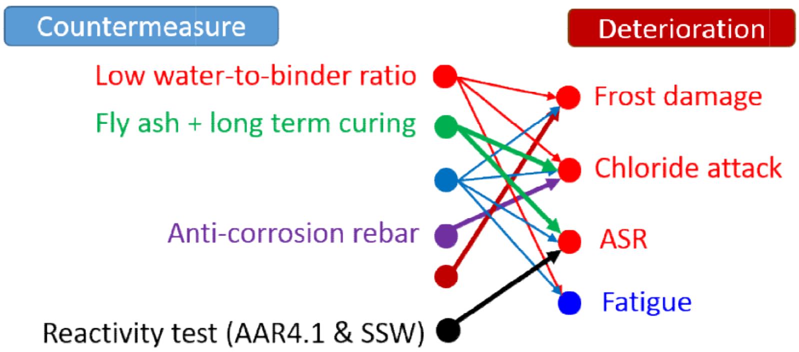

Fig. 4 Multiple defense system applied to bridge deck (Mukai Sadanai Bridge)

The first bridge to be treated in this way was the Mukai Sadanai Bridge, where an RC slab was carefully constructed with fly ash concrete. Wet curing continued for three months to obtain a pozzolanic reaction of the fly ash. The quality of the hardened concrete was checked by element tests and nondestructive tests. The additional costs incurred in applying these durability enhancements were 26%, which is acceptable with regard to risk control because replacement cost is much higher as 4 times of initial cost (Fig. 4).

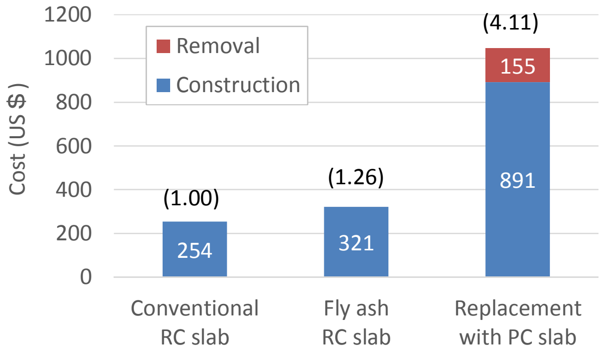

Fig. 4 Cost of conventional and fly ash RC slabs (Mukai Sadanai Bridge)

Success with the work at the Mukai Sadanai Bridge was followed by construction of three further durable RC bridge decks along Reconstruction Roads. An alternative method of protecting against the assumed deteriorations using blast furnace slag was developed and used for the Shin Kesen Bridge.

This project was commended for its contribution to the life cycle management of road bridges and the JSCE award was announced in May 2017.