Ten years' maintenance of Seto Ohashi Bridges

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Ten Years' Maintenance of Seto Ohashi Bridges

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Summary

On April 10th, 1998, the Seto Ohashi Bridge celebrated its tenth anniversary since its opening. During these ten years, some problems which were due to the initial defects were found. In this paper, the inspection of these bridges is introduced first then some of these problems are reported. These are, the corrosion of main cables of suspension bridges, the damages of cables of cable-stayed bridges due to vibrations, the accident of an inclination of one link type expansion joint, the noise problem of same joints, the noise problem of rolling leaf expansion joints and the noise problem of end links of the Shimotsui-Seto Bridge.

1. Inspection

The inspection can roughly be divided into three types. They are the fundamental inspection, the emergency inspection and the close examination. Except for patrol inspections, bridges are closely eye-inspected and hand-inspected once a year utilizing inspection ways and inspection vehicles. This is the fundamental inspection. The emergency inspection is carried out after earthquakes, strong winds, or other abnormal conditions to confirm the bridge conditions. The vertical alignments of the bridges, the sags of the main cables of the suspension bridges, the inclination of towers, the tensile force of the cable-band bolts and so on are inspected one year and three years after the completion and once every three years afterwards. This is the close examination.

2. Findings of the inspection and their repairs

In 1992, main cables of the suspension bridges were inspected and some corrosions were found. Since then main cables were being treated to remove stains. Recently it is decided to protect main cables by blowing dry air into the main cables. At present, this work is in progress.

Two rows of vibration control ropes, which connect cables each other laterally, are installed on the cables of the cable-stayed bridges. In May 1994, it was found that one of these ropes had been cut due to the vibration. The broken ropes were exchanged immediately and all other vibration ropes were examined afterwards. Some ropes, which had larger damages, were exchanged.

The cables are fixed inside of the upper codes of the truss bridge deck. The angular bend buffers of cables are installed just above the upper codes. In June 1995, some damages of the buffers of the Hitsuishi-jima Bridge was found. The epoxy resin fillers were broken, the polyethylene tubes of the cables were broken and the polyurethane resin filler inside of the polyethylene tubes spilled out. Other buffers were examined afterwards and some damaged buffers were also found. These damages were caused by the

vibration of the two parallel cables due to the wake galloping. At present, the method of repair works of these damages are being considered.

The cable-stayed bridges and truss bridges of the Seto Ohashi Bridge employ the link expansion joints for the road way. These expansion joints had noise problems in 1988, when the bridge opened, so the noise reduction countermeasures were carried out but this could not be a fundamental solution. From 1993, the structure of fingers which consisted of many individual steel bars, which was the source of noise, has been changed to one structure. That is, all fingers are cast as one piece. Also the pin joints have been changed to the rubber joints. This improvement work continued until 1997, when all of the link expansion joints were exchanged to the new structure.

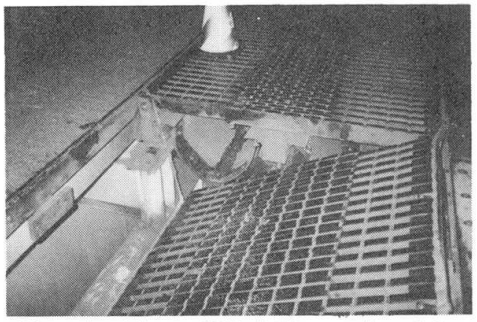

Fig.1 Accident of Link Expansion Joint

On May 3rd 1994, there was an accident that one of the link expansion joints of the Iwaguro-jima Bridge inclined and one car was damaged. This accident was due to the fact that the nuts of bolts of the universal joint which connected the expansion joint and the bridge deck loosened and fell. Consequently one end of the joint fell and the whole joint inclined. To prevent same accidents, expansion joint stoppers are installed and cotter pins are applied on all bolts which connect expansion joints and bridge decks. This improvement was finished in March 1995.

Three suspension bridges of the Seto Ohashi Bridge employ the rolling leaf expansion joints for the road way. These expansion joints also had noise problems after the opening of the Seto Ohashi Bridge. To suppress these noises, various countermeasures were adopted for these joints, until April 1989.

The ends of stiffening truss girders of the three suspension bridges of the Seto Ohashi Bridge are supported upward by end links vertically from beneath the girder. The maximum reaction force of the end link of the Shimotsui-Seto Bridge is 2558 ton, which is about twice larger than other two suspension bridges because this bridge has extended side spans which are not suspended from the main cables. From June 1993, these end links began to make large noises when heavier freight trains passed through the bridge. In January to February 1994, the noise source was closely investigated using the acoustic emission method. It was found that the noise source was the center of the semispherical boss of the lower pivot structure of the end links. The pivot structure consists of a semispherical boss which is embedded on a concrete abutment and a concave semispherical cover which is placed at the end of the link beam and over the boss. It was inferred that the movement of a pivot was not large enough to diffuse solid lubricant embedded in the concave cover, consequently a stick slip phenomenon of metal surfaces occurred and noises were emitted. To prevent this stick slip phenomenon, a hole was bored on a concave cover to reach the center of a boss and liquid lubricant was pressured into the surfaces. This countermeasure worked well and the noise problem was solved. All of the end links of the Shimotsui-Seto Bridge was repaired by this method until 1997.

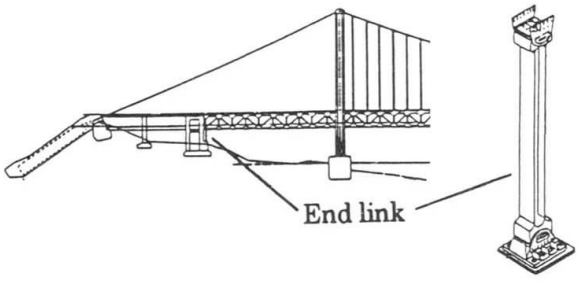

Fig.2 End link of the Shimotsui-Seto Bridge

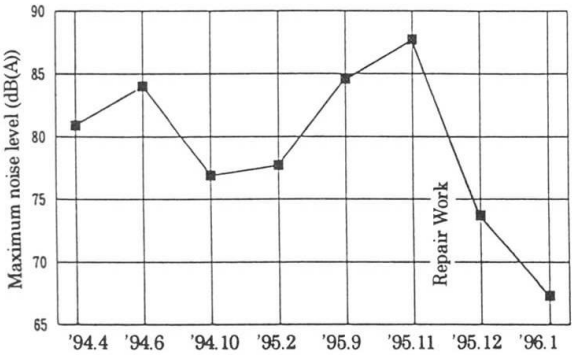

Fig.3 Noise reduction of end link