An Evaluation on Fatigue Damages of Deck Stringer with Suspension Bridge by Field Measurement, Laboratory Tests and FE Analysis

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Summary

To evaluate the fatigue damages of a deck stringer beam near a support, this report describes a series of non-destructive test in the field, field measurement, laboratory loading tests and FE analysis. In order to secure the long-term durability of floor frame, it was shown clearly that the replacement of bridge bearing is suitable for preventing the recurrence of fatigue damages, and that the pot bearing is suitable as bridge bearing for replacement.

Keywords: Maintenance management, Fatigue damage, Non-destructive test, Filed measurement, Bridge Weigh-In Motion, Floor framing, Deck stringer, Suspension bridge.

1. Introduction

Kanmon Bridge (1,068 m) shown in Photo. 1 was constructed in 1973 before the construction of Honshu–Shikoku Bridges. It has been used extensively for an extended period, with daily traffic of over 12,000 large vehicles. After about three decades of continuous use, fatigue damages (see Photo. 2) around the floor frame supports became evident and temporary repairs commenced in 2008. However, the recurrence of fatigue damage has confirmed that drastic countermeasures need to be taken. Therefore, an entire renewal is currently being proposed, with consideration being given to future maintenance. This report discusses a bridge bearing replacement study.

Photo. 1: Overall View

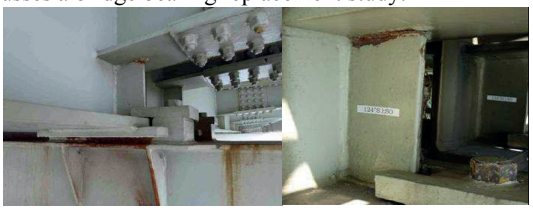

Photo. 2: Fatigue Damages near Floor Frame Support

2. Previous Study

In 2008, immediately after the existence of fatigue damage became apparent, a static loading test and actual stress frequency measurements were conducted on-site using a load vehicle so as to better understand the mechanism which occurred the fatigue damage, and to study the severity of functional deterioration of the bridge bearings. In addition, to understand the cause of this problem, FE analyses were conducted for a three-dimensional model. Considering the deteriorated condition of the existing line bearing, both a fixed constraint (constraint against movement as well as rotation) and a sliding constraint (free to move, constrained from rotating) were used as support conditions

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for the floor frame. From these results, it was determined that it is necessary to free the movement of the bridge bearing to permanently counteract the fatigue damage. Bridge bearing replacement is the typical solution. However the replacement of bearings is costly because of the number of bearings. Therefore, both lubrication treatment and repair welding were conducted as emergency repair. However, the recurrence of damage was observed in a year after emergency repair; therefore, it was concluded that permanent countermeasures be implemented simultaneously with the entire bridge repair plan. A study on the bridge bearing replacement is currently underway.

3. On-going Study

Fig. 1 shows on-going study results of both the field measurement and the laboratory loading test. It is clear that the pot bearing (with dimples) is superior in its movement ability, and can reduce the strain of the rib plate. Fig. 2 shows an example of FE analysis result. In the *Road Bridge Bearing Handbook*, the design friction coefficient of 0.25 is presented for steel on steel sliding conditions. However, the line contact has a tendency to be almost independent of the friction coefficient. The other results considering friction contact are 1/2 or less Model L.

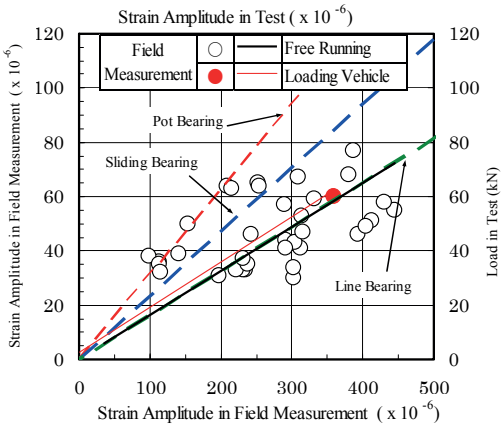

Fig.1: Results both of Loading Test and Field Measurement

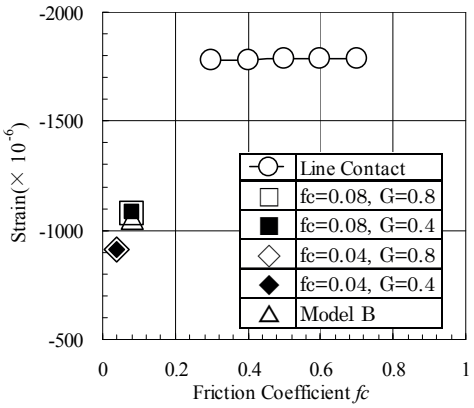

Fig. 2: Relationship between Strain of rib plate and Friction Coefficient

4. Conclusion

This report shows the outline concerned with the bridge bearing replacement study being considered as a countermeasure for fatigue around the floor frame support points of Kanmon Bridge. Although this study is currently on-going; a summary of the findings to date is given below.
(1) Field measurement: It was discovered that the current line bearing has lost its ability to move.
(2) Laboratory loading tests and FE analysis: It was concluded that the pot bearing and sliding bearing can reduce the strain around rib plates.
(3) Cyclic sliding test: It was concluded that both lubricated PTFE and dimpled plain PTFE with grease have friction coefficients lower than the design value of 0.1. In particular, the dimpled plain PTFE with grease has the low and stabilized sliding friction coefficient.