**Zeitschrift:** IABSE reports = Rapports AIPC = IVBH Berichte

**Band:** 79 (1998)

**Artikel:** Dynamic response of a full scale tested bridge

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**DOI:** https://doi.org/10.5169/seals-59897

# Dynamic Response of a Full Scale Tested Bridge

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## Summary

Presented in this paper is dynamic testing of a reinforced-concrete bridge on the Kumanovo - Titov Veles motor way. The bridge is constructed of precast-prefabricated prestressed simple beams continued by a cast-in place deck structure. The objective of the test was to define the main dynamic characteristics of the structure necessary for the formulation of the mathematical model of this type of structures. Then, a mathematical model was formulated for the tested bridge. The model consists of 79 nodal points and 89 elements. The comparison between the computed and the measured values pointed to very good agreement of the results.

## 1. Description of the structure

The considered reinforced concrete bridge represents a precast system composed of prestressed simple beams continued by a cast-in-place deck structure with a thickness of 18 cm. Expansion joints exist over the abutments and over the central pier- S5.

The bridge has eight spans (4 x 31 x 2 x 38 + 31 + 26 = 257 m) as presented in Fig. 3. The bridge deck is in a horizontal curvature of R = 600 m, with longitudinal gradient of 1,4% and vertical gradient of 5%. The superstructure rests on the substructure via neoprene bearings that enable displacements in the longitudinal direction of the bridge only. Over piers S3 and S7, the bearings are immovable. The connection with the approach banks is made by cantilever wing walls and transition slabs with a length of 5.00 m.

## 2. Discussion on the experimental results

The obtained fundamental mode shapes lead to the conclusion that the bridge vibrates as a monolith structure under the given excitation level, i.e., the expansion joint is not activated to a sufficient extent that the two structural units behave separately.

As to damping capacity, coefficients of viscous damping of 0.92% to 1.72% were obtained, with the exception of the longitudinal direction in which 2.66% was obtained for the first symmetric mode. Analysing the obtained results and taking into account the geometrical characteristics of the piers, it is evident that the effect of interaction is most pronounced at the shortest piers ($S_{13}$ and $S_{14}$). Considering the obtained values, the level of soil-structure interaction can be evaluated as considerably high, which means that the assumption of total fixation at the base is not thoroughly justified in formulating the mathematical model. This conclusion particularly refers to the transverse direction.

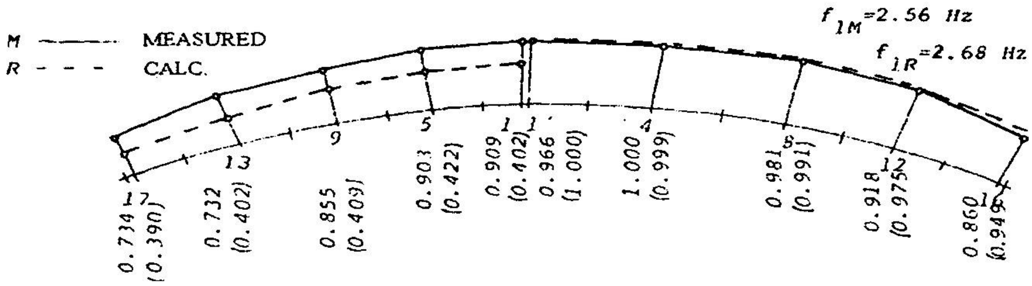


*Fig.1 Fundamental horizontal mode under longitudinal excitation, tangential component*

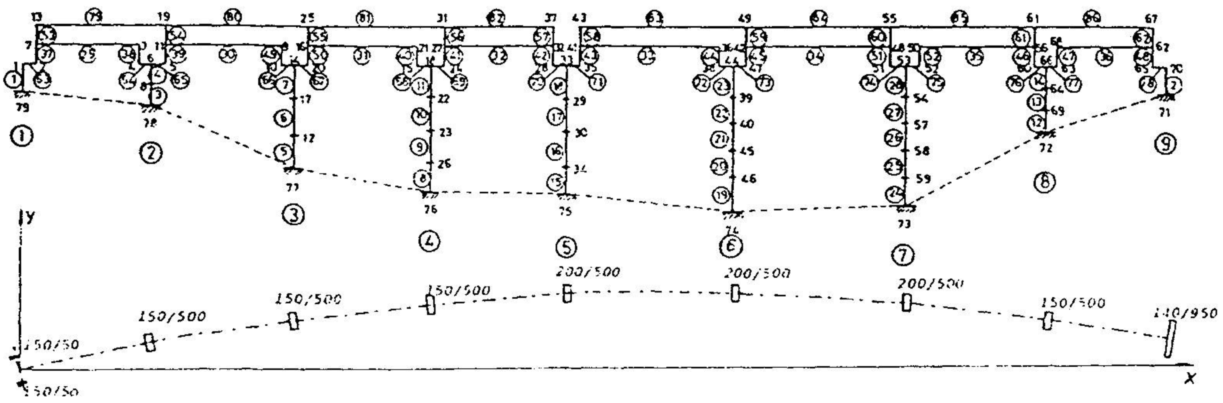

*Fig.2 Formulated discrete mathematical model of the bridge structural system*

## 3. Mathematical model formulation for two directions

Fig.2 shows a discrete mathematical model of a system consisting of 79 nodal points and 89 elements. In analysis of the natural vibrations of the system, the model enables interaction of the piers of the substructure through the deck structure which has a considerable horizontal rigidity, as well as, an independent behaviour of the left and the right part of the bridge by modeling of an expansion joint over pier $S_5$. The mathematical model represents a model of a space frame structure where six degrees of freedom of motion are considered for each node of the system. The same model was used for both longitudinal and transverse directions of vibration. The spectral theory was used for both directions in analysis of the dynamic response of the system.

A reliable proof that the mathematical model of the bridge has appropriately been selected is the comparison between the values computed through the mathematical model and the values obtained by the experimental testing of the full-scale structure.

## 4. Conclusions

Several important conclusions can be drawn: dynamic response of bridge structures is higly dependent on the structural system itself and for analysis purposes all the constituent components should be realistically modeled; experimental forced vibration tests of full scale structures provide very valuable experimental results for refinement of the formulated model; foundation soil and actual bridge configuration may produce significant soil-structure interaction effects which should be cosidered in the analysis, and based on sufficient experimental results on various bridge types, practical design methodology of bridge structures can successfully be improved.