# LOAD TESTING OF SOME NEW BRIDGES IN LATVIA

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## Abstract

This paper presents the results of static and dynamic testing of some recently constructed bridges in Latvia. According to Latvian regulations it is necessary to perform load tests for new bridge before it is taken into service. Some innovative procedures were used during these tests, like a use of The Trimble® S8 Total Station for measurements of deflections and Noptel OY PSM200 laser device for obtaining the dynamic characteristics of structures. There are analyzed loading test results of Bridge over the Gauja River near Murjani and the Dienvidu Bridge over the Daugava River in Riga with approach overpasses.

## Keywords

Bridge, Load Tests, Static and Dynamic Tests,

## 1. Introduction

Bridge over the Gauja River near Murjani has obtained a new concrete twin rib deck during the reconstruction which was completed in April 2008. The total length of the bridge is 132.5 meters. The width of the bridge is 16.27 meters.

The new Dienvidu Bridge over the Daugava River is the first extradosed bridge in Latvia, the construction of this bridge was completed in November 2008. The total length of the bridge is 803 meters. The width of the bridge is 34.25 meters.

Static and dynamic load tests have been used to take into service the new large bridges to verify the actual structural behavior of the bridge compared with that predicted by theoretical design FE model. Therefore comprehensive static and dynamic load tests were performed just before the opening of the bridges. The primary objectives of load tests are to better understand the bridge's response to static and dynamic loadings and to create an initial database of the undamaged structure to use it for the future condition assessments.

## 2. Description of the Bridges and Analytical models

The old soviet time superstructure of the Bridge over the Gauja River near Murjani , Figure 1, was replaced with a new prestressed concrete twin rib deck. The bridge has the continuous multispan superstructure - 21.85 + 4x22.2 + 21.85 meters. The existing piers and abutments were strengthened. The concrete deck was initially designed to be built as cast-in-situ ribbed slab on the formwork and the falsework supported by temporary piers. The contractor proposed to use a method of incrementally launched deck, which was approved by the Client. Therefore it was of a paramount importance to verify the structure. For this reason was prepared FE model using RFM FEM software.

Fig.1 Strengthened piers and a new twin rib deck over the Gauja river near Murjani

The Dienvidu Bridge over the Daugava River has multispan superstructure - 49.5 + 77 + 5 × 110 + 77 + 49.5 meters where is adopted extradosed system with 6 traffic lanes. There are six pylons above six central piers and the height of pylons above the roadway pavement is 12.00 meters. Each pylon has 8 pairs of cables. The superstructure is a continuous twin steel box with composite concrete deck, which is not a common practice for an extradosed bridge design. Abutments and piers are massive reinforced concrete walls based on bored pile foundations.

This is a completely new type of bridges in Latvia therefore it was important to create an initial database of the undamaged structure and to compare the structure with a three dimensional, linear-elastic finite element model of the bridge developed for tests using LIRA FEM software.

Fig.2 The new Dienvidu bridge spanning the Daugava river

## 3. Description of instrumentation and data acquisition systems

The Trimble S8 Total Station was introduced to measure vertical and horizontal displacements and deformations of bridge deck and pylons during static loading. It is a robotic laser instrument, which makes it possible to measure, survey or monitor targets up to 40% faster than conventional motorized stations. Most important, it helps to measure displacements in a wireless mode in places where it is hard to use conventional methods with wire or duct connections due to obstructions under the deck, such as rivers, live roads or railways.

To measure stresses in critical elements of structure strain gages are used. For this reason, HBM's Spider8 universal digital multi-channel data acquisition system connected to single strain gages with 3-wire technique is used.

Noptel PSM200 laser device is used to obtaining the dynamic characteristics of structures. Laser-based measuring system applied in this test consists of the laser transmitter and the position-sensitive receiver connected to a laptop computer. The laser transmitter is placed on a solid base outside the bridge in the distance up to 400 m and the receiver is located on the bridge tested. The position of the laser beam on the sensitive screen is continuously recorded in two-dimensional space. All the instruments described above are shown in Figure 3.

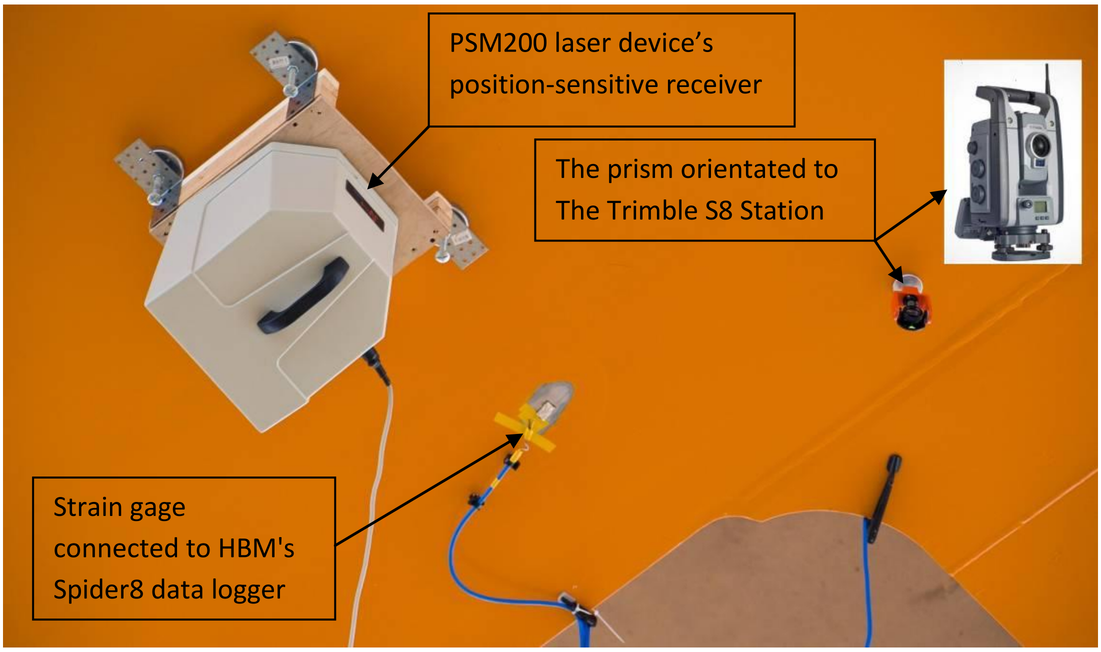


Fig.3 Various devices assembled in the critical location on a steel box of Dienvidu bridge deck

## 4. Static load test

During the static loading, tests are measured the deformations and force values, which are necessary for an independent examination of the facilities. There must be measured:

- Vertical deformation of bridge in the middle and other places where the maximum deformations are expected;
- Vertical and horizontal displacements of pylons (settlement, subsidence);
- Relative deformation of extremely loaded construction parts.

Necessary part of measurement is the observation of possible build-up of cracks in concrete. After their detection: the length, width, form and orientation of cracks must be measured.

Fig.4 Static loading of Murjani and the new Dienvidu bridges

## 5. Dynamic load test

Dynamic load testing is an important part of the acceptance process for new bridges in Latvia. As a complement to static load tests, dynamic tests yield useful information about the actual behavior of the bridge under traffic. This information is usually difficult to obtain analytically, because of the complexity of the actual structure. The effect of pavement deterioration on the dynamic response of the bridge is of particular importance for the management of the structure. This information can be easily and realistically obtained from a dynamic test.

The purpose of the dynamic load test is to determine the controlling parameters of the dynamic behavior of the bridges. The main dynamic characteristics of the structure are the fundamental vibration frequency, the dynamic amplification factor and the logarithmic decrement. These properties are usually not analyzed in detail in the design phase of small and middle sized structures. Some parameters, such as the logarithmic decrement or the dynamic amplification factor, can only be roughly estimated at the time of the design. However, these quantities are relatively easy to obtain experimentally, and can give valuable information for the exploitation and maintenance of the bridge.

The trucks used for the dynamic excitation of the bridge are usually 3-axle trucks with a total weight around 250 kN, traveling on the bridge at several speeds, although 4-axle trucks were used to test Dienvidu bridge, as shown in Figure 5. The effect of a deterioration of the pavement is simulated by the introduction of a normalized plank on the path of the truck. This induces a strong impact when the truck passes at mid-span, which represents the effect of a pothole in the pavement, or the irregularity of the surface caused by packed snow.

Fig.5  Dynamic loading of Murjani and the new Dienvidu bridges

Noptel PSM200 laser device helps to obtain absolute vertical deflection at mid-span caused by the passage of the truck. Therefore it is possible to obtain the complete dynamic influence line shown in figure 6. The dynamic influence line helps to determine the dynamic amplification factor.

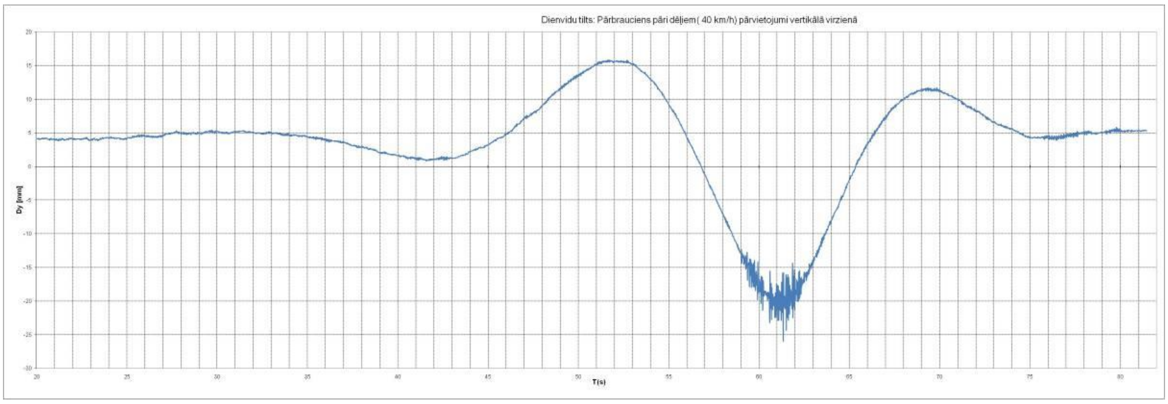


Fig.6  Approximate dynamic influence line of the passage of the truck.

## 6. Conclusion

The well planned load tests, which were carried out for both bridges about a month before the opening of bridges, were a complete success and huge amount of interesting data was collected. This data is used by authors to understand better the static and dynamic behavior of those unique structures and to provide an initial database of undamaged structure for the owners of bridges. This data can be used to create the bridge supervision and maintenance plan and to predict possible future structural damages.