**CETRA**2024 15-17 May 2024, Cavtat, Croatia
**8th International Conferenceon Road and Rail Infrastructure**

# REHABILITATION OF THE ROAD - INSTALLATION OF THE BAILEY MILITARY LAUNCH BRIDGE

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## Abstract

Flood is one of the most frightening natural disasters. With its speed of impact and the amount of water mass it has great consequences in the area of the spill. Croatia is one of the countries that are rich in watercourses and therefore is sensitive to floods. This paper deals with the topic of rehabilitation of the road route and bridging of the river at the site of the collapsed bridge with the aim of re-establishing the necessary traffic connection of the affected area. The installation of the Bailey military launch bridge in the organization of the engineering units of the Croatian Armed Forces is described. The paper points out the importance and irreplaceability of the Croatian Armed Forces in the event of natural disasters that destroy the necessary living conditions of the population.

*Keywords: water obstacle, flood, road remediation, Bailey military launch bridge*

## 1 Introduction

In one of its missions, the Croatian Armed Forces have an obligation to support civilian institutions and the population in crisis management and dealing with various types of risks and natural disasters. The task and goal of engineering units is to establish road traffic by quickly building military roads and low-rise military installations, as well as intervening on damaged public roads and objects.
This paper demonstrates the effectiveness of the Croatian Armed Forces' engineering corps in repairing a damaged road and a collapsed bridge during a flood, while adhering to the procedure for deploying forces (prescribed protocol, chain of command, and preparation of appropriate command and accompanying documents).

## 2 Floods in the Republic of Croatia

Flood is a terrifying natural disaster that, with its speed and the volume of water, causes significant consequences in the affected area [1].
It is well known that global warming caused by human activities increases both the danger and frequency of floods [2]. Therefore, significant attention should be devoted to the protection segment, and the involvement of armed forces is invaluable assistance.
Croatia is one of the countries rich in watercourses, with three major rivers - Sava, Drava, and Danube, as shown in Figure 1, and therefore floods are not a rare occurrence.

**DOI: https://doi.org/10.5592/CO/CETRA.2024.1725**


**Figure 1** River basins in the Republic of Croatia

One of the biggest floods in the Republic of Croatia occurred in 1964 in Zagreb, caused by the breach of the Sava River embankments, resulting in the death of 17 people and the destruction of 10,000 apartments, 2 kilometers of highway, 120 companies, and 61 substations.
Nevertheless, an increasing number of floods have been recorded in recent years. Due to the overflow of the Neretva River in 2010, two floods occurred with water seeping through the sewage system. In the second flood, 70% of the city of Metković was submerged. The overflow of the Drava River near Varaždin occurred due to exceptionally high flow rates exceeding 2800 m3, flooding over 100 houses and evacuating 150 residents.
The flood in eastern Croatia in 2014 was the largest flood in that area in recent history. Elevated rainfall preceded the flood, increasing the flow of the Sava River from an average of 1000 m3 per second to 5500 m3 per second. Such a significant increase in flow resulted in the breaching of levees near Rajeva Sela and Račinovci (See Figure 2). The overall damage is estimated at 1.7 billion kuna.
By deploying levees, further damage was prevented. The most engaged groups in providing assistance to the population were the military, mountain rescue service (GSS), and firefighters. More than 1000 members of the Croatian Armed Forces participated in flood defense, primarily aiding in the evacuation of affected populations using amphibious vehicles and in levee construction to prevent further damage [3].

**Figure 2** Flood in Gunja

## 3 Establishing traffic in flooded areas

After a major flood in the flatland area, a large tidal wave carried massive amounts of fallen trees, hitting the existing bridge with tremendous force, causing it to collapse and be swept away from its location. The armed forces were engaged to restore traffic in the affected area, repairing a section of the access road and installing a Bailey bridge on the supports of the collapsed bridge, as shown in Figure 3.

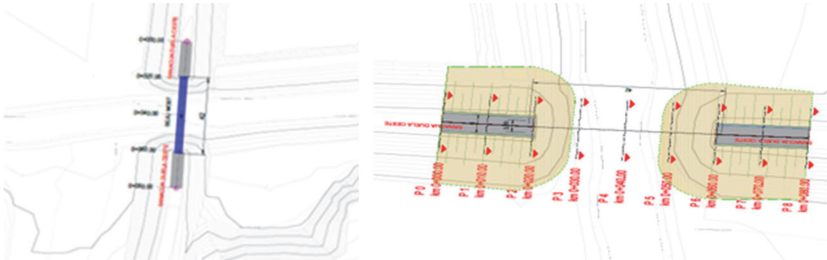

**Figure 3** Overview of the situation and display of work sections

To overcome a water obstacle with a width of 42 meters including supports, a Bailey launching bridge with a load capacity of 40 to 48 tons and a width of 3.81 meters for one-way traffic was selected. Both access roads had to be repaired on both sides, with a length of over 40 meters.

### 3.1 Bailey Bridge

The Bailey bridge set, as shown in Table 1, is not only used for crossing water obstacles but also for assembling many other structures, such as loading and unloading ramps, docks, suspension bridges, railway bridges, standing intermediate supports on land and water, scaffolding for construction work, pylons for setting up suspension bridge cables, retaining walls on roads, formwork during concrete work, and roof and other types of structures. The Bailey bridge set can also be used to assemble single-span bridges ranging from 9 to 64 meters in length with a load capacity of up to 90 tons, pontoons with a load capacity of 6 to 80 tons if the water speed is less than 2 meters per second [4]. The time required to handle the Bailey Set is shown in Table 1.

**Table 1** The time required to handle the Bailey Set

| | Day | Night |
|---|---|---|
| Loading onto vehicles without a crane | 3 h | 6 h |
| Loading onto vehicles with a crane | 1,5 h | 3 h |
| Time required for unloading | 2 h | 4 h |
| Time required for scaffold assembly | 40 min | 70 min |
| Time required for bridge assembly | 6h | 8h |

## 3.2 Installation of the Bailey bridge

The process of installing the bridge begins with site reconnaissance, if possible, and gathering soil bearing capacity data on the shore. This process consists of several phases:
- selecting a site for bridge assembly,
- designing the bridge,
- preparing the site for bridge assembly,
- assembling the bridge panels, assembling the bridge structure,
- and launching the bridge structure.

**Selecting a site for bridge assembly** entails the unit commander organizing engineering reconnaissance of the area to determine the most suitable crossing location. The assembly site should have good connectivity to roads on both sides of the shore. The shores should be approximately the same height, with the soil having high bearing capacity. Sufficient space for bridge assembly should be available in the area, with enough materials nearby for approach construction.

**Bridge design includes determining the type of bridge structure** and dimensions of the bridge panels, the method of bridge launching, calculating the required material, equipment, and tools, as well as the necessary construction time and workforce.

**Preparing the site for bridge** assembly involves the following: marking the bridge axis, preparing the entrance and exit ramps, repairing or constructing approach roads, and setting up workstations for assembling the bridge structure. The bridge axis is marked with four long red flags, two flags on each shore. Entrance and exit ramps have to be constructed when it's not feasible to set up a transition span due to the height and slope of the shore.

**Figure 4** Bailey bridge abutment

**Assembling the bridge panels** with triple-story main girders requires first placing rollers on the ground. Two grid panels of the first span are placed on them, and the crossbeam and diagonal braces are fastened to them with connectors. Then, the second span of the bridge is assembled. When the first two spans are joined, the first span is placed on the rollers, and the third span is assembled, pushing the structure forward while adding spans until the required number of spans is achieved. In our case, the bridge is 42.67 meters long, so its last three spans are triple-story, as shown in Figure 4.

**Assembling the bridge structure** involves assembling six spans with triple-story main girders, followed by installing the middle and inner walls on the second floor of the first span and the middle wall on the first floor of the seventh span. Then, the middle wall on the eighth span of the first floor is installed, the inner wall on the seventh span of the first floor, the outer wall on the first span of the second floor, and the middle wall on the second span of the second floor. In the next step, the outer wall is added to the seventh span on the first floor, the inner wall to the eighth span, and the middle wall to the ninth span, while on the second floor, the inner wall is added to the second span and the middle wall to the third span. The process continues in the same order until the entire bridge structure is assembled.
**Launching the bridge structure**, as shown in Figure 5, is done after it is fully assembled. During launching, attention must be paid to the balance of the structure. Balance is achieved by placing a counterweight made of Bailey material behind the swaying rollers on the structure. If the structure is not aligned, launching is paused until the structure is aligned. Once the span rests on the rollers on the opposite shore, the counterweight and span are disassembled. After disassembling the counterweight and span, end verticals are installed at the ends of the bridge, and a crossbeam is inserted through them. Mechanical means should be used when launching triple-story structures [4].

**Figure 5** Bailey bridge launching

## 3.3 Work Organization and resource calculation

Bailey bridges with three-sided double-story main girders are assembled in 11 tens. Parts of the main girders of the first and second floors are alternately assembled, and the road structure of the bridge, assembled by two tens, is installed, with one installing longitudinal girders and the other installing decking and parapets. To expedite grid assembly, vehicles carrying the grids should be parked on the sides of the assembly field. Pedestrian walkway brackets are installed after the completion of each bridge section, and the guardrail cable is installed after the bridge launching. The total time for completing all the work on the route, as shown in Table 2 and Figure 1, is 4695 minutes, or 8 working days of 10 working hours each. Since the first working day involved repairing the road on both sides of the bank, as well as preparatory work for installing the Bailey bridge, all bridge installation works were completed in seven working days of ten hours each. This demonstrates the engineering unit's ability to effectively repair the road and connect both sides of the 42-meter span riverbank with a Bailey military bridge, providing aid traffic access to the crisis area through good organization.

**Table 2** Resources and time required for performing the work

| Order no. | Name of works | Resources | Number | Time [min.] |
|---|---|---|---|---|
| 1. | reconnaissance | officers | 5 | 20 |
| 2. | Making the first part of the route | soldiers | 2 | 20 |
| 3. | Cleaning of the first part of the route | soldiers | 6 | 30 |
| 4. | Leveling with a dozer (Part 1) | dozer | 1 | 150 |
| 5. | Filling and leaving of the road level (Part 1) | Unloader | 5 | Simultaneously with work no. 4 |
| | | dozer | 1 | |
| 6. | Staking out the second part of the route | soldiers | 4 | 15 |
| 7. | Cleaning of the second part of the route | soldiers | 6 | 20 |
| 8. | Leveling with a dozer (Part 2) | dozer | 1 | 30 |
| 9. | Filling and alignment road leveling (Part 2) | Unloader | 5 | Simultaneously with work no. 8 |
| | | dozer | 1 | |
| 10. | Filling the route roads with rough stone | Unloader | 5 | 90 |
| | | dozer | 1 | |
| 11. | Filling the route roads with small stones | Unloader | 5 | 90 |
| | | dozer | 1 | |
| 12. | Rolling | Roller | 2 | 30 |
| 13. | Installation of the Bailey bridge | Digger | 40 | 4200 |

## 3.4 Maintenance and occupational safety

To ensure the longest lifespan and proper condition of the Bailey set, regular maintenance is necessary. Maintenance consists of:

- basic maintenance,
- intermediate repairs,
- major overhauls,
- inspections, and
- checks.

Basic maintenance of the Bailey set involves ensuring it is always in proper condition and includes cleaning, lubrication, and storage. The set must be cleaned after each use. If used over longer periods, it should be cleaned at least once daily.

Occupational safety measures must be implemented to ensure a safe work environment. During work execution, command must enforce safety measures, analyze the current conditions, and continuously seek ways to increase safety. The commander is responsible for ensuring that every soldier is familiar with safety measures and job hazards. Furthermore, commanders are responsible for conducting periodic checks on health and hygiene conditions, tool functionality, and soldiers' knowledge of occupational safety. Soldiers are obligated to work solely according to orders, use protective equipment, maintain it properly, report any tool malfunctions they notice, and report any health issues to their commander.

# 4 Conclusion

In the event of natural disasters and other crisis situations, the engagement of certain specialized units of the Croatian Armed Forces takes precedence over the involvement of civilian services and organizations due to their specific organization, high level of training, and equipment. In the presented example of task execution, the organization and implementation of the task through all segments, from reconnaissance, planning, organization, to execution of the work, are described. With their expertise and competence, armed forces personnel, along with the use of machinery, completed the construction of an access road and the installation of the Bailey launching bridge in a very short time. The Croatian Armed Forces, especially engineering units, play a significant role in the recovery and rescue of civilian populations during natural disasters, demonstrating their humanitarian character and overall importance in peacetime conditions.

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