

STRUCTURAL HEALTH MONITORING OF LATTICE GIRDER RAILWAY BRIDGES

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Introduction

This paper presents the experimental and analytical investigation procedure carried for lattice girder Railway Bridge in Sri Lanka. The use of sensor networks to investigate the performance of the bridge under static and dynamic loadings are highlighted. In order to achieve the target goals, overall testing and analysis procedure were divided in to several stages. Firstly, a visual observation was carried out and type of measurements and their locations were determined. Secondly, monitoring system based on information technology was established to understand the dynamic characteristics of bridge such as displacements, member strains and accelerations. Other than that, three dimensional finite element model of the bridge was developed and validated by comparing the experimental data obtained during the field observation process. Finally, validated finite element model was analyzed with moving loads and stress cycles for critical members were determined under past, present and future forecasted loading history and used them to perform fatigue analysis to predict the remaining life time of the structure.

Methodology

The bridge consists of a single span of semi-thorough double lattice girders, supported on abutments. The bridge carries a single railway line of gauge 1.75m. The main girders of the bridge are of equal span, each 33.65 m end to end, and width is 5.20m. The bridge is made of riveted wrought iron members. The cross girders are placed at the panel points of the main girders and also at the centres of each panel. There are two longitudinal girders connected between cross girders in each panel and bracings can be seen in between main girders. The

general view of the bridge is shown in Figure 1.



Fig.1 General view of the bridge

The bridge is made of riveted wrought iron members. The cross girders are placed at the panel points of the main girders and also at the centers of each panel. There are two longitudinal girders connected between cross girders in each panel and bracings can be seen in between main girders. Detail evaluation procedure includes the deflection measurements, strain measurements and acceleration measurements of the bridge under static and moving load conditions (figure 02).



Fig.2 Fixing of displacement gauges to the bridge

M 8 type Locomotive was used for this field survey. The strain gauges were fixed at selected

locations to measure normal stress. In addition to that, vertical and lateral deflections were obtained at the centre of the bridge under static loading conditions. Specially, the bridge was instrumented with accelerometer in order to establish the dynamic factor for the particular bridge under the moving load conditions. In order to measure the free vibration of the bridge, accelerations were recorded after the locomotive engine had crossed the bridge.

Results and Discussions

The detail drawing prepared during the visual observation procedure was utilized to model the bridge with finite element procedure. The field measurement data obtained was used to validate the finite element model and it was employed to study the response of the bridge under future forecasted loading conditions. Model analysis of the bridge was performed and the compared with the free vibration results obtain during the analysis. It was found that experimental first model frequency as 2.75 Hz and numerical value as 2.92 Hz.

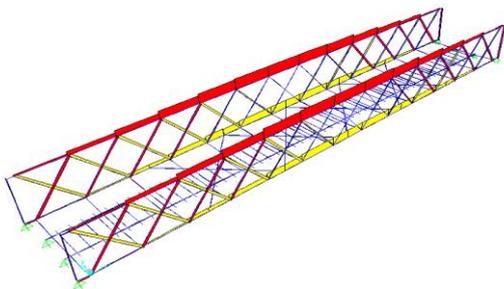


Fig.2 Validated analytical model and axial force diagram

Fatigue Life time Prediction

Members, which are subject to fluctuation of stress, are liable to suffer from fatigue, and this may be caused by loads which are very much lower than those that would be necessary to cause failure under a single application. For the fatigue life evaluation of riveted wrought iron bridges, the statistical based Miner-Palmgren cumulative damage rule (also known as Miner's rule) is used. Using the stress cycle distribution and the daily frequency of trains given in the train timetables, the number of yearly repetition of cycles (n) the member is subjected during each time period was found.

In the calculation of cumulative damage, a constant sequence of trains was assumed.

Table 01 Remaining life time of the critical bridge elements

Member description	Remaining life/years
Center of the main girder bottom chord	251
Middle cross girder	30
Diagonal tension member at middle part	300

Conclusions

The experimental and analytical procedure for structural health monitoring of lattice girder Railway Bridge is discussed in this paper. The experimental and analytical results show good agreement in this work. The results analytical result shows that the failure of the bridge due to yielding of material under future forecasted loading as impossible (providing that all corroded members are repaired). In addition to that, the residual time of the bridge was estimated with aid of the Miner's Rule and the failure of middle cross girder was found to be critical with 30 years of life time.

However, it should be also pointed out that, as Miner's fatigue life prediction theory is based on statics, fatigue could still occur in the members in the bridge due to high stress concentrations. Therefore, periodic inspection of the bridge is recommended.

Reference

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