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SUPPORT BRIDGES
PART 2. ASIAN SUPPORT BRIDGES WITH A SPAN OF 40 M

Abstract. The article presents Asian bridges designed to act as support bridges, which can also serve as line-of-communication bridges or be used in crisis situations. The designs presented enable construction of bridges with a span of at least 40 m for loads of tracked main battle tanks (MBT) of the individual states. Tactical and technical specifications of the individual designs are presented. Material and structural solutions of the main components and the applied bridge assembly technologies are described.

Keywords: military bridge, support bridge, bridge layer, bridge span, launching beam.

1. INTRODUCTION

The first part of the article [1] presented support bridges of at least 40 m span of European design. In Asia, problems of the negotiation requirement for obstacle gap width are similar to those in Europe [2]. The leading armies in Asia have also developed their support bridges to enable the construction of spans of at least 40 m. The load capacity of these bridges should ensure the passage of their MBT tanks, which currently are lighter than American and European tanks.

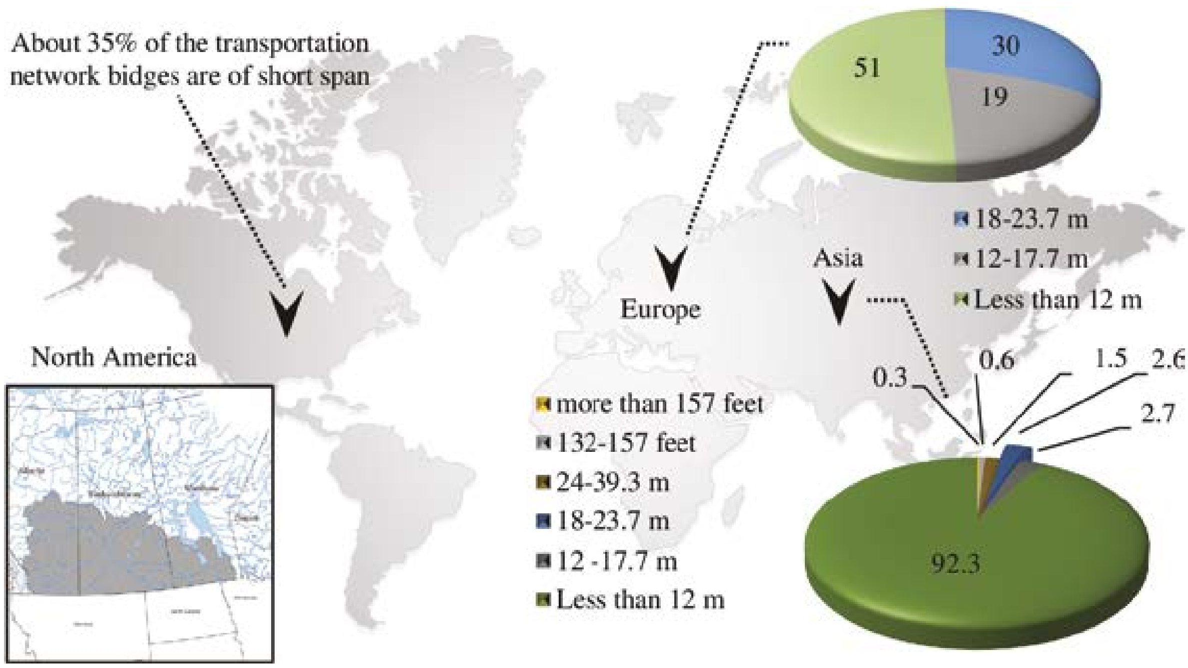

Fig. 1. Terrain obstacle gap widths and their distribution in various regions of the world [2]

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Requirements and development plans for bridges have been conceived in several armies, where geographical considerations and needs of the armed forces were taken into account [1]. Despite the fact that the vast majority of terrain obstacles are less than 12 m wide (e.g. over 92% in Central Europe and over 51% in Southeast Asia - see Fig. 1), most of the world's armies are building military bridges with a span of at least 20 m. In addition, in the case of support bridges, there is a tendency to expand the required span. A span of over 40 m (even 60 m) is required for new constructions, while increasing the load capacity. The increase in load capacity results from the on-going increase in the weight of tanks and other vehicles, including wheeled ones. The solutions sought currently also include structures that can act as support bridges as well as line-of-communication bridges and replace foldable bridges along the lines of supply and be useful during an economical crisis.

2. REVIEW OF ASIAN 40m SUPPORT BRIDGES

2.1. Chinese HZQL51 bridge

At the beginning of the 21st century, China began looking for a new support bridge [3]. The effect of the work of researchers and the industry was a new support bridge which was called, in available sources, HZ 51m Fast Mechanized Bridge or HZQL51 Emergency Mechanization Bridge. The bridge is manufactured by the CHINA HARZONE INDUSTRY CORP. LTD.

Initially, the HZQL51 bridge was built as a span with a length of 46 m. Later the structure was improved and a set was designed to allow the construction of a span 51 m long. The 51 m bridge set consists of 1 layer vehicle, 6 carrier vehicles, electrical and hydraulic systems and accessories.

Fig. 2. View of HZQL51 bridge span being deployed [4]

The bridge span module is formed of two V-shaped trackway truss girders and a deck panel on top. The launching beam, on which the two V-shaped girders rest, has a triangular cross section. The bridge span consists of three middle bridge sections with launching beam sections, two bank sections with launching beam sections, wide roadway panels, four ramps, hydraulic latches and other parts. The length of the launching beam corresponds to the length of the individual sections of the bridge. The launching beam is fixed in each section of the bridge with hydraulic latches. Each bridge section is 9.4 m long and 3.38 m wide (or 4 m when side panels are arranged). The set enables construction of temporary bridges of the following lengths: 17 m, 25.5 m, 34 m, 42.5 m, 51 m. Basic tactical and technical specifications of the bridge are listed in Table 1.

Table 1. Main tactical and technical specifications of the HZQL51 bridge (based on [4] and [5])

Parameter	Span length	
	51 m	46 m
Maximum length of span (m)	51	46
Maximum useful length of span (m)	≤ 48	≤43
Design load capacity for tracked vehicle[1]	LD-60 (60 t)	LD-60 (60 t)
Design load capacity for wheeled vehicle (per axle)	LT-20 (13 t)	LT-20 (13 t)
Width upon launching (m)	≥4 (3.38)	≥4 (3.38)
Height upon launching (m)	1.6	1.6
Span weight including launching beam (t)	56	48
Bridge layer vehicle weight (incl. crew of 3) (t)	32.5	32.5
Carrier vehicle weight (t)	20.8	20.8
Maximum weight of single part (t)	≤9.4	≤9.6
Maximum overall dimensions (m)	9.4×3.38×1.8	9.4×3.38×1.8
Maximum difference in support point elevation (m)	±3.0	±2.5
Maximum speed (km/h)	80	80
Entry/exit angle (°)	≥22	≥22
Maximum angle of elevation (%)	40	40
Minimum clearance (mm)	355	355
Longitudinal tilt (unloaded/loaded)	10% / 5%	10% / 5%
Transverse tilt (unloaded/loaded)	5% / 2%	5% / 2%
Ambient temperature	-41℃～+50℃	-41℃～+50℃
Erection time	90 minutes	75 minutes
Number of bridge layer vehicles	1 (8×8)	1 (8×8)
Number of carrier vehicles	6 (6×6)	5 (6×6)
Number of operators Number of drivers	6~7 6	6~7 5
Maintenance frequency	Every 10,000 erections	Every 10,000 erections

The layer vehicle consists of a chassis, a vehicle stabilizing device, a launching device and a special robot arm. The bridge layer is shown schematically in Fig. 3.

The middle and bank sections are moved by the layer equipment on a previously stabilized and properly levelled chassis. Levelling of the bridge layer chassis is important

[1] in accordance with "China national military standard: general code for military bridge design" Tech. Rep. GJB 1162-91, 1992.; some sources specify 55 t for LD-60.

because of the operation of the special robot arm used to properly join the individual bridge sections.

The hydraulic system of the bridge can be divided into the hydraulic system of the layer vehicle and that of the carrier vehicle. The assembly vehicle is responsible for joining all sections as well as launching and dismantling the bridge. This system is controlled by two independent hydraulic units using electrohydraulic valves (rated pressure 31 MPa).

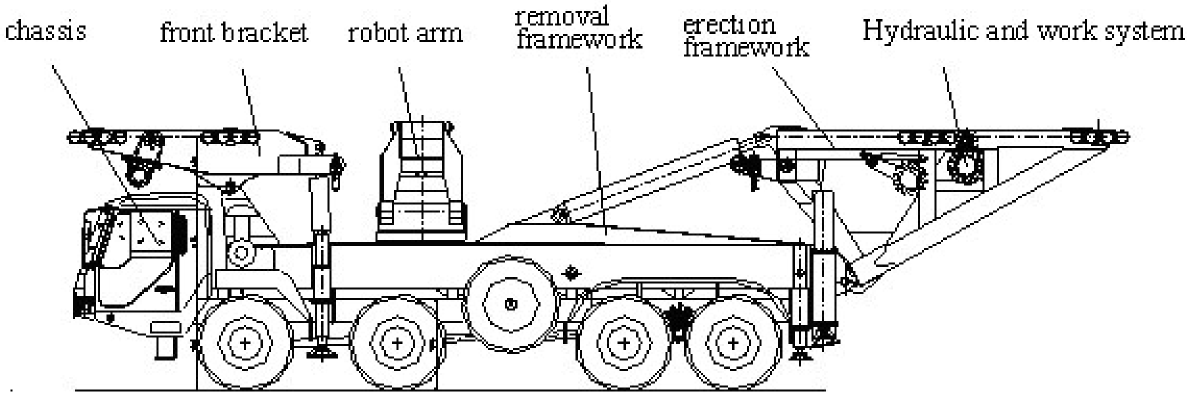

Fig. 3. Schematic of the launching vehicle [5]

The control system is secure with a complete safety system. Operations performed by the bridge layer vehicle, after the control system has been programmed, are carried out automatically: locking, limiting, vehicle levelling. The CAN-type control system is operated from a stationary or portable control panel or remotely. The control system features safety functions, data supervision, auto-detection and problem indicating.

During launching, the span is mounted directly above the bridge layer vehicle (Fig. 4) and during the extension of the launching beam it constitutes a counterweight (Fig. 5). This significantly reduces the loads on the supporting structure of the layer vehicle resulting from the cantilever extension of the launching beam. The process of dismantling the bridge consists in performing the steps in reverse order to those shown in Fig. 5.

Fig. 4. Launching operation, arranging the middle section of the span on the layer vehicle [6]

a)

b)

c)

d)

e)

f)

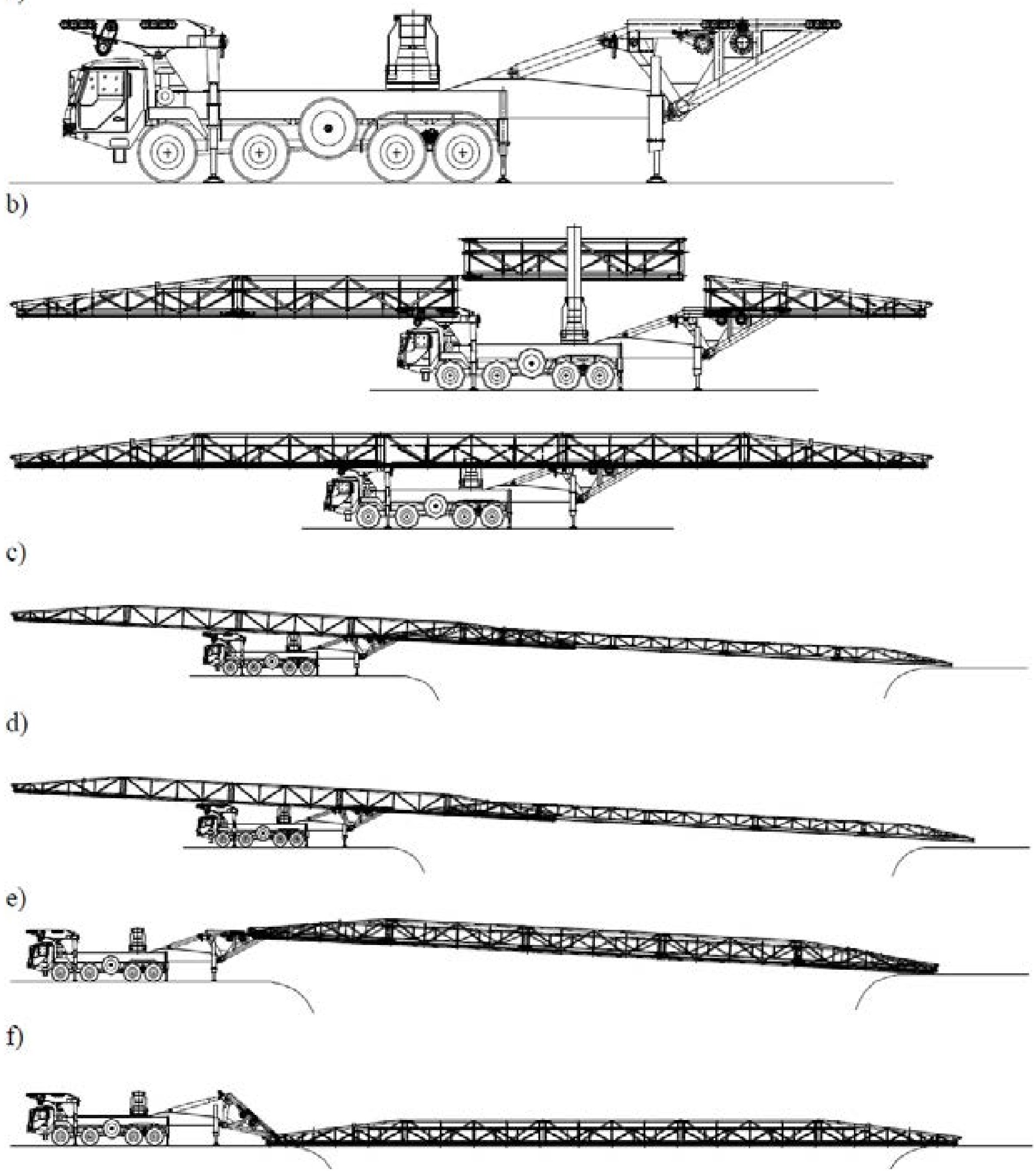

Fig. 5. Subsequent stages of the launching of an HZQL51m bridge (in accordance with [4] and [5]):

a) setting the hydraulic stabilizers of the layer vehicle and levelling thereof;
b) with the help of a special robot arm, individual sections of the span are lifted individually onto the layer vehicle - until the complete bridge is assembled;
c) as the centre of gravity of the span is shifted, the layer vehicle first slides the launching beam until the opposite bank is reached;
d) with the help of supporting and sliding devices of the layer vehicle, the launching beam is mounted on the ground of the opposite bank;
e) then the bank and middle segments of the span are moved along the launching beam;
f) lowering of the span and installing approach ramps.

Fig. 6. Launching operation, setting the HZQL51 m span over an obstacle [6]

2.2. Japanese Type 07 support bridge

Japanese Type 07 support bridge (Japanese -０７式機動支援橋), English nomenclature: Mobility Support Bridge (MSB07), was developed and modernized by Hitachi commissioned by the Japanese government (Fig. 7). Due to the insufficient load capacity and the small span of the Type 81 trestle bridge, in 2003 development work on a new support bridge began. The existing European designs were studied and evaluated during the work on the concept of the new bridge [8]. The German DORNIER bridge design became an archetype for the new bridge, which was adapted to better fit the narrow roads of Japan. This work was completed in 2007 and its cost amounted to approximately 32 billion yen [8], while the manufacturing cost of the bridge, according to the budget for 2014, amounted to 1.2 billion yen [9].

Fig. 7. Type 07 bridge over an obstacle [7]

Eleven Type 74 three axle 7-ton vehicles make up one bridge set (Fig. 8). The set comprises: 1 bridge layer vehicle, 1 vehicle carrying parts of the guide beam (6 middle segments plus 2 bank segments), 4 vehicles with bridge spans (6 middle and 2 bank segments) and 5 vehicles carrying additional equipment (including launching accessories, bridge reinforcement system).

The Type 07 support bridge is assembled with the use of a special vehicle furnished with equipment for launching the bridge. The layer vehicle is operated by 3 soldiers. It may travel at a speed of up to 85 km/h. The up to 60 m long and 4.2 m wide bridge can be launched by a bridge platoon within about 2 hours.

Table 2. Various support bridges compared to evaluate the concept of the new Japanese bridge [8]

Bridge	Country	Span length (m)	Bridge class	Roadway width (m)	Layer vehicle parameters			
					Width (m)	Height (m)	•Length (m)	Weight (t)
Type 07	Japan	60	CL	4.2	3.0	3.7	11	25.0
LEGUAN 42	Germany	42	CL70	4.0	4.0	4.0	15.2	43.0
DORNIER	Germany	46	CL70	4.4	2.75	4.0	15.3	25.0
BR 90	United Kingdom	44	CL70	4.0	3.2	4.0	12.0	45.0
FB48	Sweden	48	CL70	4.0	3.2	3.8	20.9	40.0

Fig. 8. Layer vehicle and carrier vehicle with span segments [11, 12]

Fig. 9 illustrates the bridge launching procedure. First, a special crane on the layer vehicle unloads the launching beam sections from the carrier vehicles. Then, the sections of the guide beam are connected to each other at the back of the layer vehicle and extended to form a supporting bracket. To minimize the weight of the support formed of the guide beam sections, they have a welded structure of durable aluminium. Aluminium is more susceptible to bending than steel, and therefore the more beam sections are joined together, the greater the deflection. To deal with this, a support is placed between the extended guide beam sections and the layer vehicle equipment. This support can be raised or lowered to ensure that the far end of the guide beam properly reaches the opposite side, even if a high degree of deflection occurs (Fig. 10).

When the guide beam is fully extended, its end is lowered onto the opposite bank. Then a special crane on the layer vehicle unloads the bridge segments from the carrier vehicles, places them on the guide beam, joins them and moves them along the guide beam to erect the bridge (Figs. 7 and 10).

The bridge sections must be strong enough to carry heavy vehicles (new Type 90 tank - weight 50.2 t) when deployed over an obstacle, and at the same time light enough to be carried on a vehicle moving on ordinary roads. Therefore, they and the guide beam have a welded structure of high-strength aluminium.

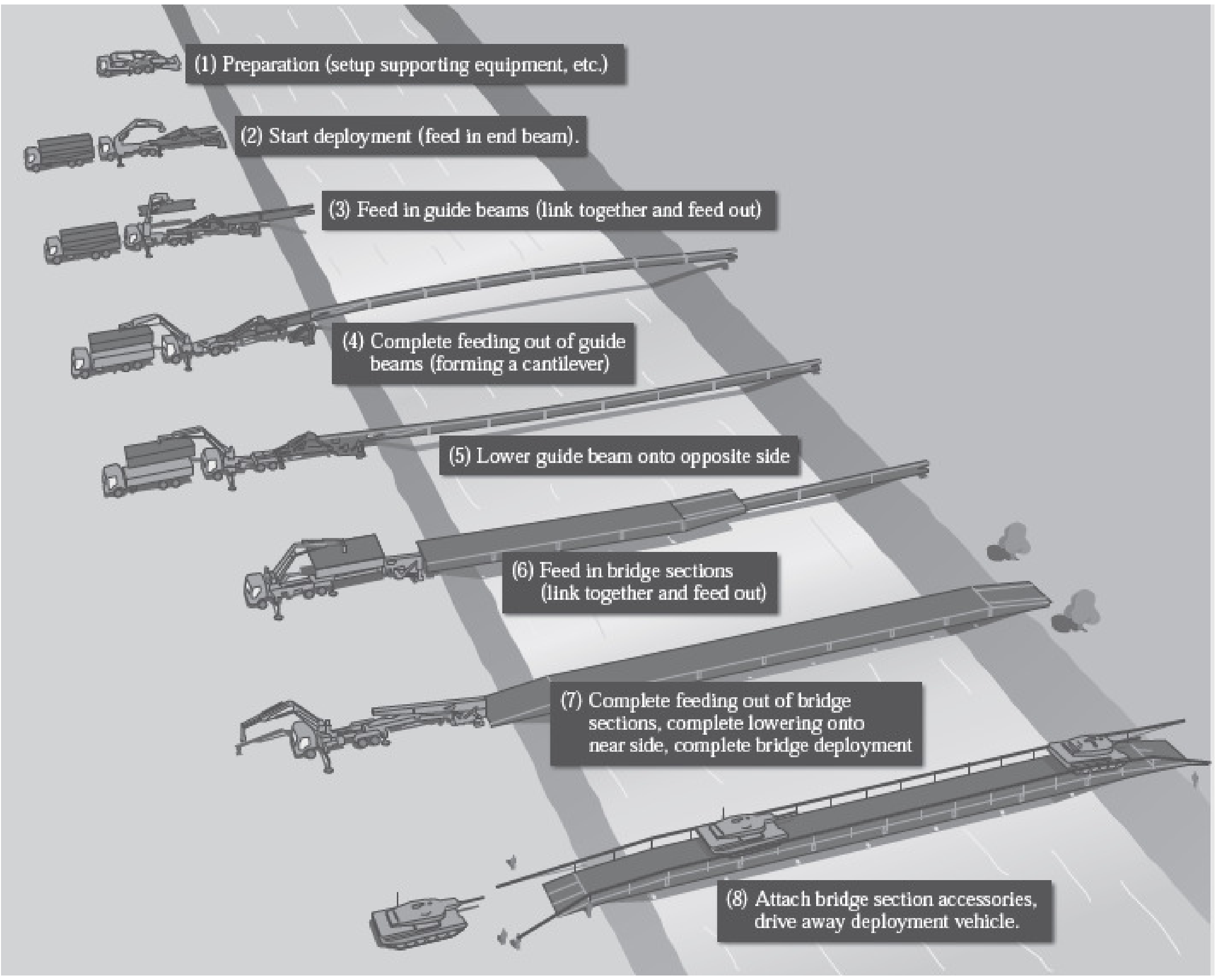

Fig. 9. Launching of the Type 07 bridge over an obstacle [7]

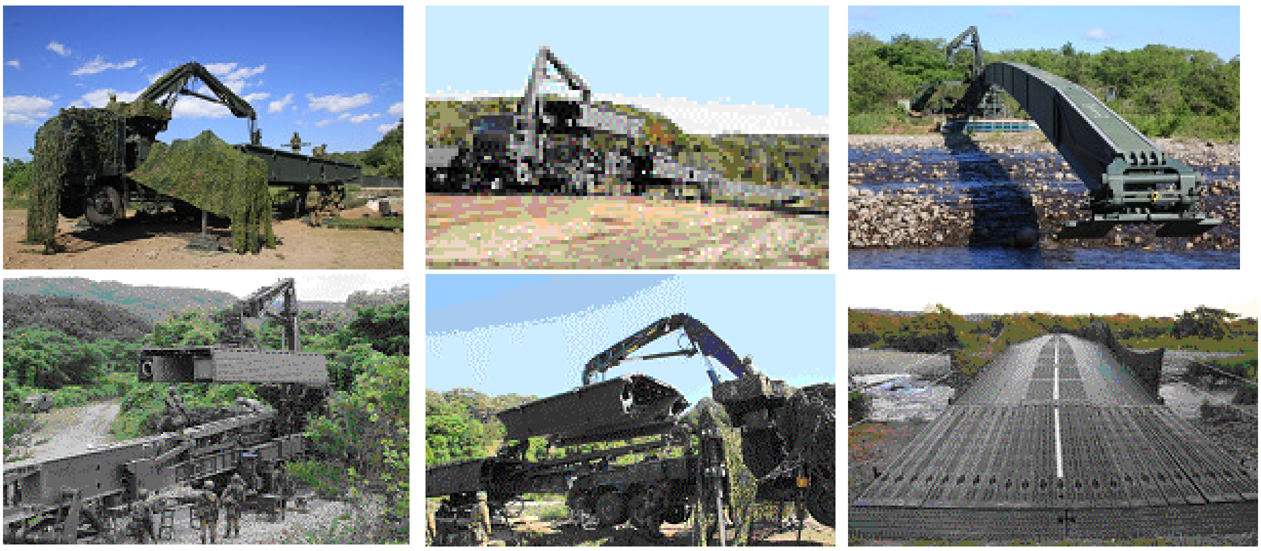

Fig. 10. Main operations in the Type 07 bridge launching procedure [11, 12]

The Japanese engineers emphasize the usefulness of the bridge in operations of combating the effects of natural disasters (floods, earthquakes). Since 2017 the Type 07 bridge is offered to foreign customers [13].

2.3. Indian 46m MLC 70 Modular Bridge

Fig. 11. View of 46m MLC 70 Modular Bridge [14]

The most recent support bridge is the Indian 46 m MLC 70 Modular Bridge, the prototype of which passed qualification tests in February 2019 [14]. This bridge has a relatively long history, as the first project was commissioned to a governmental development agency, the Defence Research and Development Organisation (DRDO), in 2002. The general staff of the Indian army commissioned the development of a bridge with a span of up to 46 metres and load class MLC 70. DRDO had problems with the performance of the contract in terms of the required load capacity and span of the bridge. In 2007 a bridge with a span of 20 m was constructed for the load of MLC 40 [15]. Therefore, in January 2010 another project was approved for the development of a 46-metres MLC 70 bridge. The major problem was the insufficient counterweight for the launching of the bridge span. The first carrier vehicle was a Tatra 8 × 8, which was sufficient for MLC 40 class only. During the execution of the project, a Tatra 10 × 10 vehicle was introduced, which, according to DRDO, guaranteed the MLC 70 load capacity.

Fig. 12. Subsequent stages of setting up launching beam of of the 46m MLC 70 Modular Bridge [16]

In 2014 DRDO, together with Larsen & Toubro (L&T), completed the first prototype of the 46m MLC 70 Modular Bridge which met the customer's requirements. The bridge is of modular design and enables erecting spans 14 to 46 m long, in 6.5 m steps, with a 4.0 m wide roadway.

The bridge is made of steel and has already passed the test of 2000 tanks (1000 T-72s and 1000 Arjuns). It is in the final stage of acceptance by the Indian army [14], in technological terms the bridge is similar to the German DORNIER and Japanese Type 07 (Fig. 12). The launching beam has a form of a truss girder, and the bridge span is a plate girder.

3. SUMMARY

European bridges presented in the first part of the article [1] constituted a model for Asian bridges. Majority of the Asian bridges are similar, in technological terms, to the DORNIER bridge. One may notice that the design of new bridges, longer and higher load-bearing, is not an easy issue. The efforts to attain satisfactory spans and bearing capacities were not always successful. This was a lesson design engineers from India and South Korea have learned. In 2003 the staff of the Korean army set an ambitious task of building a bridge with a span of 60 m capable of carrying MBTs [17]. The project was implemented by Hyundai Rotem's, who developed the concept of a bridge similar to the English DSB. However, the project was not completed by 2013 and it was abandoned.

Compared with previous prefabricated temporary bridges that used spans with intermediate supports, the benefits of increasing the span length are significant. Rejection (or limited use) of intermediate supports enables eliminating the limits on the depth of the obstacles negotiated and reducing the amount of preliminary work required to level the river bed.

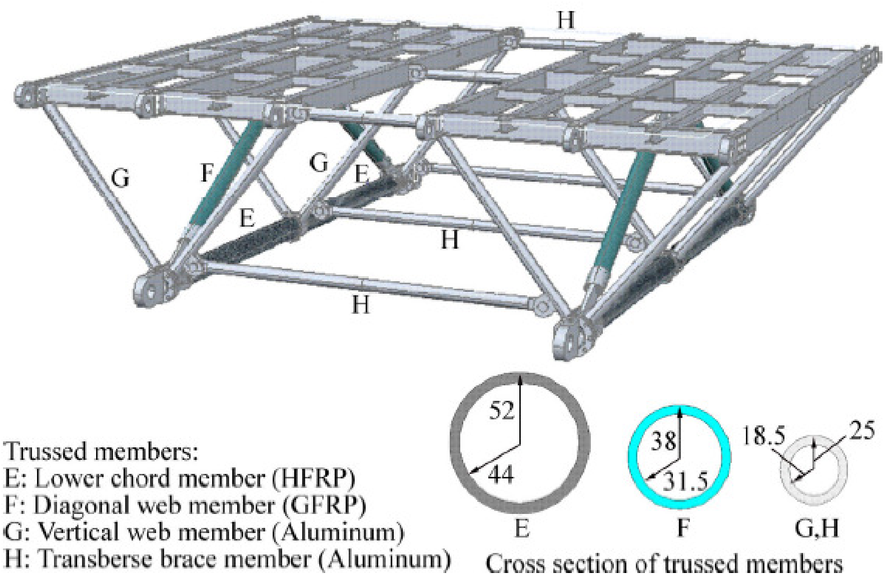

Fig. 13. Hybrid truss made of aluminium and composites [18]

Further progress in military bridge engineering will be possible with the introduction of cutting edge launching technologies and construction materials. Hybrid structures created using aluminium and composite materials seem to be an interesting solution (Fig. 13). However, increasing the load capacity of the bridges, while ensuring high mobility of carrier vehicles, is not a straightforward process. Without increasing the permissible dimensions of carrier vehicles, it will not be possible to build longer and stronger bridge spans. There must be a compromise between the civilian requirements for road transport and the capability of constructing "large" support and line-of-communication bridges, using oversized means of transport.

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