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SUSPENSION BRIDGES IMPORTANT COMPONENT OF MILITARY MOBILITY

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Abstract: *Suspension bridges, as part of a land communication, are works of art that occupy a special place in the overall construction of bridges at national and international levels. Appeared and developed as a necessity to cross large obstacles (rivers, large lakes, sea straits), they cover very large openings, which reach impressive lengths, of the order of kilometres. The structural system of suspension bridges ensures appreciable navigation dimensions both in terms of height and width. Viewed from the perspective of the construction materials used, suspension bridges can be placed in the category of massive bridges, being large-scale structures that use a combination of concrete and steel. This combination of materials gives them a special aesthetic appearance, along with increased flexibility and resistance to mechanical and dynamic loads, thus ensuring the durability and stability necessary to support intense traffic and variable loads. All these particularities presented above highlight the importance of suspension bridges for achieving the military mobility in operations, both on land, by ensuring connectivity between points located at great distances from each other, and for achieving the river/maritime one, by ensuring a navigation gauge, under the large bridge.*

Keywords: land communications, suspension bridge, military mobility

1. Introduction

In the current security context, this scientific approach aims to be an analysis that highlights the importance of the suspension bridge, as part of the terrestrial communications infrastructure for achieving military mobility.

The world we live in is in constant motion, in which the fight for access to the planet's mineral, energy and other resources reconfigures economic and military alliances, and therefore the way in which areas of influence and interest are established. A direct consequence of this phenomenon is the tendency of states to integrate into various economic and military alliances in order to overcome all the barriers that may arise. Integration cannot be conceived without a very well-developed terrestrial, naval and air communications network.

The bridge, as an integral part of land communications, has a special importance in the overall development of all military and economic activities. Viewed from the perspective of the types of civil construction works, the bridge falls within the framework of works of art, which over time has fascinated, fascinates and will fascinate architects, infrastructure builders, but also many people, admirers of beauty. Moreover, the construction of suspension bridges has become one of the most suitable and most frequently used solutions for

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overcoming large obstacles which cover very large openings, reaching impressive lengths, of the order of kilometres.
The choice of this topic corresponds to the need to study the new procedures used in the construction of bridges, as technical solutions, which can be adopted in the context of military actions to support the mobility of forces in operation.
The topic addressed is a very topical one, especially from the perspective of the fact that bridges, as part of the land communications infrastructure, are essential to ensure military mobility on the territory of Romania in the current security context.
The research work is structured in two chapters.
In chapter 1, the research aimed to identify the main constructive elements, as well as to present some details regarding the engineering of the construction of these types of bridges.
In chapter 2, the research focused on the importance that bridges present in military operations
The methods, techniques and instruments used in carrying out this scientific endeavour are:
- the method of data collection through documentary analysis, observation of the field and its specific phenomena, data processing by systematizing and unifying and correlating the identified information with the already existing theoretical meanings;
- the analysis method, used extensively throughout the research.

2. Structural Elements and Engineering of Suspension Bridges

Highlighting the importance of suspension bridges in achieving military mobility cannot be achieved without focusing on their structural elements.
Suspension bridges are bridges whose bridge track is supported by overhead cables, and their construction is lost in the mists of history. One of the earliest forms of this type of bridge is found among primitive peoples who used "climbing plants (like vines), helping people cross an obstacle" (in China, Li Bing built seven such bridges in Chengdu around 95 BC) [1]. A much stronger type of suspension bridge was introduced to India around the 4th century AD by using woven bamboo as cables, and later this was replaced by chains or iron cables.
They are suspended by means of strong cables, supported by massive pillars and anchored to the ground, which allows them to cover large distances, without requiring intermediate supports. The main structural elements of suspension bridges are made up of the suspension cables, the tie rods, the bridge track, the abutment, the pillars and the anchor blocks, presented suggestively in Figure 1.

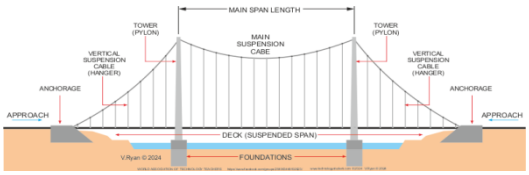

Figure 1: Structural elements of suspension bridges [2]

• Bridge track – represents the component that makes it possible for both pedestrians and vehicles to cross the bridge. This differs depending on the type of bridge. Thus, in suspension bridges that are built primarily for vehicle traffic, it consists of the roadway and sidewalks.
• Deck – consists of a multitude of elements that help support the track and transmit the loads produced by pedestrians and vehicles to the main resistance elements. It was originally made up of longitudinal solid core beams, called main beams, and transverse beams, called trusses. "To increase the rigidity of the deck, truss beams were used in suspension bridges. The decks of suspension bridges, built in the modern era, were designed and built as a result of studying their behaviour in wind tunnels. As a result of these studies, the shape of the suspension bridge decks is

orthotropic and provided with wind deflectors" [3].

"One of the first suspension bridges where the deck has an aerodynamic shape in cross section was the Humber Bridge (Figure 2), with a span of 1410 m"[4]

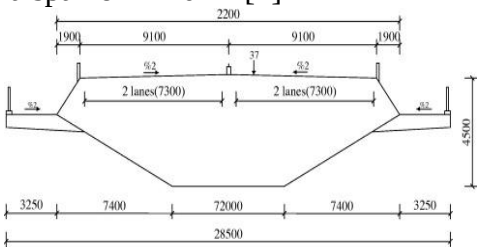

Figure 2: Cross section through the deck of the Humber Bridge, England [5]

• Stiffening beam - its role is to take over the loads produced by the convoys that circulate on the bridge and obviously the permanent load of the deck and to transmit it to the supporting cables, through the support ties. In static mode, the stiffening beam does not have significant stresses, but it has a very important role in ensuring the aerodynamic stability of the structure, which is why it must have an appropriate rigidity both in bending and in torsion.

• Hanger/Tie rods - are the connecting elements between the supporting cable and the stiffening beam. They can be made in different shapes and from various materials, such as round steel bars or wire cables. Their purpose is to ensure the solidity and stability of the structure, transmitting the forces and tensions from the supporting cable to the stiffening beam or other structural elements. These devices are often composed of two half-cylinders that are tightened with screws, firmly fixing the tie rods in the desired position. To adjust and control the tension in the ties, they are provided with threaded sockets.

• Cables, Figure 3, represent the main resistance elements of suspension bridges. The main cables have a curved shape "established from the condition of the bending resistance of the deck, under the effect of permanent loads". They are made of hot-rolled steel wires, then cold-drawn and heat-treated by quenching in a lead bath. The drawn wires, having a diameter of 4-5 mm and high strengths of 150-160 daN/mm², are protected against corrosion and are used in the manufacture of closed strands [2]. These strands are delivered to the construction site on wooden drums.

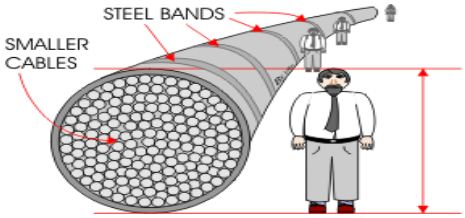

Figure 3: Main cable [2]

The strands - are mounted parallel on the pylons and are assembled with presses, thus forming the cables themselves. Each cable is provided with a clamping socket at the end, after which the strands spread out and are fixed in the anchoring devices, usually truncated conical. Another cable mounting system, used in the USA (Roebling method - Figure 4) consists of mounting the wires brought on rollers, with a device called "spider" [2], directly on the pylons. This "spider" is a trolley that runs on an auxiliary cable, having the shape of the supporting cable and which deposits two or four wires with each round trip, thus creating a bundle of parallel wires.

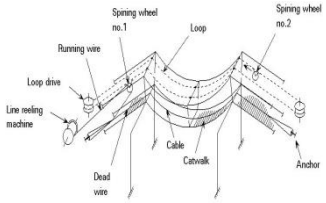

Figure 4: Roebling method of tensioning load-bearing cables [6]

As a result, the main cables are passed and rest on the upper part of the portal towers, being anchored at the two ends of the bridge. The anchoring of the main cables is carried out by means of two reinforced concrete blocks called anchor blocks, in which the axial force from the cables is

transmitted directly to the foundation ground.
Cable anchors are essential components in the structure of suspension bridges, having the role of taking over the loads transmitted by the cables. These forces, generated by the tension in the cables, must be distributed effectively to the foundation ground to ensure the stability and safety of the bridge. There are two main methods of anchoring the cables: anchoring in the foundation ground and anchoring by means of massive concrete blocks [4].
A concrete example of an anchoring system is the one used at the Firth of Forth Bridge in Scotland [6], shown in Figure 5. Here, the cable anchors are integrated into a complex system that involves inserting the cable strands into a tunnel excavated in stable rock or soil, followed by locking them in a "cast iron" and concreting the tunnel to ensure solid and permanent anchorage of the cables.
By using such effective anchoring systems, suspension bridges can be built safely and can successfully withstand the loads and stresses during their use. Anchors are an essential element in ensuring the stability and functionality of suspension bridges, allowing them to fulfil their role effectively and safely.

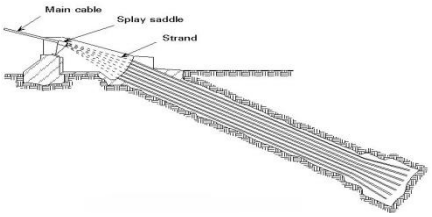

Figure 5: Anchoring the carrier cable in the rock [6]

• Towers/the pillars have the role of ensuring the support of the load-bearing cables to take over the permanent loads of the structure, so that under the action of these loads, the deck is not required to bend.
To avoid over - or under-dimensioning of the component elements, the height of the pillar must be at least equal to the deflection of the load-bearing cable, deflection determined by a calculation of optimizing the consumption of steel in cables, economic and efficient structural design. This principle is crucial in the design of structures to minimize the consumption of materials, especially the steel used in the load-bearing cables. This approach contributes to obtaining a safe and performing structure, while minimizing the consumption of materials, in this case, the steel used in the cables (Figure 5).
From the point of view of support in the foundation, the pillars are executed embedded in the foundation and less often articulated.

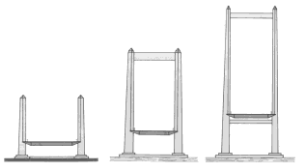

Figure 5: Shapes of pillars used in suspension bridges [4]

All these elements together constitute a suspension bridge whose construction involves a complex activity that requires average execution costs, extensive coordination between the teams involved and a rhythmic and sufficient logistical provision.
The technology used for the construction of suspension bridges is based on the Roebling Method, named after the German-American engineer John Augustus Roebling.[4] This is an innovative technique and was first successfully applied to the construction of the famous Brooklyn Bridge in New York [4].
The process begins with the construction of support towers on both sides of the watercourse/obstacle to be crossed. Then, steel cables are stretched between these towers, and the bridge platform is subsequently suspended from these cables.
One of the defining features of the Roebling method is the use of steel wire cables to suspend the bridge platform. These cables are tensioned between the bridge's support towers and solidly anchored in their

foundations and are used to support the weight of the bridge platform and road or rail traffic.

3. The Importance of Suspension Bridges in Ensuring Military Mobility

In a military context, mobility refers to the ability of military structures to move efficiently and quickly in various terrain conditions.

Suspension bridges, as part of land communications, are key works of art that facilitate the movement or manoeuvre of military structures, especially in areas of operations crossed by rivers, canals or other geographical obstacles or in areas where other types of infrastructure are not available. The constructive characteristics of these types of bridges allow the rapid and safe passage of all categories of military equipment, which is essential during military operations.

Therefore, it can be said that the suspension bridge plays a crucial role in ensuring military mobility, being an essential element for ensuring the rapid movement or manoeuvring of forces and assets in a designated area of operations (AO), zone of operations (ZO) or theatre of operations (TO).

In the direction of substantiating the above, some functions performed by suspension bridges to ensure military mobility will be presented below.

a) *Ensure the crossing of large obstacles*

Suspension bridges are often built to cross very wide watercourses, canals or gorges, where other types of bridges are difficult to build, due to the large dimensions of the obstacle. From a military point of view, such obstacles fragment the terrain, with direct consequences on the mobility of forces and military equipment. Consequently, the construction of a suspension bridge can provide an efficient and fast solution to maintain connectivity between different points in the terrain, but also the mobility of military structures.

b) Flexibility in construction and use

A major advantage of suspension bridges is their flexibility. They can be built quickly in strategic locations, without requiring a pre-existing infrastructure. This is especially important in conflict situations, when armed forces need to move quickly and install functional bridges in areas where there is no necessary infrastructure.

c) High operational load-bearing capacity

Suspension bridges are usually designed to support large loads, which also include heavy military equipment (tanks and trucks with heavy loads, etc.). Thus, they allow armed forces to move their forces and military equipment efficiently during conflict, while maintaining high mobility.

d) High resistance to extreme weather conditions

Suspension bridges are usually built to withstand not only the weight of vehicles, but also difficult weather conditions and external attacks. In a conflict, they must be able to withstand explosions, impacts and other types of damage that may occur due to bombing or air strikes. This type of bridge is built with resistant materials and is designed to minimize the risks of destruction.

e) Ensures accessibility in isolated or difficult-to-access areas

Military operations are carried out in all types of terrain, and when they are carried out in mountainous regions or other isolated places, military structures may face the absence of road infrastructure or its destruction. Suspension bridges can be quickly built in such places, ensuring the access of forces and means to areas that would otherwise be inaccessible and at the same time constituting a crucial supply route for forces in contact.

f) Ensures the possibility of rapid reconstruction

During military combat operations, existing bridges, as key points in the field, can be affected by enemy actions, in order to achieve the countermobility of their own forces. In this context, the construction of suspension bridges represents a viable

solution to ensure the continuity of military operations. They can be designed to be quickly reconstructed or even temporarily installed, so as to allow the rapid passage of forces and means over natural obstacles in a strategic manner.

g) Ensures efficient logistical support

Military mobility refers not only to the movement of military structures during military operations, but also to their supply with food, ammunition and other military equipment. Suspension bridges can ensure a continuous and efficient flow of supplies for units in the field, thus maintaining their operational status. Also, these types of bridges are essential for the evacuation of wounded personnel and damaged equipment from the combat zone.

h) Use in special operations forces actions

In the actions carried out by special operations forces, speed of movement is essential. Suspension bridges can be used to facilitate the rapid movement of these types of forces or research teams, which need quick and safe access to enemy-held territory or isolated areas.

4. Conclusions

Suspension bridges are designed to cross large bodies of water, such as rivers or straits, without impeding navigation, thus connecting areas that at first glance can be considered isolated and contributing to ensuring continuity in military operations.

Suspended by means of strong cables, supported by massive pillars and anchored to the ground, it allows them to cover large distances, without requiring intermediate supports, thus reducing construction time, with considerable savings in materials and labour. Thus, suspension bridges represent a vital component in ensuring military mobility, having a direct impact on the combat capacity of military structures, by facilitating rapid and efficient movement in a theatre of war. They ensure not only the crossing of major obstacles, but also the sustainability of logistics and the ability to react quickly to unpredictable or extreme situations. In essence, they contribute to maintaining high-performance operational mobility, essential for the success of any military operation.

The construction of suspension bridges in conflict time has certain advantages, for supporting military mobility:

- the creation of larger/longer main spans than any other type of bridge;
- reduced need for materials, which leads to a reduced construction cost;
- the waterway can remain open for almost the entire duration of the bridge construction;
- high flexibility and resistance to any external factors, allow armed forces to move their forces and military equipment efficiently during conflict, while maintaining high mobility.

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