STRENGTH TESTS OF FOLDING BRIDGES' SPANS

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Abstract

The restoration of the road infrastructure to its earlier state is a long and costly process and it is often the case that local government authorities cannot afford it. Due to this, alternative solutions are sought, which will shorten to the minimum the time dedicated to reconstructing destroyed parts of roads and bridges on one hand and which will constitute an economical solution on the other. A good idea for achieving the former and the latter at the same time seems to be the utilization, in the process of rebuilding permanent bridge crossings, of the military folding bridges' elements which have been withdrawn from use in the engineering subsections of the Polish Armed Forces.

This paper presents non-military applications of military folding bridges, with special attention to strength tests thereof. It describes currently applied Polish and foreign methods of testing this type of bridge crossings and introduces a new method, indicating further development in this field.

Keywords: *hydrostatic drive systems, support and assault bridges, mMLC class*

1. Introduction

The destructive character of natural disasters, the havoc they wreak, the damages they cause and the process of liquidating and eliminating their effects have acquired major significance, especially in the context of the recent events in our country. The effects of another flood which swept through Poland included, among other things, the destruction of road communication infrastructure as well as that of bridge crossings. The restoration of the road infrastructure to its earlier state is a long and costly process and it is often the case that local government authorities cannot afford it. Due to this, alternative solutions are sought, which will shorten to the minimum the time dedicated to reconstructing destroyed parts of roads and bridges on one hand and which will constitute an economical solution on the other.

a) b)

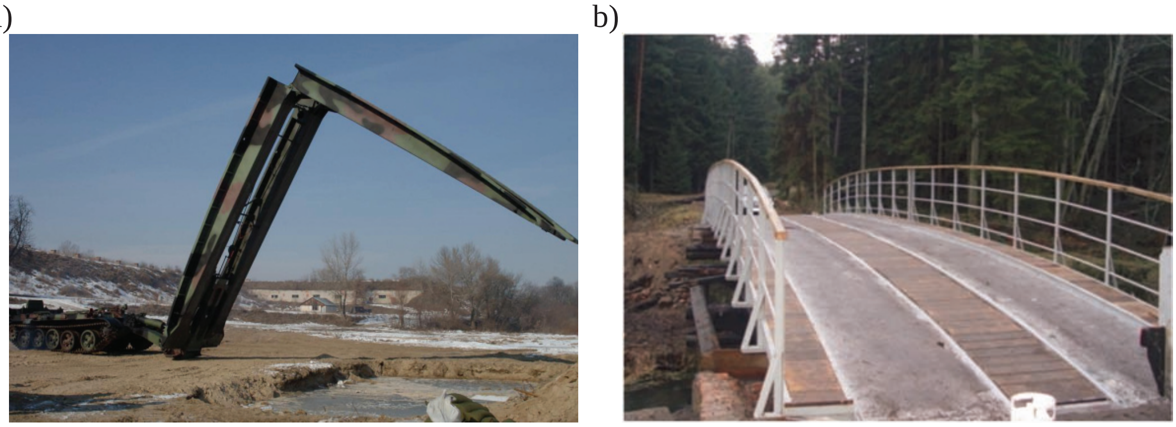

Fig. 1. Adaptation of a 20-metre long BLG-67 support bridge span to non-military traffic in Kletno, gmina Stronie Śląskie, Kleśnica creek: a) deployment of BLG-67 b) span adaptation

A good idea for achieving the former and the latter at the same time seems to be the utilization, in the process of rebuilding permanent bridge crossings, of the military folding bridges' elements which have been withdrawn from use in the engineering subsections of the Polish Armed Forces although their technical condition allows further use.

The advantages of military folding constructions, their availability in civilian services management and the existing applications thereof confirm the practicability of utilizing the bridges as alternative solutions to destroyed, damaged or renovated permanent crossings. The possibility of quick reconstruction of communication routes, ensuring continuity of traffic in a relatively short time and at relatively low costs in the period of increasing volume of road and railway traffic must not be underestimated [5, 6].

What seems to be a separate problem is the issue of determining the actual strength of the bridges' construction elements, which certainly diverge from nominal values due to the natural degradation resulting from their wear and tear. The results of such tests would enable classification of bridge constructions under appropriate load capacity classes and thus would unequivocally determine which permanent crossings could be made with the use of a particular item of a military folding bridge

2. Methods of testing folding bridges' spans

In Poland, strength tests of folding bridges' spans are conducted, among other places, at the Bridge, Concrete and Aggregate Research Center in Żmigród at the test stand called "Stend". The stand consists of an 80-metre long and 12-metre wide reinforced concrete foundation equipped with the system of appropriate anchors, along with an industrial hall and a steel frame which constitutes a bearing construction for load-exciting hydraulic devices. The stand is equipped with a system of SCHENCK hydraulic actuators and with up-to-date control and power supply systems, which allow obtaining full, real-time control of excited loads. It is equipped with a system of data collection and acquisition, enabling measurement of many quantities describing changes occurring in tested constructions. The stand components include:

- two actuators with the maximum exciting force of 1000 kN and the maximum stroke of 40 mm enabling excitation of dynamic loads in the range of ± 800 kN,
- hydraulic power unit with the efficiency of 130 l/min, along with an automatic air-cooling system
- Hydropuls S-59 electronic system which enables independent control of the two actuators on the basis of the real-time measurement of both the cylinder and thrust force values.

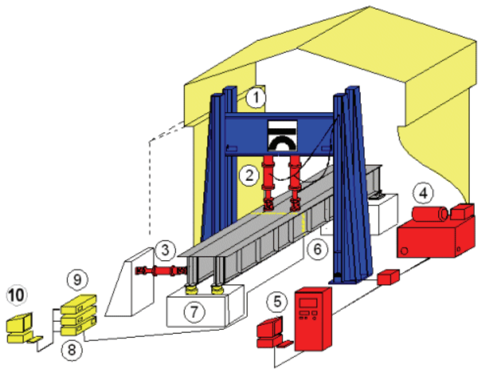

Fig. 2. Diagram of „Stend" stand for testing bridge spans

In Germany, on the other hand, bridge spans are tested with a specially designed BELFA truck (Fig. 3). In its transport position, the vehicle is capable of moving on public roads.

In an unfolded position, bridges of up to 18 metres in length can be tested. The weight of the vehicle with ballast is intended to balance the forces of the tested bridge's reactions. The load is transferred by means of five hydraulic actuators (Fig. 4).

Fig. 3. BELFA truck in transport position

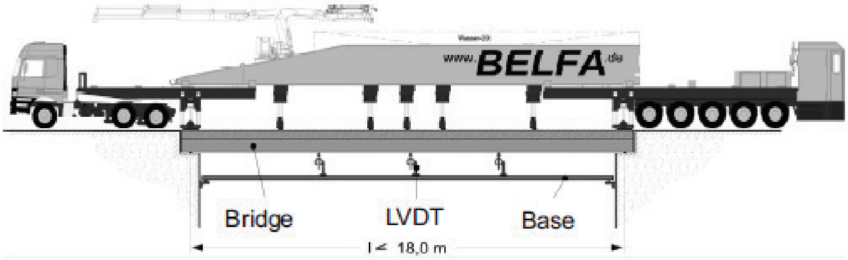

Fig. 4. BELFA truck during span test

The actuators can be expanded along the tested bridge independently. Each actuator is equipped with a separate control mechanism and is capable of generating a load of 500 kN. The vehicle is equipped with a hydraulic crane used for loading additional ballast. During the test, the last axle of the semi-trailer is off the bridge. Additionally, in order to increase the load, the hydraulic crane lifts up the tractor unit and thus transfers its weight onto itself. The basic parameters of the vehicle are presented in Tab. 1.

Tab. 1. Basic parameters of BELFA truck

Length in transport position	22.5 m
Length in test position	22.5m – 34.5m
Bridge span	6m – 18m
Vehicle weight	67.5 t
Ballast weight	10 t

3. Military university of technology research stand for tests on folding bridges' spans

A research stand for testing folding bridges' spans has been constructed on the premises of the MUT Chair of Engineering Equipment [2, 4] (Fig. 5).
The stand was used for testing the BLG-60M2 (BLG-67M2) bridge track and the research resulted in determining:

- fatigue limit of the span

- in accordance with the research program, an arranged number of cycles (5500) were completed, which was an equivalent to the load exerted on the bridge by a 50-ton track vehicle,
- recording the deflection curve and the inspection of the research object (of welded joints, in particular) after completion of an arranged number of cycles.

- Immediate strength

a) in the presence of eccentric load (asymmetric):
- measurement of girder deflection curve;

b) in the presence of maximum static load
- measurement of girder deflection curve.

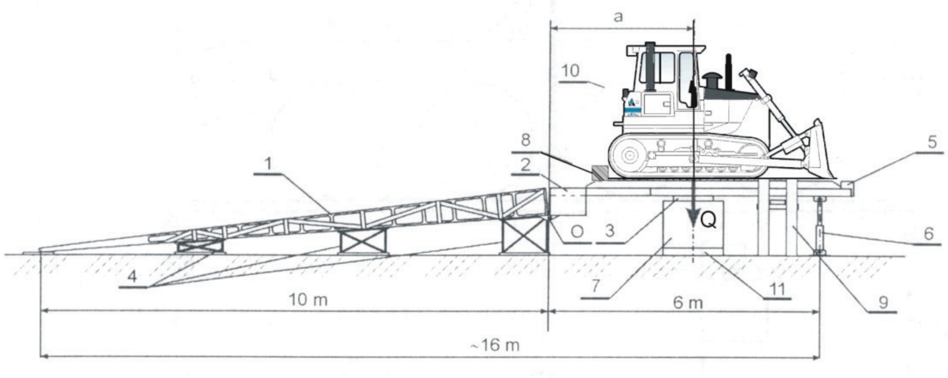

Fig. 5. Diagram of research stand for testing load capacity of bridge tracks: 1 – approach ramp, 2 – loading platform, 3 – load transfer slab, 4 – supports, 5 – front beam, 6 – span-loading actuators, 7 – span (bridge track), 8 – rear beam, 9 – side guides, 10 – load-generating vehicle; 11 – span support

Fig. 6. General view of research stand during test: 1 – load-generating vehicle (SG 15 bulldozer), 2 – loading platform, 3 – load-transfer slab, 4 – BLG-60M2 (BLG67-M2) span (bridge track)

The required load was obtained by driving an 18-ton SG bulldozer onto the loading platform of the research stand. The required load value for particular tests was obtained by means of determining the bulldozer's centre of mass on the loading platform [1].

In each cycle, by means of resetting hydraulic switches, the loading platform was slowly lowered on to the tested bridge track. In the meantime, the bridge track deflection curve, the pressure values inside the cylinders of rodless hydraulic lifting actuators [7] as well as the condition and reactions of the bridge construction components were observed and recorded. The bridge was lowered until hydraulic lifting cylinders were stopped by the deflecting track elements, which occurred when the tested construction's deflection curve reached its maximum. The loading cycle was ended with another resetting of the switches and with lifting up the loading platforms along with the bulldozer. The distribution of the deflection curve measurement points is shown in Fig. 7.

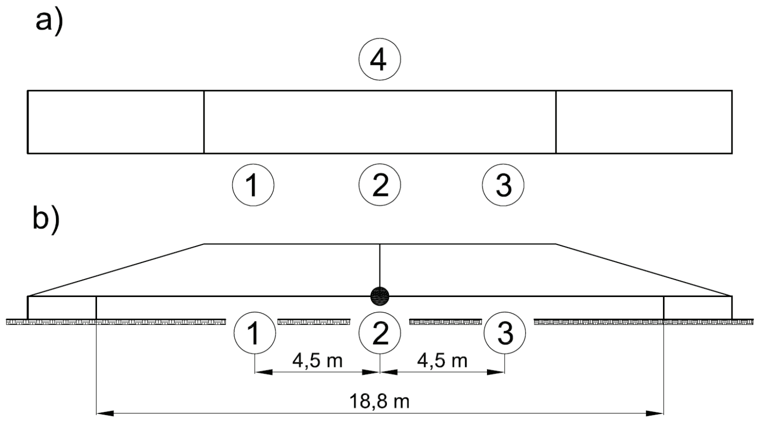

Fig. 7. Diagram showing distribution of measurement points during tests of BLG-60M2 (BLG-67M2) bridge tracks: a) top view, b) side view

The measurement of the deflection curve was performed by means of inductive displacement sensors (Fig. 8a) and, alternatively, by means of the GNSS (*Global Navigation Satellite System*) method (Fig. 8b).

Fig. 8. Measurement arrangement of bridge span deflection curve: 1- antenna for GNSS measurement; 2-inductive displacement sensor a) measurement point no. 1; b) side view of the stand

The GNSS measurement makes it possible to obtain a real-time, three-dimensional antenna position with the accuracy of up to 1 cm for horizontal components and up to about 2 cm for a vertical one. The displacement is determined on the basis of a relative position shift between the mobile receiver (placed on the bridge) and the reference station off the construction. A higher level of accuracy as regards displacement coordinates can be achieved by means of postprocessing (=computational process after the fact).

During the research, the assessment concerned changes in the deflection curve value due to the growing number of span loading cycles and, every 250 cycles, detailed inspections were conducted, with special attention to welded joints and pin lugs.

Exemplary timing of changes in the deflection curve value and in the pressure inside the lifting actuators during the research are shown in Figure 9.

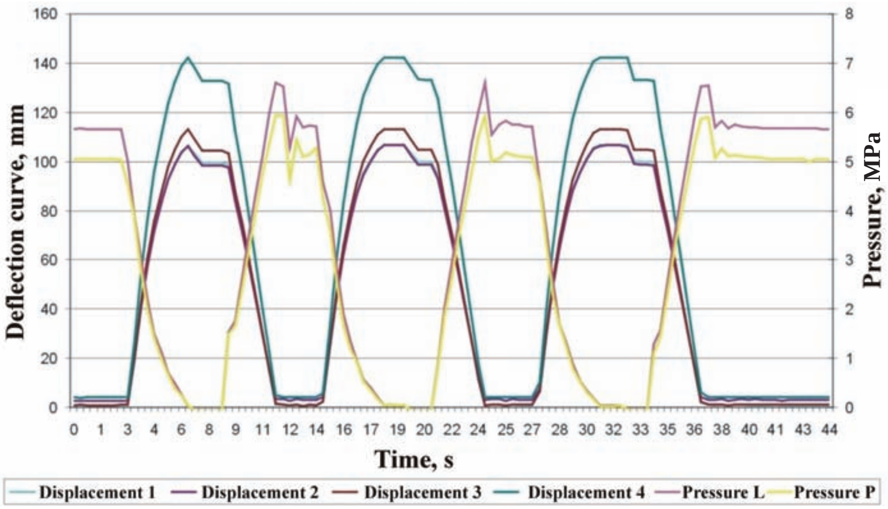

Fig. 9. Timing of changes in deflection curve values and in pressure values inside lifting actuators during one of loading cycles of BLG-60M2 (BLG-67M2) bridge span

4. Conclusions

The usefulness of military folding bridges in the time of more and more frequent natural disasters, destroying permanent crossings, is indisputable.

The growing popularity of utilizing folding bridges' spans as temporary, non-military bridge crossings requires the development of new testing methods and the improvement in the old ones, especially as regards strength tests. New construction assumptions result in the necessity of developing, for this type of spans, methods of lifespan assessment different from the current ones.

A detailed cost analysis would make it possible to determine precisely whether or not the use of folding bridges as permanent crossings for minor water obstacles is cheaper than the construction of classical non-military bridges.

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