10 Mar 1998, 2:30 pm - 5:30 pm

Use of Jet Grouting Method for Elimination of Suffusional Destructions of Sand Backfilling of Sheet Pile Wharf

I. I. Broid
Remgydrospecstroy Co. Ltd., Moscow, Russia

G. V. Melnik
Remgydrospecstroy Co. Ltd., Moscow, Russia

Proceedings: Fourth International Conference on Case Histories in Geotechnical Engineering, St. Louis, Missouri, March 9–12, 1998.

USE OF JET GROUTING METHOD FOR ELIMINATION OF SUFFUSIONAL DESTRUCTIONS OF SAND BACKFILLING OF SHEET PILE WHARF.

I.I. Broid
Remgydrospecstroy Co. Ltd.
Moscow, Russia

G.V. Melnik
Remgydrospecstroy Co. Ltd.
Moscow, Russia

Paper No. 7.01

ABSTRACT

At the sheet wharf of Chazan port the large suffusional caverns and areas of loosy soil had been formed in sand backfilling. For elimination of them the jet grouting method had used for the first time.
It was succeeded to execute the contrsuffusional curtain of complex configuration, to discover and eliminate all suffusional caverns, areas of loosy soil and openings in the sheet pile wall with help of the mentioned method. It was developed new the jet grouting monitoring method, which allows to determine the caverns of big sizes and areas of loosy soil outlines and them locations.
The jet grouting method can be used for elimination of underground caverns, of separate openings and especially of loosy soil areas which are an impending danger what new caverns will be formed.

KEYWORDS

Sheet pile wharf, suffusional cavern, loosy soil area, jet grouting method, jet grouting monitoring.

INTRODUCTION

Suffusional destructions in ground backfillings of sheet pile wharf are the frequent appearances which create the serious problems at the ports. The causes of them are a deficient account of natural agents under a project work as well as an unsatisfactory constructional works execution. Under certain geological and geohidrological conditions combination a water levels difference can arised on both sides of a sheet pile wall. Because the suffusional phenomenons are initiated.
A ground massive which is subjected to suffusional destruction has a structure including large and small caverns surrounding by loosy soil areas. The presence of such areas is explained by what a suffusion process (especially following under small groundwater effluent) induces a soil loosening and a flux of their characteristics. After that with time a loosy soils collapse has occurred with separate caverns formation, then loosy soil is fall into the formed caverns as well as with new caverns formation. After that under continuing suffusion process new loosy soil areas are formed. Because caverns elimination by filling of them only new cavern formation doesn't can avoided even if the suffusion process will stoped.
Conventional methods of struggle against this appearance as for example, a sinking of sacks which are filled by cement into suffusional cones of a fall or a filling of caverns by hardening solutions through holes or injectors immediately are effective not always.
In this paper those questions are concerned at the example of the works which had executed in Chazan river port.

SUFFUSIONAL DESTRUCTIONS AT CHAZAN RIVER PORT.

The section of the sheet pile wharf of Chazan port at the Volga river was occurring in hazardous state. The wharf wall was constructed of Larsen-V type sheet piles with the length of 19.3 m which was drived into the ground at the depth of 8 m. A divergence of many sheet piles joints under driving of ones into pebble soil was caused of many openings in the piling formation. The greater part of those openings were placed lower of river bed.
In sand backfilling of sheet pile wall the clayey layer with thickness of near 1m was formed at the depth of near 6 m. While water levels in the port's water space was variated that clayey layer was served by impervious bed and was facilitated for water levels differences on both sides of pile sheet wall formation. That all was caused an unsteady filtration process accompanying by soil suffusion in local disruptions of the sheet pile wall continuity. Over of period of many years

suffusional phenomenon was displayed by systematic spontaneous cones of a fall forming on the surface of the backfilling. Those cones of a fall had filled by sand-gravel mixture, but that was didn't avoided against of new cones of a fall formation. In last 5 years this section of the sheet pile wharf was prohibited for ships unloading.

TECHNICAL DECISION AND WORKS EXECUTION.

In 1991 the decision was taken to use jet grouting method to construct of a contrsuffusional curtain from the backfilling side. The curtain was constructed to the depth of 21 m, 2 m below the foot of the sheet pile wall. The building site was disposed on a narrow cramped strip of the ground 0.8 m in the wide limited by the sheet pile wall and a track stringer of a crane, with the presence of the underground lateral anchor rods arranged with the interval of 1.6 m.

The special monitor with two pair of water and air nozzles spaced apart at the angle of 90 deg. was used for this work. The service nozzles were drilled with the interval of 0.8 m, so that the whole complex surface of the sheet pile wall was practically scanned by the monitor's cutting jets while rising upwards.

As a result contagious sections of the curtain were intersected. It is showed at the plane of the figure 1 .

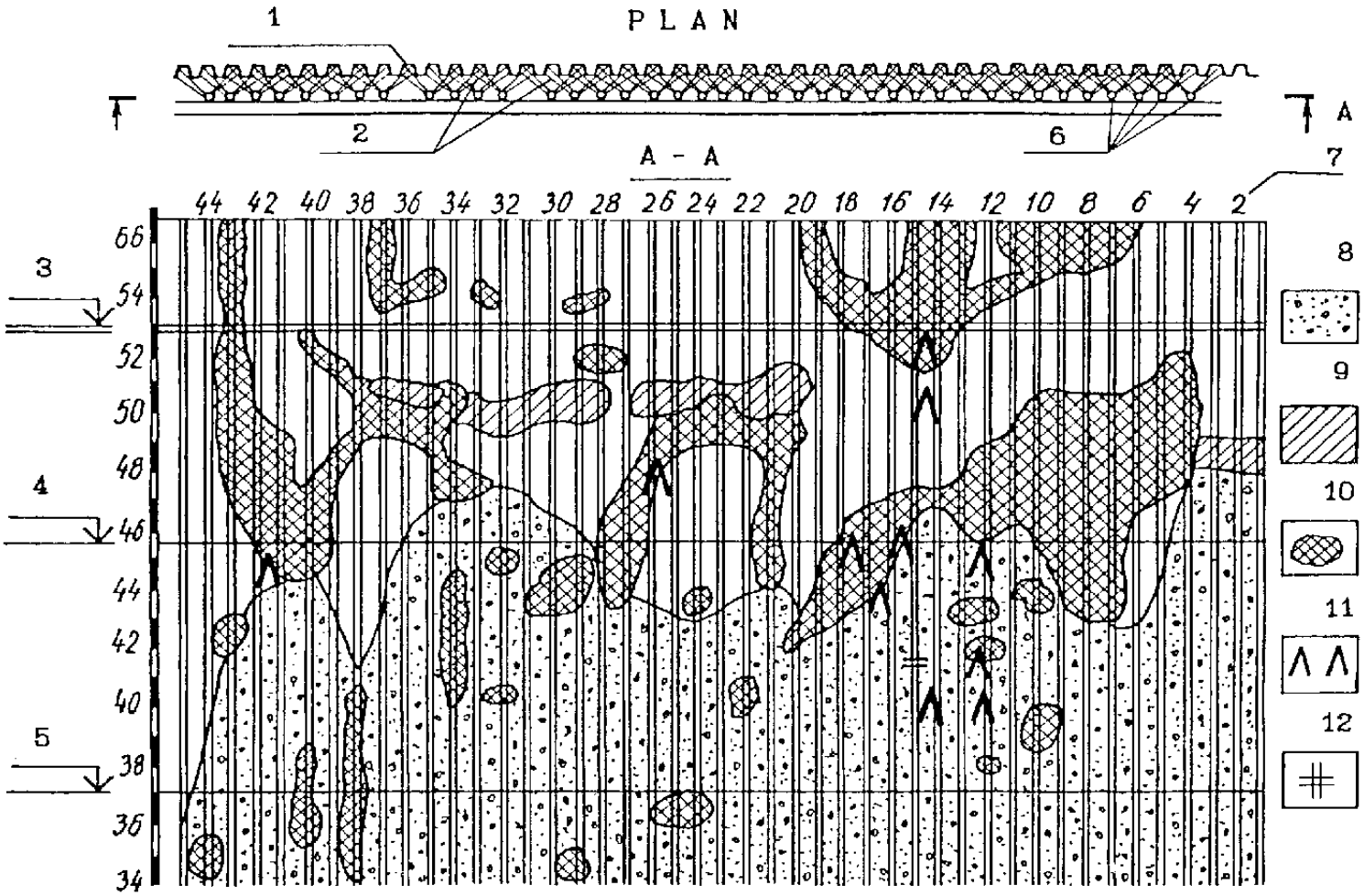

Fig. 1 Contrsuffusional curtain at the sheet pile wharf of Chazan river port. The cross-section had drowed with use of the Jet grouting monitoring results.

Contents: 1 - piling; 2 - sections of curtain; 3 - level of anchor rods; 4 - level of river bed; 5 - level of piling foot; 6 - service holes; 7 - №№ of sections; 8 - pebble; 9 - loam; 10 - suffusional cavern; 11 - opening in the piling; 12 - object of a metal.

As a material of curtain construction the clay-cement solution was choosed because this material can maintain a minimal water release, high impermeability and adjustable strength.

The experienced works were executed in 1991. In those works process the jet grouting method use was developed in loosy soil with underground caverns, with account what the available experience had been involving the method use in continuos soil only.

In the works execution any phenomenons were occurred which were by extraordinary as applied to a jet grouting method: walls of the holes collapses during drilling of ones under clayey solution, large solution absorptions, earth surface

shaking with cones of a fall formation, stop of liquid flow out from service hole, stop of aerating spout over one, an egress of solution in the river water space, a deep pit formation after a section washing up completion, a jam of the jet monitor at a large depth by collapsing soil, the spout emergence at large distances from an operating hole, a seals of monitor water and air nozzles etc. But all those difficulties were overcomed as far as understanding of the proceeding processes nature.

In the jet washing up of soil local soil collapses into existing caverns were happened as well as the collapses in loosy soil areas with new caverns formation.

The clay-cement solution feeding from the monitor, was filling the caverns and caves-in under piling, and falling down soil masses were mixing with the solution. The solution was penetrating in the suffusional passages connecting the caverns with the port's water space and sealing them - therefor a free flow injection was taking place.

The cutting jets scanning in whole surface of the sheet pile wall inevitably met the openings in the wall and they were appearing in the water space of the port, that was notice on the surface the air bubbles and a solution appearance. During the further rise of the monitor a mixture of the solution with a sand was flowing into the openings which were sealed after hardening the mixture.

Almost all sections of the curtain were made repeatedly. After performing of a due section of the curtain the solution was feeded in the hole up to the complete stabilisation. In 1992 the contrsuffisional curtain was completed with use of the developed technology.

As a result all underground caverns, areas of loosy soils as well as all caverns and the openings in the sheet pile wall were sealed. The contrsuffisional curtain in the dense soils had complex form, which was formed by the intersected sections and it was a body in the space of suffision destructions according to a form of the filled caverns.

THE CONTROL OF TECHNOLOGICAL PROCESS AND NEW MONITORING METHOD.

In the experienced works any qualitative characteristics properties of the technological process had revealed. It has determined the mutual-conclusive correspondence inter the process following in underground space under jet washing up and the distinctions of liquid and air flow over service hole. The indications of normal following of washing up of a soil and slotes filling by solution process in soils of a stable density are low height of an airating spout over a service hole forming by flowing out from it a liquid and an air and a regularity of one's pulsations (with the frequency near 1 Hertz). The pulsations frequency and their amplitude have the reverse mutual dependence.

Stop of liquid flow and from the hole indicates a total internal absorption of a feed water and a solution volumes. With a presence of the caverns or the loosy soil areas in underground space the distinction of a liquid and air flow out from hole allows to interpret the phenomenons, following there as well as a soil structure in corresponding area. So, stop a liquid flow out from the hole in presence of a airating spout indicates the presence of an underground cavern at the same depth. The renewal of a flow of a liquid indicates that the cavern upper bound is overcomed in monitor lift. Fixing the depth of a liquid flow stops and its reneval points in the different holes a vertical cross-section of the cavern can be obtained. A decrease of rate of flow out from the hole indicates a presence a loosy soil area of increased permeability. A high soil content in a liquid flowing out from the hole indicates a presence of loosy soil collapsing under the jet action . An absence of a soil solution traces in flowing out liquid indicates a presence of a cavern with stable walls, disposed lower than underground water level. The total stop of a flow of an airating spout indicates the presence of the cavern disposed higher than the underground water level.

Thus, underground space monitoring was carried out. It was named «The Jet grouting monitoring».

At the figure the results of such monitoring are showed.

At the longtitudional section of backfilling adjointing to piling, the underground caverns and cones of a fall real counters as well as positions of the openings in piling are indicated.

CONCLUSION.

The executed work results confirm that in evolution of suffusional phenomenon process an extensive loosy areas formation is precedeed and accompanied to underground caverns one.

During the process of the work on elimination of suffusional caverns it is necessary to carry out a preventive forced fall of the adjacent areas of loosy soils with a help of dynamic action, for example, with the use of a jet grouting method. That forced fall can be carried out apparently too by use of rotating liquid jet.

During the executed works the new underground space monitoring was developed. It had named the «Jet grouting monitoring».

During design works on underground caverns elimination including carst-suffusional ones it is expediently a jet grouting monitoring to carry out, that will allow to determine at the presence of the caverns of big sizes, the volume of the work and to use the appropriate equipment.

A jet grouting monitoring mus to carry out apparently by plane slots washing up with fill of ones by hardening solution, that will allows to avoid a loosening of the soil massive. It is necessary to carry out the monitoring before the works on underground caverns eliminating in order to avoid of new loosy soil areas and caverns formation.

At least, during the executed works it had developed the technology of a repair of wharfs which are under a suffusional destructions danger.