POSSIBILITIES OF USING MAKESHIFT TECHNIQUES IN CONSTRUCTION OF ROOT PILES

POSSIBITES DE REALIZATION DES PILOTS DU DIAMERE MINIMES PAR DES TECHNOLOGIES MANUELLES

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SUMMARY:

Root piles can be effectively used in an array of structures in order to resolve a variety of technical problems. The equipment used in their installation is relatively simple. Despite this fact, when taking a wider view, on is confronted with the conclusion they are not applied to the exent that ought to be expected. The reason is partly the price of the installation equipment commonly in use and partly in the unfamiliarity with possibilities of adapting other, otherwise often avaiable and cheaper technologies.

The evil war presently threatening Croatia has instigated the authors of this paper to consider some of possibilities how to construct root piles making use of makeshift devices and equipment. A war is often a situation calling for out-of-series solutions, but a similar approach can also offer a suitable solution for countries being at a relatively low level of technological development and limited potential. In such situations any improvisation yielding beneficial results is an enormously favourable factor.

Making use of a number of actual cases, it is sought to present some of possibilities offering themselves in this context.

INTRODUCTION

We are witnessing a perpetual progress in building technologies, both concerning structures as a whole or their particular structural parts. This progress almost regularly goes along with the use of more and more sophisticated equipment. Economics of civil engineering operations justifies the implementation of such new technologies, notwithstanding the fact that he purchase price paid for them is sometimes quite high. Despite the final economic justifiability of procuring such equipment, it is evident that at present it comes within reach of more developed and richer societies.

Even today, a large number of countries find themselves at a development stage where they are forced to use an obsolent technology and, accordingly, obsolent techniques of building. In such circumstances a certain good and rational construction is discarded in advance, due to a lack of appropriate equipment (and, in some cases, also the knowledge) to be used in its execution. The ultimate outcome is a further increase of difference in the state of development among various countries.

One of possible ways to overcome such problems would be to build certain types of structures using the makeshift (improvised) equipment.

It turned out that, a certain effort being presupposed, it is as well possible to erect a certain structure without the customary equipment and that it nevertheless meets the expected quality standards. All being said, this can in the end also be a rational construction, despite the fact we were not able to build it in the manner and with the technology which we could have desired.

As an actual case, in Croatia we have at present a large number of structures either damaged or totally ruined during the war and these must be urgently reconstructed as cheaply as possible. They often happen to be very valuable (culture, historical) structures, so that remedial works must be of top quality and, at he same time, acceptable for the very type of structure (preservation of the original construction). The objective is therefore a high quality accompanied with a subtle remedial operation with insufficient equipment and scanty funds.

Although the Croatian situation happens to be specific (the war), from a wider viewpoint it reflects the position a large part of poorer countries presently find themselves in, so that the feasible solutions are also similar.

The paper presents certain experiences gained during remedial operations on foundation structures through installation of root piles and using the makeshift (improvised) equipment.

CONSTRUCTION OF ROOT PILES

In tecnical practice the application of root piles is in general well known, so that this paper will stress the way of their construction employing unorthodox and simple technologies. It shall be at the same time understood that the pile quality meets all presuppositions of safety and durability.

Two techniques are presented: bored and driven root piles.

Bored Piles

Drilling

Possibilities of preparing pile boreholes with the so called "vineyard" drill, which is often used in agriculture for, e.g., making holes for seedlings, holes for poles in vineyards, etc., were examined by organizing a test site.

This is a small machine, its total mass being slightly over 20 kg and measuring appr. 40 40 40 cm. Manipulation bars can be fixed to the machine sides, whilw the clamping arrangement for drilling accessories is to be found at the bottom. The engine is powered appr. 4.5 kW and the number of rotations can usually be adjusted between 25 and 300 r.p.m. It is handled by two or three manipulatiors.

Drilling down to the depth of appr. 6 m can be accomplished without greater difficulites, holding the machine by hands. At larger depths a makeshift tripod must be used. The practice has shown that with the use of tripod depths of no less than 20 m could be reached.

Tests of making the root pile boreholes with manual accessories (not employing the engine) were also made, reaching in this manner depths of appr. 6m.

Of course, the results were dependent on both the composition and characteristics of the soil, the auger diamter et sim. A large number of positive results was also achieved in incoherent materials, even in gravels.

It was realized that he original auger and rods were too heavy for manual drilling operation. Instead of these, the so called pedological augers were successfully used. These, together with the accessories, were more than one half lighter (appr. 10 kg vs. 25-30kg).

Unfortunately, operating this boring rig is in gravelly materials impossible, while the work in sand is made rather more difficult.

Depending on the soil material, boreholes had stable walls, or else the latter had to be supported by inserted plastic pipes of appropriate diamter, most often only upper parts of boreholes.

Diameters of boreholes we were making were 100, 150 and 200 mm. Larger diamters posed, as a rule, less problems.

Pile Filling

The pile filling had been accomplished in two ways: either by grouting with prepared suspensions or by pouring the "prepac" concrete.

Filling with Grout

In the process fo filling the pile by grouting with prepared suspensions, a grouting pipe (The O 14 mm plastic pipe) had been instroduced adjacently to the reinforcement rod and along the whole height, while at the upper part a short air outlet pipe would be inserted. In order to attain the pressure in the course of grouting, a pipe made of sturdy plastics or of concrete, with its diameter corresponding to the borehole diameter, would be installed in the top 0.5 to 1 m of the borehole. The pipe would be then sealed (quick-setting cement mortar), obtaining thus an improvised packing. The space between the pipe and the soil would also be sealed by ramming clay into it. Thereafter the filling compound would be pressed in by means of a grouting machine, from bottom upwards.

The compound used contained 700 kg of cement per 1 m3 of ready mortar. Its consistency was corresponding to the grouting technique. The maximum diameter of aggregate granules was 4 mm. The compound used was:
- cement 50-60%
- sand 50-40%
- swelling additive

in the mixing ratio of dry matter: water = 1:4.

After the borehole was filled up, the air outlet would be blocked, so that the pressure grew up to appr. 5 bars, measured at the grouting machine. Pressure at the borehole orifice was appr. 3.5. bars. The loss in system was appr. 1.5 bar (out of which 0.2 bar is due to the loss in grouting pipes). This is very good result, considering the improvised manner of sealing (pipe - soil).

The "Prepac" Concrete Filling

The material used was uniformly graded broken stone aggregate of the 0 15-30 mm granules. Its relative porosity was determined in laboratory: at min 0.5 and at max 0.4. On the basis of these values were subsequently analysed material consumptions, fulness of the borehole et sim.

The aggregate has been built in by manual filling of the borehole through a makeshift hopper. The filling operation was slow, in order to avoid the formation of nests.

The built in aggregate was then grouted through a small plastic pipe, from the bottom upwards. Sometimes a 0 2/3" steel pipe has been used, acting in such cases as the reinforcement. As a whole, such root pile installation proved to be a quite good solution.

During the grouting operation pressures have been reaching 2 to 6 bars. The grouting compound was prepared from cement plus an additive against shrinkage and segregation, at the mixing ratio of 40 1 of water to 100 kg of dry matter. The grouting effectiveness was monitored through the relationship between the quantity of material which has been built in and the computation volume of the borehole. At one building site, numbering 50 piles, where a detailed instrumentation had been implemented (the aggregate as previously described was used), we had the following situation:-

- number of piles	50
- diameter of drilling tools	200 mm
- average pile length	7.70 m
- average theoretical pile volume	250 dm^3
- average volume of built in aggregate per pile	235 dm^3
- average net volume of built in aggregate in a pile (n = 0,4)	140 dm^3
- average volume of the built in grouting compound	195 dm^3
- average overall volume of pile	335 dm^3
- average increase of pile's volume	33.6%

The maximum volume increase of a single particular pile was 148%. At two piles there appeared a volume decrease of 6.6 to 14.6%. On these piles we ran into a markedly loose fill and then a deposit of peat, so that the borehole has either caved in or shrinked.

Figure 1 illustrates the elementary details of the previously described piles.

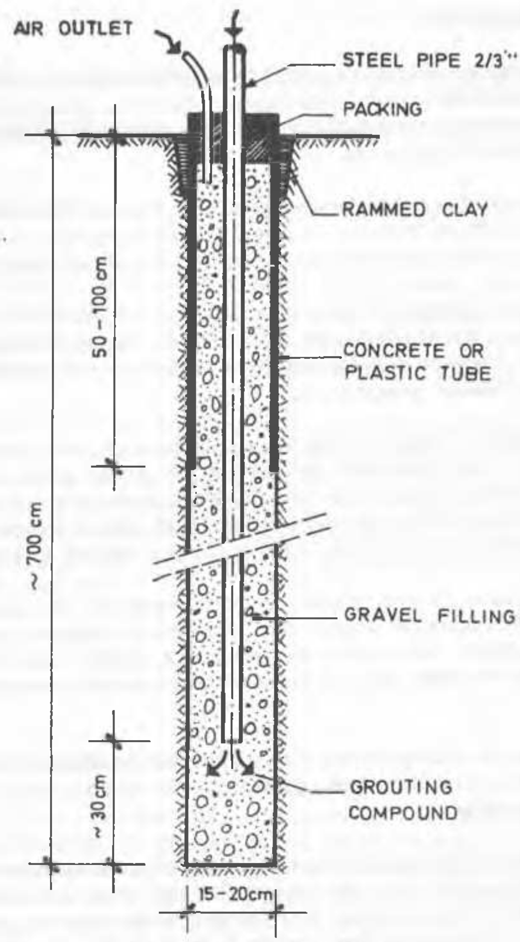

Fig. 1 The bored root pile

Driven Piles

In a certain Romanesque church in was necessary to remedy its choir pillars. As immediately adjacent to pillars old tombs are placed, no works which could desecrate their piety could have been undertaken.

An adequate solution came to the fore in form of driven piles, which had kept the disturbance of the tombs' integrity to a minimum.

Prior to the commencement of construction of root piles, an additional soil investigation had been performed, using the improvised "Häfeli" probe. Lengths of single particular piles were thereby determined in advance and such appropriate piles prepared to be driven in. Their lengths varied between 3.0 and 3.5 m.

A Ø 3" steel pipe has been used for the pile skin. The pipe's lower end has been formed into a tip and its skin perforated by a range of holes, so that the grouting compound had been able to flow out from the pile, increasing thus the friction. The steel skin was not supposed to from a permanent component part of the pile.

In order to ensure the vertical placing of the pile into the soil in course of driving, a hole of smaller diameter had been bored along the pile axis, to a depth of appr. 2/3 of pile's length. Piles were driven manually, with the hammer which is otherwise used in the course of SPT-s in soil mechanics investigations.

The reinforcement consisted of corrugated steel with guide-bars. Two plastic pipes were fixed along the bar: one along the whole length of reinforcement and the other only at its upper end. The pipe's end was sealed with cement mortar. The longer pipe's purpose was to serve for pouring the fill into the pile shaft by means of grouting, while the shorter pipe was used as the air outet. The packing at the borehole's top had to sustain grouting pressures.

The grouting had been taking place under the pressure of up to appr. 4 bars.

The following sketch schematically illustrates the structure of these piles.

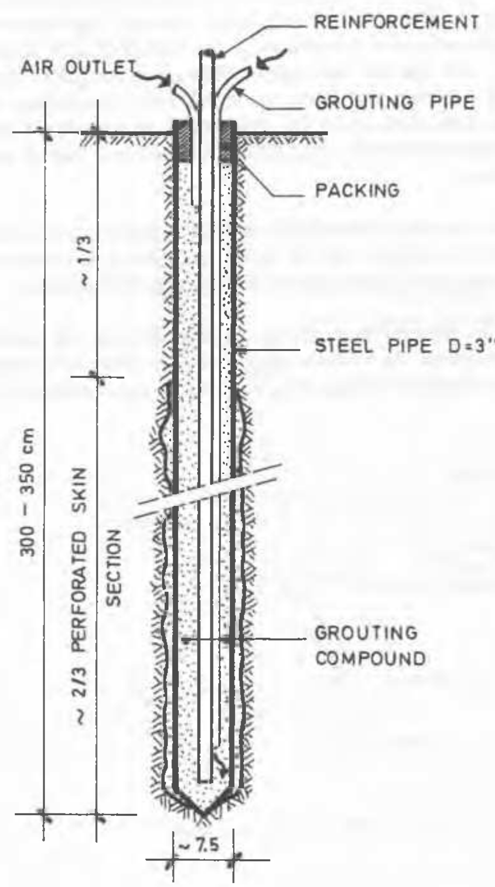

Fig. 2 View of the prefab steel root pile

GROUTING MACHINE

In accordance with what was previously said, in order to place root piles, it was necessary to provide appropriate drilling tools, as well as a grouting machine. The hand-held drill had been in use for drilling with or without its engine and boreholes had been made using the tripod or by direct manual manipulation.

For purposes of pouring the filling into the pile shaft, a grouting machine was regularly used, being usually a classical one, with continuous or phase grout feeding. In certain situations, a grouting machine with the so called pressure boiler was used. The classical grouting machine with pressure pump is ordinary a factory product, while the grouting machine with pressure boiler is relatively wasy to make at the building site itself.

So, for example, once an utterly makeshift grouting machine was fabricated in the local locksmith's shop. Its pressure boiler was concocted out of an old domestic water supply pressure unit (hydrophore) and the compressor borrowed from the local car-body spraying shop was used as the pressure building device. Pipes to serve for various connections, as well as for grouting, were ordinary transparent 0 14 mm plastic pipes. Together with the installation of a few ball valves (of the sort ordinarily used in gas fittings) and one or two manometres, a quite good makeshift grouting machine had been assemled. Such a machine allowed grouting operations up to the pressure of no less than 8 bars and such pressures are more than sufficient in more or less all remedial operations.

It can be therefore deduced that even this portion of the otherwise expensive equipment can be made available and technologically linked into an efficient unit without greater investments.

There are experinces of filling the pile directly, by means of a concrete pump. As in such cases it is very diffucult to check the achieved quality of filling, this is not to be recommended.

CONCLUSION

On certain occassions, a necessity to perform certain operations in a non-standard manner might appear. Root piles, construction of which by extremely makeshift technology is presented in this paper, is also one of such cases.

In the actual cases the installed piles were used for the transmission of vertical forces of an apps. 150 kN mangitude, while a certain nubmer was employed in remedies of shallower landslides.

Over the number of more than 200 piles constructed in this manner, it turned out that the attained quality has been very good. Besides, the piles from the test site had been unearthed and their quality checked visually as well.

An additional merit is that he equipment is of small size and weight. It was possible to dismantle it into smaller parts and to bring it even to inaccessible sites. In certain cases, such as are old urban intergrations destroyed by war, with streets where only pedestrians can move, this turned out to be a decisive advantage.

Furthermore, it was possible to start operations very quickly, without deliberation whether the "appropriate" equipment might be available. Decision on the manner of remedy used to be brought then and there and works could begin within a very short term.

In cases of damaged structures a quick commencement of the remedial operation is often a guarantee of its success or even of its appropriateness.

The experiences listed here are a product of special circumstances presently governing in our counstry, but such an approach could well prove to be a solution over a range of other situations. Apart from root piles, we believe (having at the same time the relevant experiences) that by making use of a certain improvisation it is also possible to perform a number of other constructional operations. The basic presumption here is the familiarity with a particular problem, as well as a flexible approach to its solution. The authors would be glad should this paper become an instigation to other colleagues to starts thinking along similar lines.