THE PROTECTION OF GROUND WATER FROM SEEPAGE OF INDUSTRIAL AND RADIOACTIVE WASTES

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ABSTRACT

The storage of industrial and radioactive waste materials presents a major problem, as many of such products have long period of decay, and present a direct threat to living organisms. The only protection from these substances is total isolation until their natural decay, which could last many years. Handling of such materials is costly and dangerous, and storage must ensure that there is no access to avoid the possibility of leakage.
A number of case histories of the application of STG clay-based grouting method for protection of ground water from seepage of industrial waste are presented along with the major principles of protection of aquifers from radioactive waste at Chernobyl Nuclear Power Plant.

INTRODUCTION

The objective of this paper is to propose the use of the STG clay-based grouting technology in the creation of engineering barrier system at the different industrial and radioactive waste dumps.

The specific grouting technology being considered was developed by STG. Such clay-based grouting technology may prove to be a significant barrier to surface and subsurface water flow and the potential resultant migration of hazardous materials and radionuclides.

Several initial applications have been identified as potential targets for the STG technology:

- The protection of ground water from seepage of industrial wastes by localising disposed wastes with sealing vertical grout walls having required depth, shape and size.
- The protection of ground water from seepage of radioactive wastes around and underneath of storage areas.

These potential applications of the STG technology are presented below.

STG CLAY-BASED GROUTING TECHNOLOGY BACKGROUND

Ukrainian government STG Agency has developed a kaolin-illite clay-based grouting technology for groundwater flow control in underground installation. The STG grouting technology has been proven effective in dramatically reducing permeability in granular or porous media in fractured rock media and in fault zones. It has been very successfully used in many applications dealing with soils and unconsolidated rock for creation of barriers to the movement of chemically contaminated, acidic, saline or radioactively hazardous liquid materials.

Over the last 30 years, STG has successfully completed over 400 large to medium to small scale grouting projects using its technology in the Ukraine, Russia and Eastern Europe Block countries, as well as USA and Taiwan. Most of this projects were performed to control groundwater inflow into underground installations. STG has also applied this grouting technology to other problem areas as waste isolation and water pollution control projects.

STG has also modified its grout injection technology to be able to construct slurry wall barriers. The key elements in the STG grouting technology revolve around grout composition, geologic, geochemical and hydrogeological characterisation and analyses of the soil or rock, and an integrated design procedure. Currently, the grout composition runs approximately 91 percent natural local clay, 8 percent cement or fly-ash and one percent special additives. The STG grout formulation and its application are customised for each project and the entire process is integrated, based on the nature of the problem, the objective of the application, and the detailed site specific information on geology, geochemistry and hydrogeology of the host ground.

The natural clay portion of the grout can be obtained from nearly any source which is available in the vicinity of the construction site. This has significant economic advantages as well because the transportation of the clay is not a high cost factor. Another important feature is that the STG clay-based grout remains plastic and unpermeable throughout its history. The grout material is also inert and non-toxic which will allow it to be used in environmentally sensitive employment.

Applications of the STG grouting in Environmental Restoration technology include the sealing of underground trench to preclude generation of hazards drainage, to containment of chemically-contaminated soils, liquids and sludges; to stabilising and isolating toxic and radioactive wastes in deep geologic media. Some of the more common problems encountered with high-cement grouts are avoided, such as breaking down under acid or basic environments and cracking due to ground movement. The low cement content of STG's normal grouting formulation creates a barrier which is less susceptible to cracking, enables the grout to remain plastic, and allows the use of special additives for corrosive or radioactive situations. Additionally, the STG high clay grout would be chemically resistant to the contaminants, virtually impermeable to contaminant outflow and long-lasting even under corrosion conditions (Spichak et al., 1993).

CREATION OF IMPERMEABLE GROUT WALL AROUND TAILINGS PONDS

The unique ware isolation properties of clay-based grout have created new opportunities for its application. Remedial operations after the construction of tailing ponds at the many are crushing and grinding mill in Ukraine were successfully completed using this grout.

Following construction of the large receiving pond N1 for the ferromanganese wastes from the Nickopol Ferroalloy Factory in Ukraine and it start-up a waste loss was observed through the dam of this pond.

Study of the situation revealed a numerous vertical fractures and cavities in the earth dam portion of this tailings pons. This fracture formed as a result of the unequal load carrying capacity of the earth dam foundation at its southern and western flanks. This flanks subsided more rapidly than the earth dam portion of the embankment.

As a result hazardous waste products with ground water are progressed into neighbouring river systems.

For protection of ground water from pollution the dam of the tailing pond was grouted using clay-based grout. According to the plan, the thickness of injected grout wall was 2 meters to 5 meters.

The vertical fractures was grouted through 216 vertical drillholes drilled to a depth of 20 meters to 30 meters (Figure 1). After the holes penetrated fractures and cavities 1035 cubic meters of clay based grout and 262 cubic meters of cement-sodium silicate grout, were injected into them. The practical results of creation of injected grout wall around tailings pond No. 1 of the Nickopol Ferroalloy Factory are summarised in Table 1.

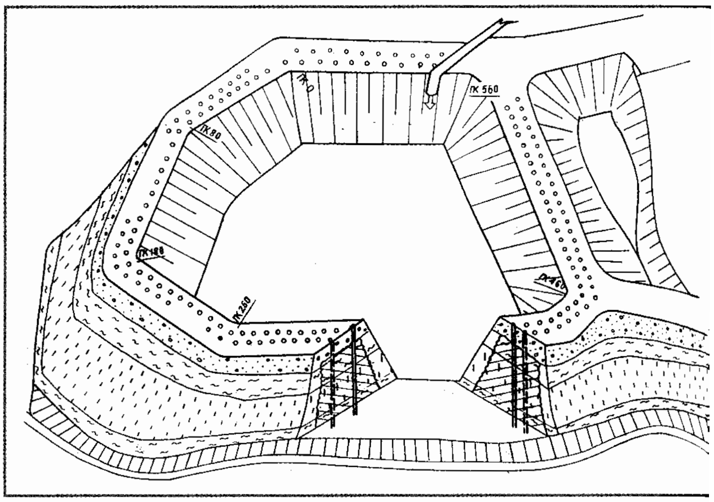

Figure 1. Arrangement of grout holes around tailing pond No. 1 of the Nicopol Ferroalloy Fac

When the grout appeared at the surface of the dam, grouting was stopped. This grouting stopped all leaks from the tailing pond No. 1 of the Nickopol Ferroalloy Factory.

Grouting operations of an almost identical nature were carried out at the many other sites to restore the integrity and permeability of the dam in slurry storage areas of their foundation.

THE PROTECTION OF GROUND WATER FROM SEEPAGE OF RADIOACTIVE WASTES

The storage of radioactive waste materials presents a major problem, as many of the products of radioactive decay have very long half lives, and present a direct threat to living organisms. The only protection from these substances is their total isolation until their natural decay, which could last for many centuries, renders them inert. Handling of such materials is costly and dangerous, and storage must ensure that there is no access to or chance of leakage or seepage from the storage area.

Flank	Intervals of grouting, meters	Type of treated soil	Calculated dimensions of grout curtain around hole, m	Quantity of grout holes	Depth of the grout holes, m	Grout injection pressure, Kg/cm^2	Volume of grout injected through each holes, m^3	
							Clay-based	cement
Southern	3-9 9-20 20-30	Loess loam, Loess	1-1.5 1.5-2.5 2.5-3	97	30	5-10 15 20	372	60
Western	3-10 10-19 19-25	Loess loam, Loess	1-1.5 1.5-2.5 2.5-3	55	25	5-10 15 20	188	102
Eastern	4-9 9-15 15-20	Loess loam	1-1.5 1.5-2 2-2.5	44	20	5-10 15 20	290	65
Northern	5-10 10-20	Loess loam	1-1.5 2-2.5	20	20	10 15	205	35
Total				216			1035	262

Table 1. Principal grouting data for Tailings pond No. 1 of the Nickopol Ferroalloy Factory.

Due to the size of underground radioactive waste dumps and storage tanks the task of removal from their present location to a prepared storage area, with all the necessary logistics and safety precautions, is costly and arduous. Access to existing dumps and contaminated areas is already restricted, but often it has not been possible to prevent leakage or seepage. The isolation of these dumps in situ is recognised as the most expedient and practical solution, as long as the isolation barrier can meet the standards needed for a final storage area.

An isolation system has been devised by STG and his partner Paurat Geotechnik GmbH, using well established mining technologies, which within a minimal operating period, effectively excavates and erects a clay-based impenetrable barrier around large or small underground tanks or volumes. Such system provides a unique, in situ solution for the treatment of areas contaminated with radioactive materials.

The new encasement system is designed to erect an underground grout wall around the perimeter of the target waste material. The wall is totally sealed off at the base by installing a water impermeable floor. The waste material is undisturbed throughout the construction process, and becomes totally isolated from the surrounding ground areas. The perimeter wall can be square or rectangular, with side length from tens meters up to several hundreds of meters if necessary. Installation of the floor can be effected at depth of up to 100 meters, subject to ground conditions. The result is a fully "boxed in" containment of the target waste material.

The installation of the new underground encasement system can best be understood by breaking the process into several distinct steps, namely:

1.- preparation of vertical or inclined trenches;

2.- erection of the underground walls; and

3.- installation of the water impermeable floor to complete the barrier.

Let us take a below presented plan as an example of creation of grouting encasement under reactors 4 and 3 of Chernobyl Nuclear Power Plant (ChNPP), Figure 2.

DESCRIPTION OF THE BARRIER INSTALLATION

The first step in the process is the excavation of a vertical or inclined trench around the Block 3 and Block 4 of Chernobyl NPP. In the example the trench is in the form of a rectan-

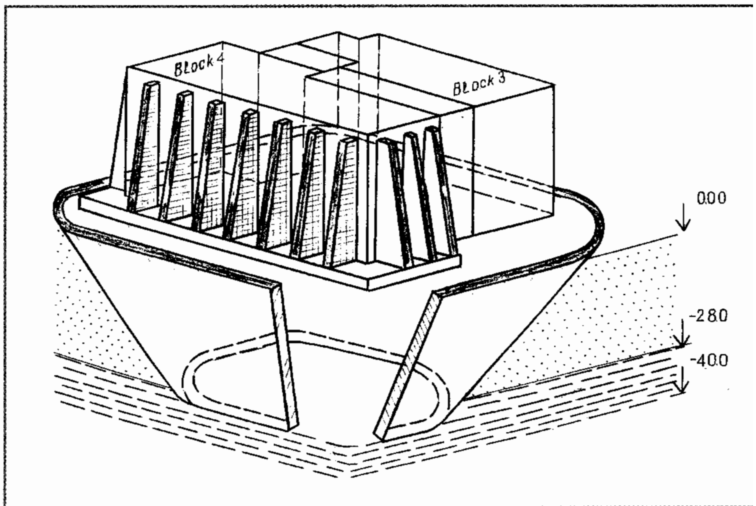

Figure 2. Encasement of the block 3 &4 of the Chernobyl NPP.

gle sides length 260 and 370 meters. The trench totally encircles the contaminated area and has a width of 2.5 meters.

The complete the excavation both quickly and accurately, the full perimeter of the trench is excavated at the same time using a specifically designed auger referred to as a Paurat Trench Helix Machine. The Helix, with their rotating cutting picks and auger configuration cut the width of the trench along its full length, whilst simultaneously conveying the excavated material to the corners of the rectangle, where it is immediately brought to the surface using bucket elevators. The cutting process is monitored closely to ensure even progress along the length of the trench, using fine adjustments in the cutting rates (Spichak et al., 1993).

The cutting process, with the ongoing addition of frames is continued until the desired depth is reached. Then the trench is progressively filled up with a STG Clay-Based Grout (the Second step).

To prevent migration of water from the area to be isolated, the Third step of the system is the construction of an impermeable floor, to cover the entire area defined by the base of the prepared trench. There are two methods (back filling and injection) which can be employed to fabricate the floor, the geological nature of the area to be isolated being the prime selection factor.

In the first method Paurat machine travelling on crawlers on the base of the trenches i. e.: a trench running down one side of the rectangular shape trench in the example. Large diameter holes, up to 80 cm, are then drilled to the base of the trench opposite using an especially designed auger, the excavated material being drawn back to the initial trench base. The excavated material is then conveyed to the lower end of the bucket elevators using a chain conveyer.

Following completion of a bore hole, the auger is withdrawn, is opposite rotation mode. Throughout the withdrawal process STG Clay Based Grout material are pressed forward to fully fill up the void created by the auger, and to compress the filled core. By boring, filling and sealing circular holes in parallel with one another, on the same horizontal plane, with a predetermined overlap, and covering the total area defined by the base of the trenches, a water impermeable floor is installed. A thicker floor can be produced by, in a similar manner, creating a second layer, overlapping the first layer to obtain maximum integrity.

SUMMARY

The above new underground encasement system offers a simple and practical solution to treatment small and large underground masses of industrial and radioactive waste materials. The quality of the resultant underground barriers completely isolate the offending waste materials, and remain in situ until natural decay renders the materials inert.

REFERENCES

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