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ELIMINATION OF CONSEQUENCES OF THE ACCIDENT AT CHERNOBYL ATOMIC STATION

LIQUIDATION DES CONSEQUENCES DE LA AVARIE A CHERNOBYL ATOMIQUE STATION

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SYNOPSIS: The questions of ecology and environmental protection become especially actual recently. Grouting is one of the important measures for protection of groundwater from radioactive pollution. "Gidrospetstroy" company carried out protective measures for elimination of consequences of the accident at Chernobyl atomic electric power station in May-October 1986. The principal of them was erection of cut-off curtain protected basin of the Pripiat river against underground filtration from polluted area of damaged reactor.

Reconstruction works gave gaint practical material and some pecularities were find out for the process of construction in extreme situation. These pecularities are recommended to be considered for objects of atomic energetics. The analysis of technology and experience of construction under radioactive pollution danger is presented.

Joint-stock company "Gidrospetstroy" took part in organization and management of activities connected with elimination of consequences of the accident at Chernobyl atomic electric power station in May 1986.

Our specialists faced 3 urgent and important problems:

1. Erection of rain canalization wells at the lower places of polluted area for interception and removal of shallow toxic groundwater.
2. Erection of additional reinforced concrete foundation plate (with colling) at the base of damaged reactor of Chernobyl station.
3. Erection of cut-off curtain for protection of groundwater and underground flow of the Pripiat river from possible radioactive pollution.

All of these problems were successfuly solved in a good time despite suddenness of the extreme situation and the lack of time for preliminary preparations.

This report deals with the problems of execution, technology and organization of activities for erection of protective cut-off curtain.

The primary important problems in unique circumstances consisted in solution of organization questions connected with the lack of dwelling, industrial and material base, repairing facilities, transport in men, communication, project documentation and all that is usually considered to be necessary for begining of construction. The situation was complicated by considerable radiation danger and extremly shortened, sometimes seemed to be unreal, period of construction. The optimum centralization of industrial structure, created by "Gidrospetstroy" and included special administration, factory of non-standard equipment, design institute and educational facilities for employees, played the decisive role in this situation.

In several days huhdreds of specialists were delivered to the place of accident and problems of their accomodation, nourishment and creation of normal living conditions were solved. Questions of communication, choice and arrangement of industrial base, repairing and depot areas were regulated at the same time. A group for control of radioactive safety was organized. Employed specialists were changed according to the rigorous schedule in order to provide security of people.

Chernobyl station is situated at the right-bank flood plain deposit of the Pripiat river with complicated geological and hydrogeological structure. Sands with the different particle size dominate in Quaternary fluvial outwash. Sands contain thin layers and lenses of clay sand and loam in the upper part of soil massif and peat deposits in some places. The total capacity of Quaternary deposit is 24-36 m. Fluvial deposit is underlayed by Kiev marl clays of Palaeogene deposit with 6-12 m capacity. The deeper layers consist of Buchaksky and Kanevsky sand underlaid by chalk.

Hydrogeological situation of this area is characterized by presence of two water tables: head water table in Quaternary sand and headless table in Buchaksky-Kanevsky sand. The average coefficient of permeability is: Kf = 4-35 m/day for the first and Kf = 8-10 m/day for the second. Water-bearing layers are separated by marl clays with low permeability: Kf = 0.001 - 0.1 m/day. Communication of water-bearing layers through separating layer was observed sometimes. The hydrogeological regimen of Quaternary water-bearing layer at the Chernobyl station site was complicated by several factors: infiltration from cooling pond, influence of existing horizontal drainage and exploitation of water table depression system.

The analysis gave an opportunity to determine that radioactive pollution of groundwater could potentialy occur as a result of following causes:

- infiltration of water used for extinguishing of fire at the place of accident and polluted during the first two hours after the catastrophe;
- infiltration of technical water from damaged systems of repair reactor;
- infiltration of water in the result of possible leakages from inlet and outlet channels communicated with polluted water in cooling pond and also the direct water infiltration from cooling pond;
- direct infiltration at the site surface of atmospheric precipations polluted by the contact with radioactive substances.

Entrance of pollution in Buchaksky-Kanevsky water table under infiltration process through the upper zone of aeration, that consisted of soils with relatively low permeability (fine grained sands with inclusions of clay sand and loam), was possible only by leaking through marl clay layer. Thus the possibility of lower water table pollution was estimated as very small. The samples of water from Quaternary deposit, that were taken at the site in June and July 1986, demonstrated the absence of radioactive pollution.

Thus the main goals of protective measures were reduced to prevention from entrance of potentialy polluted groundwater of Quaternary deposit in the Pripiat river and creation of conditions hindering leaking from Quaternary water table to Buchaksky-Kanevsky water table. More than 30 variants of drainage and grout were considered. The efficiency of cut-off curtain was determined by decrease of permeability coefficient to 0.001 m/day.

The basis for optimum choice of final variant of measures was confirmed by repeated project studies and model investigations.

Project decision,consisted of cut-off curtain in complex with drainage system, was adopted as a result of study. This decision eliminated threat of pollution of groundwater used for watersupply of great territories at the Ukraine including Kiev and other large towns at the Dnieper.

Large scale preparatory works were begun simultaneously. They included manufacture of aggregates SVD-500R, purchase of technics abroad,solution of transport problems,training of employees etc.

The following engineering preparations precede erection of cut-off curtain:

1. Fulfillment of radiation detection and deactivation of curtain's route.
2. Determination of junctions of curtain's route with communication lines and disjunction of the last.
3. Construction of temporary roads and squares.

Main activities for cut-off curtain's erection consisted of following elements:

1. Construction and assembly of equipment for manufacture of bentonite slurry.
2. Construction of foreshaft,levelling and laying of rails for SVD-500R aggregate.
3. Loading and unloading of bentonite at site's depot.

4. Assembly of the main cut-off trench equipment.

5. Excavation of trench and filling it up with lump clay.

6. Organization of repairing works.

7. Planning of the territory.

The work was organized day and night with 4 shifts and was escorted by radiation safety control services. Output of project documentation was carryed out by a design group organized in Chernobyl town.

Preparation of bentonite slurry was executed by three units equiped with native and italian ("Casagrande") machinery. One unit served for a section of curtain 700 m long in average.

Three slurry units in general provided simultaneous work of 5 aggregates SVD-500R and 6 aggregates "Casagrande". Total productivity of slurry units was up to 2300 m^3 of slurry per day or 100 m^3/h.

Aggregate SVD-500R was a self-propelled trench excavating machine of continuous action with rail track. Soil mixed with bentonite slurry was elevated from trench by airlift. Purifying of soil was executed with the help of shaking sieve and hydroextractor or special sumps.

Purchased italian equipment of sectional action (grabs aggregates with hydraulic drive S-50 and S-90 of "Casagrande" (Italy) showed its reliability and efficiency especially at the sections with junctions of curtain and underground communications,angle sections etc. Foreign equipment proved to be very productive, requiring small place and impoluting the site. Productivity of native equipment at the straight sections of route was higher than that of "Casagrande" aggregates.

The technology of cut-off curtain's erection consisted of excavation of trench under bentonite slurry preventing collapse of the walls and following filling up with lump clay by primary pouring in with the help of bulldozer.

Cut-off diaphragm was installed at the depth of 32-35 m and was penetrated for 1 m in dense marl clays. Diaphragm wall was 0.6 m thick and about 2200 m long. Filling of the trench was executed with clay of Chistagalovsky doposit situated in 7-8 km from the site (Table 1). Quality of clay for fill was preliminary tested at experimental site. Volume of the clay that filled trench was 79% of trench's volume. That satisfied requirements for quality of fill.

Table 1. Main Technical Characterictics of Cut-off Curtain Construction Under Elimination of Consequences of the Accident at Chernobyl Station

1. Length of cut-off curtain	- 2200 m
2. Depth of cut-off curtain (average)	- 32 m
3. Thickness of curtain	- 0,6 m
4. Types of used trench equipment: native - aggregate SVD-500R (of continuous action) foreign - aggregate "Casagrande" (of sectional action).	
5. Types of used bentonite	- Maharadzevsky (Georgia) - Idjevansky (Armenia) - bulgarian - Cherkassky deposit (the Ukraine) (moulding powder)
6. Number of slurry units	- 3
7. Average productivity of foreshaft construction	- 40 m/day
8. Expenditure of bentonite for 1 m^3 of trench	- 350 kg (2.2 m^3 of slurry in average)
9. Total expenditure of bentonite	- 14500 tons
10. Average productivity of cut-off curtain construction	- 30 m/day
11. Period of construction (including design, engineering preparation, main construction and planning of territory)	- May-October 1986.

Main works were executed during July-August 1986 (Fig.1). Average day productivity of trench filling with lump clay was 18 m in July and 49 m in August.

Authors' supervision, executing control of technology, quality and reliability of cut-off curtain,gave high estimation for the results of work. All actions for erection of cut-off curtain (including territory planning) were finished and adopted by customer in October

1986.

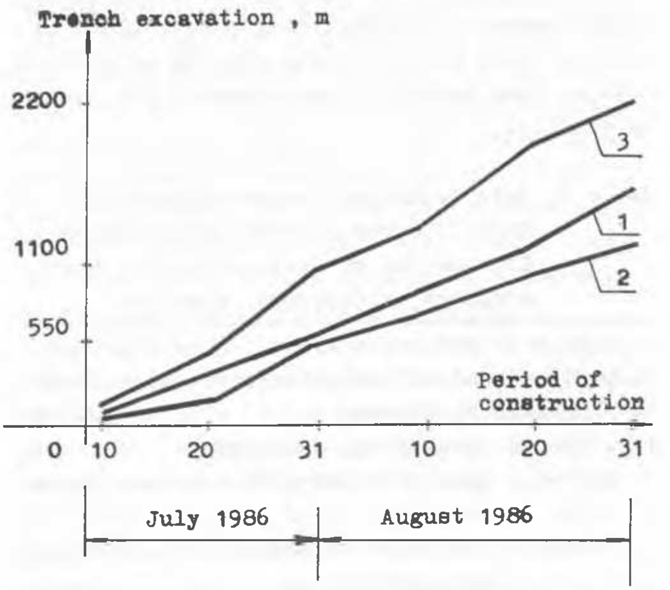

Fig. 1. Productivity of works for construction of cut-off curtain at Chernobyl station with the help of native and foreign trench aggregates: 1-trench excavation with SVD-500R aggregate; 2-trench excavation with "Casagrande" aggregate; 3-total trench excavation along the route.

The control samples from the cut-off curtain were taken 15 months later. Laboratory investigations showed that the tightness of samples was much higher than tightness of surrounding soil. That proved quality of measures.

It is worth while mentioning that the main peculiarity of reconstruction activities in conditions of high radiation danger consists in necessity to find correct technical decision and to embody it as soos as possible. Rigorous time regulations in extreme situation make it very difficult and sometimes practically impossible to find optimum technical solutions. Therefore authors,who personally took part in elimination of consequences of the accident at Chernobyl station,propose to foresee the necessity of measures preventing possibility of penetration of radioactive substances in groundwater. These measures must be reflected in design documentation and executed during construction of an atomic power station.

CONCLUSIONS

1. Generalization of experience of special activities for elimination of consequences of the accident at Chernobyl station,in spite of negative character of the fact itself,was very actual. The results of works could be considered as analysis of forced large scale experiment that demands deep practical conclusions and recommendations.

2. Additional testing of quality with the help of samples of cut-off curtain proved correctness of designed project and technology of curtain's erection.

3. The most important peculiarity of reconstruction activities in conditions of radioactively polluted zone is fast search of optimum technical solution and ability of its qualitative implementation in the shortest period.

4. Authors recommend to undertake preventing measures before the beginning of exploitation of an atomic station. These measures may include diaphragm curtain,drainage system and collecting wells for interception of polluted shallow groundwater.

5. Normal exploitation of protective system requires a net of piezometric holes. It is necessary to work out maps of isohypses,isopiezes, migration of radioactive pollution and its concentrations.

6. It is recommended for organizations participating in construction of atomic stations to foresee creation of special radiation safety services. Organizations that do not create such services must not be permited to participate in construction or reconstruction of the objects of atomic energetics.

7. Engineering,technical and working staff employed at atomic stations (exploited and constructed) must systematically take course of special training including study of behaviour in extreme situation and use of instruments for radiation control. All builders must also pass prophylactic medical inspection as the constant staff of exploited atomic stations.