Vibration Monitoring of the Bridge Loaded by Heavy Vehicle Traffic

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Abstract: - The paper presents vibration monitoring on the road concrete-steel composite slab-on-girder bridge in Prague – Barrandov in period 2006 - 2008. The main aim of the experiment is the investigation of the influence of the intensive heavy vehicle traffic on the bridge response changes. Representative evaluated results (the fatigue stress levels, heavy duty truck passage density over the bridge) are presented in the paper.

Key-Words: - Fatigue, Slab-on-girder bridge, Traffic flow, Long-time monitoring

1 Introduction

Intensity of the road traffic has increased in resent twenty years in Czech Republic, especially on highways, and also composition of the traffic flow has changed. The contribution of heavy vehicles has significantly increased and thus the load of the roads and bridges has increased.

Long-time monitoring of the stress and strain response caused by traffic is carried out on some bridges in Czech Republic [1]. The basic aim of these experiments is to obtain real basis for assessment of the representativeness of used models for loading of road bridges. From the obtained experiments it is evident that the significant static and dynamic response of bridges is caused by heavy vehicle passages and this response significantly influences the gradual bridge degradation, life time of bridges, periods of their inspections, repairs and reconstructions.

This paper describes the arrangement of the long-time dynamic experiment, which is carried out on the concrete-steel composite slab-on-girder road bridge crossing over the Road Ring around Prague at 15.87 km on the approach road to the street K Barrandovu in Czech Republic. The experiment is focused especially on monitoring of dynamic response of the investigated bridge caused by intensive heavy vehicle traffic but it can be also used for monitoring of intensity of heavy vehicle traffic (Fig. 8).

2 Description of the Slab-on-girder Bridge

The investigated bridge is concrete-steel composite slab-on-girder road bridge crossing over the Road Ring around Prague (SOKP) at 15.87 km on the approach road to the street K Barrandovu (Fig. 1). In the south traffic lane, the heavy vehicle traffic goes in direction Plzeň (highway D5) – Praha (SOKP) – Brno (highway D1). It is three span continuous bridge with spans 17.7 + 34.5 + 17.7 m. The bridge is skew with the angle 76°. The carrying structure of the bridge is composed from four main I-shaped girders. The distance of the girders is 3300 mm. The girders are welded with constant height of the wall 1380 mm. The flanges of the girder are with different thickness along the length of the bridge. The upper flange has width 330 mm and thickness 14 or 18 mm. The lower flange has width 400 mm and thickness from 14 to 46 mm. The walls of the girders has stiffeners on both sides in variable distances from 1500 to 2500 mm. The reinforced concrete slab of the bridge floor is monolithic without cross inclinations, with constant thickness 240 mm. Short cantilevers with length 420 and 820 mm are at the edges of the slab.

Fig. 1 The south view of the investigated bridge, the visible girder is the main girder No. 4.
3 Measurement System

The measurement line for monitoring of the dynamic response of the bridge is composed from the recording station EMS DV 803 of the firm EMS Miroslav Pohl from Brno in Czech Republic and fourteen strain gauges. The measuring station EMS DV 803 is permanently placed in the electric power distribution box, which is under the bridge near the pillar No. 2. The strain gauges are placed on the structure in the south half of one cross-section. This cross-section is in the middle of the mid-span of the bridge. The schema of the strain gauges positions in the half of the cross-section is shown in the Figure 2. Three strain gauges are glued on the inner side of the outer girder No. 4 (Fig. 2), which is shone by sunshine in the morning. Seven strain gauges are glued on the both sides of the inner girder No. 3 (Fig. 2) and three strain gauges are glued on the lower face of the concrete slab (Fig. 3). The influence of the sunshine to the response of the outer girder No. 4 can be seen very well on the Figure 4. The resistance strain gauges of type 100/120 LY41 HBM are used for measuring the relative deformations of the concrete slab and the measurement of the relative deformations of the steel girders is done using the resistance strain gauges 10/120 LY11 HBM (Fig. 3).

Fig. 2 The schema of the strain gauges positions on two main girders in the investigated cross-section.

Fig. 3. The view on the strain gauges No. 1 (concrete slab) and No. 2 (upper flange of the outer girder No. 4).

Fig. 4 The strains on the lower flanges of the girders No. 4 (T04 – red) and No. 3 (T09 – green) - 5.9 2008.

Fig. 5 The detail of the strains 5.9. 2008– considerable loading of the bridge, measured strain 246 μm/m corresponds to the stress 52 MPa.
control program, the control station initiates the second recording mode, in which the station records the amplitudes of vibration, which are exceeding the limit. After the end of the excessive vibration the station returns the basic mode. The example of the changes between the modes can be seen in the Figure 5.

4 Conclusion
The response of the heavy vehicle passages is usually only quasistatic response with amplitude of the relative deformation in the lower flanges of the main girders No. 3 and 4 up to 100 $\mu$m/m (Fig. 4 and Fig. 6), which corresponds to the amplitude of the stress 21MPa. Irregularly a very heavy vehicle passes over the bridge, which induces the dynamic response more than two times larger than usual response (Fig. 5). The very heavy vehicles pass over the bridge very irregularly, in some days several of these vehicles pass over the bridge daily and in another time period no one of these type of vehicles pass over the bridge during several days.

The heavy vehicles usually induce vibration of the bridge with amplitudes of acceleration up to 0.3 m.s$^{-2}$ but also more considerable vibration of the middle span of the bridge was recorded with amplitude about 0.6 m.s$^{-2}$.

The number of vehicles crossing over the bridge with the total weight more than 11t is about 24 000 weekly (Fig. 8). In comparison with the years 2006 and 2007, the total number of heavy vehicles in the week No. 36...
was lower in the year 2008 (23,786 heavy vehicles) but the weight of the heavy vehicles has increased (Fig. 8).

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References: