Burial place for radioactive waste

V.G. Ofrikhter
B/O "Permtetcstroy", Perm, Russia

A.B. Ponomaryov
Perm State Technical University, Perm, Russia

Keywords: Case study, Environmental application, Geomembranes, Radioactive polluted soil, Solid waste containment

ABSTRACT: Thirty years ago underground nuclear charge was blasted on the oil field at the Western Urals for increasing of formation pressure and production performance of oil reservoirs. The result was radioactive pollution of the soils on the adjacent sites. The hermetic farm project was carried out for the environmental protection

1 INTRODUCTION

At the end of 60-th at one of the fields underground nuclear charge was blasted for increasing of formation pressure and production performance of oil reservoirs. The result was radioactive pollution of the soils on some areas adjacent to the equipment and pipes. This radioactive waste is classified as a I group waste (Russian code SPORO-85). For the environmental protection special measures were carried out.

2 DESCRIPTION OF THE PROJECT

The main issue was hermetic farm project. The storage was designed as a trench fully isolated from the environment.

Firstly a set of soil investigations was executed. The subsoil is clay (I_L = 0,47). The main soil characteristics are included in Tab. 1.

Table1. Soil characteristics

Characteristics	Index	Unit of measurement	Value
Water content	w	%	32
Liquid limit	w_L	%	19
Plastic limit	w_P	%	46
Plasticity index	I_P	1	0.28
Liquidity index	I_L	1	0.47
Density of soil	ρ	kg/m^3	1803
Density of dry soil	ρ_d	kg/m^3	1382
Density of solid particles	ρ_s	kg/m^3	2742
Porosity	n	%	49.63
Void ratio	e	1	0.988
Degree of saturation	S_r	%	85.1
Hydraulic conductivity	k	m/s	$4,6 \times 10^{-7}$
Cohesion	c	kPa	19
Angle of internal friction	φ	°	10

During the investigations two negative factors were revealed: insufficient filtration coefficient and possibility of frost heaving. Russian codes order clay seal of 1m thickness and $k \leq 1*10^{-10}$ m/s. During the investigations was determined $k = 4,6*10^{-7}$ m/s. For the 100% isolation reliability and safety HDPE-geomembrane antifiltering screen of 2mm thickness was designed. For the protection from radiation-chemical oxidation and untimely degradation anti-oxidant was added to the geomembrane material during manufacture.
The second negative factor revealed during the soil investigations was the possibility of frost heaving. As the heaving deformations are uneven, the resulted deformation differences on the adjacent areas are unpredictable. The frost heaving deformations are typical for the light constructions.

For the evaluation of frost heaving degree we determined the parameter $\boldsymbol{R_f}$.

$$R_f = 0,012(w-0,1) + \frac{w(w-w_{cr})^2}{w_L w_p \sqrt{M_0}} \quad (1)$$

where:
w – calculated water content in the freezing zone (before winter period);
w_p, w_L - weighted plastic limit and liquid limit
w_{cr} - critical water content;
M_0 - non-dimensional coefficient.

Using determined soil characteristics the calculated $\boldsymbol{R_f}$ = 0,0092 so the subsoil is highly frost - heaving. The heaving intensity is between $\boldsymbol{f}$ = 0,07 - 0,12

Heaving deformation is determined from the equation:

$$h_{fp} = h_{fi} \left(1 - \beta \frac{P_i}{P_r}\right) \quad (2)$$

where
h_{fr} - heaving deformation
P_i - normal pressure;
P_r – normal heaving pressure;
β - non-dimensional coefficient.

After this calculations we found that heaving deformations exceeded limited deformations.

For the protection from the frost heaving the drainage system under the farm was designed. Also this system is foreseen for monitoring as staff can indicate the changes in the underground water level during the year and its possible pollution.

Taking into account the reliability a set of pressure gauges was installed beneath the geomembrane (fig. 1). Firstly measurements were taken before trench filling and then after filling. With the help of this gauges the stress - strain behavior of the geomembrane can be evaluated.

500m^3 of polluted soil were buried into the first trench. On the first stage the trench was excavated and drainage system was installed. Then 2mm HDPE - geomembrane screen was done on the sand sublayer of 300mm thickness. The polyethylene sheets were joined by the channeled joint which was pumped later by the testing pressure. Before welding the respective welding parameters (temperature, welding speed, etc…) were determined on site and checked by the field tensiometer. During the laying and welding we used the temporary loads for anchoring and regulation (fig. 2) appeared very useful for the screen adjustment. Later they was fully removed from the construction site. The HDPE screen was protected by 300mm sand layer.

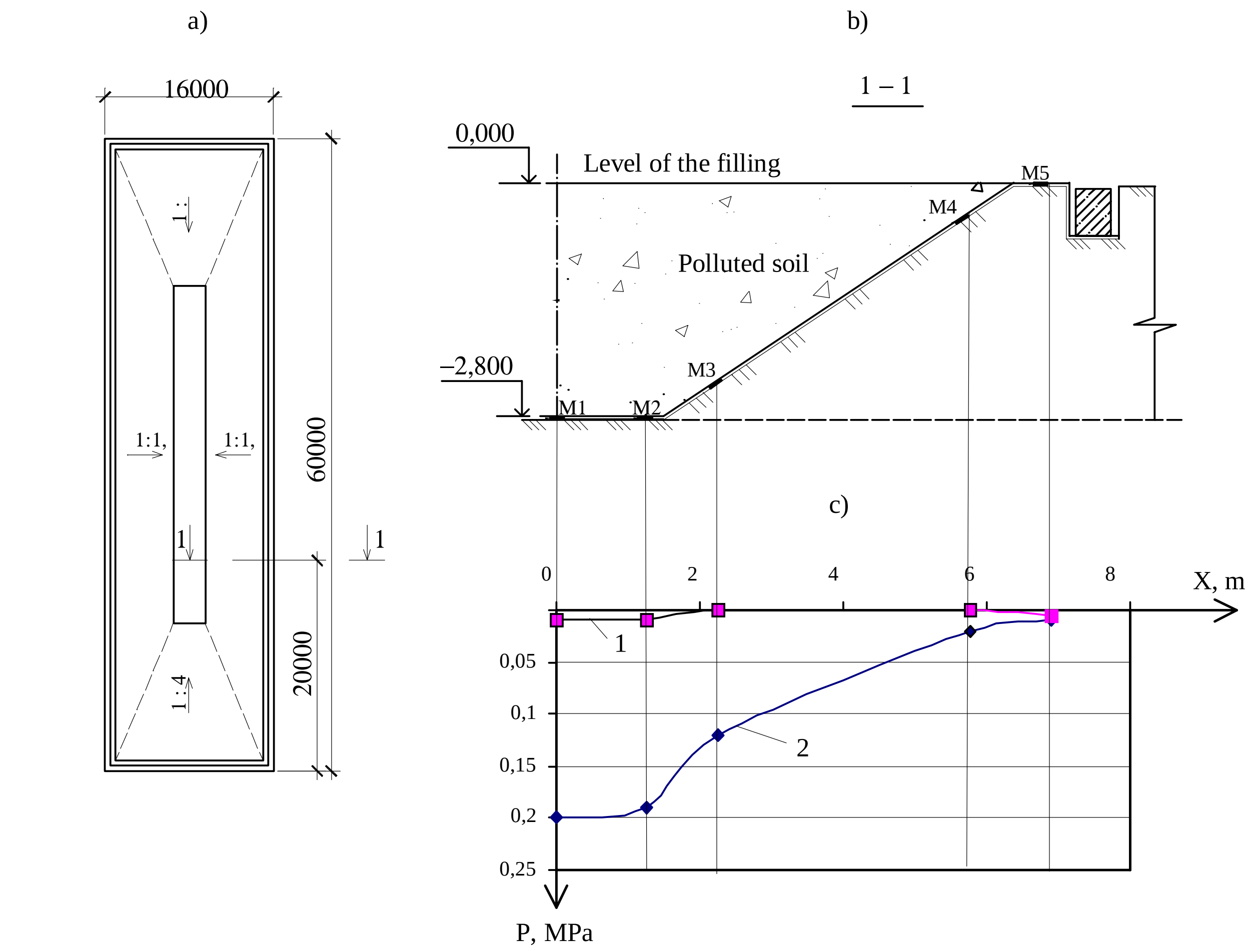

Fig.1 Normal pressure measurements
a) layout; b) pressure gauges installation scheme: M1 … M5 normal pressure gauges;
c) normal pressure curves: 1 - before filling, 2 - after filling.

Fig. 2 The isolated trench before filling

After completion of the first stage the trench was filled by polluted soil packed in plastic bags. Before burying these waste was collected during the year and accumulated in the repository. During the filling the bags were placed layer by layer. The gap of 300mm between the layer and protected trench slope was left, and then filled by the sand. The measured radiation was 700 - 800mkr/h. Polluted soil was covered by the clay layer of 500mm thickness and radiation level decreased to 20 - 30mkr/h. All works were carried out under the strict supervision of specialized laboratory and sanitary inspection. Next stage was capping. Firstly the trench was covered by the upper HDPE screen which was jointed with the bottom one by extrusion welding. After completion before capping these joints were fully tested by spark method. In another words we built the hermetic envelope around the polluted soil. (fig. 3).

Fig. 3   HDPE envelope around polluted soil

Former the trench was covered by the drainage layer, dissipative clay layer and fertilized soil for erosion protection (fig. 4)

Fig. 4 Completed farm

3 CONCLUSIONS

This project is foreseen for the 15 - years period as it consists of 15 farms. The using of geomembranes allows to reduce the durability of construction period and provides the reliable environmental protection.

REFERENCES

SNiP- 2.01.28-85 (Russian code). 1985. Remediation and burying farms for toxic industrial wastes. Moscow
SPORO-85 1985. Sanitary rules for radioactive wastes. Moscow