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# Estimation of the Remaining Fatigue Life of a Railway Bridge

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## Summary

The *Dangsan* steel railway bridge was located in Seoul, Korea, crossing the famous Han river for subway traffics (The old bridge was disassembled and a new bridge is under construction at the same location). Upon requests, the bridge had undergone many inspections near the end of its service life since it was reported that there were several fatigue cracks found, and the city authority considered deeply about the safety of the bridge. The remaining life of the bridge had been estimated through the field measurements and the corresponding fatigue test conducted. The results are briefly presented herein.

## 1. The Bridges

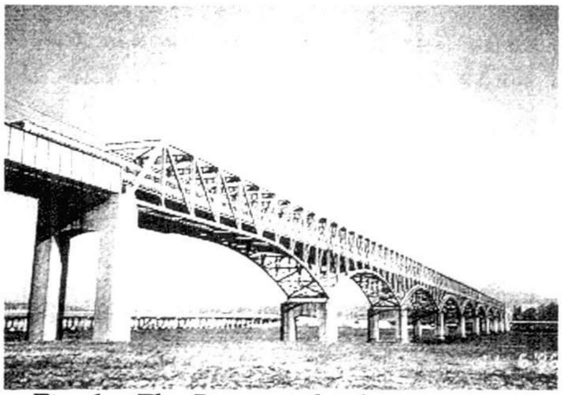


*Fig. 1 The Dangsan bridge*

The bridge consisted of three units of three-span-continuous steel Pratt truss with length 90-90-90m for its main spans in the middle and plate girder bridges on both ends. The picture, profile and corresponding FEM model are depicted in Fig. 1, 2, and 3, respectively. The bridge was made to serve the subway traffics only, and was experiencing about 510 trains daily in two way system.

Via both visual and ultra sonic inspections, most cracks were found from the floor systems (specially, stringers), and improper welding were also found. Based on the inspection and structural analysis, the critical members, which was assumed to dominate the remaining life of the whole bridge, were determined. Some peculiar details, of which the category was hard to be determined, were observed, and corresponding experimental models were manufactured to conduct fatigue test to determine the appropriate category for the details.

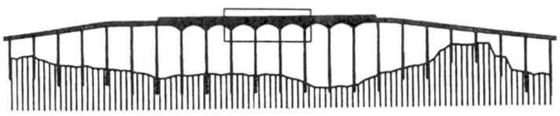
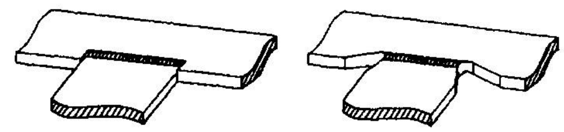


*Fig. 2 Profile of the bridge*

*Fig. 3 FEM model*

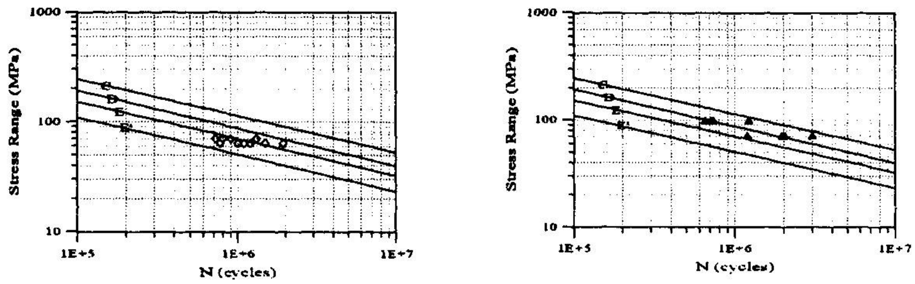
## 2. Fatigue test



*(a) Model A* *(b) Model B*

*Fig. 4 Fatigue Model*

Some upper chords connected with bracings were found to have peculiar details at the connections of gusset plates due to the bad manufacture (See Fig. 4a). About 2cm of flange edges were cut off, and then the gusset plates were attached. Fatigue tests were carried out to identify the fatigue strength of these particular details. Based on visual inspections, experimental fatigue models were made to simulate the actual welding and manufacturing conditions by applying the improper cutting and welding to the flange edges. Repairing method was proposed by finishing the rectangular corner at the welding parts in the round shape according to AASHTO, which may improve the fatigue strength of the detail. Two models were prepared: with actual condition (model A); with proposed condition (model B) shown in Fig. 4a, b, respectively. In addition, the experimental models with typical details were also prepared for fatigue test to compare the results with those of other two models. Upon the test results, the Fatigue strengths for each model were measured and plotted on the AASHTO's S-N curves (Fig. 5). Fig. 5a is the result of the model A which simulates the actual detail condition, and Fig. 5b is the result of model B with the repaired detail. The model A shows that the fatigue strength is a little lower than Category E due to the improper details, but clearly higher than Category E'. The model B shows an apparent improvement.




*(a) Model A* *(b) Model B*

Fig. 5 Measured fatigue strength

## 3. Estimation of Remaining Fatigue Life

The stresses due to the applied loads on the bridge vary randomly, and this results from the uncertain nature of the input variables, which are traffic schedules, passenger volumes, and so on. The coincident incidents of two trains crossing the bridge at the same location were also considered, since it produced the worst loading conditions. The coincident rate was numerically simulated based upon the provided time schedules of subway trains. It is not possible to obtain all the stress time histories for each loading condition from field measurements, due to the complexity of loading conditions. Consequently, a finite element method (See Fig. 3) was utilized to provide the time history for each loading condition, and the simulation results were modified according to the measured field data. Field measurements were conducted mainly through strain gages on the critical main members, which were selected from structural analysis. Two loading conditions for field measurements were considered: One was the normal traffic condition; The other was the controlled traffic condition. Under normal condition, tests were performed in a day while the trains traveled at the normal speed with passengers. The passenger volumes were obtained from visual survey at the station nearby. Under controlled situation, the tests were performed with the empty trains transferred to the site at night. The trains were traveling at speeds from 5km/h to 80km/h. Acoustic emission tests were also conducted to verify the possibility of crack growth, and some cracks were found to be growing. By using the stress ranges obtained from the loading simulations, the remaining fatigue lives of main truss members were estimated and found to be reasonable.