Danubian Economy and Legislation

Solutions and Associated Costs for the Development of River Crossing Infrastructure in the Lower Danube Region

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Abstract: The paper presents several system for crossing the river and an originally solution that no necessity expensive costs to built. The maintenances costs are very low. The results are related to the dynamic characteristics of the crossing systems, because each of them necessity a lot of technically solutions. Because of their size and the nature of the crossed obstacles, these types of structures can offer easy access outside and inside for inspection maintenance works, but comparing with bridges. In time these crossing systems are exposed to a variety of phenomena which can cause them damage but the intervention modality for repair the damages it is not so costly.

Keywords: crossing the river; immersed tunnel; retractable mobile system

JEL Classification: R11

1. Immersed tunnel across the Danube River

A**n immersed tunnel** is tunnel build in a dry dock in a ship yard and immersed on a river bottom. This kind of tunnel is composed of segments that can floated and when this segment arrived in a nominate place of river, are immersed and then linked together by using a special gaskets. They are commonly used for road and rail crossings of rivers.

The tunnel is made up of separate elements. These elements are made from concrete and steel in a manageable length. At the ends the segments are opened with bulkhead. These opened is necessary because the segment of tunnel must floated to the choice place to be immersed. At the same time, the corresponding parts of the path of the tunnel are prepared, with a trench on the bottom of the channel being dredged and graded to fine tolerances to support the elements.

The next stage is to place the elements into place, each towed to the final location, in most cases requiring some assistance to remain buoyant. Once in position,

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additional weight is used to sink the element into the final location, this being a critical stage to ensure each piece is aligned correctly. After being put into place the joint between the new element and the tunnel is dewatered and then made water tight, this process continuing sequentially along the tunnel.

The trench is then backfilled and any necessary protection, such as rock armour, added over the top.

The ground beside each end tunnel element will often be reinforced, to permit a tunnel boring machine to drill the final links to the portals on land [3]. After these stages the tunnel is complete, and the internal fit out can be carried out. The segments of the tube may be constructed from reinforced concrete box and this construction has been the standard.

The segments being launched (figure 1) but before the segments are assembly in dry docks then flooded to allow their removal.

The main advantage of an immersed tunnel is that they can be considerably more cost effective than alternative options like a bored tunnel beneath the water being crossed (if indeed this is possible at all due to other factors such as the geology and seismic activity) or a bridge. Other advantages:

- Their speed of construction;
- Minimal disruption to the river;
- Resistance to seismic activity;
- Safety of construction (for example, work in a dry dock as opposed to boring beneath a river);
- Flexibility of profile (although this is often partly dictated by what is possible for the connecting tunnel segments types (figure 3);

Disadvantages include:

- Immersed tunnels are covered with two types of rock, for stability and protection reasons (figure 2);
- Direct contact with water necessitates careful waterproofing design around the joints;
- The segmental approach requires careful design of the connections, where longitudinal effects and forces must be transferred across;
- The starting point of an immersed tunnel design is required cross-sectional area;

• The tunnel must have the same number of traffic lanes as the road;

• Dimensional requirements vary from country to country;

Above the headroom there should be adequate room for ventilation booster fans, luminaries and signal.

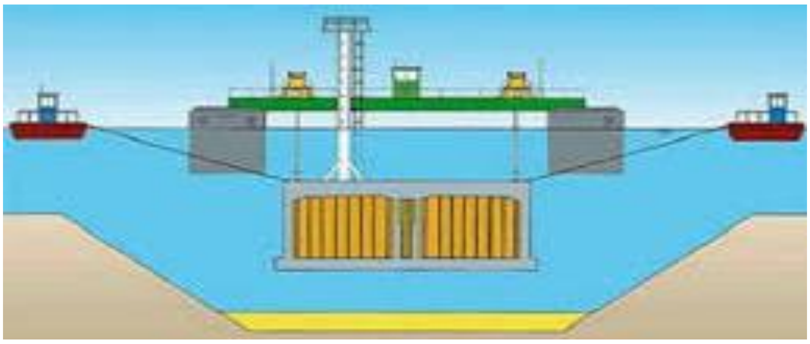


Figure 1. Launch of Immersed Tunnel Segment on the River Bottom 2.

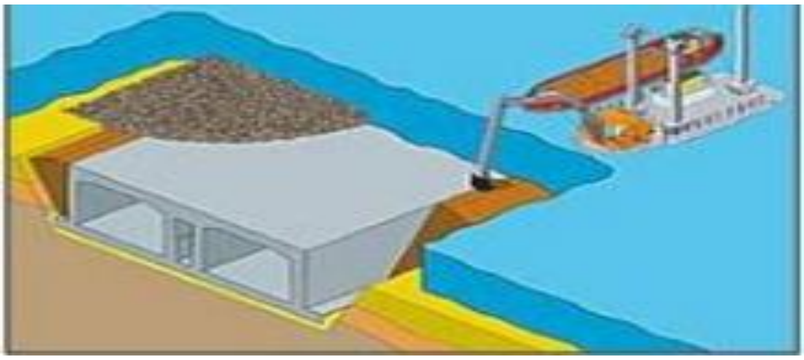


Figure 2. Immersed Tunnels are Covered with Two Types of Rock and Sand, for Stability and Protection Reasons 3.

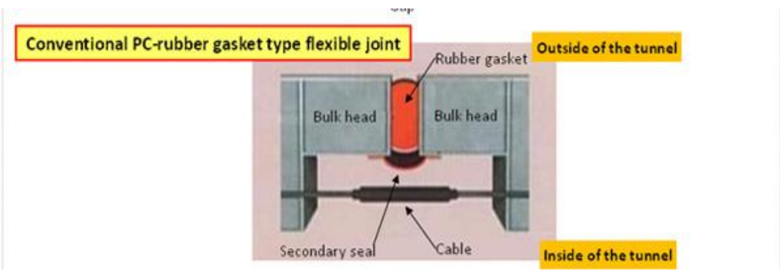


Figure 3. Elastic Coupling with Rubber Gasket between Immersed Tunnel Segments 5.

2. Originally Solution-Retractable Mobile System for Crossing the Danube

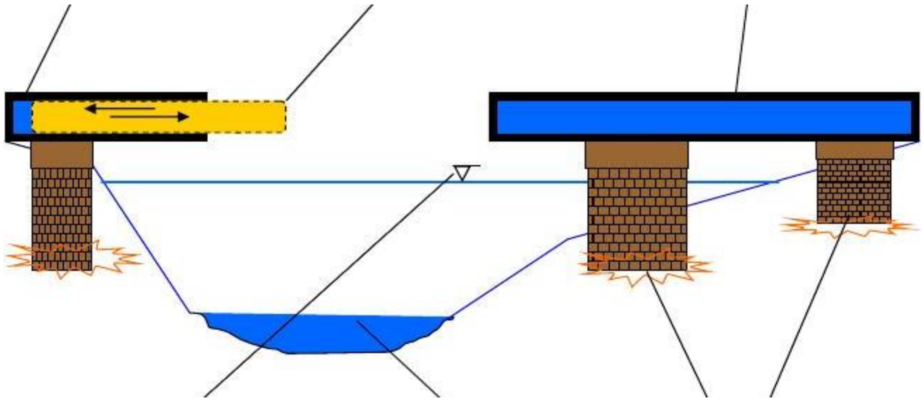
A solution that can be applied in the area where the Danube is the smallest width in the area of Galati town is the use of a retractable mobile system for crossing the Danube (figure 4).

The advantages of applying this solution are the low cost of execution, around 80 billion of Euros.

The investment time is about one year and the technical equipment is common and workers' qualifications are medium. Steel panels for construction are carried out in the steel mill Liberty Galati.

Comparing the results highlighted the advantage and the need for a calculation at execution stages. It has been highlighted that on the model calculation directly on the final structure, the effort in the hobby cannot be controlled, which is very important to consider when calculating the bulkhead resistance.

The bulkhead located on Galati coast Retractable-bulkhead driven The bulkhead located on of Danube, with hydraulic cylinders by hydraulic cylinders Tulcea coast of Danube



Maximum level of Danube Dredged waterway Bulkhead support pillars

Figure 4. Proposal for Retractable Mobile System for Crossing the Danube.

2.1. Hydraulic System Components

These components are necessary for transmitting of hydraulic parameters delivered by hydraulic pump. Hydraulic parameters are used for accomplish of some important function like: command, measuring, connection and regulating.

The hydraulic system for controlling the mobile part of the bridge consists of:

- the command and control system for the operation of the bridge;

- auxiliary devices, which perform storage (liquid tanks), filtration, flexible connection between parts, thermostatic, etc.;

- devices for measuring and controlling the parameters of the hydraulic environment.

General characteristics of hydraulic pump are:

Average flow:

QT = ΔV.z.i.n, [5] were :

ΔV is volume fluctuation of hydraulic fluid pump chambers;

z - number of pump chambers;

i - number of suction cycles –relief per pump shaft revolution;

n - pump shaft rotation speed in m/s;

Real flow rate:

QR = QT - ΔQ m3/s [5]

ΔQ - pressure loss, when the hydraulic fluid passes through the pump;

c) Flow rate pulse: its variation in time due to the successive action of the pump chambers in the discharge chamber and the non-linear variation in time of the pump flow, characterized by:

- pulse frequency f p = z.i.n,

- degree of non-uniformity, δ= (Qmax-Qmin) / Qmed ;

d) Nominal pressure, pn ;

e) Hydraulic pressure, Nh = Q. p;

f) Total efficiency:

ηt = ηv. ηp. ηm , were; [4]

ηv is volumetric efficiency; ηp is pressure efficiency and ηm is mechanically efficiency.

Fot the first is must to calculus of rod diameter at compression force by using the external forces that action on the cylinder rod.

The actuation pressure “p” is chosen according to the strength of the resistance, the available gauge and the minimum of the cost, in principle high values are recommended.

The diameter of the cylinder D is determined from the expression of the active force on the piston FP, by explaining the effective master surface.

For D and d, normalized values are finally adopted, based on which the length of the pass is chosen from the catalogs engine according to the data application.

2.2. Volumetric Adjustment of the Drive Hydraulic Cylinder Flow Rate

The Q flow required to achieve the desired speed is adjusted from the pump P and fully enters the engine, the maximum valve SM is intended solely to limit the pressure in case of overload (relief valve). The pump directly supplies the required power to the engine, so that the drive output is maximum and operating costs are minimal.

For resistive flow rate Regulation is used a method that has very common applies to small-medium power circuits. These power circuits are supplied by constant flow pumps, and consist of the introduction of hydraulic resistors in the circuit following the principles of semi-valves and hydraulic axles.

Such a circuit contains a constant flow pump (Qo = ct), the hydraulic resistances corresponding to the maximum valve (RHV), the hydraulic motor-RHM an adjustable resistance for flow Regulation (RHR) [4]. The pump flow Qo is divided into the two flow rates Qm and QV, in the opposite proportion to the resistance of the two circuits, so we can write relationships:

Qo = Qm + Qv [m3/s] [5]

3. Conclusions

The advantage of using these hydraulic pumps when driving the mobile part of the bridge is that adjustable flow pumps are more expensive than constant flow pumps, so that their use is economically justified only on high power circuits as is the case in point.

In the study case we may be used volumetric flow-meters (based on parallel-linked volumetric pumps principles), that are useful when two motors are to be simultaneously supplied from a single pump, usually constant flow.

Another advantage for the type of crossing of the river proposed by the author is the cost of the investment.

So if a classic bridge like the one that is currently being worked on costs about 500.billion of Euros. The solution proposed in this project does not exceed 150 billion of Euros.

Another advantage is the simplicity of the construction and the time of construction that does not exceed one year, while the construction of the bridge over the Danube in the Galati-Braila area takes about 4 years.

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