

Review Article

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Modern structures of military logistic bridges

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Abstract: The growing paste of military operations, as well as the increased involvement of the Armed Forces in countering the ramifications of natural disasters, impacts the design solutions used for military bridging systems. The most vital optimization factor is the speed of deployment to which all the structural solutions are subject. Another determinant is a wide range of the parameters of the gap to be crossed using one bridging structure transported using typical means of transportation, including its width and the height of the banks. There is a worldwide tendency to fill the space between the treadways, making them more solid and thus much more usable for civilian vehicle traffic as well. That in turn makes them a provisional replacement for the damaged bridge infrastructure used by the population. This poses a number of challenges to be tackled by the state-of-the-art line-of-communication (LOC) bridges and both the close- and general support bridges, which seem to assume the tasks of the LOC bridges.

Keywords: line-of-communication bridges, general support bridges, logistics, temporary construction, disaster relief bridges

1 Introduction

Enabling manoeuvrability or mobility is one of the three fundamental tasks of engineering troops, and the most complex element of these activities is crossing or bridging natural obstacles in the form of existing terrain features,

including water gaps. The North Atlantic Treaty Organization armed forces divide the existing bridge potential into three categories:

- assault bridges, aka. close support bridges, are carried and launched on a tracked chassis, with spans of about 20 m in length;
- general support bridges (GSBs), where the span, ca. 40 m long, is transported on several wheeled vehicles;
- line-of-communication (LOC) bridges, which are most often folding or pontoon structures, are used to cross very wide bodies of water.

This classification was created in response to various use-case scenarios, as well as the design differences between the listed three categories of equipment. In addition, the LOC support bridges and GSB are often used as part of crisis response efforts to support the local populace, when such structures are used as part of the crisis response efforts and serve as a temporary replacement of bridges damaged by floods, or a temporary structure onto which a pipeline was placed after the failure of the *Czajka* sewage treatment plant in Warsaw [1].

We are witnessing a global tendency towards blurring the differences between the GSB and LOC bridges [2]. This is due to the increased flexibility of new GSB span structures that can take over the tasks of LOC bridges while reducing the workload required for their deployment.

We should bear in mind that military bridges are designed differently from those structures that are public utilities. Civilian bridges are optimized by quantifying their costs and benefits, while the focus for the military is on having specific capabilities to perform specific tasks. In particular, these objectives include ensuring transportability, understood as the capability of transporting bridge components using typical means of transport that need to be compliant with the clearances/loading gauge. However, another vital feature of such structures is the reduction of the workforce required for the gap crossing by limiting, to a minimum, the time necessary to ensure traversability.

The operational requirements, such as the bridge load capacity or its span, are also of import here. The military bridge load capacity is determined by a Military Load Classification (MLC) number, which represents the

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safe amount of load exerted by individual types of vehicles that a given surface is capable of withstanding. This is described in detail in the STANAG 2021 standard [3]. Along with the development of the armoured forces and the growing weight of tanks, the requirements for the bridge load-carrying capacity increased. Table 1 shows a comparison of the loads for different MLC classes. Over the last two decades, load-carrying capacity requirements have increased significantly, from MLC 70T to MLC 100T and MLC 110W [4] (T stands for tracked vehicles and W stands for wheeled vehicles), and in special cases, such as pontoon bridges, even to MLC 120W. Concerning the bridge span, the available analyses, as carried out by the US Navy [5], indicated that a 24-m span provides the capability to negotiate 73% of obstacles. On the other hand, the geographic characteristics of Central European countries [6] show that 70% of water gaps are up to 50 m wide, and these obstacles are found every 6–7 km on average.

- bridge span;
- launcher system;
- a system of piers (optional);
- transportation vehicles; and
- auxiliary equipment.

The last two decades saw the biggest changes in the area of span construction and launching systems. The current span requirements [7] consider, for example, the filling in of the space between the treadways, which makes these structures resemble LOC bridges more and enables civilian traffic. The following bridging systems were selected for comparison: the British Dry Support Bridge (DSB – used by the US Forces), the Swedish Krigsbro 5 (KB5), the Russian mechanized bridge (Мотовой механизированный комплекс, ММК), and the Polish MS-40. The comparison of the selected technical parameters of the chosen support bridge is provided in Table 2.

2 GSBs: technical solutions

2.1 General information

GSBs consist of the following essential elements:

2.2 Bridge span construction

In GSBs, the spans are steel or aluminium structures made using plates or trusses as girders, albeit the latter less frequently. Contrasting them with civilian bridges of

Table 1: Comparison of selected MLC classes based on the STANAG 2021 standard [3]

MLC	Tracked vehicle (T)	Wheeled vehicle (W)
50	Weight, total: 43.36 tonnes 	Weight, total: 52.62 tonnes
70	Weight, total: 63.50 tonnes 	Weight, total: 73.02 tonnes
100	Weight, total: 90.72 tonnes 	Weight, total: 104.33 tonnes

Table 2: Comparison of the selected parameters of support bridges

Parameter	Bridge type			
	DSB	KB5	MMK	MS-40
MLC				
T – tracked vehicle	Normal: 70T/96W	70T	60 t*	70T
W – wheeled vehicle	max. 120W	110W		110W
Maximum bridge span (m)	46	48	41	42
Road width (m)	4.3	4.0	4.0	4.5
Dimensions of a key module deployed length width height (m)	$5.95 \times 4.3 \times 1.19$	$8.0 \times 4.0 \times 1.5$	$6.25 \times n/a \times n/a$	$5.7 \times 4.5 \times 1.5$
No. of modules required for maximum length bridge	8	6	6	8
Module weight (kg)	4,417	5,300	n/a	5,380
Weight per running metre (kg)	742.4	662.5	n/a	672.5
Structure material	Aluminium alloy	High speed steel (HSS)	Steel	HSS steel
Main girder type	Plate girder with rectangular cross-section	Truss	Plate girder with triangular cross-section	Box girder
Launching beam type	Box girder	Box girder	Box girder	Truss
Support type	Bridge built directly on the span	Two dedicated supports	Two dedicated supports	Two dedicated supports
Launch method	Under a launching beam	On a launching beam	On a launching beam	On a launching beam
Means of transportation (launch vehicle + transport vehicle)	1 + 3	1 + 6	1 + 5	1 + 5
Launch time (min)	90	75	60	90
Crew	8	7	11	8

* – Russia does not use MLC.

similar design, we notice that these spans are made as modules, enabling them to be transported by road, sea, and air. Such a design concept is necessary for mobility to be maintained and enables the bridging systems to be assembled *in situ* without the need for additional heavy machinery in the form of bridge layers integrated with chassis. The disadvantage of such a solution is the presence of joints between modules (segments), which are areas of potential failure. Furthermore, the dimensions of individual segments are limited by the width and height of clearances, and the weight is limited by the carrying capacity of transport vehicles. For example, the entire structure of the DSB span consists of two aluminium alloy U-shaped girders with a deck spanning the girders, where a single module is 5.95 m long, 1.19 m high, and 4.3 m wide.

A similar bridge structure was used by the Russians in the MMK, where the girders are two-plate girders with a triangular cross-section and the module length is 6.25 m. However, another solution is the Swedish KB5, where the main girder is a truss and the length of a single module is 8.0 m, and a launching beam in the form of a plate girder is also used. The discussed designs are shown in Figure 1.

Another key difference compared to civil bridging systems is that the girders and the roadway surface are permanently connected in military bridges. Thanks to this change, we can significantly reduce the time required to bridge the gap. In this case, the roadways are most often made of rifled steel plates adapted to the passage of tracked vehicles without rubber protective covers. Otherwise, the passage of tracked vehicles could quickly damage the roadway, which in turn would lead to the destruction of the bridge [8]. It is worth noting that, in contrast to the legacy structures, where the vehicles were moving on treadways [9], the systems produced have no gaps. It is due to this change that such bridges are capable of performing two or even three functions: serve as LOC bridges, support crisis response operations, and be temporary replacements for permanent bridges damaged by natural disasters (Figure 2).

The last important aspect of changes in the span design is the possibility of combining it with other types of bridges and supports, in particular, floating piers. This is of particular importance in terms of interoperability. The possibility of using existing bridge structures that have not been damaged, such as piers or abutments,



Figure 1: Bridge span designs, from the top left: MMK, DSB, and KB5 [2].



Figure 2: Types of spans: the BLG-67 [11] with treadways on the left and the MS-40 span with no gaps between treadways.

would significantly speed up the work on the reconstruction of the damaged infrastructure. On the other hand, floating piers, practically unused in civil engineering, enable the crossing of wider gaps in any area, without the need to construct fixed piers. Pontoon bridges or barges with proper decking suitably properly anchored in the crossing axis can be used for this purpose [10,11]. From a technological point of view, however, the use of floating piers is extremely difficult despite its advantages, as such supports experience significant transverse and longitudinal displacements when transferring vehicle dynamic loads. However, the additional problem is the

changing river water level, which may increase or decrease daily, and therefore, the combination of such structures must be able to compensate for these fluctuations. Figure 3 shows the MS-40 bridge being connected to a ferry made of the PP-64 pontoon park.

2.3 Launching system

GSBs are designed to be ready for the gap crossing from one bank only, without the possibility of using heavy machinery. This need generated the design of a special vehicle equipped



Figure 3: MS-40 bridge being placed on a floating support.

with a launching system and tasked to perform two essential functions: to assemble and extend the launching beam and then to slide the bridge spans into their places. Basically, the launcher vehicle consists of a support for auxiliary span, actuators for pushing the span, and a crane for lifting and stacking other span elements (Figure 4).

Two types of launching beam designs can be distinguished in the structures currently used in GSBs, namely upper and lower launching beam; the difference is illustrated in Figure 5.

Both techniques are valid and have their advantages, but the launching beam at the bottom is used more often, mostly because the launching beam assumes part of the vehicle traffic load. As a result, the bridge span elements can be lighter and therefore easier to transport.

In addition, the pace of the crossing is increased by the time necessary to dismantle/disassemble the launching beam. However, in such a situation, one launcher may deploy only one bridge. When using the upper launching beam system, after the spans have been slipped into place, the beam can be disassembled and used to slide the GSBs in other areas.

An important aspect of the bridge laying systems is to provide a counterbalance during the first stage of bridge construction, i.e. the sliding of the launching beam. This is achieved by the maximum shift of the centre of gravity of these vehicles towards the cabin and the use of stabilizing support that is placed close to the edge of the water obstacle. In the case of the above structures, the stability margin is more than 30%.



Figure 4: A vehicle with an MS-40 launching system.



Figure 5: Different types of launching beams, DSB (on the left) and MMK (on the right) [2].

2.4 Bridge construction tempo

Time is a principal factor in conducting any military operation, and it is of particular importance when maintaining mobility is crucial. Military units cannot wait for days or weeks necessary for the logistics to repair damaged bridges in the traditional way, and therefore, bridge designs for the military are optimized in terms of reducing the launching time and labour intensity when crossing a gap. All the aforementioned bridge designs have been drafted with maintaining the short construction time in mind.

Comparing GSBs to those of traditional folding bridges, such as the DMS-65 and medium girder bridge, described in more detail in [12–14], we can notice an over sevenfold reduction in labour consumption, which is expressed as the number of person-hours spent on the execution of one running metre of the bridge. This is illustrated in Figure 6. It is also worth noting that the BLG-67 and

MG-20 assault bridges [2,14,15] mentioned in the comparison are very specific structures with precisely defined tasks in the course of operations, and due to their design, e.g. the use of treadway spans, have limited throughput and are not suitable to perform LOC bridge tasks. Nevertheless, the possibility of bridging a 20 m gap under 5 min is an achievement worth considering.

3 Summary

The designs of modern military GSBs are able to meet very stringent requirements in terms of load-bearing capacity and the time needed to cross a gap. In addition, such designs make it possible for GSB to assume the tasks of supporting other types of constructions, such as folding bridges. Moreover, the limitation of the deployment time to

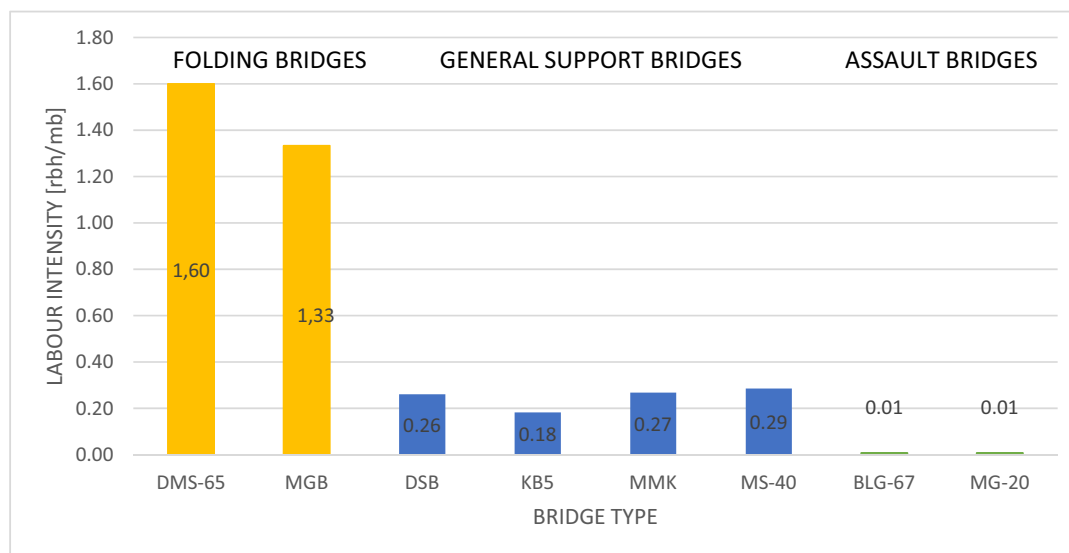


Figure 6: Comparison of the labour intensity of different bridging systems.

90 min means that they can replace damaged infrastructure very quickly when necessary. No need to use heavy machinery, and the ability to operate from only one bank, means increased availability of construction sites for such bridges.

Considering the above advantages, we can conclude that, in addition to military applications, such constructions will prove useful during crisis response operations, such as ensuring the continuity of damaged communication lines for a specific period of time. What is more, they can be used during repairs of existing bridge structures, particularly when such repairs have not been planned, where they could be used as temporary structures.

At this point, it is also necessary to mention the greatest limitation in the operation of this type of structure, i.e. ensuring that the transport of the bridge system is within the legal clearance values. This requirement results in significant limitations on individual bridge dimensions, as they must not be exceeded. That leads us to the conclusion that without a breakthrough in the field of modern materials, such structures have already achieved their peak parameters.

Conflict of interest: Authors state no conflict of interest.

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