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EXPERIMENTAL AND NUMERICAL VERIFICATION OF THE PONTOON BRIDGE SECTION

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Abstract

The object of the paper is experimental and numerical verification of a pontoon bridge prototype section. The main part of a single segment is a waterproof cassette which contains a shell (pontoon). After filling with the air, the pontoon assures the required buoyancy. The cassette, in which the shell is located, has a movable bottom. Pontoon bridges are built of ready-to-use repeatable segments and they may be used as temporary crossings. Verification of the bridge modules was performed by launching a demonstrator compound of two modules of the pontoon bridge section, filling the pontoons with air and measuring their immersion. The test was performed in the pool, in the Military Engineering Works. S.A. (WZInż. S.A.) in Deblin. Recording and measurements were performed with two Phantom V12 cameras placed on static tripods. It allowed reading from each of the cameras the heights of the midpoints of the prow and the starboard above the water surface, and the inclination angle of the pontoon unit in transverse and longitudinal planes. The combination of these results allowed calculation of height of the roadway centre of pontoons set above the water surface. Displacement and stability of the structure was specified based on analytical calculations. This paper presents the results of numerical calculations of launching a pontoon bridge section demonstrator. Correctness of the numerical methods of calculation was examined based on a comparison of numerical and experimental results.

Keywords: *pontoon bridge section, demonstrator of construction, verification of numerical analysis*

1. Introduction

The paper presents one of the stages of the research on a kinematic chain fragment of prototype floating bridge pontoons [1]. The main part of a single segment (Fig. 1) is a waterproof cassette which contains a shell (pontoon). After filling with the air, the pontoon assures the required buoyancy. The cassette, in which the shell is located, has a movable bottom. Pontoon bridges are built of ready-to-use repeatable segments and they may be used as temporary crossings.

There was proposed a constructional solution for a single floating segment of which transport volume is 2.5 times less than in the case of the currently applied structure Pontoon Park PP-64, utilized by the Armed Forces of Poland [1] at enlarging of its carrying capacity.

The object of the paper is experimental and numerical verification of a pontoon bridge prototype section [5]. Verification of the bridge modules was performed by launching a demonstrator compound of two modules of the pontoon bridge section, filling the pontoons with air and measuring their immersion.

2. Experimental verification

The test was performed in the pool, in the Military Engineering Works S.A. (WZInż. S.A.) in Deblin (Fig. 2). Recording and measurements were performed with two Phantom V12 cameras placed on static tripods. It allowed reading from each of the heights of the midpoints of the prow and the starboard above the water surface, and the inclination angle of the pontoon unit in transverse

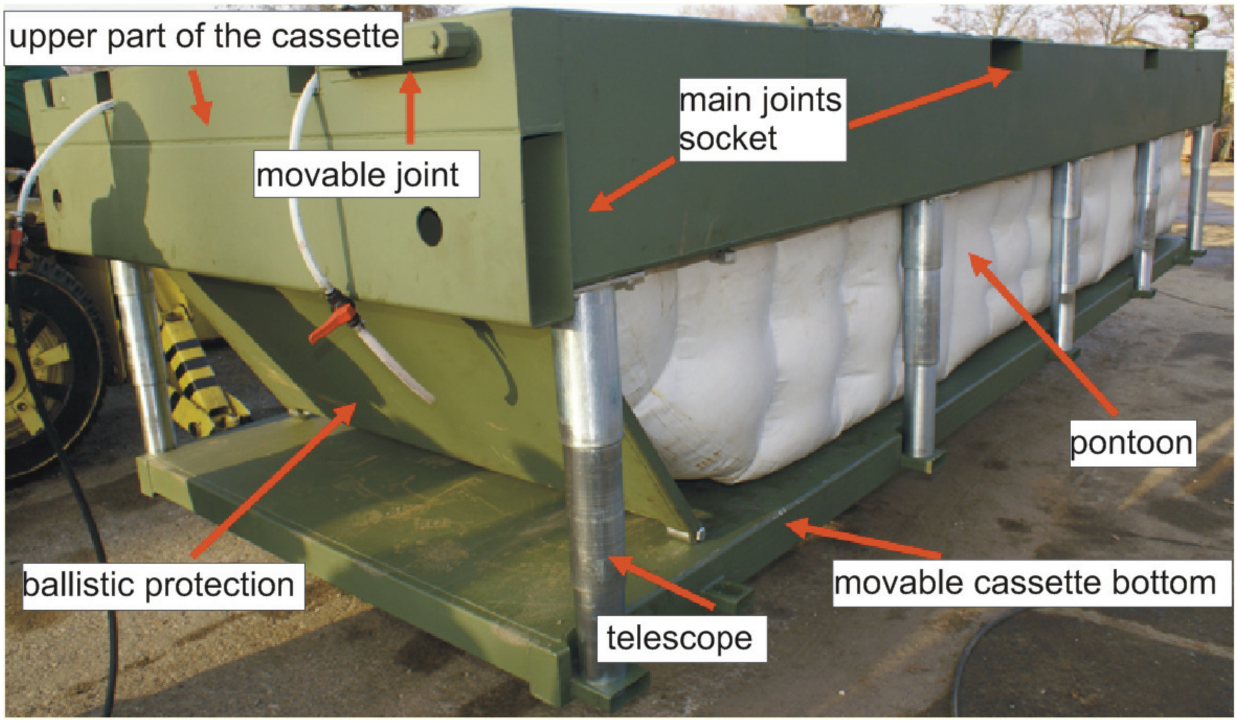

Fig. 1. Prototype construction of a single cassette of a pontoon bridge

Fig. 2. Experimental examinations of two pontoon bridge cassettes loading

and longitudinal planes. The combination of these results (Fig. 3) allowed for calculation of the height of the roadway centre of a pontoons set above the water surface. Displacement and stability of the structure was specified based on analytical calculations.

These courses show the behaviour of a set of pontoons during a load test. Tab. shows the occurences accompanying the registered changes.

Tab. 1. Description of the occurences in a function of time

Time [s]	Q Load [tons]
I (from –250 to –127)	4 × 1.6 = 6.4
II (from –127 to –20)	5 × 1.6 = 8.0
III (from –20 to –8)	6 × 1.6 = 9.6 – first placing
IV (from –8 to 0)	6th weight has been removed
V (from 0 to 100)	6 × 1.6 = 9.6 – second placing

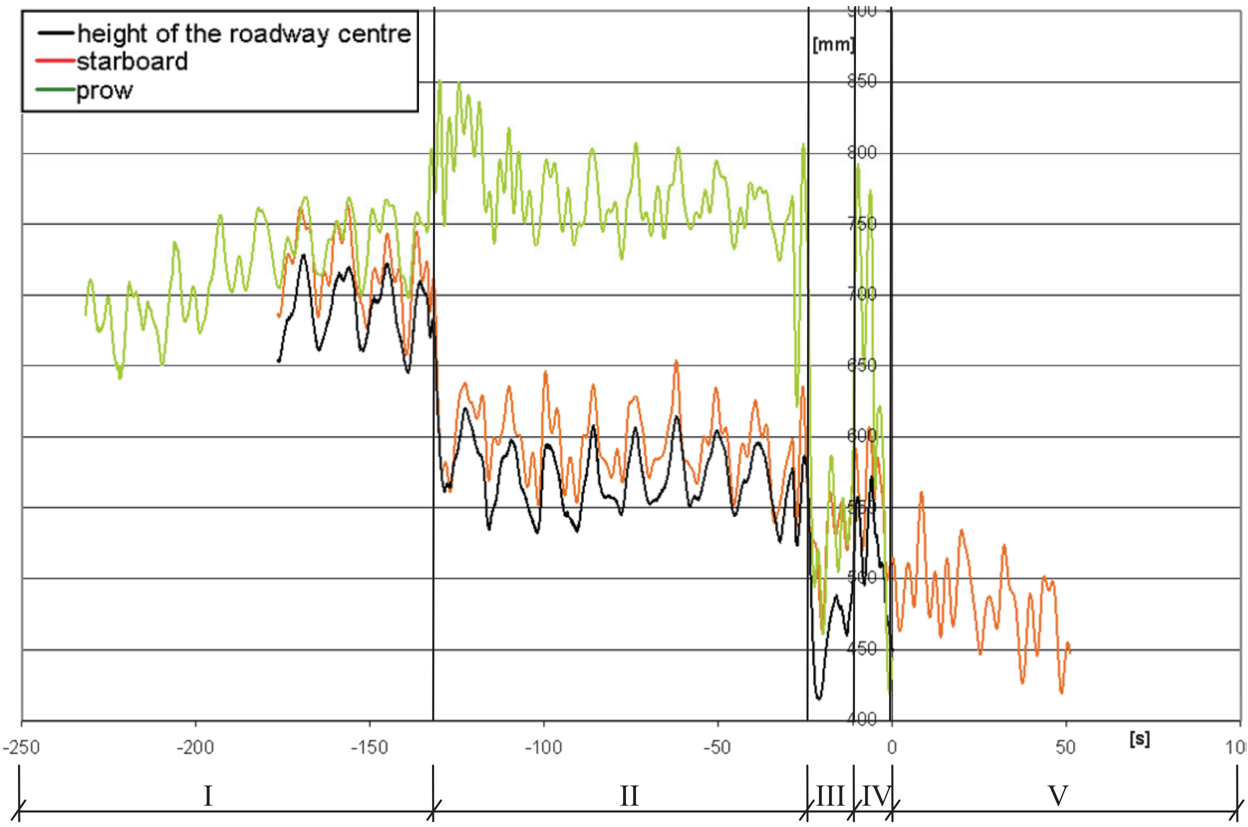

Fig. 3. Immersion of a set of pontoons during a load test

3. Numerical analysis

The paper presents the results of numerical calculations of launching a pontoon bridge section demonstrator. A discreet FEM model [2] was developed with the aid of MSC Patran preprocesor, while MSC Marc code was applied for simulations [3]. The pontoon bridge section was modelled with the use of the 2D shell elements (Fig. 5).Calculations were performed using a deformable model in the scope of linear statics [2]. Correctness of the numerical methods of calculation was examined based on a comparison of numerical and experimental results.

The influence of water was mapped in the model with the use of Winkler model [1]. The model is possible to be illustrated with a discrete springs of K stiffness based on/leant against a rigid base. The influence of water occurring on the surface of an immersed object limited by $A \times B$ dimensions is modelled by each separate spring. The spring stiffness is calculated by formula:

$$K = \gamma \cdot A \cdot B\,, \tag{1}$$

where:

γ – specific weight of water (9790 N/m^3),

A – length of the pontoon,

B – width of the pontoon.

Spring stiffness calculated according to equation (1) is equivalent to the water buoyancy influence on a single pontoon during single immersion. The division of the pontoon was carried out due to specific character of the buoyancy of the ponntoon filled with air. A pontoon model was divided into 4 different areas to determine the stiffness of spring elements modelling the water influence. In the first area there are springs placed on the stern pontoon, in second and third areas there are six springs placed on the edges of the cassette, and in fourth area there are two springs placed on the prow (Fig. 4). Adequate spring stiffness for each separate part was calculated (1) and placed in a designated area (Fig. 4).

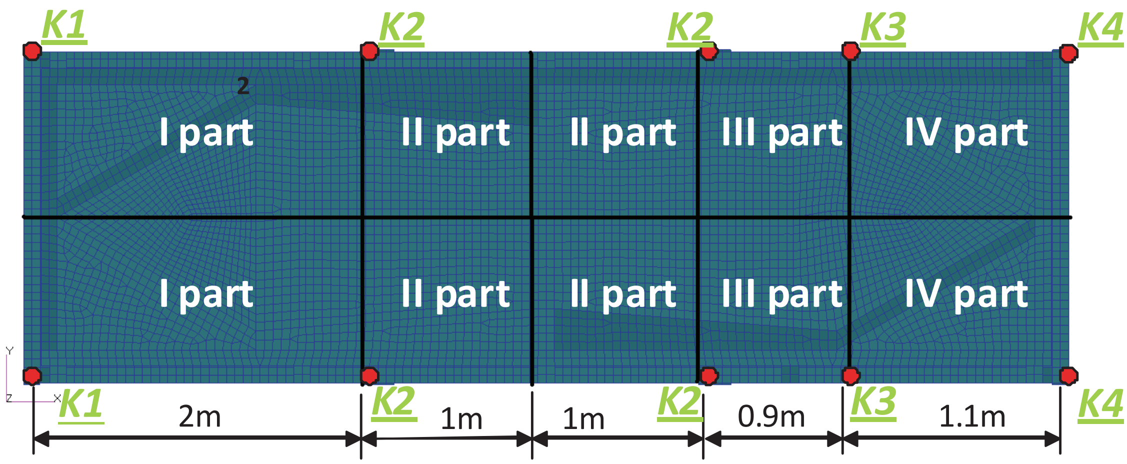

Fig. 4. Schematic layout of the springs on a single segment of the bridge

Markings in Fig. 4:

I, II, III, IV part – designated areas for individual spring stiffness calculations,

● – springs location,

K1,K2, K3, K4 – spring stiffness calculated according to formula (1).

Such arranged springs allow discriete modelling of the water influence on the bottom of each pontoon bridges. The influence of the weigths on the pontoon was replaced by static pressure, with equivalent values, superimposed onto the roadway slab (Fig. 5).

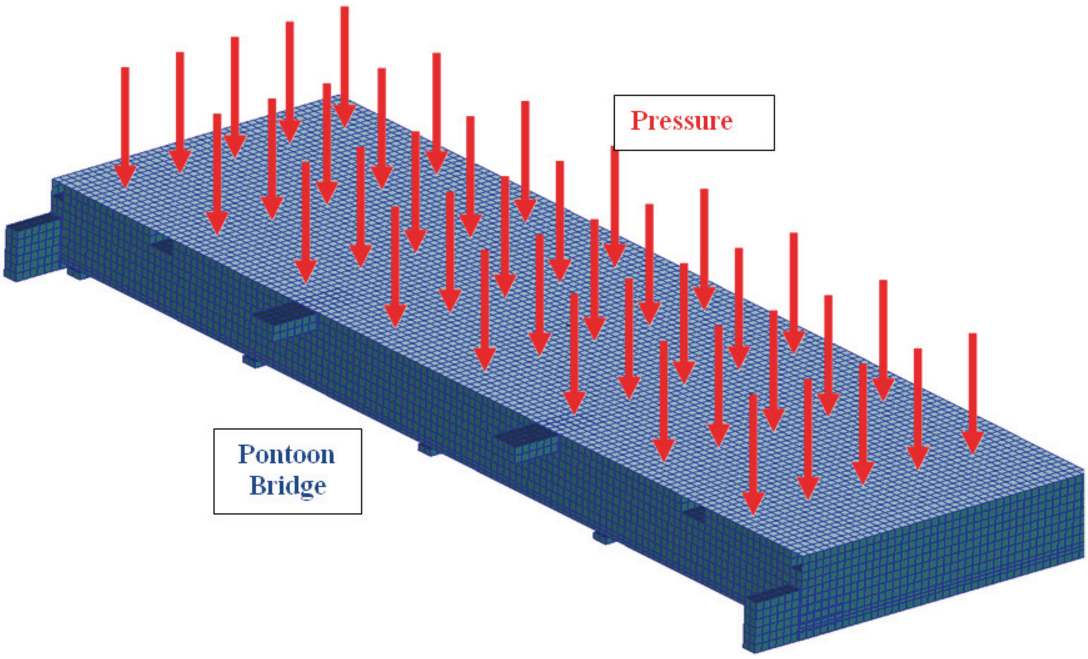

Fig. 5. FE model of the single pontoon bridge section

4. Results

Based on numerical analysis, it was calculated that the value of the drafts of the road amounts to 615mm (Fig. 6). The value measured in the experimental test ranged from 550 mm to 610 mm (Fig. 3). The difference is insignificant and results mainly from the simplifications used in the numerical model.

The highest stresses occurred on the roadway slab (Fig. 7). The maximum values of the reduced stresses according to Huber-Mises-Hencky (HMH) hypothesis were 70 MPa.

Fig. 6. Pontoons section immersion determined in numerical analysis

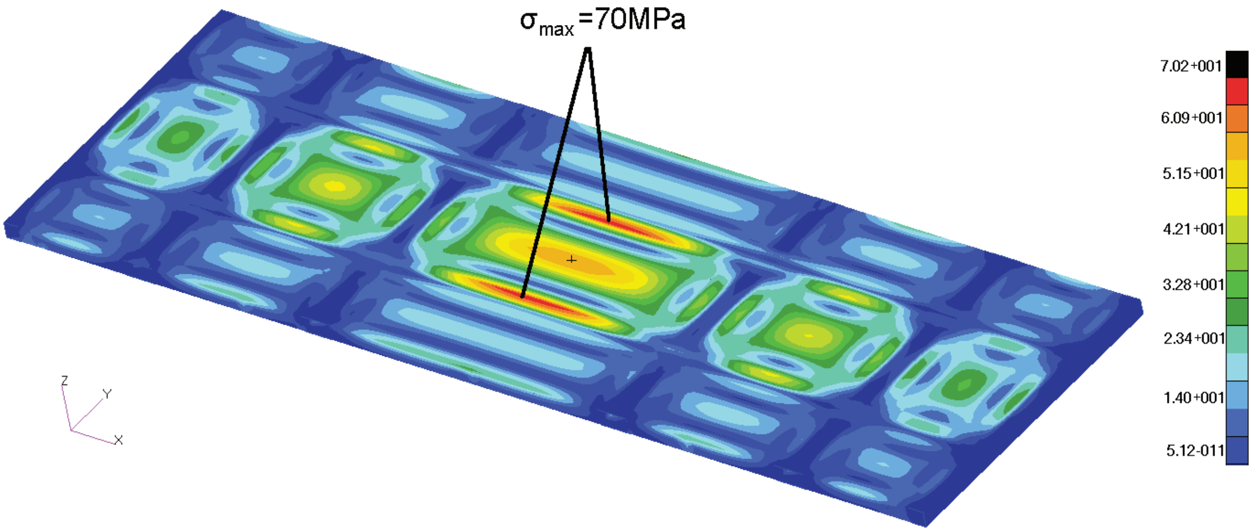

Fig. 7. Reduced HMH stress map, roadway slab view, the maximum value 70MPa

5. Conclusion

The paper presents one of the testing stages of prototype pontoons of a floating bridge. The results of experimental investigations and selected results of numerical analysis were presented. Accuracy of the numerical model was found based on the experimental verification. Conducting more complex analyses of the kinematic chain of the floating bridge cassettes in terms of their displacement is possible owing to an accurately validated model.

The influence of static load impact on the strain of structural elements of the joint of two cassettes was examined based on the map of reduced stresses. It was found that in the given load test the greatest stress occurred in the roadway slab.

The proposed construction was developed within the framework of the research and development project financed by the Ministry of Science and Higher Education. The idea was created at the Department of Mechanics and Applied Computer Science, Military University of Technology [4]. Institute of Security Technologies "MORATEX", Motor Transport Institute and Military Engineering Plant have been invited to co-operation. The result of this cooperation is a full-size two-segment demonstrator of the bridge, which successfully passed tests on proper functioning of mechanisms and floating module subsystems and on loading on water.

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