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Bridge on the Volga River, in Ulianovsk

Pont sur la Volga à Oulianovsk

Brücke über die Wolga in Uljanowsk

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SUMMARY

The paper considers the interrelation between the geomorphologic, engineer-geologic, climatic and hydrologic construction conditions and adopted designs and methods of erecting a bridge across the Volga River in the town of Ulianovsk.

RESUME

La communication examine la corrélation des conditions géomorphologiques, géologiques, climatiques et hydrologiques de la construction avec les solutions constructives et les méthodes de réalisation utilisées pour la construction du pont sur la Volga à Oulianovsk.

ZUSAMMENFASSUNG

Dieser Beitrag stellt die Wechselbeziehung der geomorphologischen, ingenieurgeologischen, klimatischen und hydrologischen Bedingungen mit den angenommenen konstruktiven Lösungen und Baumethoden der Brücke über die Wolga in Uljanowsk vor.

INTRODUCTION

In the practice of designing and erecting bridge passages in the USSR in connection with the necessity of crossing water areas of large reservoirs, location of routes on the town detours outside settled territories under the complex nature-climatic conditions, increasing navigation safety requirements, etc. arises the necessity of erecting large bridges with long navigation spans, as for example the bridge across the Volga River in the town of Ulianovsk now under construction.

1. ERECTION CONDITIONS AND GENERAL INFORMATION ON THE BRIDGE PASSAGE ROUTE

The bridge across the Volga River is designed for passage of the municipal motor transport, and the lines of the highspeed street cars (underground railway).
The constraction area is characterised by complex geomorphologic, hydrologic and geologic conditions - the rightside shore is elevated over the reservoir level by more than 100 meters, the bed depths exceed 30 meters, and the seasonal fluctuations of the level reach 8 meters, the ice cover thickness exceeds 1 meter, dimensions of observed ice fields 700 x 700 meters, wave height is up to 3 meters, the right-shore slope is subject to landslips.
The total extent of the bridge passage route is about 12 km, including 5 km of bridge. In places where the highways abut the passage route construction of 4 various level gradecrossing elimination structures has been envisaged.
The passage longitudinal profile was determined by the terrain relief, maximum longitudinal gradients within the artificial structure limits.
To ensure stability of the right-hand slope a complex of anti-landslip measures including depressions of up to a 40 m depth, tracing of the slope upper and lower parts, cutting of landslide accumulations, strengthening of the slope lower part at the shore line against the wave effect.
The left-shore approach to the bridge at the water area section having depthsup to 8 m was arranged in the form of about 2.5 km long embankment erected by hydraulic filling and strengthened against the wave effect with a reinforced concrete sheet piling.

2. BRIDGE DIAGRAM

The following factors influenced selection of the bridge diagram:
- necessity of spanning the lower most unstable part of the slope without arrangement of intermediate piers;
- maximum reduction of the number of piers on the reservoir water area, especially in the zone of large depthswithin the bed navigational part of the water area in the right-hand shore area;
- provision of reliable operation, comfortable and safe conditions for the city traffic and navigation;

The double-deck bridge under construction (Fig.1) includes the following sections:
- bed part in the form of a cable-stayed single-pylon double-deck superstructure against the diagram 220 + 2 x 407 + 220 m;
- viaduct part on the reservoir water area with double-deck steel superstructures 2 x 220 m;
- right- and left-shore reinforced concrete viaducts making it possible to bring the high-speed street çar (underground railway) lines from the bridge lower level.

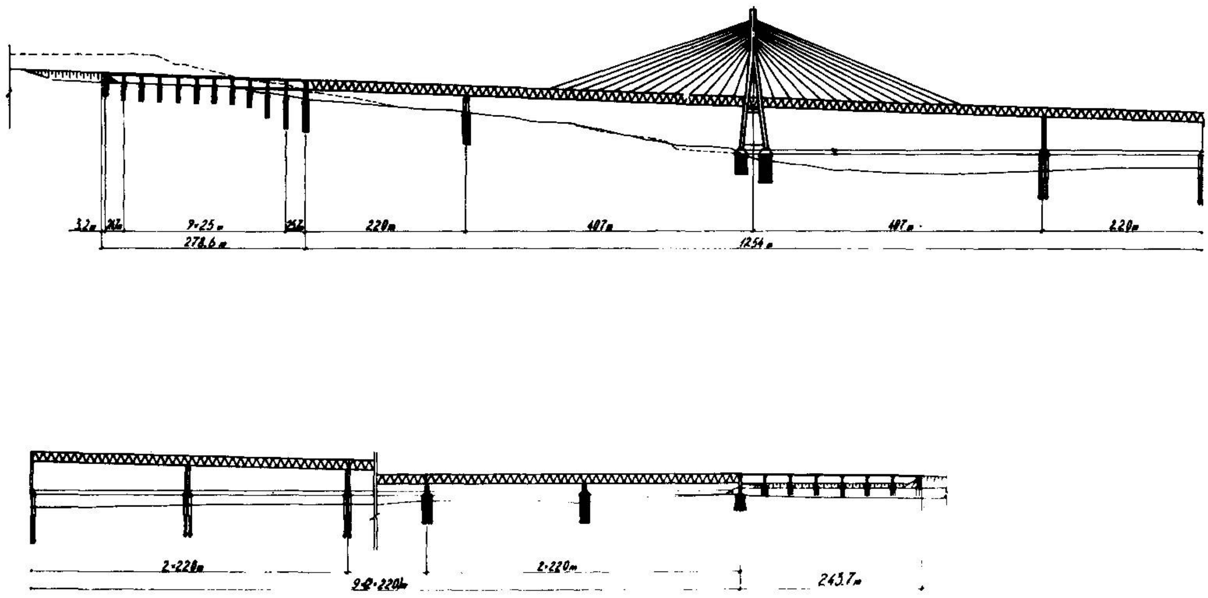

Fig. 1 Bridge diagram

2.1 Bed Part

The cable-stayed superstructure consists of a reinforced concrete pylon and steel stiffening beam, fixed in spens by 407 m stays. The superstructure system is a multi-stayed with a two-plane dispersal of stays.

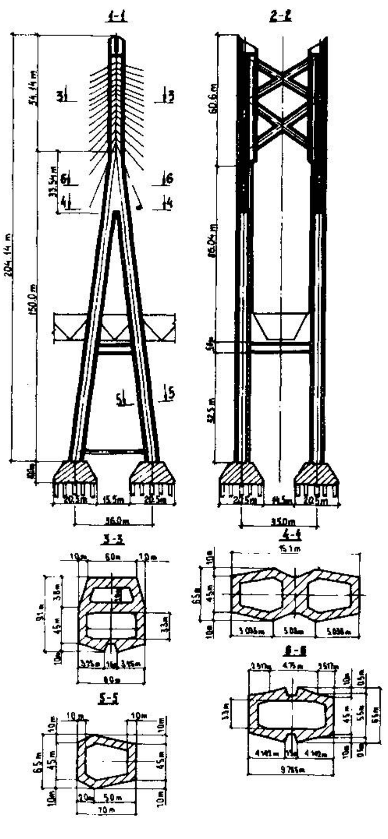

Fig. 2 General view of pylon

According to conditions of the system static operation in the erection and operation stages, the reinforced concrete 212 m high pylon was designed as a rigid frame structure (Fig.2).

The face Λ-shape planes include a 58 m high vertical part intended for fixing stays, and inclined legs combined at the lower part of the stiffening beam by a distanse piece, embedded in separate foundations.

The face planes are intercombined with two cross-shaped distance pieces in the stay attachment zone and with horizontal cross bars under the stiffening beam.

To take the outward thrust and force regulation at the height of 5 meters above the foundation edge the inclined legs are tied in the face plane with a prestressed 6-stay bracing. The stays consist of 127 dia. 7 mm aluminium wires.

The pylon elements are of box section having the wall thickness from 0.8 to 1.0 meters.

The foundation separate for each leg are made in the form of pile foundation mats on drill piles of diameter 1.7 m with a base broadened to 3.5 m.

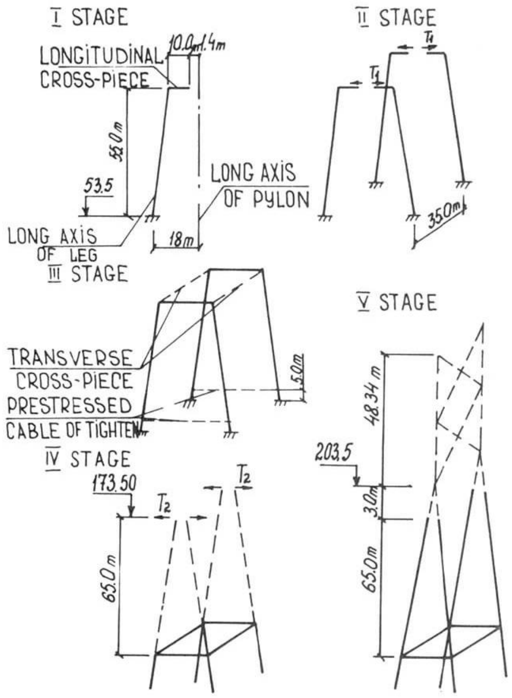

Fig. 3 Pylon erection diagrams

The pylon erection includes five basic stages (Fig.3).

Stage I. Concrete the inclined legs and cantilevers of longitudinal distance pieces in the travelling forms without arranging temporary distance pieces.

Stage II. Adjust efforts in legs by strutting them off with the help of T_1 = 250 tf horizontal jacks. Then, cast concrete in cantilevers of longitudinal distance pieces in pairs between each other.

Stage III. Tension the bracing stays for total force of P = 1200 tf. Mount suspended steel girders at the level of the pylon legs cross distance pieces. Using the above girders as scaffolds, place concrete into the box cross distance pieces simultaneously including the girder chords and struts into the reinforced concrete section of cross struts as a rigid reinforcement.

Stage IV. Concrete in the travelling forms cantilevers of inclined legs above the level of horizontal distance pieces without any auxiliary temporary distance pieces. Adjust the forces in place of legs convergence by strutting them off with the help of horizontal T_2 = 200 tf jacks. This done, place concrete in the legs cantilevers.

Stage V. Concrete in the travelling forms the vertical posts and cross-shaped cross distance pieces simultaneously installing the steel structures for anchoring stays in the pylon body.

For the legs reinforcement use is made of the long-size rigid frames height-lap interconnected without welding.

The steel stiffening beam (Fig.4) of trapezoid section has been designed in the form of two inclined through girders with a triangle lattice, combined by the top and bottom roadway orthothropic plates engaged in a combined operation.

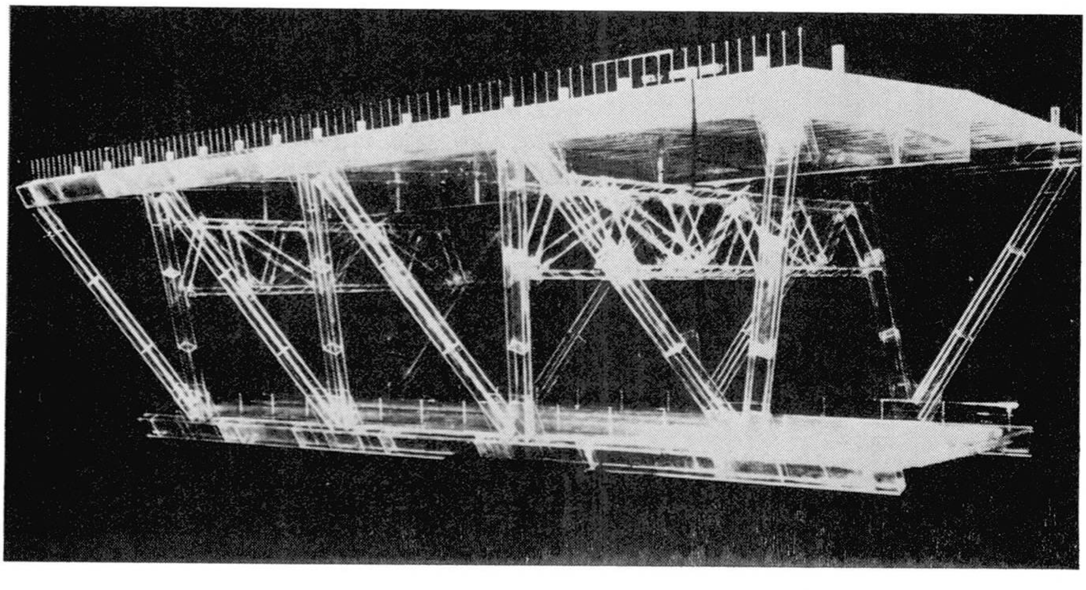

Fig. 4. Model of stiffening beam section

The main girders have the height of 12 m and spaced apart at the top level 26,4 m and 13 m at the lower level. The girder elements sections are welded box, closed with sealed internal space.
The main girder units are designed in the form of prefabricated welded unit boxes.
The cross ties are located on the struts comprising a rigid structure bearing the auxiliary beams of the motor roadway part.
The box longitudinal ribs of the orthothropic plate are supported by cross ribs arranged at a 5.5 m pitch.
The erection joints are welded using also dia. 27 mm high strength bolts.
To determine the aerodynamic characteristics the stiffening beam fragment was subjected to the wind tunnel tests.
The stays dispersed along the stiffening beam are secured directly to the main form units at the top chord level and 22 m pitched.
Every stay is made in the form of two separate hexagonshaped ropes from dia. 7 mm parallel wires. The number of wires in a rope from 127 to 271 pieces.
Each wire is coated with anticorrosive layer of 1.0 mm thick pure aluminium providing stays protection throughout the entire period of operation.
The stiffening beam metal mass per one cable-stayed superstructure is or 20115t or 16.04 t/pm. Mass of stays is 1900 t or 1.5 t/pm.
The superstructure erection is performed by suspension assembly on both sides from pylon.

Erection of superstructure

The suspension assembly of a multi-stayed superstructure may entail to twisting in the horisontal plane of the assembled superstructure around the pylon as a result of aerodynamic action of wind on cantilevers if they are of large size. In case of the cantilever overhang in excess of 210 m the pulsation effect of the wind load causes excessive twisting and bending moments in the pylon legs capable of destroying the structure. Similar effect arises during action of a single wind puls (gust) on one of the cantilevers being assembled.
Installation of temporary shore piers taking the horizontal forces across the bridge appears to be non-effective in case of rigid restraint of the superstructure beam on the pylon in a horizontal plane, as in case of the wind gust against the river cantilever , the pylon all the same cannot keep the superstructure turning in plan.
On the other hand, the problem could be solved by erecting in addition to the shore temporary piers of two more temporary piers keeping the river cantilever in plan. However, erection of such temporary piers is very difficult because of large water depths, complicated ice conditions and their considerable elevation (up to 60 meters) above water. In view of this, a method of elastic-pliable attachment of the superstructure beam to pylon has been adopted. According to its concept the pylon-to-beam connection is accomplished by two pairs of crossing horizontal stays fixed from the bridge upper and bottom sides to pylon legs and to the beam bottom chord, as well as four side horizontal stops between pylon legs and upper wider chord of the superstructure beam. Upon balanced suspension assembly of cantilevers having the length of 203 m each, the first temporary pier taking only horizontal forces across the bridge is installed on the shore side. Then the side horizontal stops between the beam and the pylon are removed and the suspension assembly, balanced in the vertical plane, is continued.
Having assembled the cantilevers of 291 m each, the second temporary pier, operating in a manner similar to the first one, is installed on the shore. This done, the suspension assembly with cantilevers of up to 407 m long each is continued.

Upon removal of the side horizontal stops, a restricted turning of the superstructure beam in horizontal plane about the pylon is enabled. The aerodynamic calculations have shown that due to the elastic-pliable ties operating only for stretching, the twisting torques in the pylon legs are lowered by 2.8 - 3.0 times as compared with rigid attachment in the assembly stage at an inconsiderable increase of the bending moments.
The shore piers are made in the form of two separate posts of hexagon section on the common foundation mat. The foundation is of dia. 1.7 m drill piles.
The bed piers of similar construction have been gesigned on dia. 2.7 - 3 m drill posts with up to 5 m broadenings using metal enclosures within the free length of piles and alluvial deposits.

2.2 Viaduct part on water area

The 2 x 220 m continuous superstructures are similar in design to the stiffening beam of the cable-stayed superstructure differing only in arrangement of the cross section.
The main girders are located vertically at a distance of 13 m, and the top chord orthothropic plate has 6.3 m long cantilever overhangs.
Erection of superstructures has been envisaged in two versions:
- shore jig assembly by 220 m spans, floating bridging and joining of two spans above the pier into a continuous system;
- suspension assembly along the bridge axis with the use of a temporary pier.
The piers of a two-pillar design rest on high pile foundation mats on drill posts of 2.7 m in diameter having up to 5 mbroadening and of 2 m having up to 3.5 m broadening (Fig.5).

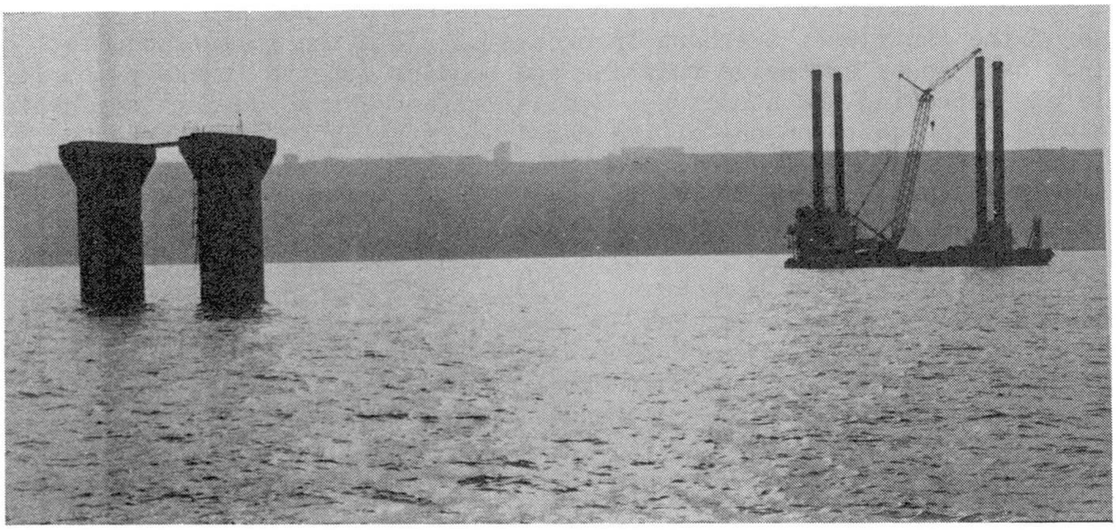

Fig. 5 Bridge bed pier

In the process of the bridge passage designing and erection, a complex of scientific-research and experimental work (modeling, determination of aerodynamic stability, solution of technological problems, etc.) has been accomplished.
The designs meet the advanced experience of the Soviet and world bridge building.
In compliance with the accumulated experience the design institute envisage application of the specified designs in erection of a number of large rivers and re- servoirs both in the European and Asian parts of the country.