Technological and Organizational Solutions of the Construction Process of Temporary Bridges in Emergency Situations

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Abstract

The article describes the procedure for using the Engineering Troops of the Armed Forces of the Republic of Poland in eliminating the effects of the natural disaster that hit south-western Poland in September 2024. In the emergency management system, the Voivode may apply to the Minister of National Defense to allocate subunits or units of the Polish Army to, among other things, perform tasks related to the repair and reconstruction of technical infrastructure, or participate in ensuring the passability of transportation routes. Shortly after the flood wave passed, Operation Phoenix was launched, bringing together different types of troops for one purpose - to help civilians deal with the effects of the natural disaster. Even before the above-mentioned operation, the Engineer Troops Task Force was established (later included in Operation Phoenix), which coordinated the use of engineer troops for various tasks. The flooding destroyed many engineering structures, which were replaced with temporary bridges, thus enabling the reconstruction of flooded buildings and damaged critical infrastructure. Temporary bridges constructed by the engineering troops are DMS-65 panel truss bridge structures. The authors have presented in detail the characteristics and application of panel bridges, providing examples of their use from different parts of the world. Using Glucholazy as an example, they have described the operation of the bridge construction team separated from the engineering unit, the method and manner of assembling DMS-65 panel bridges and the schedule of the construction process. The applied structural solutions of the abutments, as well as the span part of the bridge structure, were described in detail. Using the example of the Czech concept of Reach-Back and Operation Phoenix (the actions of the Task Group of the Engineering Forces), the differences in the actions of troops from different countries in the reconstruction of transportation infrastructure damaged by floods were shown. It was found that panel truss structures are extremely important for the rapid restoration of transportation routes, but existing structures, either on the equipment of the Polish Army or in the strategic reserves, do not meet the requirements set forth in the technical conditions to which such facilities should conform.

Keywords: *emergency management system, engineering troops, panel bridges, panel bridge technology, Operation Phoenix*

1. Introduction

The changing global climate brings adverse changes in hydrological conditions. The nature of precipitation is becoming more erratic, and longer periods of rainlessness are followed by heavy rains. There is an increase in the frequency of extreme weather events and natural disasters, which have a huge impact on the economies of countries around the world. Heavy rains bring the risk of flooding, waterlogging and damage and destruction to transportation infrastructure. In September 2024, many European countries, including Poland, were facing the consequences of tragic flooding.

Following the declaration of a state of disaster in Poland on September 16, 2024, engineering troops were sent to the Opolskie, Lower Silesian and Silesian provinces in the area of the greatest damage to identify engineering facilities destroyed by the flood. Military sappers were also sent to the area to restore the passability of roads, as well as the Territorial Defense Forces to help the civilian population. Beginning on September 23, 2024, Operation Phoenix was launched to rebuild damaged infrastructure, repair and strengthen flood control systems, and support civilian authorities in providing medical and psychological care. Based on the 1st Sapper Regiment, an Engineering Troops Task Group was formed, responsible for restoring road permeability and building temporary bridges, which conditioned the pace of the reconstruction process and constituted the highest priority task in the operation. Engineering troops in the flooded areas built panel bridges (DMS-65) and portable tank bridges (BLG-67 and MS-20).

A reconnaissance group was separated from the engineering troops as a first step, tasked with identifying, damaged by the flood wave, bridge engineering structures and determining places where restoring road passability was a priority. One such place turned out to be the damaged bridge in Glucholazy on national road number 40, which was an important transportation link for the Upper Silesian Industrial District. It was the only bridge in Glucholazy allowing heavy vehicle traffic leading from the state border with the Czech Republic to Pyskowice. The bridge was also of great local importance. This is because it enabled communication between residents from the western and eastern parts of Glucholazy. The crossing was torn down as a result of the natural disaster that struck the area on September 15, 2024.

The expert group from the Military University of Technology, appointed at the request of the Head of the Board of Military Engineering,

also acted as part of the support provided by the engineering troops. As part of their activities, specialists from the WAT, among other things, carried out a technical assessment and allowed limited use of the damaged St. Adalbert Bridge in Glucholazy. This was extremely important due to the possibility of delivering humanitarian aid and the passage of residents' cars from places cut off by the flood. Specialists from the Academy worked closely with engineering troops (bridge construction teams) on the construction of temporary bridges on national road 40, as well as on other construction of panel bridges in Opole and Lower Silesia in terms of design and construction.

The subject of the work are selected technical and organizational aspects of the construction of temporary bridges in a emergency situation related to flooding.

The aim of the paper is to analyze the procedure for the use of engineering troops of the Polish Armed Forces in emergency situations on the example of the town of Glucholazy.

The scope of the presentation includes an overview of the construction process of temporary bridges along with a presentation of the construction process schedule and the method of assembly of the span structure of the panel bridge taking into account the terrain conditions.

2. Procedure for the use of engineering troops in a emergency situation in Poland

On the basis of the Emergency Management Act of 26 April 2007, the Voivode may request the Minister of National Defense to use subunits or units of the Armed Forces of the Republic of Poland to perform, among others, the following tasks:

1) evacuate the affected population and property;
2) carry out safety, rescue and evacuation work at endangered buildings and monuments;
3) carrying out works requiring the use of specialized technical equipment or explosives which are in the resources of the Armed Forces of the Republic of Poland;
4) perform tasks related to the repair and reconstruction of technical infrastructure;
5) participation in ensuring the passability of communication routes.

Subunits or units of the Armed Forces may be placed at the disposal of the voivode in their full-time composition or as ad hoc task forces [1].

The procedure for allocating forces and resources of the Polish Armed Forces to support public administration in a crisis situation begins when local authorities (facility manager) report to the appropriate voivode the need for the construction of a temporary bridge by engineering troops. At this stage, arrangements with military engineers are necessary to specify the possibility of constructing the crossing and the scope of responsibilities of the parties involved. The governor initiates the emergency management system procedure – applies to the Minister of National Defence (MON) for military support. MON issues consent for military support of public administration, stipulating that the applicant must meet the necessary formal and legal conditions imposed by, among others, the Construction Law. Then, the General Command of the Armed Forces (DG RSZ) designates a unit of engineering troops responsible for carrying out the task.

In addition, if the potential bridge is to be of a panel structure, the facility manager submits a separate application to the Minister of Internal Affairs and Administration for the loan of the bridge structure from the Government Agency for Strategic Reserves (RARS). The technical assortment of strategic reserves is made available on the basis of an agreement concluded for a fixed period between the Agency and the entity requesting the provision, specifying in particular the conditions for the provision of the assortment and its return.

3. Characteristics and purpose of panel bridge structures

The DMS-65 type panel bridge structures were used to build temporary crossings by the Polish Army in the Lower Silesian and Opole voivodeships after the September flood in 2024. From the definition of this type of bridges, we know that these are sets of previously prepared component elements.

Their main advantages are: relatively fast construction speed while ensuring high load-bearing capacities and the possibility of recovering elements after dismantling the crossing. This state of affairs means that panel bridges are used in many areas of communication construction in different parts of the world. They are used both for crisis response activities and in projects for the national economy.

Fig. 1. The use of MS structures in the national economy: a) a temporary crossing in Ostroleka, b) the use of a panel bridge structure for a temporary crossing in Kalisz [author: A. Ostrowska].

The typical structure of road-type panel bridges consists of girders in the form of flat trusses (panel). In addition to the flat trusses, the basic bridge segment of approximately 3.0 meters in length consists of transoms, sway braces, stringers, wall bracing frames and plates. Also a characteristic element in the construction of panel road bridges is the arrangement of the lower and upper chord with a cross-section of two C-sections turned "back to back". Between these C-sections, posts and cross-braces are mounted, which allows for the axiality of individual longitudinal sections of trusses lying in one plane. The girders can be reinforced by stacking panels (trusses) or reinforcing the chords with linear elements.

Among the main applications of panel modular bridge structures in the national economy, we can include the construction of temporary bridges for the duration of the renovation of fixed bridges, their adaptation to the role of fixed bridges and the construction of relief supports. An excellent example is the construction and operation of temporary crossings for the duration of repairs of fixed bridges in Poland, e.g. in Warsaw, Grudziądz, Kiezmark, Kalisz or Ostrołęka. All the mentioned crossings were made of DMS-65 structure [2] (Fig. 1). Another example is the use of Mabey Bridge Compact 200 structure for the construction of a bridge used as a permanent structure in South Africa [3].

In the field of emergency response operations, modular bridges are commonly used to restore communication infrastructure damaged by the negative impact of natural forces or military action. Examples are numerous, both domestic and foreign. Particularly interesting ones include the use of a Bailey-type panel structure to restore the passability of the A14 Motorway in Portugal in 2016. [4], or the restoration of local crossings damaged by natural disasters e.g. in the state of Michigan on the Tobacco River in 2020 [5], at Hadle Szklarskie in the Podkarpacie region in 2020, in Slovenia in 2023 or in Szeligi in 2021 using the DMS-65 and other structure [6, 9] (Fig. 2.).

Fig. 2. Examples of the use of modular structures to rebuild damaged crossings in emergency situations: a) in Szeligi (Poland) in 2021 [author: A. Ostrowska], b) in Slovenia in 2023 [9].

It is worth noting that dealing with the consequences of natural disasters in the context of restoring transport infrastructure is extremely important, as can be evidenced by the separation of special entities in the Polish Armed Forces, i.e. Military Reconstruction Units (WJO). WJO units are separated from the structures of existing engineering units, deployed in areas where the risk of natural disasters is greatest. These entities carry out emergency response tasks using, among other things, panel bridge structures.

In repairing the damage caused by the 2024 natural disaster in Poland, the DMS-65-type road panel bridge structure, which is in the State's depot and strategic reserves, was used.

4. Reconstruction of transport infrastructure - Glucholazy

In accordance with the procedure described above and the priority need to support the public administration, a bridge construction team separated from the 2nd Engineering Regiment was directed to Glucholazy. The main effort of the soldiers was focused on the construction of temporary bridges over the DK40 in Glucholazy. Engineers there planned the construction of two single-span structures of type DMS-65 spanning 36 meters each. The load-bearing capacity of the crossing for civilian traffic was calculated at 30 tons – vertical load of class C car fleet according to PN-85/S-10030 [7]. The construction of two bridges resulted from the need to ensure two-way traffic, and the width of the roadway of 4.2 m makes such traffic organization impossible. The assembly of the span structure, which was made available by RARS, began on October 6, 2024 after the earlier removal of destroyed objects and flood waste lying in the Biala Glucholaska riverbed (Fig. 3), and the construction of abutments by a civilian company.

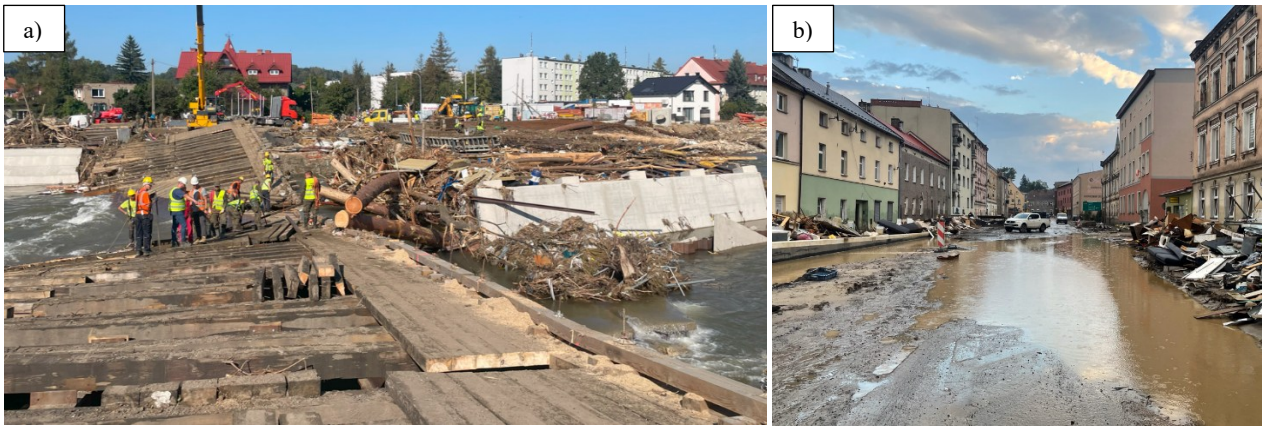

Fig. 3. a) Destroyed bridge structures lying in the Biała Głuchołaska riverbed (temporary bridge and permanent bridge under construction); b) access to the bridges – DK40 after the flood [author: A. Ostrowska].

Already at the reconnaissance stage, taking into account the difficult location conditions, it was determined that the assembly of the structure would take place parallel to the water obstacle, using a method other than the standard method using an launching nose and cantilevered sliding of the span structure. After the assembly of the structure on the assembly site, the placing of the spans on the abutments was performed using a crane with a load-bearing capacity of 500 tons (Fig. 4).

First, the army cleaned up the car park located on the east bank of the Biala Glucholaska River to prepare the area for the assembly platform. The structural elements were then transported to a convenient location for storage and assembly. On October 6, 2024, two assembly sites (with a system of assembly rollers) were prepared in the place designated by the designer and engineers,

so that it would be possible to later assemble the structure on bearings using a 500-ton crane. From October 7, 2024, two bridge construction teams began the parallel assembly of two single-span structures of the DMS-65 type reinforced with an overlay with a total length of 36 m. Each group, consisting of 9 soldiers and a commander, had a Jelcz 862 Hiab crane at its disposal. The assembly was carried out in an axial system using the method of assembly of individual elements, which were arranged within the reach of truck cranes or were delivered on an ongoing basis by a universal engineering machine (UMI 9.50).

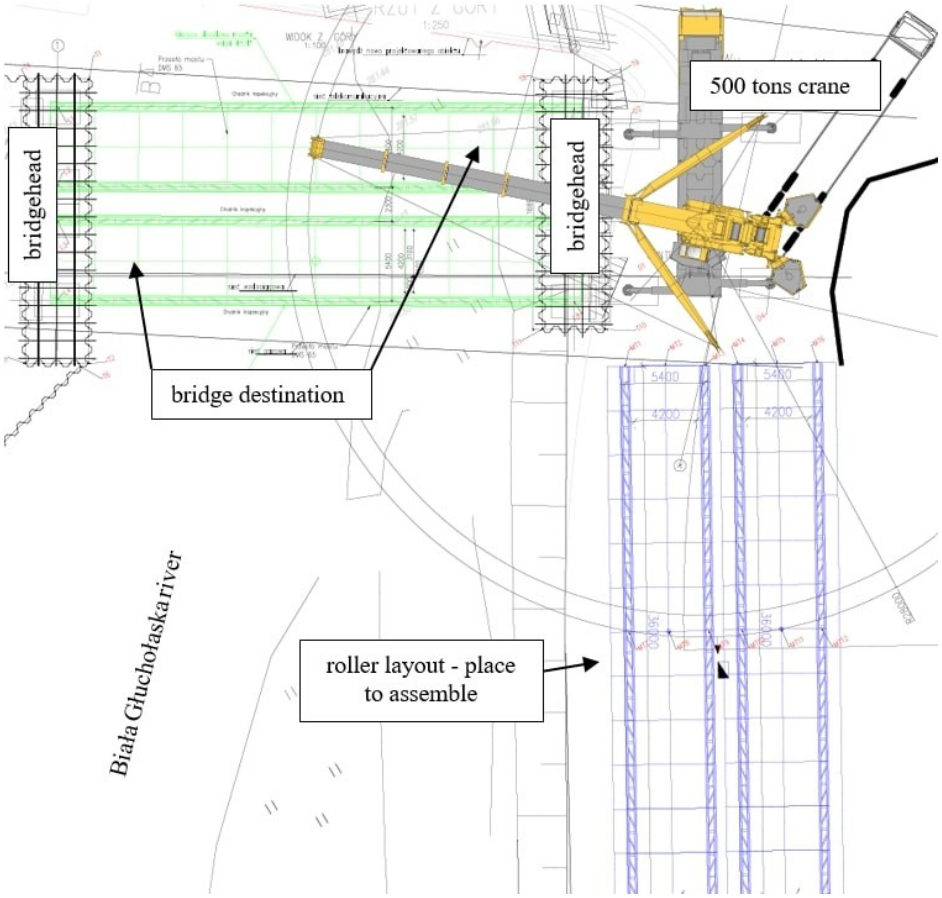

Fig. 4. Scheme of assembly of the structure on the abutments of the panel bridge [designer: G. Łagocki]

Parallel to the work of the engineering army soldiers, a civilian company carried out construction work on the site. The company was in charge of making the abutments for the temporary crossing. The abutments of the temporary bridge were designed with Larssen sheet piling protection. Bridges was supported by bearings on prefabricated foundation slabs 300x230x60 cm. A 20 cm thick layer of non-structural concrete class C8/10 was designed under the slab. The ground under the foundations was prepared by replacing non-structural soil with non-cohesive soil compacted to Is>1.0 (compaction index). The sheet pile walls were connected with tie rods with a load capacity of over 145 kN at a spacing of 1.2 m. The tie rods were prestressed with a force of 120 kN. The tie rods were covered with a 150 mm PVC casing pipe. 20x20x1 cm pads were used for their assembly. Behind the edge of the bridge structure, at its entrance, a retaining wall was designed made of prefabricated, reinforced concrete L-shaped elements, intended for heavy loads. In order to be able to shape the slopes on the access roads, additional sheet piles were designed to be located on the sides of the abutments.

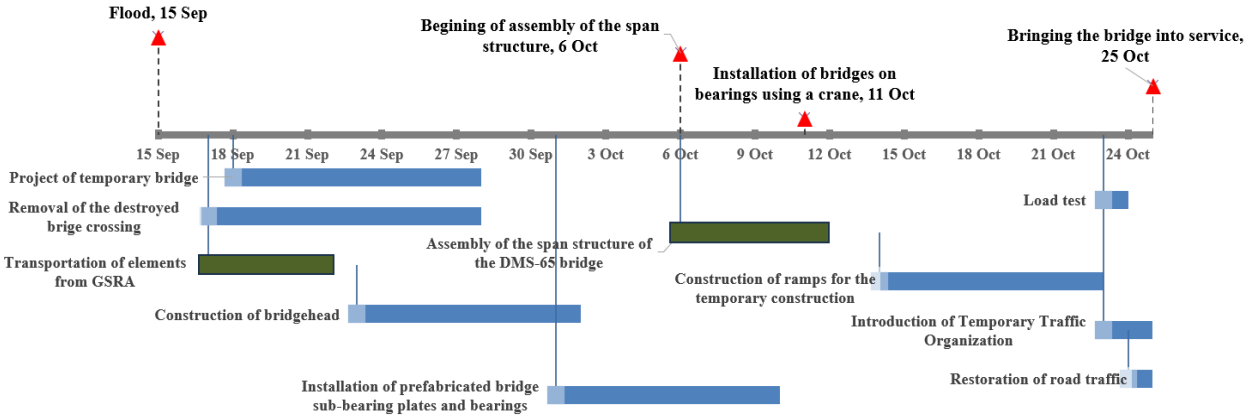

Fig. 5. The timetable for the construction of temporary bridge DMS-65 on national road No. 40 in Glucholazy [construction engineer: B. Szornak]

The construction time of two single-span structures of the DMS-65 type was three calendar days, while the installation of the structure on the abutments using a 500-ton crane took less than an hour. Due to the need to build access roads, the required verification of the crossing under a test load and the introduction of a temporary traffic organization, the facility allowed vehicle traffic at the end of October 2024. The timetable for the construction of the temporary bridge in Glucholazy is shown below (Fig. 5.). The green bars indicate the activities carried out by the engineering troops. The total time from the flood wave to the Bridges being put into service was 40 calendar days.

5. Conclusion

An interesting solution for broader action and cooperation of various military entities is the Reach-Back concept used in the Czech Republic. There were three units of Czech Army participate in operation: University of Defense, Military Geodetical and Hydrometeorological Office and 15 Engineer Brigade. Reconnaissance team (reco-team) consists of experts from Military Geodetical and Hydrometeorological Office and one member from Department of Engineer Technology. Reco-team was responsible for geodetically survey of the construction site of temporary bridge. The team made Reconnaissance Report with photo documentation and inspection of the construction site. They suggested which type of bridge is suitable for a particular gap. The next entity was the project team. The five-members project team were from Department of Engineer Technology at University of Defense. Last member was a leader who was responsible for communication with civilian authorities. Two members of the team worked with geodesists as members of the reco-team and other two members designed temporary bridges. The third entity was the engineer unit responsible for the transport of structure elements and assembly of the bridge [8]. The Reach-Back concept undoubtedly requires its participants to have extensive experience as well as appropriate competences and construction licenses.

Flood phenomena occurring in recent years confirm the validity of using modular bridge structures, as well as the need to develop new construction solutions that would fully meet contemporary technical requirements. The use of panel road bridge structures allows the adjustment of the span system to the terrain conditions and to the requirements of users. The construction time of a span from ready-made elements is relatively short, the most time-consuming stage is the preparation of the support system [9]. The requirements for temporary bridges are identical to the requirements for permanent bridges, hence the preparation and construction of temporary bridge takes tens of days rather than days. Despite the imposed state of natural disaster in Poland, the design stage and the necessary administrative decisions could not be omitted. This is due to the fact that the safety of bridge users should be ensured regardless of the conditions under which the structure is used, even in the event of a natural disaster. From the point of view of those responsible for the maintenance of buildings, detailed legal solutions are contained in the Act of 11 August 2001 on special rules for the reconstruction, repair and demolition of building structures destroyed or damaged as a result of the action of a natural disaster [10].

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