Deep column foundations of large bridge piers

Deep Column Foundations of Large Bridge Piers

Fondations tubulaires profondes de ponts de grande portée

Tiefgegründete Stützenfundamente für Pfeiler von Grossbrücken

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Reinforced concrete columns of thin wall hollow piles filled with concrete and bore piles (columns) with enlarged bases are widely used in the USSR as bridge foundations. Out of a great number of bridges recently constructed in the USSR the practice of erecting two exceptional bridges is of big interest. One of the bridges was erected on column foundations 3 m in dia socketed into bedrock, the other - on batter columns 1,4 m in dia with enlarged bases 3,5 m in dia embedded into compact clay.

The first railvvay bridge is made of seven steel spans each 158 m long mounted on piers in water. The river bed at the bridge crossing consists of alluvial gravel and sand deposits over inclined rock layers with ultimate compressive strength 300 to 1400 kgf/cm^2. The alluvial deposits over the rock surface is 2 to 30 m thick. The river bed is about 22 m deep. The water level at high water rises up to 8-10 m.

Foundations are designed as vertical columns made of 3 m reinforced concrete tubes filled with concrete. Because of inclined strata of rocky soils the foundation columns of two piers rest on gravel grounds (Fig. 1) and other five piers rest on bedrock (Fig. 2). Each column is loaded by 2500-30000tf, this load depends on the number of columns in a fondation.

Reinforced concrete pipes for columns were assemlled section by section each 6 m long. Section flanges are fastened to each other with bolts. Pipe walls are 12 cm thick.

Sections are reinforced with a row of bar each bars being 25 mm in dia. Bars are welded to section flanges. Compressive strength of concrete is 400 kgf/cm^2. Flanges are welded at plants.

To install foundations means :

to fabricate pipes ;

to socket them into ground ;

to spoil ground soil from the pipe ;

to drill a hole in bedrock ;

to fill holes with concrete mixture ;

to cast foundation slab.

Pipe sections were fabricated in vibrating forms at a bridge site casting yard. Finished sections are delivered to assembly line and then they are transported to the installation site by pontoons.

To provide for designed in plan position of piles they were driven into soil (where each foundation is to be installed) through a template its preset designed in plan position being fixed.

The piles were embedded into soil with the help of a vibrating unit whose disturbing force was equal to 280-340 tf. Vibrating unit was fastened to the top of a pile with a ciamping cap.

At the first stage the piles were driven by vibrating unit at a rate of 1.5 - 2 m/min, if in the pile hole there was a soil core 2 - 3 m high. As long as the core grew up the rate of penetration was cut down to 1.0 - 0.5 m/min. The rate of penetration through the bottom stratum of dense gravel soils war less than 0.1 m/min even at the absence of a core.

To increase the rate of penetration thraugh such of soils they were spoiled below the pile edge for 0,8-1,2 m. Under these conditions pile sections were filled with water to a level higher than that of the river surface for 4-5 m, thus resulting in extra hydrostatie pressure which served as a barrier against possible collapse of cohesionless soils in the uncased hole. That extra pressure was kept up all the time the pile was driven to a design elevation.

So as to install foundations for five river piers the piles were driven down through alluvial deposits to the very bedrook surface. The rock then was drilled through the pile hole for the depth of 3-3.5 m. Diameter of the drill hole was 2.6 m.It was furnished with reinforcing bars and filled with concrete mixture with the purpose of to anchor columns into rocks so that they could sustain designed loads. The holes in the bedrock for the pile base were drilled by the RTB-2600 drilling machine developed at the All-Union Research Institute for Boring Equipment of ihe Ministry of Oil Industry of the USSR. The machine consists of four turbo-drills which are in mass production for oil industry. They are unified into a fixed plain structure. These turbo-drills opevate at a time, the fourth one without a bit is reserve. External turbo-drills are fit with cone bit 490 mm in dia, internal one - 750 mm. The turbo-drills are driven with water which is pumped through hoses under pressure of 30-50 kgf/cm^2.

In the course of drilling small particles of broken rock were pumped out with water. Coarse particles were periodically sucked with air-lift. Altogether 50 holes for foundations were drilled, average rate of drilling being 0.4 m/hr.

Every hole drilled to a design elevation was cleaned of muck. The reinforcing cage was then installed into the pile and hole and ihe concrete was poured down through a tremie. A special pipe with a hopper at its bottom end was pushed down the hole to clean it completely.

At a pressure of 7 kgf/cm^2 the water was pumped down through the pipe, sucked with the muck into the hopper and settled down there.

The concrete mixture was poured through a tremie 0.3 m in dia at a depth of 28 m.

The quality of concrete laid down into holes was checked due to test results of samples prepared from bored cores. According to compression test data the concrete streingth was about 210 to 410 kgf/cm^2. Designed compression grade is 200.

It took 3-4 days to install a column 3 m in dia and fix it into bedrock.

The columns driven to design elevation and filled with concrete were coupled by a foundation slab which served as a base for a cast-in-place concrete pier.

Foundations made of batter columns with enlarged base were implemented in a railway bridge over a broad river in a northern zone of the country.

Under the bridge area lies a stratum of fine-grain sands 10–25 m thick over Paleogene clays of stiff plastic consistency with a safe pressure of 6 kgf/cm^2. The river depth at low water is 5–9 m, at high water 10–14 m. The bridge erected the river bed at piers will be washed out to a depth of to 12 m.

Each of 13 river piers bears a span structure 132 m long. Foundations of river piers are made of batter bore columns 1.4 m in dia (rate of batter from 15:1 to 5:1) with enlarged base 3.5 m in dia embedded into Paleogene clays at a depth of 40 m from low water level (Fig. 3).

Every column is armed with a reinforcing cage 1.16 m in dia, 25 m long. Every cage is made of bars 28 mm in dia and spirals 15 cm in pitch.

Upper part of columns at a depth of 12 m. below the foundation slab is encased with a steel pipe (its wall is 10 mm thick) to protect concrete columns from sand abrasion at high water.

Compressive strength of concrete used in columns and foundation slabs is 400.

Designed load per each column is 800 tf. Static tests of columns proved that the bearing capacity of columns in soils is twice more than the designed load on a column.

Complex of operations in erecting each foundation comprised as follows :

preparation of construction site for boring equipment :
drilling of holes ;
installation of reinforcing cages ;
pouring of concrete into holes ;
excavation of pits and concreting the slab.

Boreholes were drilled with a mobile drilling machine consisted of a pile driver (lifting capacity 20 t) with a jib 35 m long containing a drilling mechanism with a motor and a hollow rod 40 m long. At the bottom of the rod is fastened an auger bucket of 1 m^3 of capacity. At the top of the bucket there are blades of expander with a hydraulic drive to close and open them.

Noles were drilled with a cyclic procedure. First they were drilled at a depth of 0.6–0.7 m, then the soil was excavated. In the process of drilling the holes were filled with bentonite slurry to protect the hole from possible sand slides. Then the hole was filled with a reinforcing cage and concrete mixture.

The top of the borehole was encased with a ring 1.7 m in dia to prevent its walls from failure.

While drilling deep there was a fear that the batter holes would be deflected. Therefore after drilling is over their alignment was checked with a special device which is widely used in oil drilling.

As observations showed the hole axis at its botton was declined from the straight line usually for 40 cm per 40 m of the hole length, which was considered as quite normal.

These deflections might have been much more if there have not been two centralizers fixed along the rod of the drilling machine.

After measuring deflections in every hole they (holes) were arranged with a reinforcing cage and casted with concrete mixture through a 0.3 m dia tremie.

It took 1–2 days to mount a pile. A foundation pit done the upper part of all concrete columns were cut for 0.7–0.8 m to remove weak concrete with grains of brocken muck.

The foundation slab then was laid down in accordance with a well known technology of erecting a bridge foundation slab made of cast-in-place piles.

SUMMARY

The article deals with the conception and execution of two large bridges. In one of them the foundations were made of columns 3 m in diameter stocketed into bedrock. In the other case they were made of bore piles 1.4 m in diameter with an enlarged base 3.5 m in diameter embedded into clays.

RESUME

La conception et l'exécution de deux grands ponts sont décrites. Les fondations de l'un de ces ponts reposent sur les faisceaux de pieux tubulaires de 3 m de diamètre et les fondatations de l'autre consistent en pieux forés d'un diamètre de 1.4 m à base élargie de 5 m de diamètre, enfoncés dans l'argile.

ZUSAMMENFASSUNG

Konzept und Herstellung von Fundamenten für zwei Grossbrückenbauten werden beschrieben. Bei einer der Brücken besteht die Gründung aus im Fels eingespannten Pfählen von 3 m Durchmesser. Die zweite Brücke ruht auf in lehmigen Böden eingebrachten Bohrpfählen von 1.4 m Durchmesser mit Fussverbreiterung auf 3.5 m.

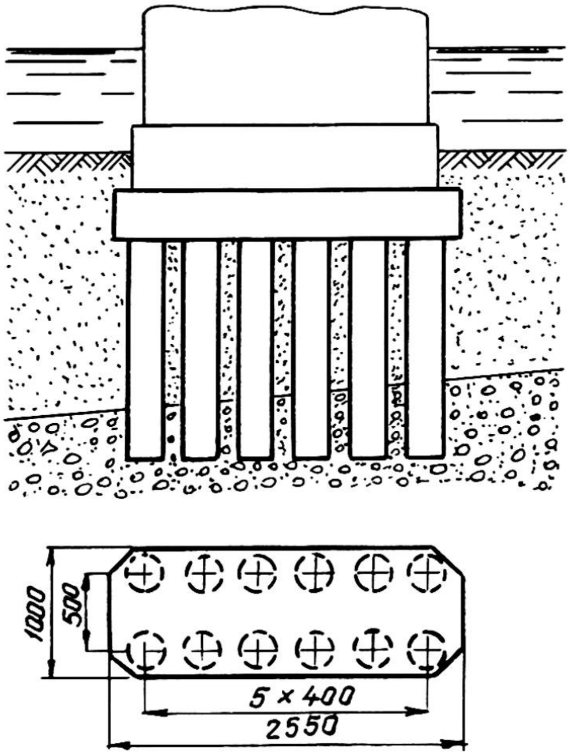

Fig. 1

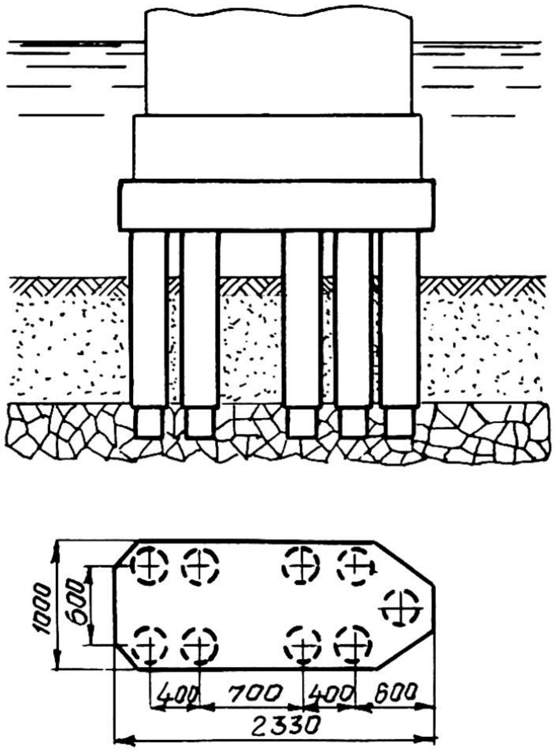

Fig. 2

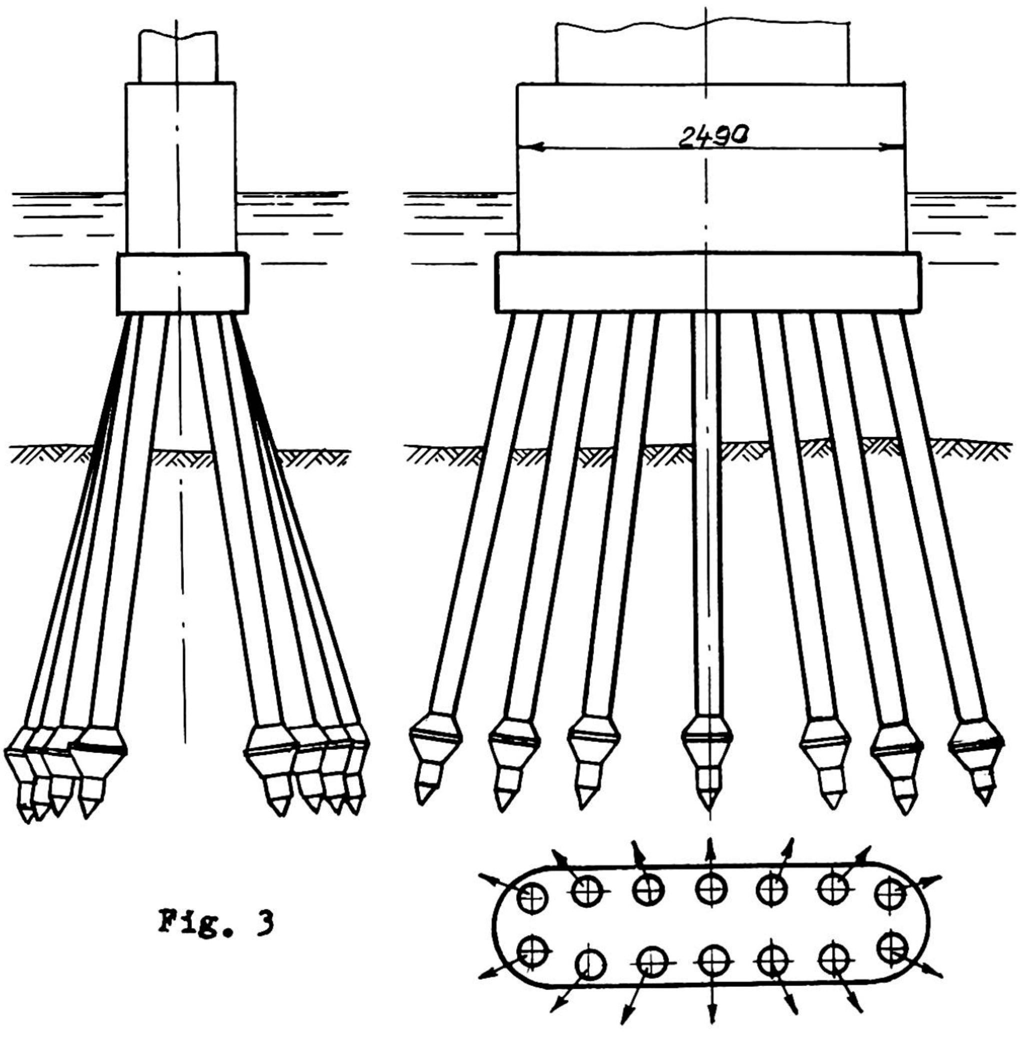

Fig. 3