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DYNAMIC CALIBRATION OF A MODEL OF A MIXED STRUCTURE BRIDGE DECK BASED ON DYNAMIC TESTS OF THE BRIDGE

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1. Introduction

Considering the socio-economic importance of bridge structures, their acceptance testing is generally a mandatory requirement before the bridge is put into operation. The dynamic test is a component of the acceptance testing process used to verify the numerical model of the bridge structure from a dynamic perspective. This paper presents the procedure for conducting dynamic tests on a segment of a bridge with a mixed structure deck, under standard conditions using test loads.

The experimental findings served as the basis for structural verification of the bridge deck in terms of execution quality and for the numerical model calibration, for future references studies.

2. Experimental dynamic test of the bridge

The overpass located on the outskirts of Timisoara city, ensures the crossing of a single, non-electrified railway line by the Timisoara South Bypass.

The bridge has 8 spans, with a total length of approximately 331.62 meters, and it is composed of reinforced concrete beams at the end spans and a composite steel–concrete deck in the central zone, including the span that crosses the railway line.

In the steel–concrete composite section of the deck, the superstructure consists of continuous steel beams with three spans (40.30 + 55.30 + 40.30 m). In cross-section, the deck includes two continuous main steel girders and a central longitudinal beam, with the structure stiffened by steel crossbeams, bracings, and a reinforced concrete slab acting compositely.

The experimental testing procedure was made accordingly with the specific Romanian standard, STAS 12504-86 [1].

2.1 Experimental test assembly

The dynamic response of the bridge was evaluated using a test truck loaded with ballast, having a total mass of approximately 40 tons. Bridge accelerations were continuously recorded in real time during the entire crossing of the truck.

To generate a shock-type dynamic load, an artificial obstacle was placed on the roadway surface. To simulate various levels of dynamic excitation, the truck passed over it at different speeds.

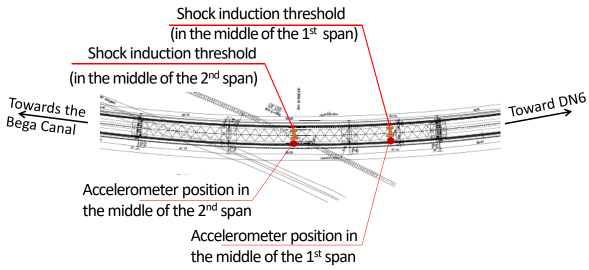

Fig. 1. The position of the accelerometers and the shock thresholds

For each obstacle, one can consider five incremental speed levels (10, 30, 50, 70 and 85 km/h, were used). For each passing of the test truck, accelerations were recorded along three orthogonal directions, at the positions indicated in Fig. 1.

3. Experimental results

Given that the excitation was predominantly vertical, the horizontal response of the deck was deemed not representative for the dynamic test.

		Vibration frecqency resulted from Modal FEM Analysis [Hz]		Distinct Vibration Frequency [Hz] / All tests				
Speed of the test truck [km/h]		Vertical Modal Participating Mass Ratios	Modal Frequency [Hz]	Speef of the test truck / 1st and 2nd position of the artificial obtacle				
				10	30	50	70	85
Vibration frequencies bands [Hz]	0.1 ÷ 1 Hz	-	-	-	-	-	-	-
	1 ÷ 2 Hz	1.18%	1.42	1.44 1.48	**1.44***	1.48	1.44 1.48	**1.48***
	2÷ 3 Hz	0.61% **67.67%**	2.82 **2.95**	**2.12*** **2.28*** **2.88***	2.12 **2.40*** **2.68*** 2.88 2.92	**2.40*** **2.68*** **2.76*** **2.84*** 2.88	**2.80*** **2.84*** **2.88***	**2.40*** **2.84*** **2.88***
	3 ÷ 5Hz	-	-	3.68	-	-	-	-
	5÷ 10 Hz	-	-	-	-	8.64	-	-
	10 ÷ 12 Hz	18.14%	11.28	-	-	-	-	-
	12 ÷ 14 Hz	-	-	-	-	13.92	-	13.80
Average frequency [Hz]				2.55 Hz				
Median frequency [Hz]				**2.76 Hz**				
Note: * The frequencies with maximum amplitude in the Power Spectra of each recorded accelerogram								

Fig. 2. The results of the experimental testing of the bridge

The vertical acceleration records (accelerograms) capturing the bridge deck vibrations were subsequently analyzed to determine the frequency characteristics of the structural response [2]. For each recorded accelerogram, baseline correction and filtering procedures were applied, followed by the computation of power spectral densities, through which the dominant vibration frequencies were identified (see Fig. 2).

4. Modal FEM Analysis

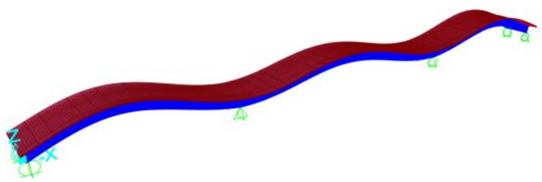

Fig. 3. Mode 4 with a frequency of 2.95 Hz, for a 67.57% modal participating mass ratio.

The modal shape of the predominant mode of the deck is presented in Fig. 3, in terms of modal participation mass ratios at vertical translation.

5. Dynamic calibration of the FEM model

As one can observe in Fig. 2, the frequency content of the bridge vibrations is very close to the predominant modal frequency of the FEM model. This experimental result assures that the real structure of the bridge deck has good behavior under loads, close enough to presumed behavior resulted from the FEM analysis. Although, one can observe that the stiffness of the FEM model is a little higher than the real structure. To perform subsequent analyses of the bridge's behavior under dynamic loads, the numerical model was calibrated based on the experimental findings.

Considering that the fundamental frequency depends on terms such structural mass (m) or structural stiffness (k), as results from Eq. 1, the numerical model calibration can be conducted in terms of mass or stiffness [3].

$$f_1 = 2\pi\sqrt{k/m} \quad (1)$$

Because the modal analysis is conducted mainly with respect to the dead weight of the structure, the only term which can be tweaked is structural stiffness. After some minor modification on the values of the Young Modulus of the structural materials and the stiffness of the connections between structural elements of the bridge deck, the model was calibrated in order that the fundamental vertical mode to be almost identical with the median value of the predominant frequencies of the recorded accelerograms. After the calibration, the resulting fundamental frequency is 2.76Hz, with a Modal Participation Mass Ratio of 68.27% (Fig. 4)

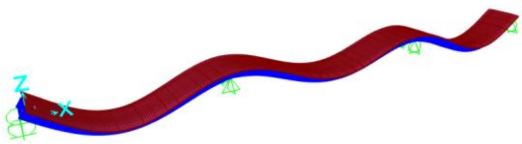

Fig. 3. The fundamental mode, after the calibration.

6. Conclusions

The experimental tests showed that the bridge has good behavior, but for future analysis the numerical model was calibrated to be tuned with the real structure in terms of fundamental frequency.

Acknowledgments

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