Bridges Dynamic Parameters Identification Based On Experimental and Numerical Method Comparison in Regard with Traffic Seismicity

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Abstract. The technical seismicity negatively affects the environment, buildings and structures. Technical seismicity means seismic shakes caused by force impulse, random process and unnatural origin. The vibration influence on buildings is evaluated in the Eurocode 8 in Slovak Republic, however, the Slovak Technical Standard STN 73 0036 includes solution of the technical seismicity. This standard also classes bridges into the group of structures that are significant in light of the technical seismicity – the group “U”. Using the case studies analysis by FEM simulation and comparison is necessary because of brief norm evaluation of this issue. In this article, determinate dynamic parameters by experimental measuring and numerical method on two real bridges are compared. First bridge, (D201 – 00) is Scaffold Bridge on the road I/11 leading to the city of Čadca and is situated in the city of Žilina. It is eleven – span concrete road bridge. The railway is the obstacle, which this bridge spans. Second bridge (M5973 Brodno) is situated in the part of Žilina City on the road of I/11. It is concrete three – span road bridge built as box girder. The computing part includes 3D computational models of the bridges. First bridge (D201 – 00) was modelled in the software of IDA Nexis as the slab – wall model. The model outputs are natural frequencies and natural vibration modes. Second bridge (M5973 Brodno) was modelled in the software of VisualFEA. The technical seismicity corresponds with the force impulse, which was put into this model. The model outputs are vibration displacements, velocities and accelerations. The aim of the experiments was measuring of the vibration acceleration time record of bridges, and there was need to systematic placement of accelerometers. The vibration acceleration time record is important during the under – bridge train crossing, about the first bridge (D201 – 00) and the vibration acceleration time domain is important during deducing the force impulse under the bridge, about second bridge (M5973 Brodno). The analysis was done in the software of Sigview. About the first bridge (D201 – 00), the analysis output were values of power spectral density adherent to the frequencies values. These frequencies were compared with the natural frequencies values from the computational model whereby the technical seismicity influence on bridge natural frequencies was found out. About the second bridge (M5973 Brodno), the Sigview display of recorded vibration velocity time history was compared with the final vibration velocity time history from the computational model, whereby the results were incidental.
1. Introduction
The structure influence due to vibration is caused not only from natural earthquakes, but mainly from technical seismicity sources [1] - like traffic on transport structures, industrial machinery, blasting works etc. These problems are described in Eurocode 8, however, but solution includes the Slovak Technical Standard STN 73 0036 [2] (replaced by EC 8), which deals about the technical seismicity. This standard also classes bridges into the group of structures that are significant in light of the technical seismicity – the group “U”. Using the case studies analysis by FEM simulation and comparison is necessary because of brief norm evaluation of this issue, [3-7]. In this article, determinate dynamic parameters by experimental measuring and numerical method on two real bridges are compared. First bridge, (D201 – 00) is Scaffold Bridge on the road I/11 leading to the city of Čadca and is situated in the city of Žilina.

The comparison of numerical modelling and experimental measuring on two real bridges is the aim of this article. First bridge (“B1”); (D201 – 00), is Scaffold Bridge on the road I/11 leading to the city of Čadca and is situated in the city of Žilina. It is eleven – span concrete road bridge. The railway is the obstacle, which this bridge spans. Second bridge (M5973 Brodno) is situated in the part of Žilina City on the road of I/11. It is concrete three – span road bridge built as box girder. Second bridge (“B2”); (M5973 Brodno) is situated in the part of Žilina City on the road of I/11. It is concrete three – span road bridge built as box girder.

2. The Scaffold Bridge D201 - 00
The dynamic analysis includes the numerical and experimental part. Numerical model was done in the software of IDA Nexis. The outputs are four natural frequencies and natural vibration modes. Experimental measuring is based on the systematic placement of accelerometers (Figure 1). The output is vibration acceleration time response that was analysed in the software of Sigview.

![](image1.png)

Figure 1. The Scaffold bridge D201-00 in the city of Žilina

2.1. The FEM model of the bridge structure and results
The FEM model involves the bridge structure without abutments and piles. This bridge is modelled as slab – wall structure. The results are four natural frequencies (Table 1.) and natural vibration modes (Figure 2).
2.2. The experimental measuring and the results

The systematic placement of accelerators is displayed on Figure 3. The comparison of frequencies from FEM model and experimental measuring analysis is done on accelerators BK5 and BK6.

The frequency analysis was done in the software of Sigview like this: The time response of recorded vibration acceleration from BK5 and BK6 was put into the Sigview. Than the power spectral density, which belongs to the frequency band, was generated from the signal. The result from this spectral analysis is the frequency response of power spectral density at accelerometers BK5 and BK6 (Figure 4). Frequencies no. 1; 10; 16, correspond with the frequencies from experimental measuring.
At many cases, monitoring of all parts of structure and surroundings is needed, not only main bearable elements, [8]. The important role at evaluation of influence on structural elements is proper evaluation of properties of geological environment in contact with structure, especially time depended changes on rock and soil properties, [9]. Evaluation of these properties can be done in vertical and horizontal accelerometers but also by other monitoring tools like optical sensors, new measurement devices, and very precise sensors, [10, 11].

3. The Bridge M5973 Brodno

The dynamic analysis includes the numerical and experimental part. Numerical model was done in the software of VisualFEA. The outputs are values of vibration acceleration time response. Experimental measuring is based on the systematic placement of accelerometers. The output is vibration acceleration time response that was displayed in the software of Sigview.

3.1. The FEM model of the bridge structure and results

The model includes the bridge structure with abutments and also the piles. The type of structure is box – girder, so it was modelled from slab – wall elements. The time history of 10kN force impulse (Figure 6) was put into the model in the place, where it was caused on real place – between the middle pile and road I/11. The output from analysed FEM model was the vibration velocity time history (Figure 7).

![Figure 4. The frequency response of the power spectral density](image)

![Figure 5. The bridge M5973 Brodno in the city of Žilina](image)
3.2. The experimental measuring and the results
The accelerometers were placed as well as accelerometers on the Scaffold Bridge. The force impulse was caused between the middle pile and the road I/11. Recorded time history was opened and analysed in the software of Sigview and the output is the time history of the vibration velocity (Figure 8).
4. Results

The Scaffold Bridge: The comparison of Table 1 and Figure 4 shows that the frequency band is the same despite crossing the train under the bridge.

The bridge M5973 Brodno: The comparison of Figure 7 and Figure 8 shows that the vibration velocity does not radically change when the force impulse is caused.

5. Conclusions

The dynamic analysis was done on both bridges, where was done numerical and experimental measurements in comparison. It has been focused in these two cases for bearable structure elements, for complex structural evaluation important measurements and evaluations must be done also in geological environment at place of structure [12] and all important factors must be evaluated, [13, 14]. The comparison of the numerical and experimental method shows that the technical seismicity caused by road and railway traffic does not have any radical influence on these both bridges.

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