STATIC AND DYNAMIC TESTING OF OVERPASS ON SLAVONIAN AVENUE IN ZAGREB

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Abstract

This paper presents results of experimental testing performed on overpass located in the east of Croatia's capital, Zagreb. This overpass is included in the project of development of road infrastructure in this part of town which has a big population growth in the last decade. The main (central) overpass consists of two parallel overpasses (southern and northern)* which have identical structure system and dimensions. The overall lenght of the overpass is 164,0m (5 spans) and the overall width of the overpass is 13,50m. Load carrying structure of the overpass is based on precast prestressed longitudinal I cross – section girders layed on piers and a plate concreted on girders. Continuity of longitudinal girders is accomplished with cross girders constructed on each bearing point of the overpass (piers and abutments). Static testing was performed with six heavy trucks (~ 330 kN each) that were used to load every span of the overpass in symmetrical and unsymmetrical way. During the phases of loading and unloading deflections and strains were measured with LVDT sensors on total of 8 locations. Additionally, deflections were measured geodetically in the middle of spans and on bearings using two parallel lines with measuring points on the pavement.
Dynamic testing was performed using heavy trucks that were driving over the overpass. Dynamic parameters were determined from the response of the structure. They were measured using sophisticated equipment and are presented in this paper graphically and tabulary.
Results of both static and dynamic testing are very important for evaluation of structure's behaviour and state and they need to be in correlation with those derived from numerical model. In this case, results derived from the experiment and from numerical model show satisfying correlation.

Keywords: overpass, experimental testing, deflection, strain, traffic load

**Note: In this paper only the testing of the southern overpass is described*

1 Introduction

As it is mentioned in abstract the main bearing structure of the overpass is semi-mouting continuous structure layed on piers and abutments over 5 spans with overall lenght of 28,0×2 + 35×2 + 38 = 164,0m. Cross section consists of 7 precast prestressed I cross – section girders (height 180cm, width 120cm) and a 25cm thick plate made *in situ*. Continuity of longitudinal girders is accomplished with cross girders constructed on each bearing point of the overpass (piers and abutments). The overall width of overpass is 13,50m and it includes three traffic lanes (3,50m each), marginal strips (0,50m each) and pedestrian ways (1,00m each).

Figure 1 Overpass on Slavonian avenue in Zagreb

2 Static testing of overpass

2.1 Description

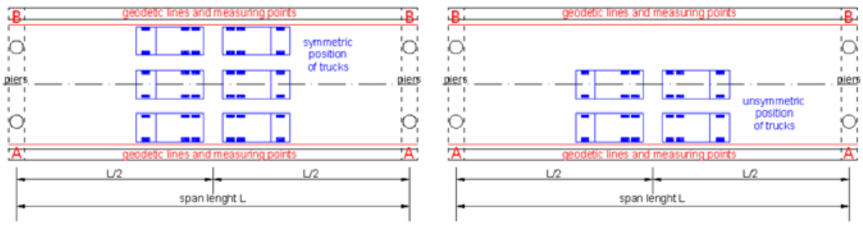

Figure 2 Some loading schemes of overpass

Static testing of overpass was conducted using six heavy trucks weighing approximately 33,0 t. The trucks were positioned in a way to achieve best correlation between internal forces from static calculation and internal forces caused by trucks. In static design, traffic load was calculated using Croatian prestandard HRN ENV 1991 – 3, model 1. Testing was carried out through 7 loading and 7 unloading phases. All spans were loaded in a symmetrical way except for second span (l = 35,0m) which was loaded in a unsymmetrical way (sides A and B) also.
During the testing, there were two teams who measured the effects of this loading. On the deck of the bridge displacements were measured by surveying method of leveling using two lines (A and B, each on one side of the bridge, near sidewalk) with measuring points above piers and abutments and in the middle of span (Points 1 – 11). Furthermore, displacements and strains were measured in second span using LVDT sensors with high sensitivity. Measuring points for displacement were in the middle of span on two longitudinal girders. Measuring points for strains were in the middle of span on four longitudinal girders and near piers on two longitudinal girders. That gives a total of two sensors for displacement monitoring and six sensors for strain monitoring. Figure 3. shows position of sensors in the middle of second span (for displacements – D1, D2; for strain – S1, S2, S3, S4, S5 and S6)
Maximal measured deflections compared with theoretical values are shown in Table 1 and Table 2. In Table 1 there are deflections measured geodeticaly and in Table 2 there are deflections measured using LVDT sensors. For symmetrical loading the greater value was considered between geodetic lines A and B. For unsymmetrical loading both values are considered since the load is located first on one side and then on another side so that symetrical behaviour

of overpass could be veryfied. Theoretical values are obtained from a numerical model of overpass made by using Sofistik software in Department of engineering mechanics, Faculty of Civil Engineering, Zagreb.

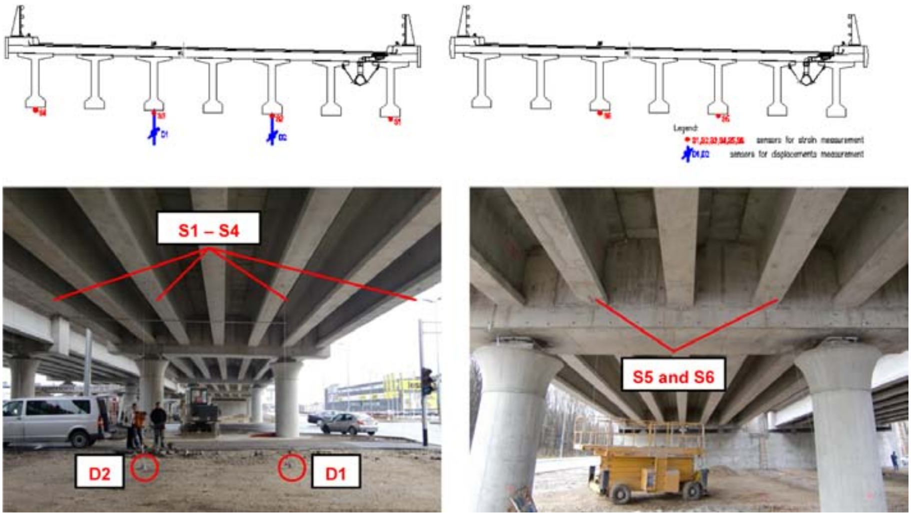

Figure 3 Measuring points in second span (middle; near pears)

2.2 Results

Table 1 Comparison of deflections measured by geodetic methods and theoretical ones.

Span	Loading phase	Measuring point	Experimental deflection [mm]	Theoretical deflection [mm]
1	2nd – symm.	2A	2,55	3,89
2	4th – unsymm.	4A	3,50	4,59
	6th – unsymm.	4B	3,35	4,59
	8nd – symm.	4A	3,70	5,00
3	10nd – symm.	6B	5,75	6,95
4	12nd – symm.	8A	3,90	5,00
5	14nd – symm.	10B	2,75	3,89

Table 2 Comparison of deflections measured with LVDT sensors and theoretical ones.

Span	Loading phase	Measuring point	Experimental deflection [mm]	Theoretical deflection [mm]
2	2nd – symm.	D1	+1,05	+1,85
	4th – unsymm.	D1	-4,22	-5,81
	6th – unsymm.	D2	-4,33	-5,81
	8nd – symm.	D2	-5,28	-7,34
	10nd – symm.	D2	+1,37	+2,67

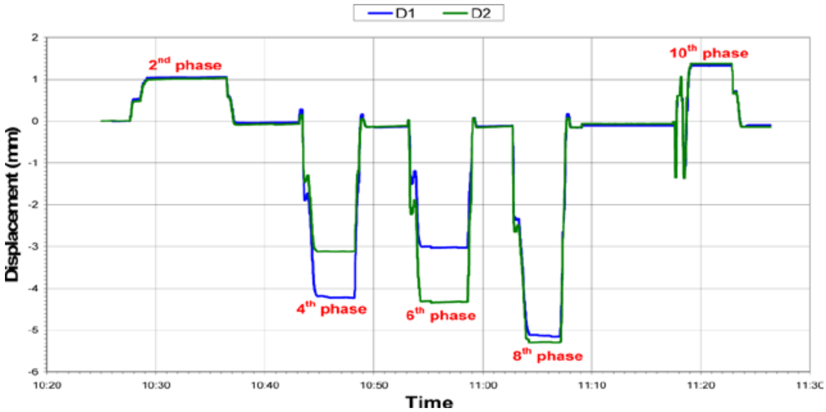

Figure 4 Displacements time record through some phases of loading

Maximal strain for some phases of loading are shown in Table 3. From these values are values for experimental stress gained and compared with theoretical ones obtained from calculated bending moments.

Table 3 Experimental and theoretical strain and stress of longitudinal girders

Span	Loading phase	Measuring point	Exp. strain [‰]	Calc. stress [MPa]	Theor. stress [MPa]
2	2nd – symm.	S5	-0,028	-1,12	-2,26
	4th – unsymm.	S2	0,053	2,12	3,34
	6th – unsymm.	S3	0,052	2,08	3,34
	8nd – symm.	S2	0,063	2,52	3,89
	10nd – symm.	S4	-0,012	-0,48	-0,96

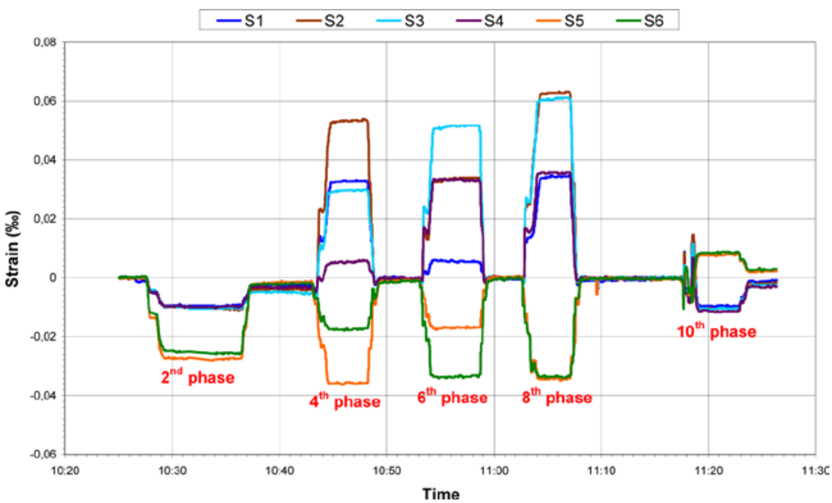

Figure 5 Strain time record through some phases of loading

3 Dynamic testing of overpass

3.1 Description

Overpass was excited with actual traffic load consisted of one heavy truck driving over the overpass. Response of the structure was captured as the time function and the function of spectral density. This kind of dynamic excitation gives structure response of a wider spectrum. The frequencies of basic vibration were excluded from the function of spectral density. Dynamic components of deflections were determined from the time functions of structure response.

3.2 Results

Table 4 and Table 5 show natural frequencies of overpass structure in comparison with theoretical frequencies and some dynamic deflections. Excitation by moving truck arrouses mainly vertical modes of vibration and their response was captured with high accuracy.

Table 4 Experimental and theoretical values of natural frequencies

Mode of vibration	Experimental frequencies [Hz]	Numerical frequencies [Hz]
1st vertical	2,935	3,07
2nd vertical	3,843	4,08
3rd torsional	not measured	4,67
4th vertical	4,953	4,95

Table 5 Dynamic deflection in the middle span of structure

Truck speed [km/h]	Dynamic deflection [mm]
20	0,037
40	0,099
60	0,124

Figures 6. to 8. show the records of dynamic testing and theoretical modes of vibration. First two eigenfrequencies visible in power spectral density record in Figure 6. show good congruency with those from numerical model (Figure 7.).

Figure 6 Power spectral density function (1st and 2nd mode of vibration)

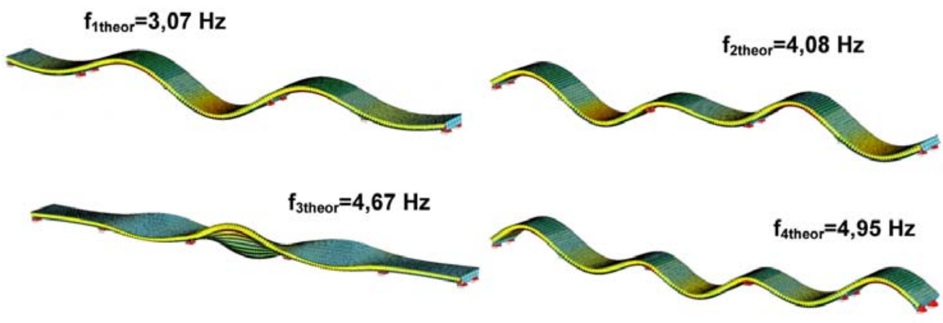

Figure 7 Numerical modes of vibration

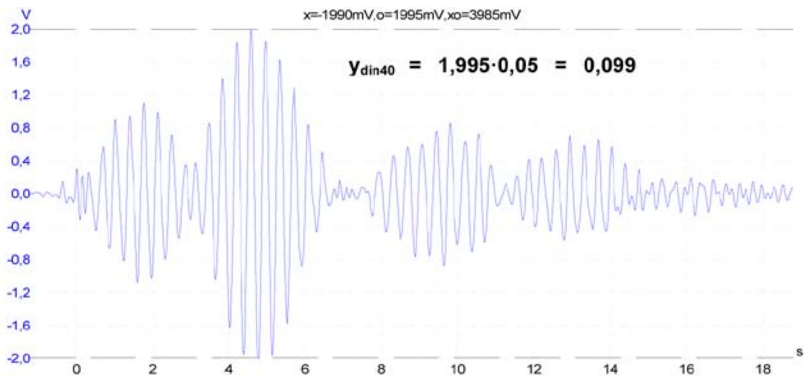

Figure 8 Experimental dynamic deflection (v_{truck} = 40km/h)

4 Conclusion

After performing static and dynamic experimental testing of overpass on Slavonian avenue in Zagreb we can conclude that the overpass is constructed as it was designed. All measured characteristics are under tolerances and in good correlation with those from numerical model. During all loading and unloading phases displacements and strain were monitored. There was no unpredictable occurence. When the phases were finished, the results of all measurements showed that the structure had returned to starting state that explicitly shows its elastic behaviour. Dynamic parameters, which are very important to determinate real state of structure have been measured and they are in good agreement with theoretical ones.

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