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Geosynthetics for disposing contaminated dredging sludge in harbour submarine basins

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ABSTRACT: The paper describes an application of HDPE liners to dispose polluted dredged sludge in the Italian harbours and meanwhile to reclaim soil. The peculiarity of the application is the installation of HDPE sheets submerged in the sea water.

1 INTRODUCTION

The paper describes an original application of HDPE geomembranes in the harbours of Italy by illustrating the steps of lining submarine basins for the disposing of contaminated dredging sludge.

Italian peninsula has about 8.000 km of shores and two large islands (Sicily and Sardinia) with many harbours distributed along the coast. Italian harbours are important for logistics on behalf of 60.000.000 Italians and the population of Central and North Europe.

Since harbours dredging sludge are polluted, the Italian authorities decided to use them to reclaim soil from the sea (instead of using landfills difficult to be located in the vicinity) based on following points:

- the design of sea areas reclamation consists in the removal of the polluted sea sediment from the subwater soil. The polluted soil is dredged as sludge and disposed in “filling basins” on the harbour side. The important advantage of such design is the harbour area enlargement in order to avoid the use of solid waste landfills;
- the above mentioned “filling basin” has to be designed like a solid waste landfill, therefore its bottom and surrounding dikes must be sealed with HDPE liner.

2 GENERAL DESCRIPTION OF APPLICATION

First installations were carried out by two Italian contractors by using HDPE geomembranes manufactured by GSE Lining Technology GmbH (Germany) and AGRU Kunststofftechnik GmbH (Austria) and complying with Italian standards. Installation procedure is developed to face problems due to high speed wind and sea storms.

HDPE liners are made of HDPE geomembranes with thickness 2.0 mm and width ≥ 7 m.

HDPE liner was selected for its high properties in terms of:

- Mechanical strength;
- Chemical resistance;
- Biological inertia;
- Elasticity;
- Durability.

The following figures illustrate the steps to build the insulated “filling basins” along the sea coast:

- Basins are first surrounded by rockfill dykes (breakwaters) and then both bottom and dikes are lined with HDPE geomembranes 2.0 mm thick (Fig. (1). HDPE geomembranes are protected against puncturing with a geotextile, in average 500 g/m^2 (Imperfoglia contractor) as illustrated in Fig. 2, or using a geocomposite formed by a HDPE geomembrane coupled with a geotextile (Macko contractor), as illustrated in Fig. 3.
- Geomembranes are laid and welded over a platform floating on the sea water level (Fig. 4) and sunk down to the bottom of basin (Fig. 5). Patented by contractor Imperfoglia.
- Basins are emptied from the sea water and then filled with dredging sludge (Fig. 6).

3 THE LIVORNO PORT AUTHORITY APPLICATION

Livorno Port Authority has provided during the last five years for the dredging of some areas of the port,

Figure 1. HDPE liner installed in an Italian harbour.

Figure 2. HDPE geomembranes (about 7 m width) are protected by a geotextile (contractor Imperfoglia).

Figure 3. HDPE geomembranes pre-coated with geotextile. Geocomposites are 2 m wide (supplier contractor Macko).

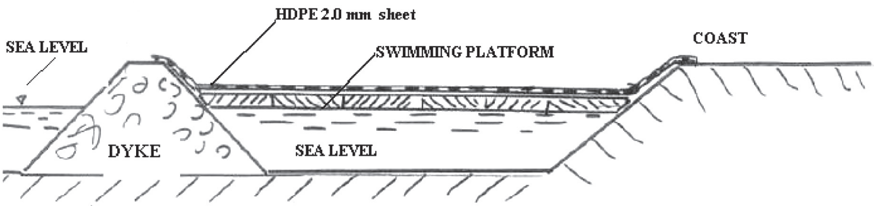

Figure 4. Laying of HDPE sheet over the swimming platform. Welding and testing of HDPE liner.

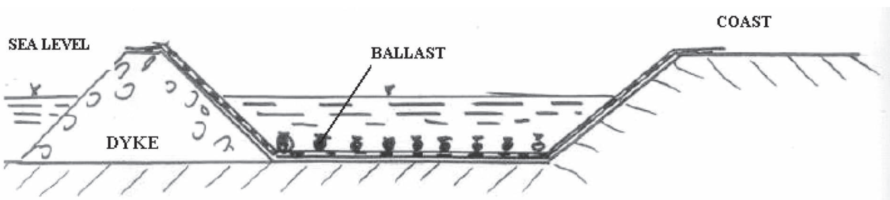

Figure 5. HDPE linear is dipped 6 m below sea level using ballast.

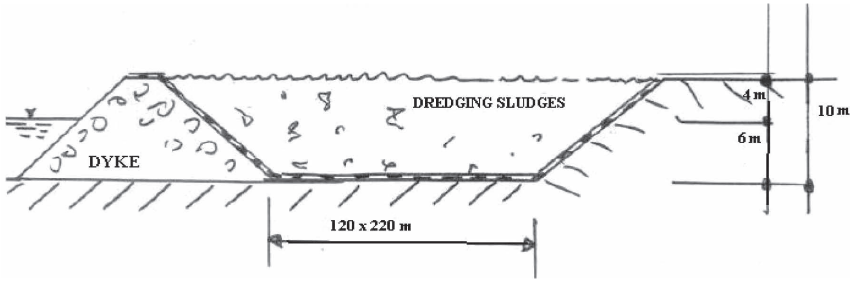

Figure 6. The sea water basin is first emptied and then filled with dredging sludge.

where the chemical-physical and biological characteristics of the substances allowed the direct spilling into the sea (Motta, 2004).

The impossibility to spill into the sea a part of the sediments, which presents incompatible values of pollution, emerged from a close analytical investigation about the quality of the further sediments to dredge, for reasons of the marine environment protection.

First of all, it should be considered that the disposal of sediments in landfills was not possible: in the first place, the quantity was so high to exclude the use of landfills in the region and in the second place because, even if this possibility was existing, it would have required excessive costs.

Taking into considerations all these facts and on the base of the Italian Ministry of the Environment guidelines, it was possible to individuate, as a final destination for the dredged sediments, the containment basin realised in the meantime near the "Toscana Dock". The works consisted in the waterproofing of only the edge of half of the basin, because this sector will receive the sediments with a pollutants content higher than the maximum levels foreseen by the Italian law DM 471, 1999 (see Table 1).

In the first phase, internal embankments to subdivide the basin were realised, considering the extension of the area. In a second phase, a HDPE geomembrane with thickness of 2 mm, placed between two layers of geotextile having protection function, was installed.

Considering the density of the materials to be dredged and the presence of water in the containment basin, realised in an external area of the port, the barrier system was initially laid down on the water surface and successively submerged with an original technique, purposely studied for this specific case.

The total cost of the waterproofing works in Livorno, financed by Italian Ministry of Infrastructures and Transportation, was about 4.250.000 €.

Table 1. Some of the pollutant maximum levels foreseen by of DM 471 (1999).

Chemical substances	Maximum levels (mg/kg)
Inorganic compounds	
Actinium	10
Arsenic	20
Beryllium	2
Cadmium	2
Cobalt	20
Chromium	150
Mercury	1
Nickel	120
Lead	100
Copper	120
Selenium	3
Tin	1
Thallium	1
Vanadium	90
Aromatic compound	
Benzene	0,1
Ethylbenzene	0,5
Styrene	0,5
Toluene	0,5
Xylene	0,5
Polycyclic aromatic compounds	
Benzo(a)anthracene	0,5
Benzo(a)pyrene	0,1
Benzo(b)fluoranthene	0,5
Benzo(k)fluoranthene	0,5
Chrysene	5
Dibenz(a)pyrene	0,1
Dibenz(a,h)anthracene	0,1
Indenopyrene	0,1
Pyrene	5
Chlorinated phenols	
Phenol	1
Dioxins and furans	
Polychlorinated biphenyl	0,001
Hydrocarbons	
Light hydrocarbons < C12	10
Heavy hydrocarbons > C12	50

REFERENCES

DM 471 (1999). "Regolamento recante criteri, procedure e modalità per la messa in sicurezza, la bonifica e il ripristino ambientale dei siti inquinati (Standards, procedures and modalities for the reclamation and the environmental rehabilitation of polluted sites)", Roma.

Motta, G., (2004). "Impermeabilizzazione di un bacino di colmata (Waterproofing of a containment basin)", Geosynthetics in Earth structures, Cazzuffi, D. and Crippa E., Eds., L'Ingegnere e l'Architetto, Proceedings of the 17th Italian Conference on Geosynthetics, Bologna, October 2003, pp. 48-49.