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INSPECTION OF RAILWAY BRIDGE OVER THE RIVER SLOBOŠTINA NEXT TO OKUČANI

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Abstract

The Railway Bridges (north and south) over the river Sloboština near to Okučani is part of double-track line Zagreb – Slavonski Brod. This article presents statical and dynamical testing of the Railway Bridges which were reconstructed and strengthened for the purpose of categorization.
Categorization which includes inspection of the construction according to now day's loads, the old railway bridges (north from 1889, south from 1947 year) were strengthened against a side impact. In article will be represented south Railway Bridge.
Statical load consisted of two electrical locomotives type of HZ 1141 with mass of approximately 82 tons, which were connected. Statical testing was carried out through total of 7 phases of loading and load releases, to cause maximum internal forces in main bearing elements of construction. During the static load displacements were measured at 18 measuring points by surveying method of levelling on all significant points of the bridge. Strains were measured at 5 measuring points. Dynamic testing of the bridge was carried out to determine dynamic parameters of the structure (natural frequencies, dynamic increment of the structure, relative dumping).

Keynote: static, dynamic, inspection, bridge, strain, deflection

1 Introduction

Inspection of Railway Bridges "SLOBOŠTINA" (north and south) in km 288+194 near to Okučani were conducted after reconstructed and strengthened for the purpose of categorization the bridges. The main bearing systems of Railway Bridges are two identical 33,4m length and 4,0m high, parallel steel truss (with verticals and diagonals) girders, with cross girders on distance of 4,18m connected to the nodes of the main girders and two parallel secondary longitudinal girders which are below the tracks.
The first bridge at this place was built 1889 (north-upstream), while the line was single-railed. The second track (south-downstream) was built the 1947 and they are still in exploitation up to the present. Bridges are made of the St-37 (Č0360) and rivets of steel St-34. Abutments are massive, made of concrete and stone. For the purpose of categorization which includes inspection of the construction according to now day's loads (UIC-71, SW/-2, SW/0, SW/1, SW/2 and D4), the bridges were strengthened against a side impact, which consisted in replacing the bracing with the new one L120 120 12. Also at same time the abutments were reconstructed.

Note: in this article will be shown the results of investigations of the northern bridge.

Figure 1 Front view of the steel truss bridge (north-upstream)

2 Investigation of Bridge

The investigation was carried out using two types of electric locomotives HZ 1141 mass approximately 82 tons, which were connected. Static load were set to span so as to cause maximum internal forces in certain important elements of the structure. During static load the deflections were measured in the most important nodes of the main girders (2 girders x 9 nodes=18 measuring nodes) in each loading phase. A vertical deflection was determined by the surveying method of levelling. Strains were measured by LVDT probes on the all important elements of the bridge.

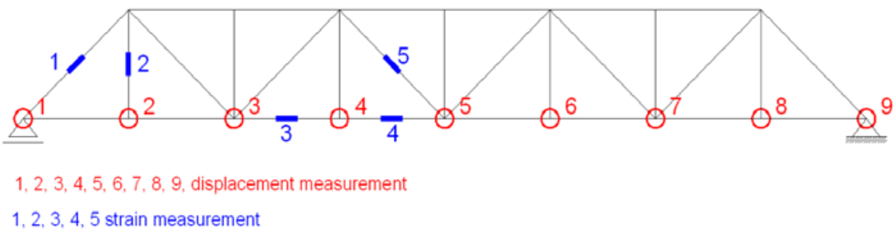

Figure 2 Longitudinal bridge disposition for strain measurement and points for displacement measurement

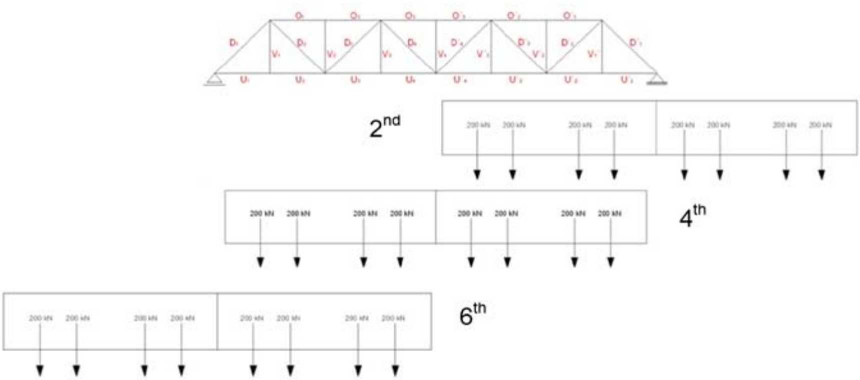

Figure 3 Scheme of the 2nd, 4th and 6th phase of loading construction

Investigation of the bridge on the static load was carried in seven phases, zero measurement, three phases of loading and three phases unloading of the construction.
In Figure 3 shows three phases of static loading of the bridge. Each axle loading the rails approximately for 200 kN. Fourth phase gives the symmetric loading, while the second and the sixth phase are asymmetric. Third, fifth and seventh are unloading phases.
After completed static loading, the bridge was conducted to determine dynamic parameters. Dynamic investigation of the bridge at excitation of two locomotives, which were driven across the bridge at speeds of 30, 60 and 90km/h. Dynamic response of structure registered in form of time function and function of the frequency spectrum.
To validate results which were determined in situ, here is given a numerical model of the structure. Static and dynamic numerical model was carried out using computer program “Sofistik” in the Department for Engineering Mechanics, Faculty of Civil Engineering in Zagreb.

3 Measurement results

3.1 Results of deflection measurement during the static load

In the Table 1 are shown comparison of measured and numerical deflections of the each loading phases. Given deflections are considering as the height difference between two phases: phase that corresponds unloading and loading phase.

Table 1 Deflections during static loading

	phase II				phase IV				phase VI			
	Exper.		Numer.		Exper.		Numer.		Exper.		Numer.	
points	A	B	A	B	A	B	A	B	A	B	A	B
4	3,0	3,0	3,5	3,5	7,9	8,2	8,4	8,4	4,5	4,7	4,6	4,6
5	4,1	4,0	4,2	4,2	8,3	8,7	8,9	8,9	4,0	3,8	4,3	4,3
6	4,6	4,8	4,6	4,6	8,0	8,0	8,4	8,4	3,3	3,0	3,5	3,5

Labels A and B in Table 1 denote line of measurement of the each main girder.

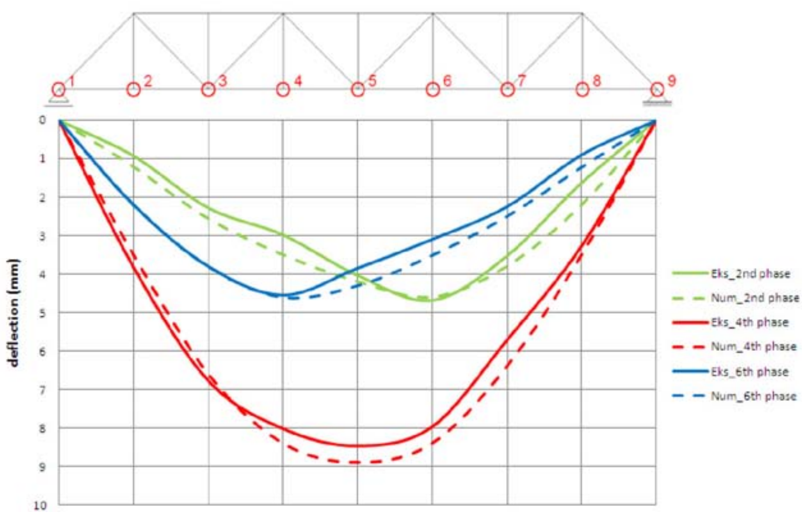

Figure 4 Experimental and numerical results of deflections

Figure 4 shows comparison of measured and numerical deflections of the 2nd, 4th and 6th loading phases
Figure 5 shows the numerical results of deflection for 2nd, 4th and 6th phase loading.

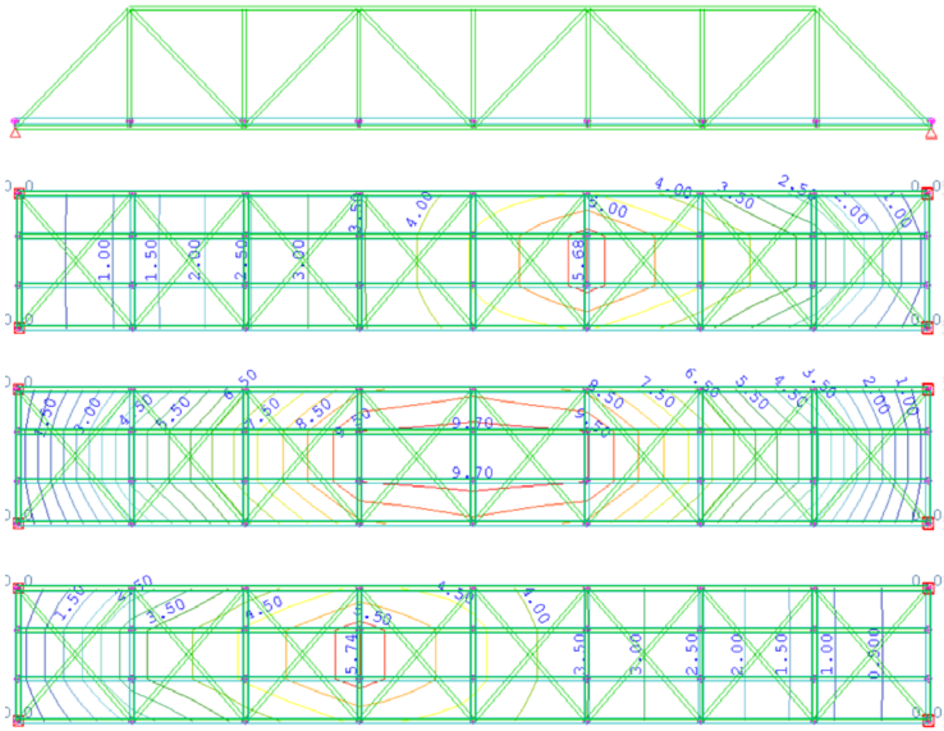

Figure 5 Numerical results of deflection

3.2 Results of strain measurement during the static load

During static testing of bridge continuously were recorded the deformations occurred in five places on the construction.
Table 2 shows the maximum measured strain for each element executed in one of the loading phase. Experimental strains are compared with proper numerical strain and trail strain obtained after unloading phase.

Table 2 Strains during static loading (‰)

Element	Labels	Experimental strain	Remaining strain	Numerical strain
diagonal D1	1	-0,0937	-0,0079	-0,0726
vertical V1	2	0,0497	0,0003	0,0433
girder U3	3	0,0531	0,000	0,0910
girder U4	4	0,0581	0,000	0,0889
diagonal D4	5	0,0321	0,000	0,0235

The following graph (Figure 6) shows continuous records of strains on elements of structure labelled in Figure 2

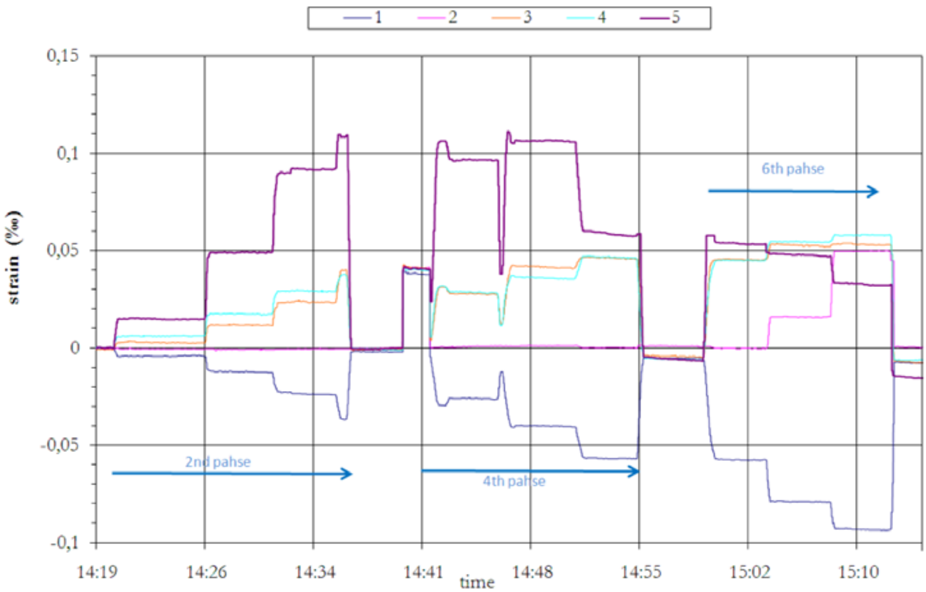

Figure 6 Numerical results of deflection of the 2nd, 4th and 6th phase

3.3 Results of dynamic testing

Results of dynamic testing during the impact of locomotives load are shown in the form of the time function and the function of spectral density of force after a fast Fourier analysis (FFT). Structural response was measured in the vertical direction and some forms of lateral vibrations that appear in the numerical analysis were not recorded.
Tables 3 and 4 shows the own frequencies dynamic and displacements of bridge structure vibration, and Figures 7-9 shows the records of dynamic testing.

Table 3 Comparison of own frequencies of the bridge structure

Experimental frequencies [Hz]	Numerical frequencies [Hz]	Mode shape
3,69	3,55	1st vertical + torsion
7,00	7,01	2nd vertical
10,26	10,36	3rd vertical + torsion

Table 4 Dynamic displacements on the bridge structure

Speed (km/h)	y_{din} (mm)	$\varphi = \frac{y_{din} + y_{st}}{y_{st}}$
30	0,224	1,023
60	0,347	1,036

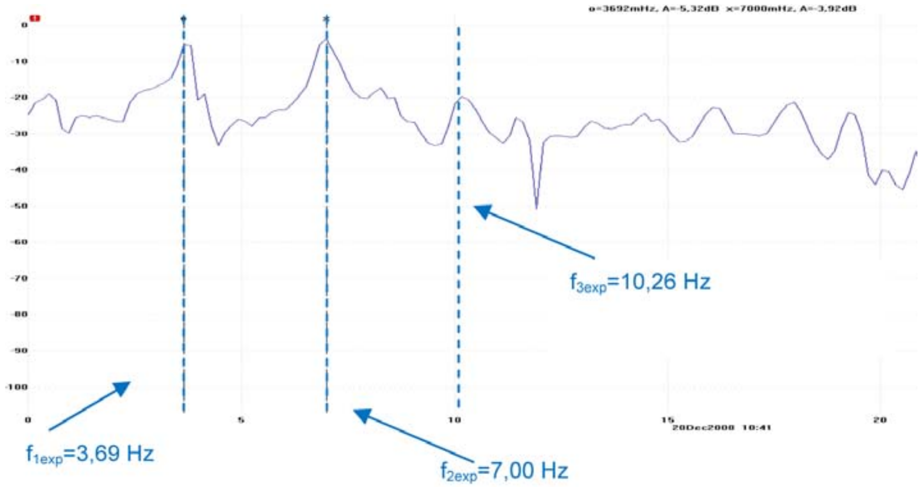

Figure 7 Records of experimental frequencies (vertical direction)

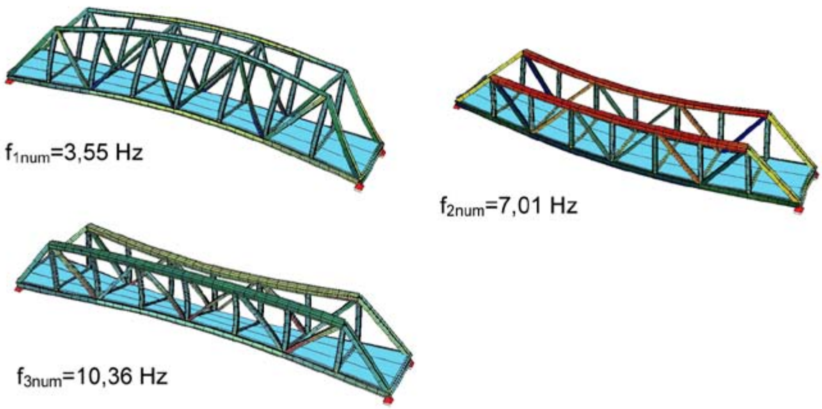

Figure 8 Numerical own frequencies for the 1st, 2nd and 3rd mode shapes (vertical direction)

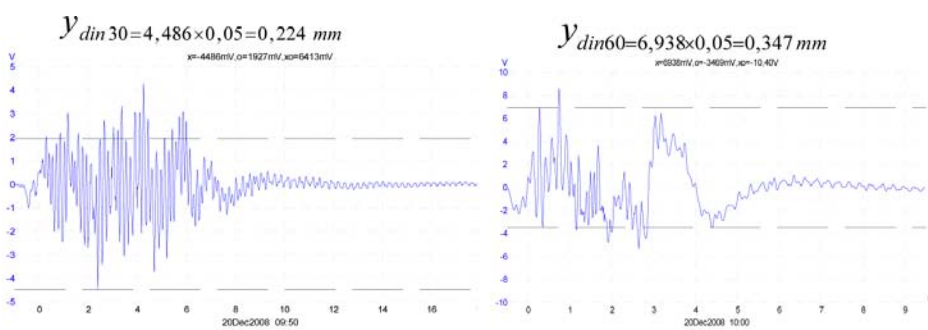

Figure 9 Records displacement-time

4 Conclusion

On the basis of theoretical analyses and the comparison with the results of static and dynamic testing of the reconstructed and strengthened bridge, the following can be concluded:
Maximum experimental values of deflections and strains on Railway Bridge are within the expected limits, and they correspond to the theoretical values.
There are no significant remaining deflections and strains after testing.
The experimental dynamic response of the structure is expected and realistic, and basic dynamic parameters are in accordance with the expected theoretical values.
No damages on the structure were observed, neither before not after the testing.

References

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8 RAILWAY DESIGN