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EXPERIMENTAL INVESTIGATION OF VARIN BRIDGE DYNAMIC RESPONSE

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A lot of bridges were tested by the Department of Structural Mechanics at the University of Žilina. Withing the framework of dynamic analyses the numerical calculations of natural frequencies, natural modes and dynamic coefficients are ussually carried out. All numerically obtained results are veryfied by the full scale or laboratory model tests. The results of experimantal analysis of a bridge and the comparison with the results of numerical analyses are presented in this paper.

1 Brief account of bridge structure

The bridge in question is a three span highway bridge situated near the town Varín in the middle of Slovakia. The construction in every field is built from 8 prefabricated reinforced concrete beams of the type I 73 with the length of 30.0 m and the height of 1.4 m. Every beam is single supported. The width ofspan is 29.0m. The cross section composition is as follows:

- bearing structure, 8 beams I 73,
- concrete levelling topping, thickness from 8 to 11 cm,
- infiltrating paint + Balex and Mastix, thickness 1 cm,
- cast asphalt, thickness 3 cm + asphaltic concrete, thickness 8 cm.

All the width of the bridge ia 11.50 m. The bridge piers are monolithics and are made of concrete B 40. Rubber fixed bearing and pottery sliding bearing are applied for the structure. The bridge is designed for the load class „A“ according to the Standard ČSN 73 6203 [1]. The cross section of the bridge is presented in the Fig. 1.

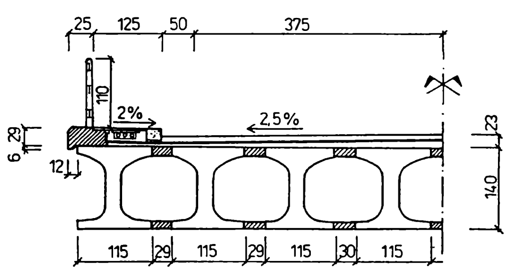

Fig. 1 *The cross section of the bridge.*

2 Experimental investigation

At the first stage the static loading test was carried out. The loading vehicle was situated in the most efficient possition in relation to the midspan bridge deflection. The deflections of the structure were registered by the Mohr mechanical indicators [2].

Dynamic loading test succeeded to static loading test. Vibration of the structure was registered by the relative inductive sensors ZPA, situated under the bridge, and connected with the structure by the steel ropes. The absolute Bruel-Kjaer 8306 sensors were situated up on the bridge deck. The distribution of all sensors can bee seen in the Fig. 2.

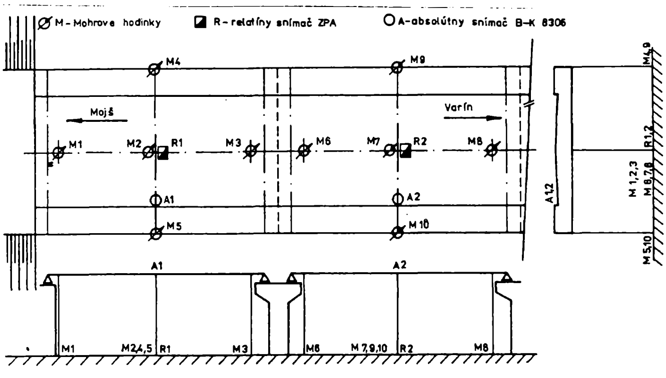

Fig. 2 *Distribution of sensors*

For registration of vehicle speed special equipment was developed. The gum hoses were located across the roadway at the begining and at the end of the bridge span. The hoses were filled by a liquid and furnished with pressure switch. Electrical signal from the pressure switches start and stop specially arranged stop-watch.

For the registration of synchronous vibration of vehicle - bridge system the telemetric transmision system, developed at the Department of structural mechanics, was used. Arrangement of measured equipments can be seen in the Fig. 3.

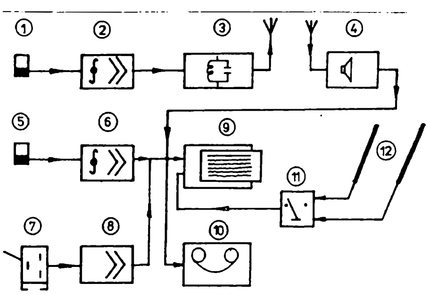

Fig. 3 *Measured equipments: 1-accelerometer FRT DK 35, 2-amplifier RFT 11013, 3-sender FM-MPC2S, 4-receiver FM-MPC2S, 5-accelerometer BK8306, 6-amplifier RFT 11013, 7-sensor ZPA, 8-amplifier SMITHS, 9-six-channel recorder CHIRAKARD, 10-tape recorder BK 7005, 11-signal box, 12-gum hoses with pressure switches*

3 Dynamic calculations

Calculation of natural frequencies and natural modes was done by the use of Finite Element Method (FEM). The computing model was created from the rectangular shell elements of constant thickness. The Mindlin's bending theory, considering the effect of shear deformation and rotary inertia, was used. The structure was devided into 812 finite elements of the 6 types. The model has 2 138 nodes and 8 259 degrees of freedom. The values of calculated natural frequencies are introduced in the Tab. 1.

j	$f_{(j)}$	j	$f_{(j)}$	j	$f_{(j)}$
-	[Hz]	-	[Hz]	-	[Hz]
1	3.96	4	18.32	7	31.30
2	9.74	5	21.53	8	33.73
3	14.59	6	26.07	9	36.92

Tab. 1 *Calculated natural frequencies.*

For the purpose of a numerical simulation of vehicle motion along a bridge structure there was worked out the computing model considering the bridge structure as a simple Bernoulli - Euler beam with continuously distributed mass and vehicle as a planar biaxial sprung load unit. Pavement irregularities were simulated by the random discrete values in the range of < +10, - 10 > mm. The programme for PC computer with the title BRIDGEW2 in language FORTRAN was devised to solve this problem in real time [3]. The calculation of the dynamic midspan deflection was performed with the values of vehicle parameters (mass, suspensions characteristics, speed) coresponding to the values used at those speed of vehicle motion which were realized during the bridge test. The results of calculation are presented in Fig. 4.

4 Conclusions

To verify the numerically obtained results the full scale bridge tests were carried out. The bridge was excited by smooth runs of vehicle T148 3S and by runs the one through a norm plank in the sense of the Standard ČSN 73 6209 [4]. From the frequency analyses of the vibration records, by the use of DAS16 system, the 1st natural frequency in the value of $f_{(1)}$ = 4.00 Hz were determined. This value very good corresponds with the calculated value $f_{(1)}$ = 3.96 Hz. The values of dynamic coefficients at midspan of the bridge were evaluated from the vibration records too. These values were compared with the ones numerically obtained withing the calculations. The comparisson of the calculated and observed dynamic coefficients for the bridge can be seen in the Fig. 4. All the experimentally found values of the dynamic coefficients fulfilled the basis criterion (1) required by the Standard [4].

$$(\delta - 1).\eta \leq (\delta^{*} - 1)\,, \qquad (1)$$

where δ is the measured dynamic coefficient, δ^{*} is the design dynamic coefficient and η is the dynamic effectiveness of a loading vehicle.

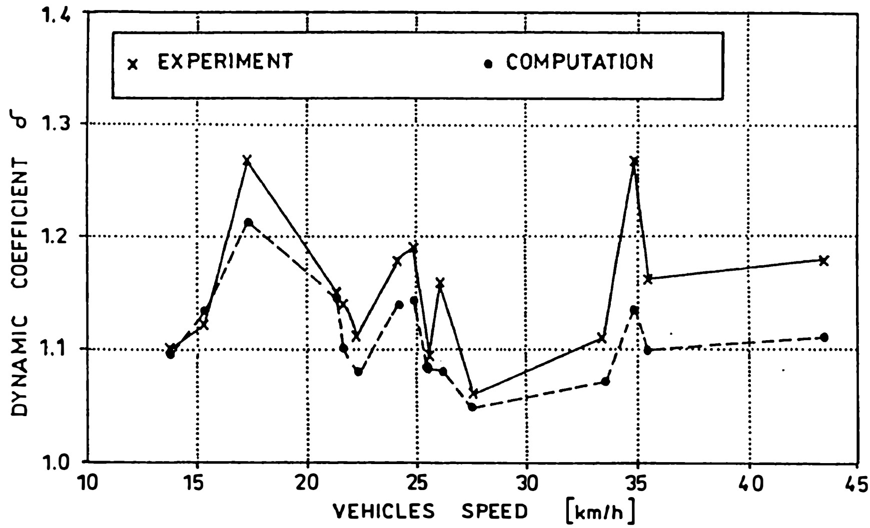

Fig. 4 *Calculated and measured dynamic coefficients.*

The equations of motions describing the synchronous vibration of the system „vehicle-bridge" were derived on the basis of acceptacion some simplifying assumptions and were integrated numerically. The results of model tests and their comparisson with the calculated ones confirm that the simplifying assumptions and numerical processes are acceptable for the solution of this problem. They are not the sharp discrepancies with the objective facts.

5 References

[1] ČSN 73 6203 Load ofbridges (inCzech). Institute for Standardization and Measurement, Prague, 1987.

[2] Pavlík,M.-Pekarovič,J.-Bednár,J.:Examples from the experimental mechanics. ALFA, Bratislava, 1975

[3] Melcer,J.:Experimental verification of numerical processes. Proceedings of the 31th Conference on Experimental Stress Analysis - EAN'93, ÚTAM AV ČR, Praha, 1993, p.203-206.

[4] ČSN 73 6209 Loading tests of bridges (inCzech). Institute for Standardization and Measurement, Prague, 1980.

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