# STATIC AND DYNAMIC TESTING OF ROAD BRIDGE SUPERSTRUCTURES

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**Rezumat**: *Această lucrare prezintă testul static şi dinamic cu acțiunile eşantion ale suprastructurii de poduri din ultimii ani. Testele au fost efectuate în conformitate cu proiectul de testare şi STAS 12.504-86 "Testarea suprastructurilor cu acțiuni de eşantionare".*

**Abstract**: *This paper presents the static and dynamic test with sample actions of the bridges superstructure in recent years. The tests have been performed in accordance with the testing design and STAS 12.504-86 "Testing of superstructures with sample actions".*

**Keywords**: road bridges; static test, dynamic test, vehicle convoy, superstructure of bridges.

## Introduction

The permanent growth of road traffic leads to the development of new ways of communication, namely highways, national roads and the rehabilitation of existing ones. Achieving an efficient transport infrastructure favours economic development and contributes to European integration.

In this context, the bridges and viaducts that ensure the crossing of natural obstacles are of great importance. The main objective of new bridges and of those already in operation is to ensure traffic safety.

From the design phase of new bridges or bridges that are rehabilitated, the calculation assumptions must be compared with the behaviour of the bridge structure under the action of big loads. Currently, the standard setting the principles and conditions for testing bridge superstructures is STAS 12504-1986, *"Railway Bridge, Road and Passage Bridges. Testing the Superstructure with Sample Actions."* The standard sets out the requirements for new bridges and for those in operation in order to test them.

This paper presents the main aspects taken into account when statically and dynamically testing road bridges with all the steps to be followed and the equipment necessary to carry out these tests.

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## 2. Static Attempt of Bridges

The static attempt of the bridges consists in requesting them with sample actions. Static test actions are carried out using vehicle convoys loaded with the tonnage provided by the test design. Fig. 1 shows the schematic of a sample truck used for bridge testing. The project specifies the total weight of the vehicles, the axle weight, the axle and the wheels position with respect to the structural strength elements of the bridges.

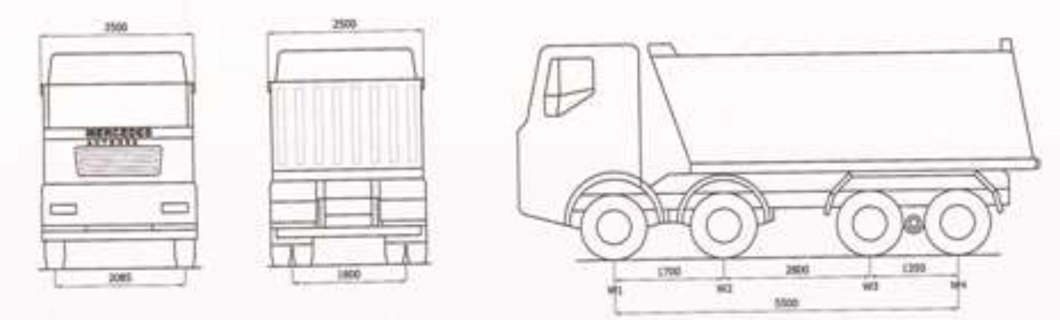


**Fig. 1:** Scheme of a truck used to bridge tests [2]

In the static test, the maximum deflection in each opening of the bridge is determined, the specific deformations in the most requested areas established by the project (tension on the supports, spins, etc.)

Vertical deformations (arrows) can be determined using precision comparators of 0.1 mm or levelling precision with an accuracy of 0.01 mm.

Vertical deformations shall be measured before the test begins, at each loading convoy and after unloading the structure. After loading the loading convoy, wait for the deformations to stabilize, both at loading and unloading, and read at all points and measurement sections.

In the attempts of bridges, S.C INCERTRANS S.A conducted the convoy test using 3 axle, 5 axle and 4 axle trucks, depending on the requirements of the test design. After weighing the trucks as much as possible on each axle, sample convoys are made.

Figure 2 shows an example of the positioning of the test convoy and Figure 3 presents some loading schemes of a road bridge over the Danube-Black Sea channel tested by S.C INCERTRANS S.A [2]

**Fig. 2:** An example of positioning of the test convoy [2]

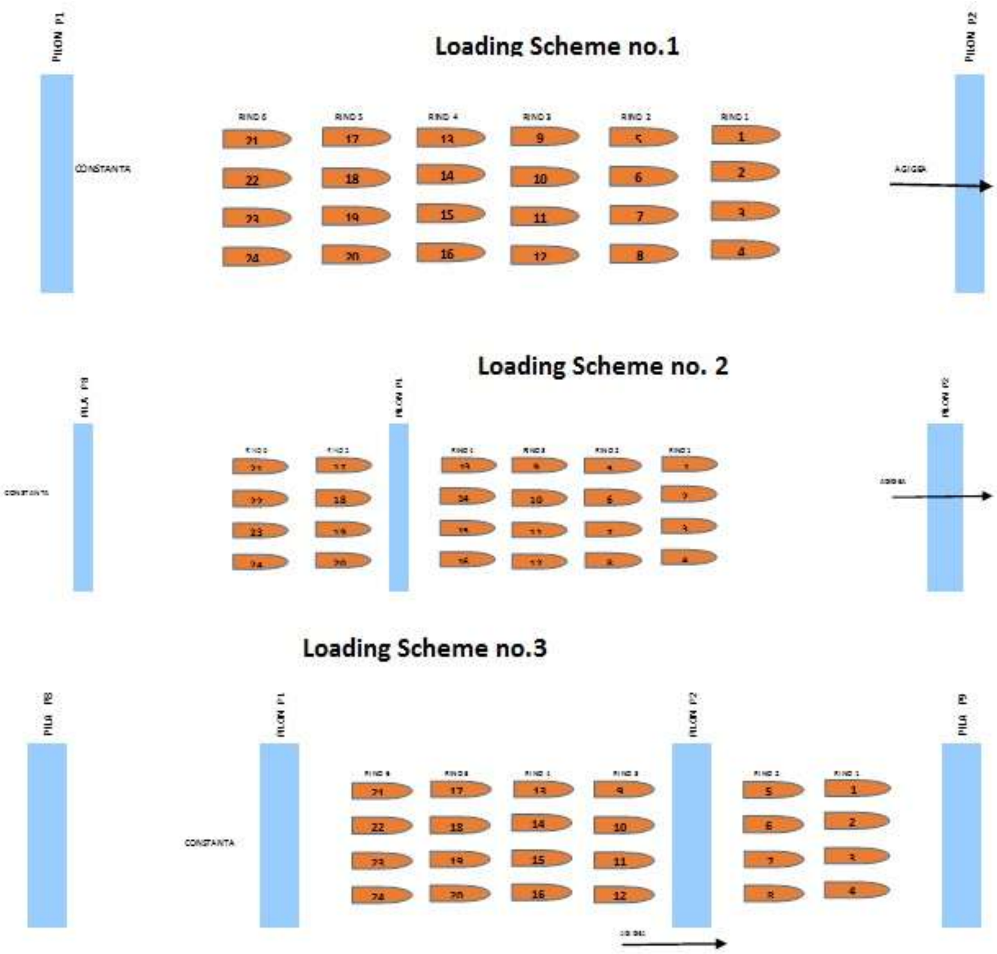


**Fig. 3:** Example of load-bearing schemes for the bridge superstructure [2]

Figure 4 shows the way of placing the poles on the pillars at the static test of the hobanate bridge.

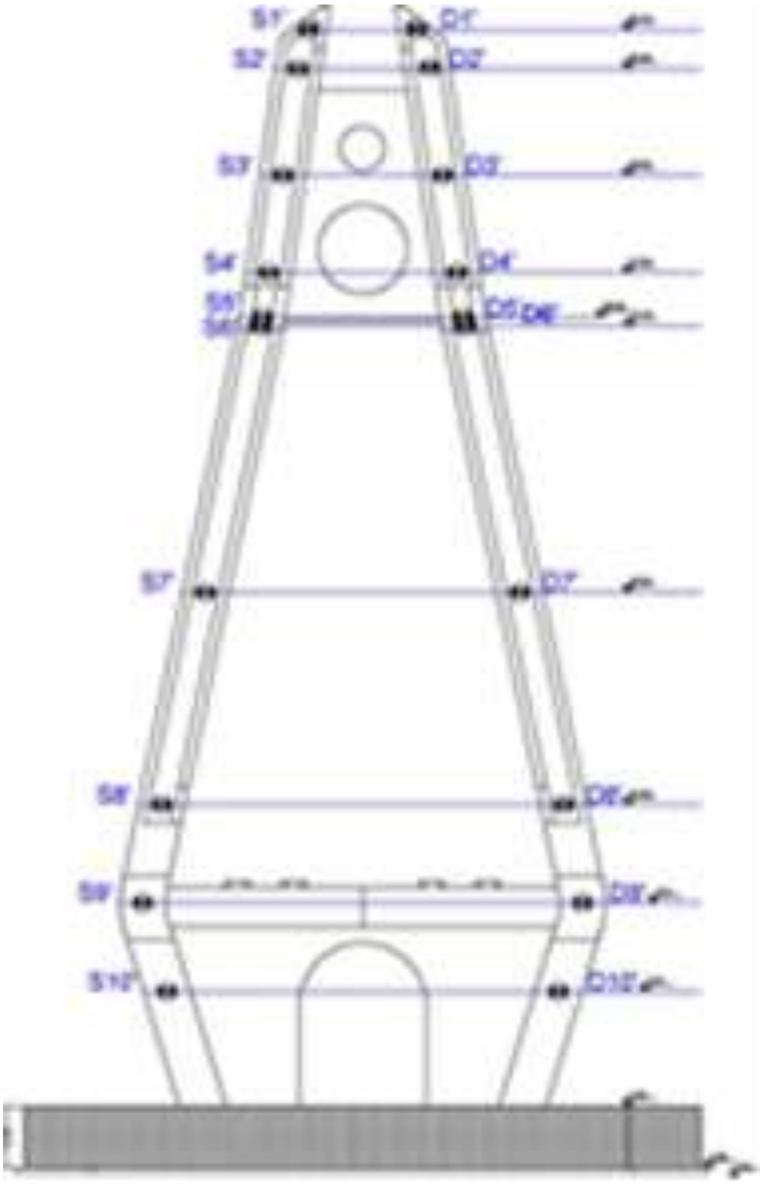

**Fig. 4:** How to place the landmarks on a pillar [2]

In order to determine the vertical displacements of the panel structure, a levelling recess is mounted outside the structure, fixed recess and in the characteristic sections determined by the project.

In the transverse direction, the recesses are located on the upstream and downstream slopes.

For measuring vertical movements on supports, horizontal displacements and crossings of the bridgeboard, microcompasses are mounted adjacent to the support devices.

Figure 5 shows an example of the measurement deformation plot [2].

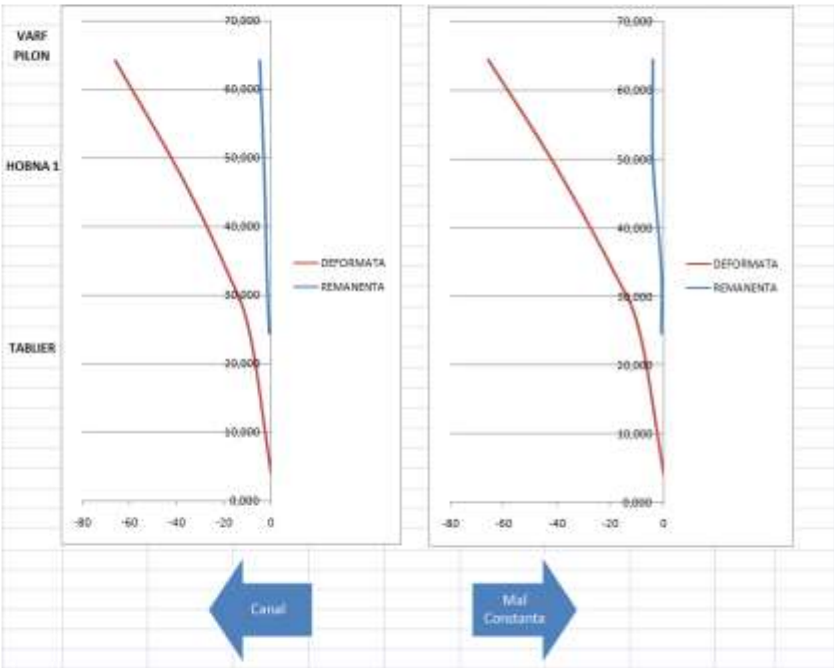


**Fig. 5:** Plot of deformations

Figure 6 is an illustration of how to determine vertical deformations (arrows) by means of levelling measurements.

**Fig. 6:** Image from the levelling measurements [2]

For the determination of the movements, rotation on the support devices, are used comparators. Figure 7 shows a roller and wire comparator for measuring vertical displacements, and Figure 8 shows a rod comparator for measuring the transverse or longitudinal displacements of the bridge to be used in a bridge test performed by S.C INCERTRANS S.A.

**Fig. 7:** Roller and wire comparator [2]

**Fig. 8:** Rod comparator [2]

The determination of the transversal load distribution is achieved by placing roller and wire comparators on the beams in the beam, where possible, or by positioning level markers along the bridge path at the axis of the beams.

**Determination of the deformation state in the bridges structure**

For measuring specific deformations, electrically resistive transducers (resistive tensiometric markers) or electro-acoustic transducers with vibrating rope, tensiometric transducers are used, which are placed in the sections where the requests have the maximum values according to the calculations.

The measuring chain for the tensiometric measurements consists of tensiometric transducers, connection cables to the switching box and measuring bridge. Figure 9 is an example of an EDES-20V-AW tensiometric transducer with vibrating rope.


**Fig. 9:** Tensiometric transducer with rope [2]

The signal transmitted by the transducer arrives via an interface to a computer for processing and recording the data.

Figure 10 shows a VibWire-108-SDI12 interface and Fig. 11 a USB-SDI12 Pro interface for connection to the computer.

**Fig. 10:** Interface typeVibWire–108–SDI12 [2]


**Fig. 11:** Interface type USB-$_{SDfI12}$ Pro[2]

After testing, data are processed and interpreted. One of the determined values is the static efficiency of the sample load:

$$E_{f\ stat} = S_{stat} / S_n \quad (1)$$

$S_n$= the size of the effort determined in the dimensioning of the section, resulting from the consideration of the useful loads with norms for the bridges, which are verified by the limit state method or the payloads, in the case of bridges which are checked by the admissible resistance method

$S_{stat}$ = the magnitude of the corresponding effort obtained from the sample loads considered to be statically applied.

As it is known, the criteria for judging the proper behaviour of bridges under static proof actions at basic tests are the observation of the bridge or its elements as showing no signs of failure or loss of stability and the fact that there are no defects that would affect the functionality of the bridge.

Deformations vertical (arrows) total measured must not exceed the limits prescribed in the regulations specific technical report arrows elastic measured against arrows corresponding calculated to be less than 1.0 or 1.05 and the ratio arrows remaining measured against arrows total measured to be less or equal to 0.10 ... 0.25 depending on the building material [1].

As a result of the static attempts at the bridge superstructure it was found that $Ef_{state}$ is equal to the value of 1 for all convoys, the bridge and the elements of this bridge did not show signs of failure or loss of stability and there were no defects that would affect the functionality of the bridge [2].

## Bridges Dynamic Test

Dynamic bridging attempt is only performed if the bridge has behaved appropriately to the static action test. The aim of the dynamic tests is that by comparing the results determined by the measurements with those provided by the project, it is possible to highlight how the structure made corresponds to the calculation hypotheses or whether there are differences in the way of their interpretation.

In the dynamic tests we determine: the dynamic coefficient; the actual bridge frequency; the bridge frequency when the sample action is near the measured location; logarithmic decrement of depreciation. In order to perform the attempts to achieve the dynamics dynamic structure of the bridge, two trucks are used as dynamic action with each weight provided by the project. The two trucks run simultaneously on the bridge at the same speed with a constant speed and with the bodies aligned according to the scheme proposed by the test design. The initial speed is 10 km/h and at the next passes the speed increases to 20 km/h, 30 km/h, 40 km/h to 50 km/h. In order to increase the impact of passing the trucks, artificial hinges of the horses are created in the form of thresholds made of 4 cm thick hardwood carpets, 30 cm wide and 300 cm long, with the edges of the upper part tapering at 45° (Fig. 12).


**Fig. 12:** Detail when passing the truck over the wooden threshold

The determination equipment used in dynamic bridge tests is measured in real time with high precision: displacements, specific deformations and accelerations.

The attempts were made in collaboration with the Technical University of Civil Engineering of Bucharest and an example of a graph with the measurement of the acceleration and frequency is presented in Figure 13 [3].

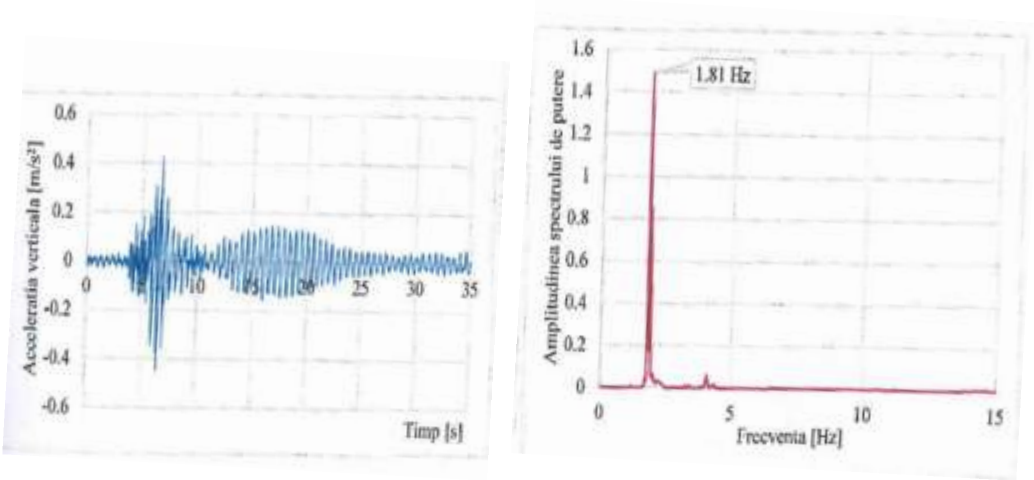


**Fig. 13:** Vertical acceleration graph and frequency graph at one point during dynamic test at 10 km/h [3]

## Conclusions

The continuous growth of road traffic leads to the creation of new communication ways: highways, national roads and the rehabilitation of the existing roads.

In the context of the development of road infrastructure, the bridges and viaducts that ensure the crossing of natural obstacles are of great importance.

Static and dynamic bridge testing is a way of checking whether the calculation assumptions underlying the project are validated by the practical results obtained by measurements made during the convoy trials.

## R E F E R E N C E S

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