CURTAIN WALLS FOR RECLAMATION OF CONTAMINATED SOIL

1 FOREWORD

In Italy there are many huge old landfills of industrial wastes without a basal lining system dating back to the years with lower environmental awareness.

If the land reclamation through removal of the waste or contaminated soil is not possible due to the high volume, it is allowed to operate a containment of wastes by surrounding them with curtain walls and covering them with a capping. In this case the bottom under the waste must be a thick layer of clay.

The lecture describes one case of containment focusing on the composite cut-off wall system.

2 INSULATION OF WASTES

The sealing system was constructed in accordance with the applicable national standards. Under this regulation the landfill for hazardous wastes requires a ≥ 2.0 mm thick HDPE geomembrane on a mineral layer ≥ 2.0 m, with a permeability ≤ 10^{-9} m/s. The contaminated soil and groundwater was encapsulated by a cut-off wall up to 33 m deep and a surface capping system.

The cut-off wall was constructed as a composite barrier system with a self-hardening bentonite-suspension and HDPE-geomembrane. The system is shown in figure 1.

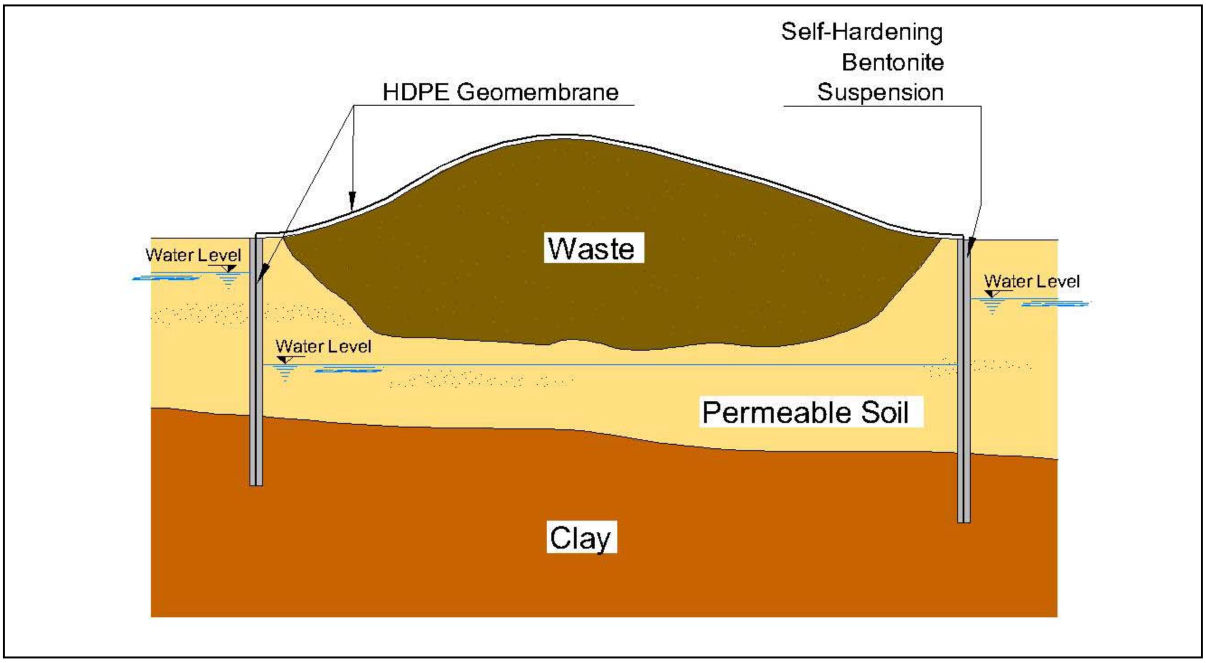

Figure 1 General section of the encapsulation system

TREVI-RODIO S.p.A., an Italian company specialized in sub soil works; used their know-how for excavating a deep trench (35 m) and in formulating a special bentonite suspension fit for receiving the HDPE interlocking panels before curing. The immersion process requires a special device (roll) for unwinding the HDPE curtain wall panels.

The components of the containment system are described herein:

<u>Cut-off wall</u>
Self-hardening mud
HDPE curtain wall panels

<u>Capping</u>
HDPE geomembrane

2.1 Self-Hardening Suspension

The suspension was designed to provide a long setting time. The self-hardening suspension consists of bentonite, cement and a specific additive.

The properties of the slurry are

- Hydraulic conductivity $k \leq 5x10^{-10}$ m/s
- resistance against the peculiar hydro-chemical conditions at site
- properties of the slurry mix were maintained over the entire depth of up to 35 m

2.2 HDPE Panels

The HDPE panel is the vital sealing element in this system as barrier for fluids and gases as well, providing durability, flexibility and excellent chemical resistance and being not susceptible to cracking. The HDPE curtain wall panels (HDPE-panels) consist of a 2.0 mm thick GSE HDPE geomembrane, fulfilling the requirements of the Italian UNI 8898/6, and welded to a HDPE-Interlock profile.

The HDPE-Interlock profiles used for the connection of the vertical wall panels have a labyrinth shape for lengthening the flow pass to 350mm into the profile. Combined with the bentonite the k-value requirements are maintained also over the cross section of the curtain wall lock.

The dimensioning of the GSE interlock was chosen so as to provide higher mechanical strength than the geomembrane itself. During construction the GSE interlock has to act as the guiding edge for the next panel to be inserted into the trench, and especially for deep trenches the shear forces reach to peak level and require a strong but simple lock. With this type of HDPE-Interlock profile cut-off walls up to 35m depth were constructed. The profile is shown in figure 2.

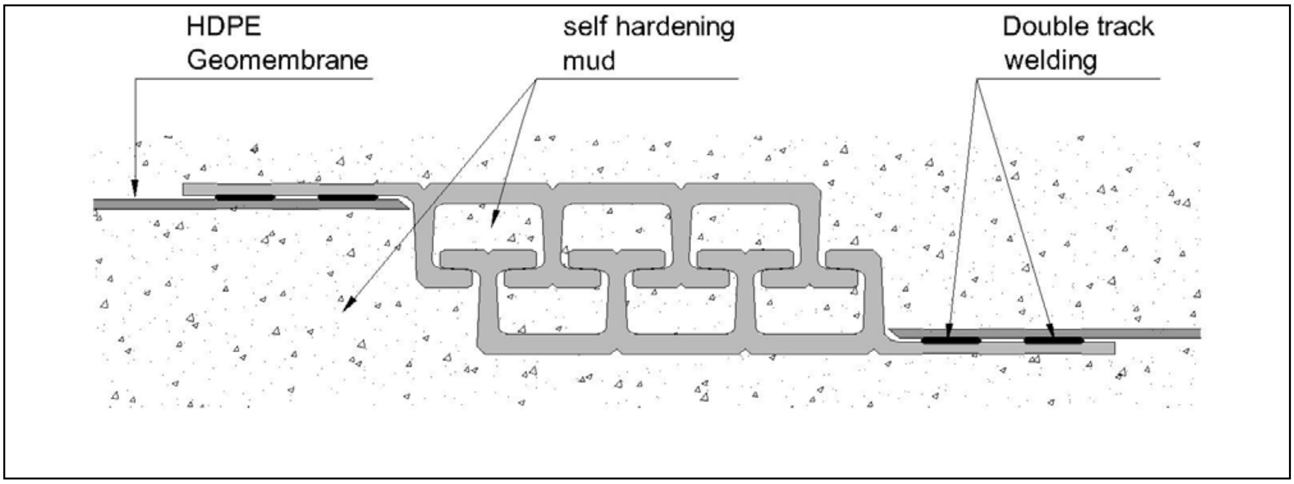

Figure 2 HDPE-Interlock profile connecting the HDPE geomembranes

In combination of the two elements the properties of the HDPE-curtain wall reaches:

- Hydraulic conductivity of system: ≤ 10^{-12} m/sec.
- Durability expectations: over 100 years.

2.3 Capping Layer

The HDPE-panels had additional length of 1 m to allow the sealing with the capping.

For the capping a 2.0 mm HDPE-geomembrane was utilized, fulfilling the requirements of the Italian UNI 8898/6 placed on a compacted silty layer, covered with a protection geotextile followed by a mineral drainage layer and the top soil layer. The GSE HDPE liner had to demonstrate that the resin formulation chosen is designed to offer a service life well in excess of 50 years.

3 THE VERTICAL BARRIER AT BRINDISI - A CASE HISTORY

3.1 Project definition

Two areas formerly utilized for the disposal of hazardous wastes in a petrochemical plant were remediated. A detailed description of the work is described by Granata and Crippa (2006). The soil and groundwater in these areas were contaminated by non-volatile hydrocarbon, solvents and heavy metals.

Within the total investigated plots, the former disposal sites that have been encapsulated have an extension of about 112,500 m² and 30,000 m².

These contaminated areas were sealed with a cap and a surrounding cut-off wall. The cut-off wall has a maximum depth of 35 m and is 0.8 m thick. The cut-off walls keys 1.5 m into the underlying natural clay – the clay horizon being located at a depth of 25 to 32 m. A continuous monitoring system to detect any infiltration through the wall and additional an emergency pumping system to maintain the groundwater level inside at a depth lower than the natural one outside were installed.

The sizes of the works on the two old landfill in BRINDISI (Italy) is shown in table 1.

	Area "South"	**Area "South-East"**
Encapsulated and capped area	30.000 m²	112.500 m²
Cut-off wall perimeter	848 m	1.526 m
Cut-off wall - Average depth	24,5 m	29,6 m
Cut-off wall - maximum depth	26,8 m	33,0 m
Total cut-off surface	20.800 m²	45.200 m²

Table 1 Project quantities

3.2 Construction of the cut-off wall

The cut-off wall was designed to guarantee as a minimum the level of safety in accordance with the National Standard in force.

It was constructed with self-hardening suspension and HDPE geomembrane, following the theoretical and practical consideration provided in De Paoli et Al. (1993).

The cut-off wall activities were carried out in double working shift, seven days a week. This allowed the installation of the HDPE panels always in the fresh self-hardening suspension, thus permitting the cut-off wall construction without interruptions, and avoiding discontinuities in the HDPE liner system. The procedure is sketched in figure 3.

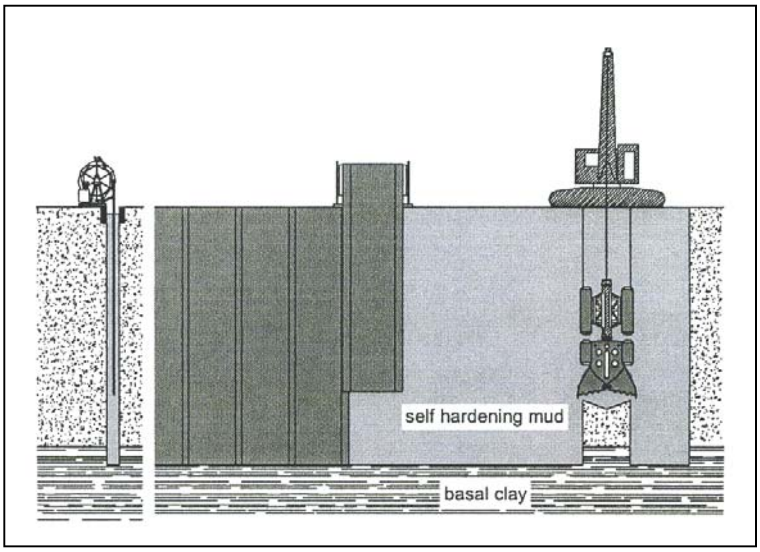

Figure 3 Construction method of a composite cut-off wall

The excavation of the cut-off wall was carried out by a hydraulically operated clamshell, 4.0 m wide, 0.8 m thick, suspended on cables. (figure 3)

Figure 4 Excavation of the cut-off wall with clamshell
(Granata and Crippa, 2006)

The cut-off walls, up to 33 m deep, were excavated through "primary" and "secondary" bites, 3.5 m spaced. The trenches, always kept full of self-hardening bentonite suspension, were excavated "in continuous", the secondary panel being excavated before the adjacent primaries had started to set. All the resulting soil was placed within the perimeter of the areas being confined.

All through the construction of the cut-off wall the bentonite suspension was under control, samples were taken from the mixing plant as well as from the trench.

Upon completion of each panel, the depth and the verticality were measured. In a conventional cut-off wall, the verticality measurement is performed, along both orthogonal axes, to verify indirectly the actual continuity of the panels. In case of cut-off walls constructed “without interruption” (fresh-on-fresh), the continuity of the wall is just given by the excavation method itself and guaranteed by the lateral movement of the clamshell and the installation of the HDPE-panels.

3.3. Installation of the HDPE-panels

The HDPE panels were prefabricated at site. The HDPE-panels having variable length function of the cut-off depth were tailored on site in the exact dimensions foreseen for their installation. After the cut, each sheet was numbered and associated to the foreseen placing site.

In the cut-off wall, the lateral continuity of the HDPE geomembrane was obtained by the HDPE Interlock profile welded by double-hot wedge welding to each HDPE geomembrane.

The welding works were performed at site by specialized, qualified personnel certified according to the national standard UNI-10567.

The prefabrication works were carried out under a shed in order to protect the combination sheet-joint from the direct sunrays that could have caused differential elongations and therefore deformations under temperature variation (figure 5).

Figure 5 HDPE geomembrane cutting and joint welding
Granata and Crippa, 2006)

The welding works/procedure as well as the on-site testing were documented in certificates. Samples were taken on site, and off-site laboratory tests on the geomembrane as well as on welds were carried out.

The tailored sheets were lowered inside the trench, filled with self-hardening bentonite suspension, by means of a specially developed piece of equipment. This is a mechanical roller, designed and manufactured by TREVIi-RODIO S.p.A., to replace the metallic frames used in the past for this purpose. The use of the roller simplifies the placing and jointing of the HDPE panels, reduces the problems related to the handling of the panels in presence of wind and allows the installation of panels longer than 20 m.

To install the HDPE panel, the roller with the panel is set at the edge of the trench. The HDPE panel is continuously unrolled and lowered in to the trench; the interlock being installed slides inside the interlock of the adjacent sheet, already in place, full of self-hardening suspension (figure 6).

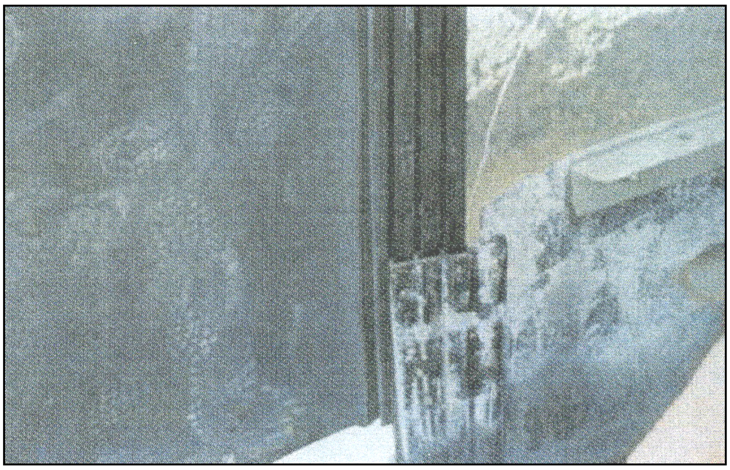

Figure 6 HDPE joint installation

The continuity of the joints is checked through a simple but effective method: a short witness semi-joint is pushed downwards by the interlock semi-joint of the HDPE panel being installed, along the groove of that already in place. The witness is tied to a rope which allows the operator to verify the correct mutual interpenetration of the two half-joints. The test is sketched in figure 7.

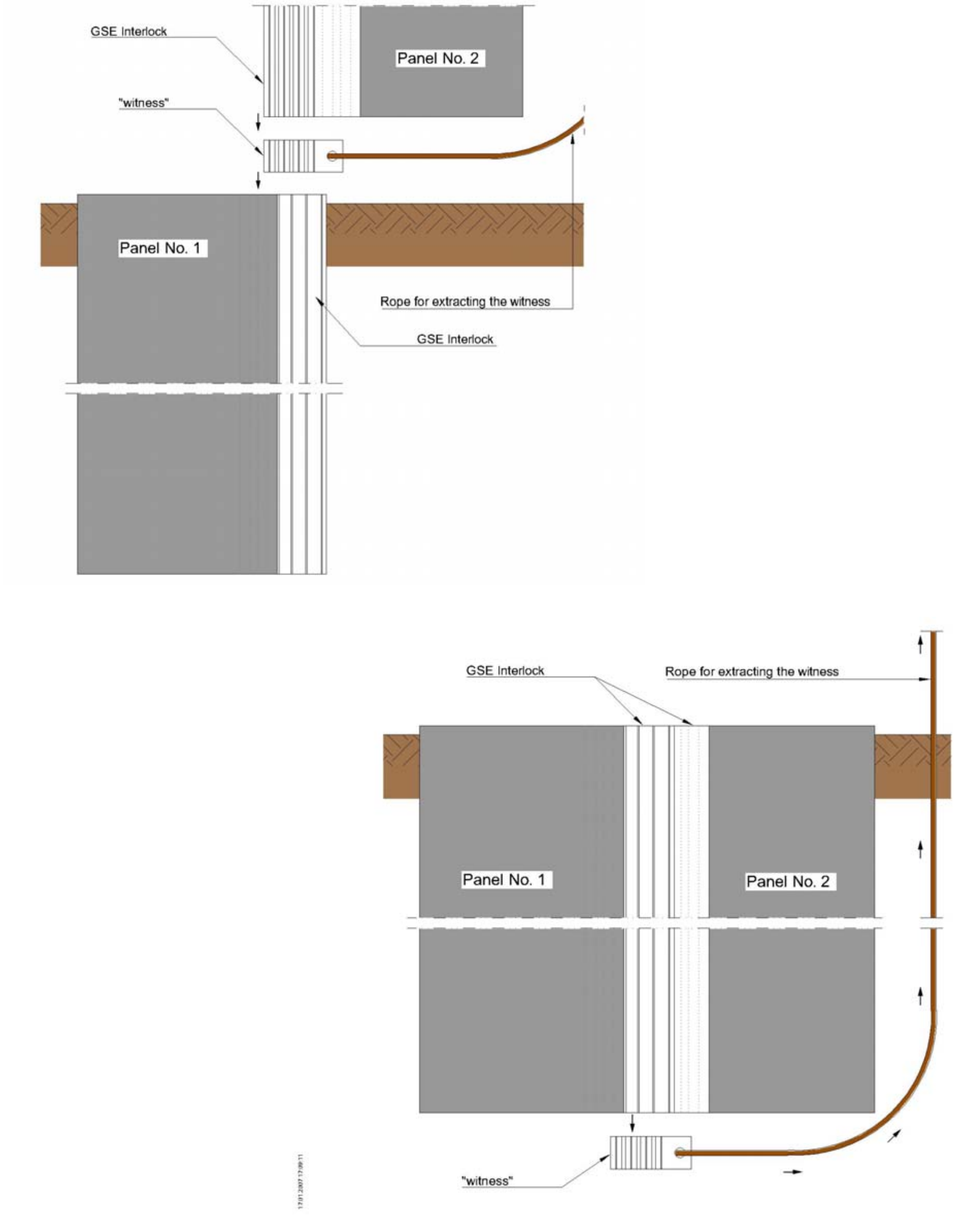

Figure 7 Check for continuity of joint

The Interlock of panel “2” has to reach the bottom of panel “1”. The test is carried out by using a “witness” (a short piece of HDPE Interlock profile). The test is positive if the “witness” can be extracted (using a rope); if discharged before reaching the bottom this can be measured by the rope length.

At the end of the installation, the sheet is unhooked from the roller and hung to supports set across the trench, until the self-hardening bentonite suspension has completely set (figure 8).

Figure 8 HDPE panels installed in the cut-off wall (Granata and Crippa, 2006)

4 CONCLUSIONS

The cut-off wall and the capping of the two areas at Brindisi were subject to a series of field tests and finally approved by the Authorities in 2003.

This system for the confinement of landfills can be considered a valid solution for the remediation of contaminated areas, in accordance with the European regulations presently in force (The Council of The European Union, 1999).

5 ACKNOWLEDGEMENTS

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6 REFERENCES

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Granata R., Crippa C., 2006, “Confinement of two contaminated sites in a petrochemical plant; case history”, Proc. “DFI 10th Conference on Piling and Deep Foundations”, pp.451-459, Amsterdam, Netherlands, 31st May-2nd June 2006