Inspection and Retrofitting of Fatigue Damaged Orthotropic Steel Deck

Takeshi KINOMOTO
Civil Engieer
Metroplitan Expressway Company Limited
Tokyo, Japan
t.kinomoto86@shutoko.jp

Masashi KAJIHARA
Civil Engieer
Metroplitan Expressway Company Limited
Tokyo, Japan
m.kajihara136@shutoko.jp

Yasuaki HIRABAYASHI
Manager
Metroplitan Expressway Company Limited
Tokyo, Japan
y.hirabayashi1411@shutoko.jp

Takuyo KONISHI
Manager
Technology Center of Metroplitan Expressway.
Tokyo, Japan
konishi@tecmex.or.jp

Masumi MURANO
Civil Engieer
Technology Center of Metroplitan Expressway.
Tokyo, Japan
mmurano@tecmex.or.jp

Gou SAITO
Civil Engieer
Technology Center of Metroplitan Expressway.
Tokyo, Japan
gos@tecmex.or.jp

Summary

Fatigue Damages in orthotropic steel deck (OSD) become a big annoying problem for the Metropolitan Expressway in Japan. One of the most serious fatigue crack in OSD is the crack initiating from the root of tough rib weld and propagating upward through deck plate. Visual detection is impossible before it penetration deck and cause water leak and surface subsidence. Special semi-automatic ultrasonic (SAUT) testing device was developed to detect the embeded cracks quickly. Several retrofitting methods have been proposed and tested. SFRC surfaceing is tentatively adopted on the damaged span. Performance of the SFRC is measured on site. This paper presents technique of OSD inspection, retrofitting methods and performance improvement of the retrofitted OSD.

Keywords: orthotropic steel deck; fatigue crack; SFRC; Ultrasonic test; retrofit

1. Fatigue damages in orthotropic steel decks

With a total length of approximately 290km, the Tokyo Metropolitan Expressway handles an average daily traffic volume of around 1.2 million vehicles (about 9% of which are heavy-duty cargo vehicles). About 95% of a total length is a structure, and an elevated structure is about 80% of it. Many OSD bridges have been adopted especially in water front bay area. The fatigue strength of OSD. is influenced by many factors, such as the transverse distribution of vehicle load, vehicle position, the number of repetitions of wheel loads, the assembly accuracy of member, and the weld quality. Many fatigue damages have been found in the deck system.The most serious damages are the fatigue cracks that intiate from the roots of the weld between U rib and deck plate bearing the wheels of trucks directly (***Fig.1***). These cracks cannot be found by visual inspection, because cracks initate from inside of the U rib and propagate through the deck plate. The Cracks reach the surface of the deck plate, accerelate the propagation rate and fainally make deck subside.

2. Inspection of orthotropic steel deck and nondestructive inspection for U rib root crack

Most of highway infrastructures are inspected once in five years in Japan. Steel Orthotropic decks are mainly inspected visually. In hands-on inspection, several type of fatigue crack in orthotropic steel deck can be detected in the junction of U rib and transverse rib or diaphragm on their surface. Fatigue crack through deck plate is invisible crack from outside. Ultrasonic testing is applied to detect this kind of inside crack. Semi-Automatic Ultrasonic Testing (SAUT) machine was developed and applied to the inspection of weld between steel deck and longitudinal U rib. This system uses customized probe holder to locate the UT probe at the optimal position and angle to detect the crack initiating from root of the weld bead and propagating into deck plate. The probe slides parallel to the weld bead and echo of the ultrasonic waves are recorded with location data

measured by wired-encoder. Recorded data will be displayed on real time B scope view (***Fig.2***).

Forty spans of orthotropic girder have been inspected with SAUT and 130 longitudinal cracks have been detected since the inspection started in January 2007. Most of cracks are shorter than 50mm, but 20 cracks exceed 100mm and stop hole penetrating U rib and deck plate has been drilled as counter measurement for these cracks.

3. Retrofitting of Cracks in Orthotropic Deck Plates

Temporary counter measurement is applied as soon as the crack through deck plate is found in order to avoid subsiding of road surface. At first, pavement is removed and stop holes are drilled in deck plates. Crack front line can not be identified by visual inspection because most of the cracks are submerged in the plate. UT is used to decide the location of stop holes. After drilling stop holes on the deck plate, a cover plate is placed and bolted with the deck plate to strengthen the deck plate.

Temporary counter measurement due to stop hole and cover plate is not sufficient to reduce stress range in OSD. There were cases where fatigue cracks initiated again after the temporary retrofitting. Undergoing retrofitting is the replacement of damaged U rib and placement of Steel Fiber Reinforced Concrete (SFRC) in 50 mm thickness on the deck plate in order to increase the stiffness of the deck plate (***Fig.3***). If the crack is longer than 300mm, longitudinal U rib is replaced and SFRC is placed on the damaged deck after that. Stress ranges in the retrofitted OSD. is less than one eighth of OSD. without the retrofitting.

4. Conclusions

There are lots of fatigue cracks in the orthotropic steel decks of Tokyo Metropolitan Expressways. The most serious cracks in those cracks are the cracks initiating the roots of weld and propagating into deck plate. New nondestructive inspection system has been developed and used to detect that type of crack. Many cracks are found by the system and the system was proved to be effective in OSD. inspection. It becomes clear that stop hole is not effective because stress range along the peripheral of the hole is very high and new crack reinitiates again around the stop hole. SFRC of 50 mm thickness is effective enough to reduce the high stress range.

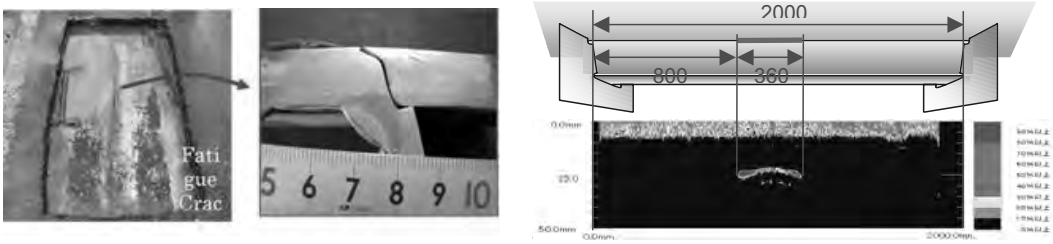

Fig.2 *SAUT result (B scope view)*

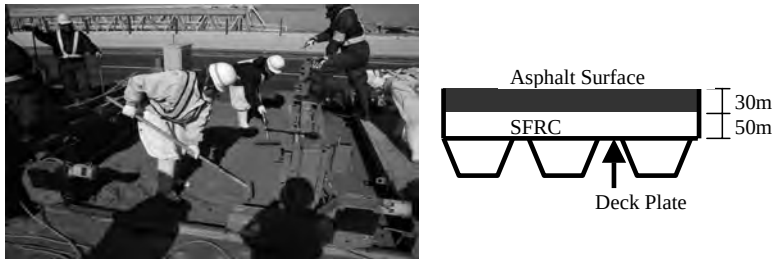

Fig.3 *SFRC Placemen*