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SHORT-SPAN RAILWAY COMPOSITE BRIDGES: TEST AND RATING

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Abstract: *This paper presents an overview of the in–service performance assessments of a steel–concrete composite (SCC) short–span railway bridge superstructure. A field load testing and visual inspections for the assessments of the SCC bridge durability under an actual service environment were conducted. The test result indicates that the SCC bridge superstructure has no structural problems and is structurally performing well in–service as expected. The results may provide a baseline data for future field SCC bridge load bearing capacity assessments and also serve as part of a long–term performance of SCC bridge superstructure.*

Keywords: ***Dynamics of bridges, load bearing capacity assessments, bridges static and dynamic loading test, railway steel–concrete composite bridges, DLF, spectral analysis.***

1. Introduction

To investigate its in–service performance, field load testing was conducted under an actual service environment. Field load testing is an attractive tool for re–evaluating the capacity rating of bridges. For the first time, the capacity rating for an SCC railway bridge under in–service environment is calculated and discussed with various existing methods for the rating factors such as allowable stress and DLF (Baťa,et al.1994; Benčat, 2003). As the SCC railway bridge superstructure was instrumented, the real load test was conducted (Benčat, 2007) under similar loading and weather conditions as during initial field loading tests in the 2002 (Benčat, 2003). This was done to ensure the structure's integrity before opening it to the public, to establish base line conditions for a future in–service field load test program, and to compare actual performance with theoretical calculations. After the initial field load test, the follow–up field load test was conducted to ensure that the SCC railway bridge structure was behaving satisfactorily and to check out any signs of degradation. The SCC bridge superstructure was tested using conventional tractile locomotion E 662.2. The results of this test were later used to evaluate bridge in–service bearing capacity.

2. The bridge case – study

The short–span railway bridge on *ŽSR* (*Slovak Republic Railways*) line *Žilina – Čadca* was built in 2002. The bridge load bearing structure is created by one span two concrete plates reinforced by rolled **I** sections. Each line direction is supported by two single span plates which are shifted one another with distance 2,425 m. Length of the span is 13 m and width of structure is 9,8 m. Thicknesses of the plates are 0,82m and they are increased on the border to shape **Π**. The soil conditions for foundations of the two abutments are very similar on both riversides the resistant substratum - gravel and sandy gravel. Foundations of the supports are reinforced concrete blocks on the same substratum as the both abutments. For both dilated bridge parts supports are reinforced concrete gravity abutments. (Benčat, 2002, 2007).

3 Finite Element Model Analysis and DLT

Bridge static and dynamic numerical analysis was performed using the *IDA NEXIS software*. The 3D global model incorporated all primary and secondary load – carrying members in the bridge were

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excluded at this stage. Computing system enable to create slab – beam stiff connection. FE model of bridge structure was composed from two main plate using 2D elements stiff connected on beam elements with **I** shape cross section (reinforcement) respecting bridge load bearing structure geometry. Also supports were modelled respecting bridge bearings positions – one side stiff joints and other side slip joints (SUDOP Košice, 2001; The Steel Construction Inst., 20014; Slovak Standard 73 6203).

A computer – based measurement system (CBMS) was used to record the dynamic response of the bridge excitations induced by testing locomotive over DLT period. The investigated vibration acceleration, deflection and stress amplitudes were recorded at selected points with maximum calculated deflection in the middle of the span. One of the most important parameter – the *Dynamic Load Factor* (DLF) were evaluated using stress and deflection time histories measured during DLT. The next part of the experimental analysis procedure results of the dynamic components structure vibration from the bridge DLT consist of: (a) *deflection time history* – $w(t)$ due to in–service slow train, (b) *stress time history* – $\sigma(t)$, (c) *acceleration time history* – $a(t)$, (d) *stress time history* – $\sigma(t)$ due to locomotive and (e) corresponding *power spectrum* – $S_D(f)$ at the measured points.

3. Conclusions

This paper presents an overview of the in–service performance assessments of an SCC short–span bridge superstructure. A field load testing and visual inspections for the assessments of the SCC bridge durability under an actual service environment were conducted. Based on the presented results the following conclusions can be drawn:

- The maximum deflection from two SLT (2002, 2007) was *max w* = 1.88 mm from both SLT. The maximum value of SLT is 59.53 % lower than the maximum theoretical value of FEM. It means that the SCC bridge superstructure may be designed with a less restrictive design deflection.
- The dynamic responses in 2002, 2007 (monitoring) also show that the passage of the trains produces insignificant vibrations, the maximum dynamic deflection effective value w_{rms} = 0.48 mm (2002) and w_{rms} = 0.32 mm (2007). This is attributed to the difference between the natural frequency of the SCC bridge superstructure and the forcing frequency of the passing locomotive and trains.
- After five years of bridge service, DLF values of the SCC bridge are well compared with values DLT measured in the initial tests (2002). All experimental DLF values are lower than prescription by the Slovak standards DLF values. Therefore there is no need to post the load limit and the capacity–rating evaluation and for the SCC bridges can use rating factor of the existing methods for the conventional materials such as the allowable stress and load–factor.
- The predicted dynamic behavior of the bridge by a simplified FEM analysis calculation was compared to the measured one. Despite both the complex structural layout of the bridge and simplifying assumptions of the model obtained results showed good agreement for all experimentally identified damped natural frequencies in the basic frequency range 0 – 11 Hz (2002, 2007) and these are well compared with the theoretical values.
- Although the data on the in–service performance of SCC Bridge are not enough, the results may provide a baseline data for the future capacity rating assessments and also serve as part of a long-term performance of the examined SCC bridge superstructure.

References

Baťa, M., Plachý, V., Sýkora, J., Bílý, V. & Polák, M. (1994) Static and dynamic tests of bridges, in: *Proc. of Czech – US Bridge Conference*, Praha.

Benčat, J. et al. (2007) *Report on dynamic monitoring results of the bridge on railway Žilina – Dětmarovice v km 256,919*, Report No. 6 – 3 – 42/SvF/07, ŽU/Žilina.

Benčat, J. et al. (2003) *Report on static and dynamic test results of the bridge on railway Žilina – Dětmarovice v km 256,919,* Report No. 6 – 3 – 19/SvF/03, ŽU/Žilina.

Design documentation. (2001), SUDOP Košice.

Slovak Standard No.73 6209 – Loading test of bridges.

Slovak Standard No.73 6203 – Loading of bridges.

The Steel Construction Institute. (2001) *Structural design of stainless steel*, SCI Publication P291, Ascot, UK.