A New Structural System of a Transformable Guiding Bridge for Extreme Conditions

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Abstract The article presents a new structural system of a transformable guiding bridge designed for the rapid arrangement of temporary transport crossings under extreme conditions. In modern emergency response, rescue, and military operations, damage to transport infrastructure significantly restricts the mobility of personnel and equipment, which necessitates the use of rapidly deployable and operationally flexible bridge systems.

The paper provides a brief review of existing guiding bridge systems and identifies their main limitations, including restricted span length, installation complexity, and the need for additional supporting elements. Based on this analysis, a transformable guiding bridge concept is proposed, which employs temporary transformable supports during the installation stage and transitions into a single-span working configuration during operation.

The article describes the structural solution of the bridge, its main components, and the installation and deployment technology. The proposed system allows rapid assembly and dismantling using minimal technical resources and personnel. The application of transformable temporary supports reduces the need for auxiliary works within the obstacle zone and enhances operational flexibility in complex terrain and environmental conditions.

The obtained results demonstrate that the proposed transformable guiding bridge system represents an effective and promising engineering solution for the development of temporary transport infrastructure intended for use under extreme conditions.

Keywords: transformable guiding bridge, rapid deployment, temporary bridge structures, installation technology, extreme conditions, emergency and military engineering

Introduction

In extreme conditions such as natural disasters, military operations, or large-scale technological accidents, damage to transport infrastructure significantly restricts the movement of civilian, rescue, and military vehicles [8]. Under such circumstances, one of the most critical engineering tasks is the rapid deployment of temporary crossings that ensure safe and operational mobility with minimal time and resource expenditure [1,5].

Rapidly deployable guiding bridges are widely used to address such challenges; however, most existing structural systems exhibit several limitations, including strict constraints on span length, the need for additional supports during installation, significant self-weight, and complex assembly procedures [3,6]. These factors reduce the effectiveness of such bridges in complex terrain and unstable environmental conditions.

This paper presents a new structural system of a transformable guiding bridge that utilizes temporary transformable supports during the assembly stage and transitions to a single-span operational scheme during service. This approach allows for increased span length without the construction of additional permanent piers and significantly reduces installation time and technical resource requirements [4,9].

1. Review of Existing Guiding Bridges and Problem Formulation

Rapidly deployable guiding bridges are essential elements of temporary transport infrastructure used in civilian, rescue, and military operations [2,5]. Their primary purpose is to overcome short- to medium-span obstacles within a limited time using prefabricated structural components.

Most existing guiding bridge systems are based on the sequential installation of steel sections using cranes or specialized transport equipment. Temporary intermediate supports are often required during installation, which increases assembly complexity and dependency on the geometric and geotechnical conditions of the obstacle [3,5].

Some systems incorporate transformable or extendable supports; however, such solutions are typically limited by allowable support height and length, making their application in deep or complex obstacles problematic [6]. Analysis of existing systems indicates the need for a structural solution that reduces installation complexity and enhances adaptability under extreme conditions [9].

2. Structural Design of the Transformable Guiding Bridge

The proposed transformable guiding bridge structural system is based on a modular approach and is designed for rapid installation and multiple reuse [1,6]. The bridge consists of initial, intermediate, and final sections that are prefabricated and adapted to transportation constraints.

A distinctive feature of the system is the integration of transformable temporary supports within the intermediate sections. These supports carry the primary loads during installation and ensure temporary stability of the span structure [4,9]. The adjustable length of the supports enables adaptation to terrain and soil conditions without the need for additional permanent piers (Figure 1).

After completion of assembly, the transformable supports are folded, and the bridge transitions into a single-span operational configuration, reducing redundant structural elements and improving service performance [7].

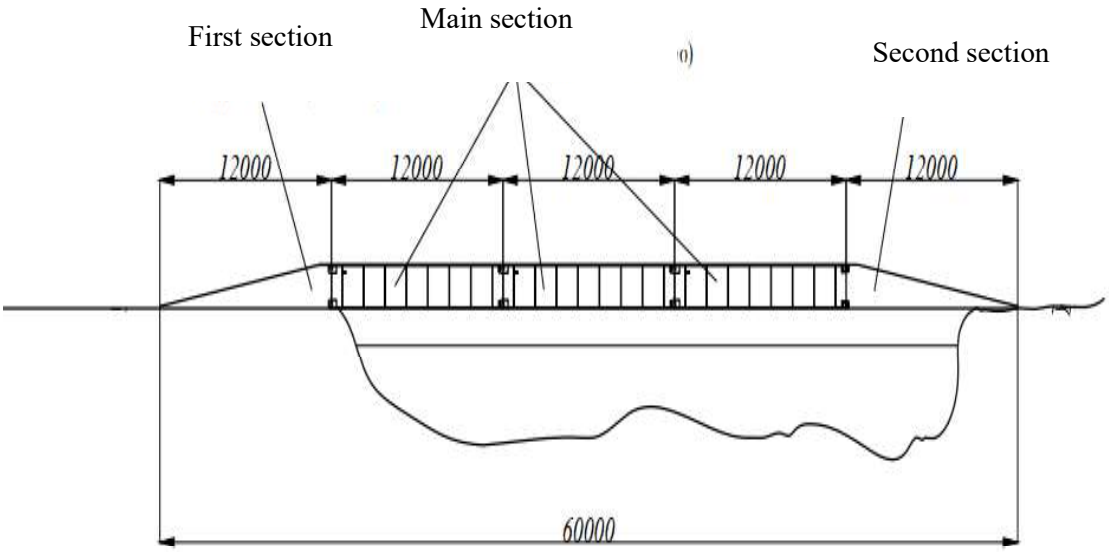
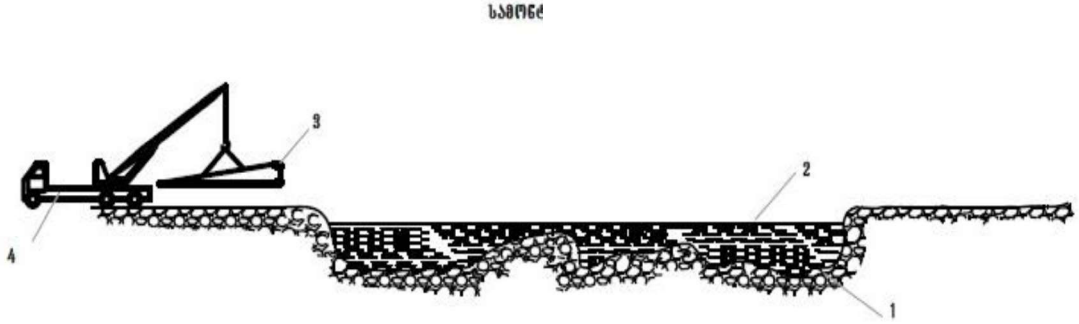
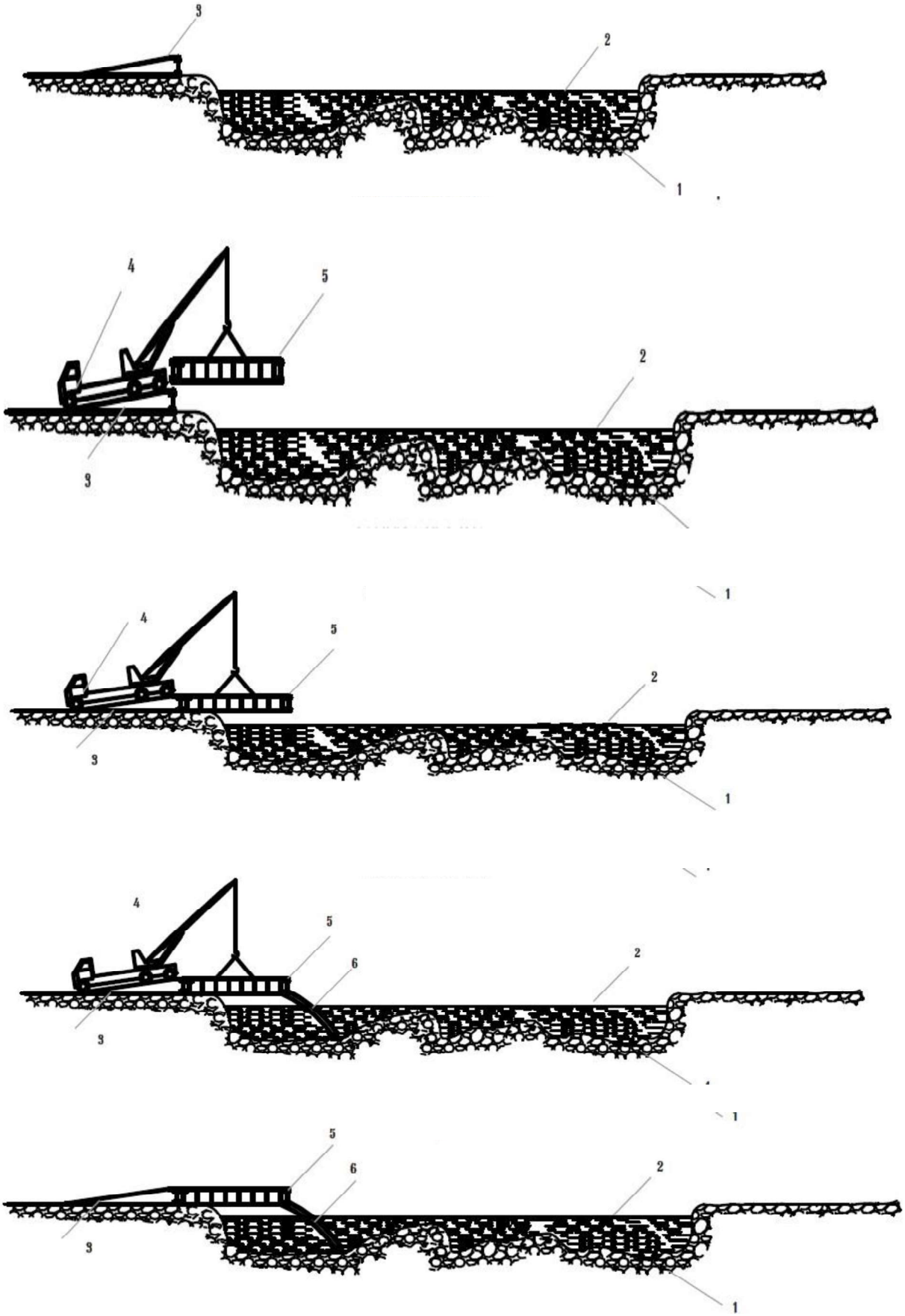


Figure 1 — Structural scheme of the transformable guiding bridge

3. Bridge Assembly and Deployment Technology

The assembly and deployment technology of the bridge is developed based on principles of rapid deployment and operational safety [5,8]. Installation begins with transporting the bridge sections to the obstacle site and placing the initial seion in its working position. Figure 2 — Stages of assembly and deployment of the transformable guiding bridge

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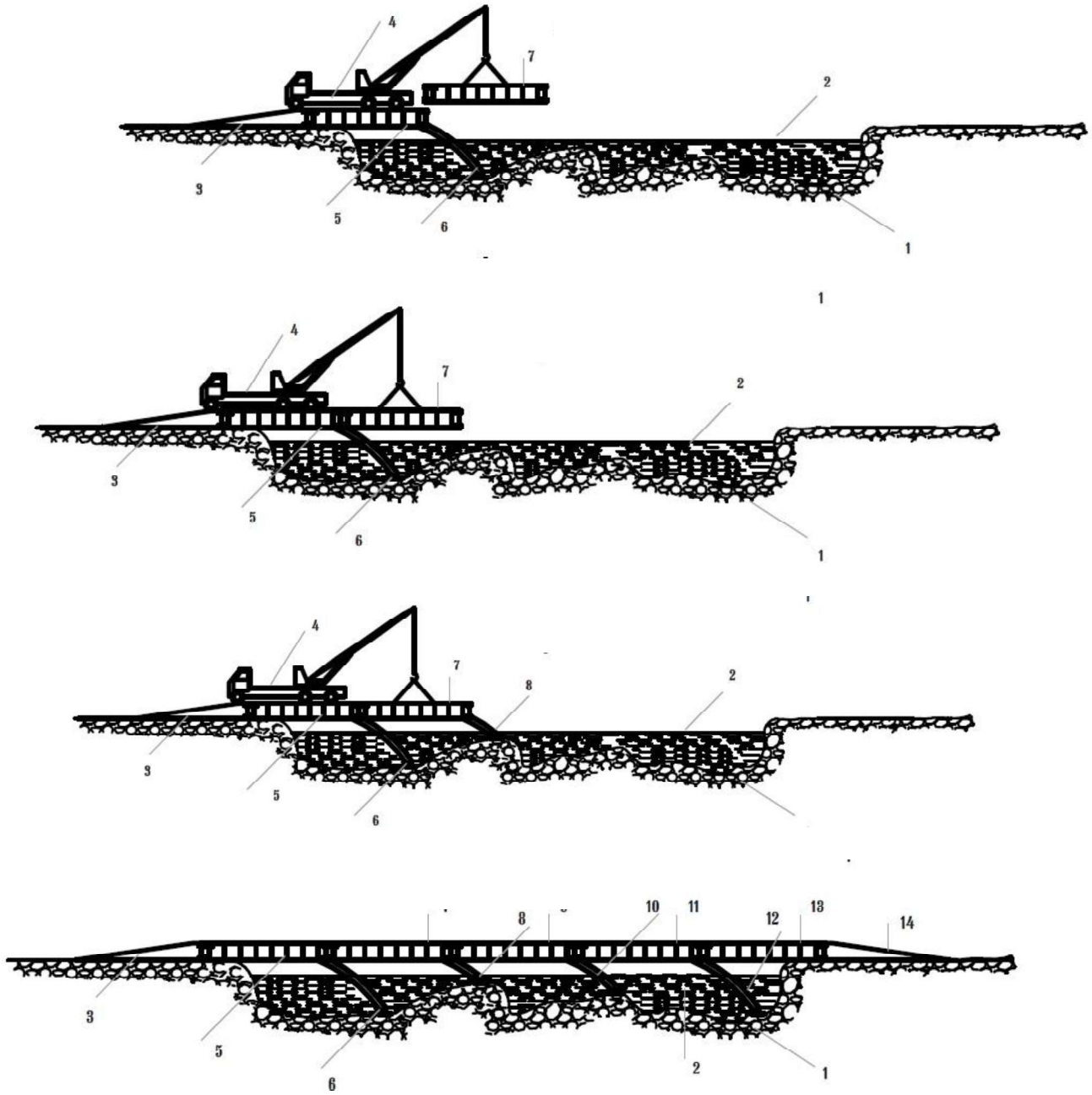

Figure 2 — Stages of assembly and deployment of the transformable guiding bridge
1 Riverbedm , 2 River, 3 Initial section, 4 Crane, 5 Intermediate section No. 1, 6 Deployable transformable support leg No. 1, 7 Intermediate section No. 2, 8 Deployable transformable support leg No. 2, 9 Intermediate section No. 3, 10 Deployable transformable support leg No. 3, 11 ntermediate section No. 4, 12 Deployable transformable support leg No. 4, 13 Intermediate section No

During installation of the intermediate sections, the transformable temporary supports are activated, providing temporary structural stability and reducing dependency on environmental conditions [6,9]. Upon completion of assembly, folding of the supports allows the bridge to transition into a single-span working state.

The proposed technology enables bridge assembly and dismantling within 2–3 hours using a minimal number of personnel [1,5].

4. Advantages and Application Potential of the Proposed System

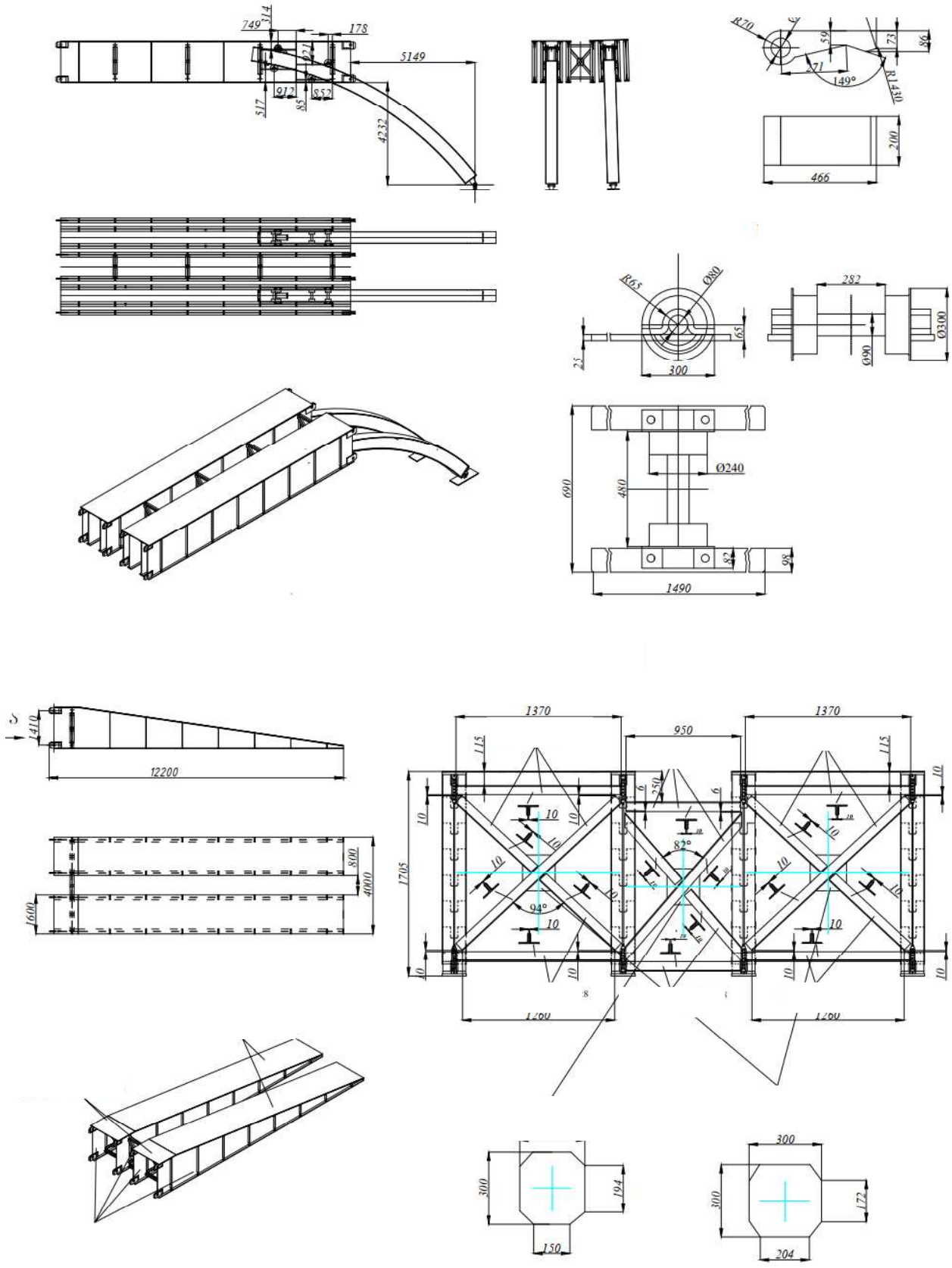

Figure 3 — Operational state of the bridge and performance of transformable supports

The proposed transformable guiding bridge system is characterized by reduced installation time, structural flexibility, and high adaptability to varying terrain conditions [4,9]. The use of temporary transformable supports minimizes the need for additional works within the obstacle zone and enhances system reliability in unstable environments (Figure 3).

The modular nature of the structure and optimized transport dimensions allow for multiple reuse of the bridge in civilian, rescue, and military operations [2,8].

Conclusions

This paper presents a new structural system of a transformable guiding bridge that effectively addresses key challenges in the field of rapidly deployable bridge systems [3,6]. The proposed solution ensures rapid installation, structural flexibility, and reduced operational resource requirements under extreme conditions.

The modular structure and use of transformable temporary supports provide stability during installation without the need for additional permanent piers. Transition to a single-span operational scheme after assembly reduces redundant elements and improves service performance, particularly in scenarios where access to the opposite side of the obstacle is limited or unsafe.

The presented assembly and deployment technology allows for bridge installation and dismantling within a short time using minimal technical resources and personnel. The adaptability of the transformable supports to terrain and soil conditions significantly expands the operational applicability of the system in complex and extreme environments.

The obtained results confirm that the proposed system represents a promising solution for the development of temporary transport infrastructure and creates a foundation for its practical implementation in various operational scenarios [4,9].

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