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INTERCOMPATIBILITY OF BRIDGE LAYERS MS-20 AND MG-20

Abstract. The paper discusses two designs, developed by OBRUM, of the so-called layers placed on military bridges MS-20 and MG-20, the purpose of which is launching and retrieving the bridge span from over an obstacle. Specifications of the PM-20 bridge span are given. Differences in the design of the bridgelayers performing the same functions are presented. Reference is made to the obtained intercompatibility effect of the layers enabling the same bridge span to be handled by two independent vehicles: wheeled MS-20 and tracked MG-20.

Keywords: support bridge, assault bridge, MS-20 bridge, MG-20 bridge, base vehicle, special semi-trailer, bridge layer, PM-20 bridge span

1. INTRODUCTION

In military engineering bridges are classified according to the defence standard [1] which distinguishes two types of military bridges:

1) standard (equipment at the disposal of engineering troops);

2) nonstandard – built utilising available structures and local materials.

Depending on the functions performed, three groups of bridging equipment may be distinguished [1]:

- tactical bridges,
- support bridges,
- line of communication bridges.

An interesting group of bridges designed for military purposes, the main advantage of which is high mobility, is the Daglezja family of bridges [2] developed at OBRUM and commissioned by the former Armament Policy Department of the Ministry of National Defence. The Daglezja bridges research and development project was launched in 2003 and covered a group of bridges designed to negotiate water and terrain obstacles of various widths.

The Daglezja group is to comprise the following bridges:

- MS-20 "Daglezja" support bridge on wheeled chassis [3],
- MG-20 "Daglezja – G" assault bridge on tracked chassis [4],
- MS-40 "Daglezja – S" mobile foldable bridge for negotiating medium-sized water and terrain obstacles [5],
- "Daglezja – P" pontoon bridge for negotiating medium-sized water obstacles [6].

The comprehensive approach to the problem of bridges assumed the necessity to standardise the developed structures during the design.

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For the group of 20m-span bridges a requirement was imposed to enable launching and retrieving the designed PM-20 bridge span [7] by two types of vehicles with bridge layers – wheeled and tracked.

This requirement applies to the MS-20 bridge and the MG-20 bridge [3], [4].

The MS-20 bridge [9] is a support bridge which is not designed to construct a passage over an obstacle under enemy fire. The above is possible with the MG-20 bridge which may launch a span from a tracked carrier vehicle. That bridge span may in turn be retrieved by a wheeled carrier vehicle during a cessation of fire.

2. PM BRIDGE SPAN

The MS-20 bridge span comprises a complete bridge consisting of two girders with deck and filling between approach ramp girders [7].

The key requirements that were laid down on the PM-20 span [3], carried on an MS-20 or MG-20 vehicle, include:

- crossing by tracked and wheeled vehicles of MLC-70 or lower class [10] at a speed of 15 km/h or higher;
- crossing by two towed tracked vehicles of MLC-70 or lower class (each) at a speed of 15 km/h or lower;
- crossing by a set of wheeled MLC110 vehicles [10] moving at a speed of 20 km/h or lower, the set consisting of a tractor and trailer or a semi-trailer carrying a tracked vehicle of MLC70 or lower class;
- crossing by no less than 5000 MLC50...70 tracked vehicles at a speed of 40 km/h or lower and/or MLC90...110 wheeled vehicles (low bed unit carrying a tank) at a speed of 30 km/h or lower;
- resistance to fire resulting from the burning of napalm (napalm IEDs and bombs) or fuel;
- when positioned over a gap, it should be provided with lighting (clearance and retroreflecting) of outer span edges to enable drivers to drive their vehicles over the bridge under conditions of reduced visibility. The lighting should not expose the crossing;
- it should enable (not applicable to wearing surface) crossing by an unlimited number of under MLC50 class tracked and wheeled vehicles [10].

The design of the PM-20 bridge span developed at OBRUM stands out among other known solutions, particularly due to two features:

1. The span is fitted with decking between ramps. The decking has a high load capacity of 97.7 kN, which corresponds to the front axle wheel load of the SŁ-34 loader with its bucket filled. It enables passage of infantry and of wheeled vehicles narrower than typical military vehicles.
2. The width of the bridge span can be reduced for transportation and in its operating arrangement.

Adjustable width of the span enables transporting the MS-20 bridge on public roads without compromising road traffic regulations. During transport or in the transport position the span is 3m wide and complies with Traffic Law [9] for loads carried by vehicles 2.55 m wide. This width is changed to 4 m prior to laying the span over the gap enabling thereby the passage of all wheeled and tracked vehicles used by the Polish Army and the armies of the NATO Member States. The PM-20 span is shown in Fig. 1.

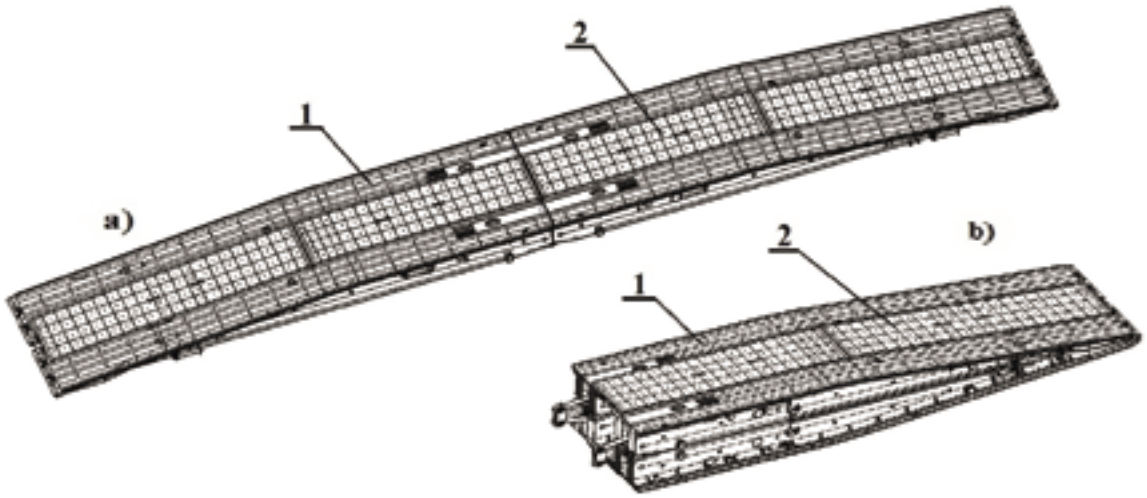

Fig. 1. PM-20 bridge span

a) in launched position; b) in transport position.
1 – bridge girders, 2 – decking between ramps

Basic technical specifications of the span:

- span capacity MLC 70/110 [10],
- span length 23.2 m (at gap width 20 m),
- length of span with approach ramps 25.6 m,
- max. width of negotiated water or terrain obstacle 20 m,
- bridge width 4 m,
- span weight incl. equipment (excl. approach ramps) ca. 15,000 kg.

2. BRIDGE SPAN OPERATION

Using the PM-20 span on various carrier (base) vehicles required designing two devices attached thereto: the so-called bridge layers providing the same functionality.

The MS-20 bridge comprises a JELCZ tractor unit and a three-axle special bridge semi-trailer which together form a bridge transport vehicle with a bridge layer and PM 20 bridge span arranged thereon [7].

The MG-20 bridge comprises a modified T-72/PT-91 tank tracked chassis extended to contain one additional axle with a bridge layer attached and PM-20 bridge span arranged thereon.

The MS-20 and MG-20 bridges are shown in Fig. 2.

a) MS-20 support bridge b) MG-20 tactical bridge

Fig. 2. Combat vehicles – PM-20 bridge span haulers

The need to implement the function of laying the bridge span over a terrain obstacle and retrieving it by two types of vehicles had an impact on the unification of basic structural units responsible for maintaining and manipulating the span during all phases of movement.

The PM-20 span (Fig. 1) hauled by the MG-20 tracked carrier vehicle or the MS-20 wheeled carrier vehicle (Figs. 2a and 2b) is a scissors-type structure that is foldable along its transverse axis midway of its length [11], [12].

The deployed bridge (Fig. 1a) has decking arranged automatically between the ramps along the entire length of the span by means of hydraulic cylinders which ensures robustness and safety when driving across the bridge. It also enables crossing the bridge by vehicles at high speed and by people over the whole of its width. The span is 4m wide and it is locked by means of special mechanisms when preparing for launching [7].

Special mechanisms installed on the carrier vehicle (wheeled – Fig. 3, or tracked – Fig. 6) slide the bridge span into the transport position where it is 3m wide and block it with special transport blocks.

The MS-20 and MG-20 bridges are also equipped with special approach ramps that enable smooth entry of vehicles onto the bridge span. These approach ramps are installed manually after the bridge span is positioned over the obstacle.

3. MS-20 BRIDGE LAYER

The PM-20 bridge span is placed on a special semi-trailer with the bridge layer installed thereon and on supports of the semi-trailer expansion mechanism. In the transport position the bridge span is blocked by means of four hook latches of the bridge layer. The PM-20 span may be

manipulated after unsecuring the hook latches, moving apart two supports and relocking the bridge layer with the hook latches. This is first done in order to position the bridge span over a terrain obstacle, afterwards it is done after completing the task, retrieving the bridge span from over the obstacle and positioning it on the semi-trailer in the transport position.

Hydraulic feed conduits with quick action couplings and an electric signal cable are connected to the bridge span. These conduits must be connected to the bridge layer when launching and retrieving the bridge span. The conduits must be disconnected before the bridge carrier vehicle moves away after launching or retrieving the bridge span and arranging it in the transport position [7].

The MS-20 bridge layer (Fig. 3) is an integral part of the special transport and launch semi-trailer which, together with the Jelcz 662D.43 tractor unit, forms the Bridge Carrier Vehicle [7].

Fig. 3. Special semi-trailer

1 - semi-trailer, 2- bridge layer, 3 - span expansion system

The primary function of the bridge layer is moving the bridge span from the semi-trailer and arranging it over an obstacle and retrieving the span from over the obstacle and its subsequent placement on the semi-trailer in the transport position. The bridge layer comprises two principal units: main arm (Fig. 4 – item 1) and catch arm (Fig. 4 – item 2). It is also provided with a foot (Fig. 4 – item 3) which enables resting against ground, and with a rotary lever (Fig. 4 – item 4) which enables rotation within the required angle range and improves stability of the system. The element that plays the principal role in the unfolding and folding of the bridge span is the expansion mechanism (Fig. 3 – item 3) which, in addition to supporting the span in the transport position, expands the span transversely enlarging thereby the useful width of the bridge by 1 metre in comparison to the width in the transport position.

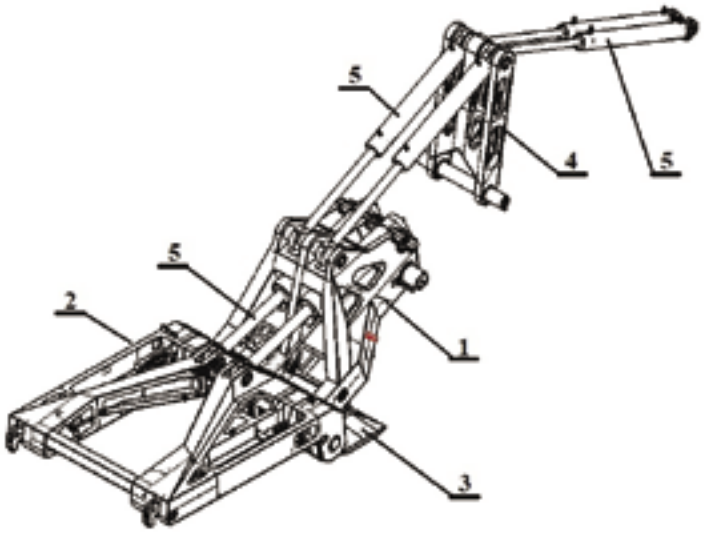

Fig. 4. MS-20 bridge layer

1– main arm, 2 – catch arm, 3 – foot, 4 – rotary lever, 5 – hydraulic cylinder

The bridge layer performs the process of bridge launching in the following sequence of operations: engaging hooks with the bridge span, lifting and rotating the span after expanding it to the width of 4 m, positioning the span over an obstacle, disengaging the hooks from the span to enable the bridge laying vehicle to pull out. Throughout the entire process the bridge layer additionally stabilises the system and enables guiding the bridge span onto the fastening hooks.

The bridge span retrieval from over an obstacle is carried out in reverse order as related to the launching operation. In order to properly engage the hooks with the bridge span [7], the vehicle is fitted with a set of special chains and equipment to align the span parallel to vehicle axis. Three sets of actuators mounted in the structure (Fig. 4 – item 5) rotate the bridge layer to position the bridge span on the frame of the semi-trailer.

4. MG-20 BRIDGE LAYER

The initial idea at the start of design work on the MG-20 tactical bridge was to adopt the complete bridge layer structure used in the MS-20 bridge. The task proved impracticable due to differences in the model of loads resulting from dissimilar geometry, weight and centre of gravity of the tracked chassis [13]. The steel structure of the bridge layer (Fig. 5) for the MG-20 bridge therefore had to be designed from scratch, while a maximum degree of compatibility had to be preserved with regard to the span holding part, units and mechanisms, and the two-member bridge layer type with support foot identical to that of the MS-20 bridge. There are also significant differences in the algorithm of span manipulation by the bridge layer.

For the MG-20 bridge (Fig. 2b), the expanding mechanism used in the MS-20 bridge (Fig. 3 – item 3) was not the main issue in the kinematics of the bridge span launching. The width of the tracked carrier vehicle was sufficient to omit the need to reduce bridge span width for transportation. However, the recommended compatibility of the bridge spans for both vehicles (wheeled MS-20 and tracked MG-20) and the necessity to apply a uniform bridge launching procedure in both cases led to

the decision to retain the expanding feature. The structural design of the span expanding mechanism applied in the MG-20 bridge (Fig. 6) was "borrowed" from the MS-20 design and introduced into the tracked chassis – hull of the MG-20 bridge.

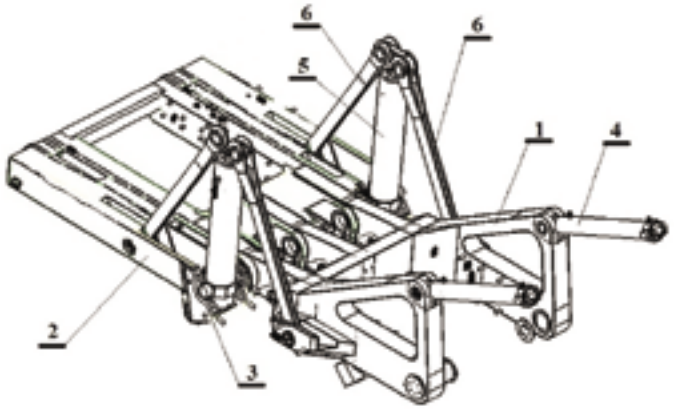

Fig. 5. MG-20 bridge layer

1– main arm, 2 – catch arm, 3 – foot, 4 – primary pair of hydraulic cylinders
5 – secondary pair of hydraulic cylinders, 6 – connecting rods

The MG-20 bridge layer also comprises two principal units: main arm (Fig. 5 – item 1) and catch arm (Fig. 5 – item 2). The supporting foot (Fig. 5 – item 3) in the main arm of the bridge layer is derived from the MS-20 bridge. In contrast to the MS-20 bridge, where three pairs of hydraulic cylinders are used, the MG-20 bridge uses only two pairs (Fig. 5 – item 4): between the hull and the main arm and between the main arm and the catch arm (Fig. 5 – item 5). To make the kinematics of bridge launching similar to that of MS-20, connecting rods (Fig. 5 – item 6) between the piston rods of the secondary pair of hydraulic cylinders and the main arm and the catch arm had to be used.

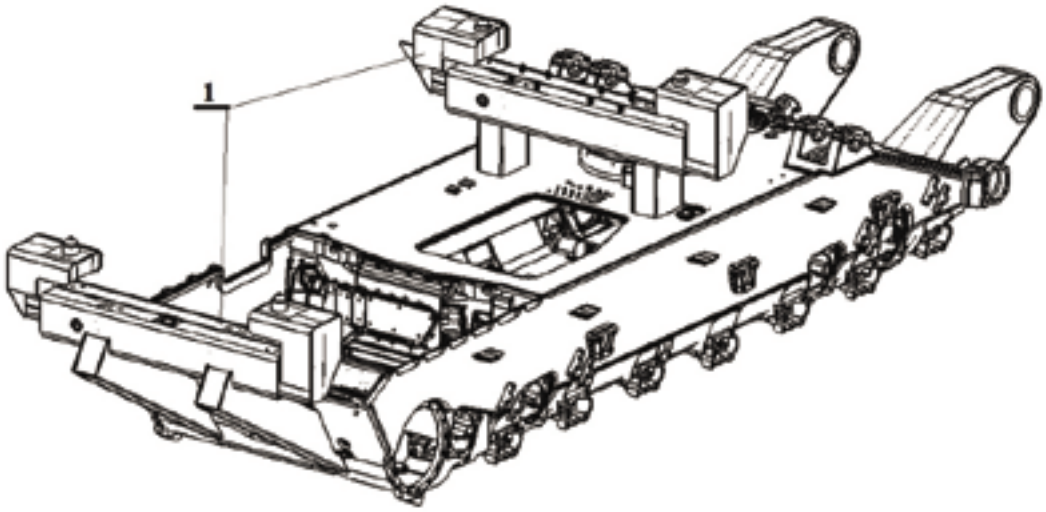

Fig. 6. Expanding mechanism of the MG-20 bridge

1 – bridge span expanding mechanism installed on tracked chassis

During launching, the bridge span is tied by means of a system of hooks installed in the catch arm of the bridge layer (Fig. 5 – item 2) and moved by means of hydraulic cylinders (Fig. 5 – items 4 and 5). The system is identical with the one used in the MS-20 bridge. Launching the bridge span over an obstacle and retrieval is effected in similar manner as in the case of the MS-20 bridge. The MG-20, however, may be launched in a fully automatic manner, without the operator leaving the vehicle. With the MG-20 it is possible to disconnect the hooks, hydraulic conduits and electric cables and to drive away the chassis without the operator having to leave the vehicle interior. These design features enable the bridge to be launched over an obstacle under enemy fire and to be classified as a tactical-assault bridge.

The MG-20 bridge was designed for operations in the area of direct and indirect enemy contact in a variety of terrain and weather conditions, even under conditions of environmental contamination with nuclear and chemical weapons.

5. SUMMARY

OBRUM engineers have carried out an in-depth analysis of platforms with regard to proper manipulation of the bridge span, launching and retrieving the span under extreme terrain conditions. Subsequent analyses [12], [13] of the model have led to new bridge layer concepts which were modified many times to eventually create final solid models. These models provided starting material for strength calculations conducted with the use of the finite elements method.

Positive calculation results enabled the creation of structural models of the bridge layers and drawing up of design documentation, based on which real metal bridge layers were constructed.

The compatibility requirement for the span for MS-20 and MG-20 bridges installed on wheeled and tracked platforms and for bridge layers has resulted in the design of bridge layers where, despite the different characteristics and kinematics of the actuators, it was possible to implement the algorithm of launching and retrieving [7] the bridge span while maintaining the declared time parameters under specified field conditions [3], [4].

Table 1 lists the basic features common to the MS-20 and MG-20 bridge layers.

Table 1. Common features of the MS-20 and MG-20 bridge layers

Operations performed	Actuator of MS-20	Actuator of MG-20	Interchangeability
Bridge layer components	Main arm, catch arm, rotary lever	Main arm, catch arm	No
Support	Foot	Foot	Yes
Span expansion	Expanding mechanism	Expanding mechanism	No
Span rotation phase 1	Cylinders LS1, LS2	Cylinders LS1	No
Support	Foot	Foot	Yes
Rotation phase 2	Cylinders LS3	Cylinders LS2	No
Span front hold	Front hooks, rear hooks	Front hooks, rear hooks	Yes
Hooks rotation	Front hooks actuators, rear hooks actuators	Front hooks actuators, rear hooks actuators	Yes
Control	CANbus wired control panel	CANbus wired control panel	Yes

The functional interchangeability of bridge layers in the MS-20 and MG-20 bridges, being the result of the PM-20 bridge span uniform design, is a success of the OBRUM's design team, which resulted in the far-reaching standardisation of engineering solutions.

Compatibility of the PM-20 spans with the MS-20 and MG-20 military bridges opens a wide area of applications of the structures designed at various stages of tactical operations. A bridge span launched by an MG-20 tactical bridge during the operations of armoured units may then be used by support troops and eventually retrieved by an MS-20 support bridge.

The successful design work completed by OBRUM opens up opportunities for further orders and projects in the area of bridge design commissioned by the Armament Inspectorate of the Ministry of National Defence [14].

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