Behaviour of Lining Systems on Waste Landfills Slopes: An Experimental Approach

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ABSTRACT: Lining systems are more and more used to provide an environmental protection to the industrial and domestic waste disposals. The behaviour of such lining systems can be critical during their installation and the placement of waste. First measurements from an experimental site are described. Two lining systems, HDPE geomembrane and bentonite membrane were installed in experimental cells with slope of 1/2 and 1/1 (vertical/horizontal). As the experimental program is still in work only information on displacements and behaviour of a bentonite membrane with its protective layer is available and discussed.

1 INTRODUCTION

Recently the French regulation for industrial waste disposals has been reviewed. The use of geosynthetics as an active security to facilitate the drainage is now enforced by law. The regulation for domestic waste disposal will probably be reviewed with a similar approach. Lining systems will be installed more and more in the next years. The behaviour of these lining systems on slope is of a great importance to be well known in order they remain as an active security. Design must involve the installation which can be a critical phase and the service conditions. Design deals with mechanical behaviour, stability on slope and interaction with waste. This paper describes an experimental site on which different lining systems were instrumented to monitor their displacements on slope and by calculation strain as well as the tensile anchorage forces on top. The results will be used as far as possible to improve the French design methods of the lining systems on slope.

2 EXPERIMENTATION

The experimentation described in this paper is a part of a more complete research program performed by a French waste management company CGEA-ONYX with public laboratories CEMAGREF (Antony), Ponts et Chaussées (LRPC Nancy) and University of Grenoble (IRIGM) at the experimental site Montreuil s/ Barse. Several publications are available on this project (Le Tellier et al., 1993).

2.1 The lining systems

Four lining systems are tested in four waste cells of identical geometry. Two of them were instrumented to study their behaviour on slope in the experimental cells. Two slopes were constructed in each cell : 1/1 and 1/2 (vertical/horizontal).

In the cell using an HDPE geomembrane the protective layer will be a layer of used tyres filled with a silty sand of the site placed as the cell is filled with waste (Fig. 1)

In the cell using a bentonite membrane the protective layer was installed in the same time as the membrane in order to confine the bentonite. On the 1/2 slope a 0.30 m thick layer of calcareous gravel was used while on the 1/1 slope ; the silty sand was used with a geosynthetic alveolar structure to confine it on the slope (Fig. 1).

2.2 Instrumentation to monitor the displacements

Lining systems (Fig. 1) were instrumented to assess their behaviour during their placement and the filling with waste. A typical cross section on each slope was chosen for each described lining system.

The displacements are monitored for both liner types (bentonite membrane and HDPE geomembrane) and for the protective layers : calcareous gravel on bentonite membrane (slope 1/2) ; silty sand confined with an alveolar structure on bentonite membrane (slope 1/1) ; silty sand filling old tyres on HDPE geomembrane (slope 1/1 and 1/2 ; to be installed). A displacement profile was doubled on the HDPE geomembrane (slope 1/1) across a welding in order to analyse the influence of the welding on the mechanical behaviour of the liner.

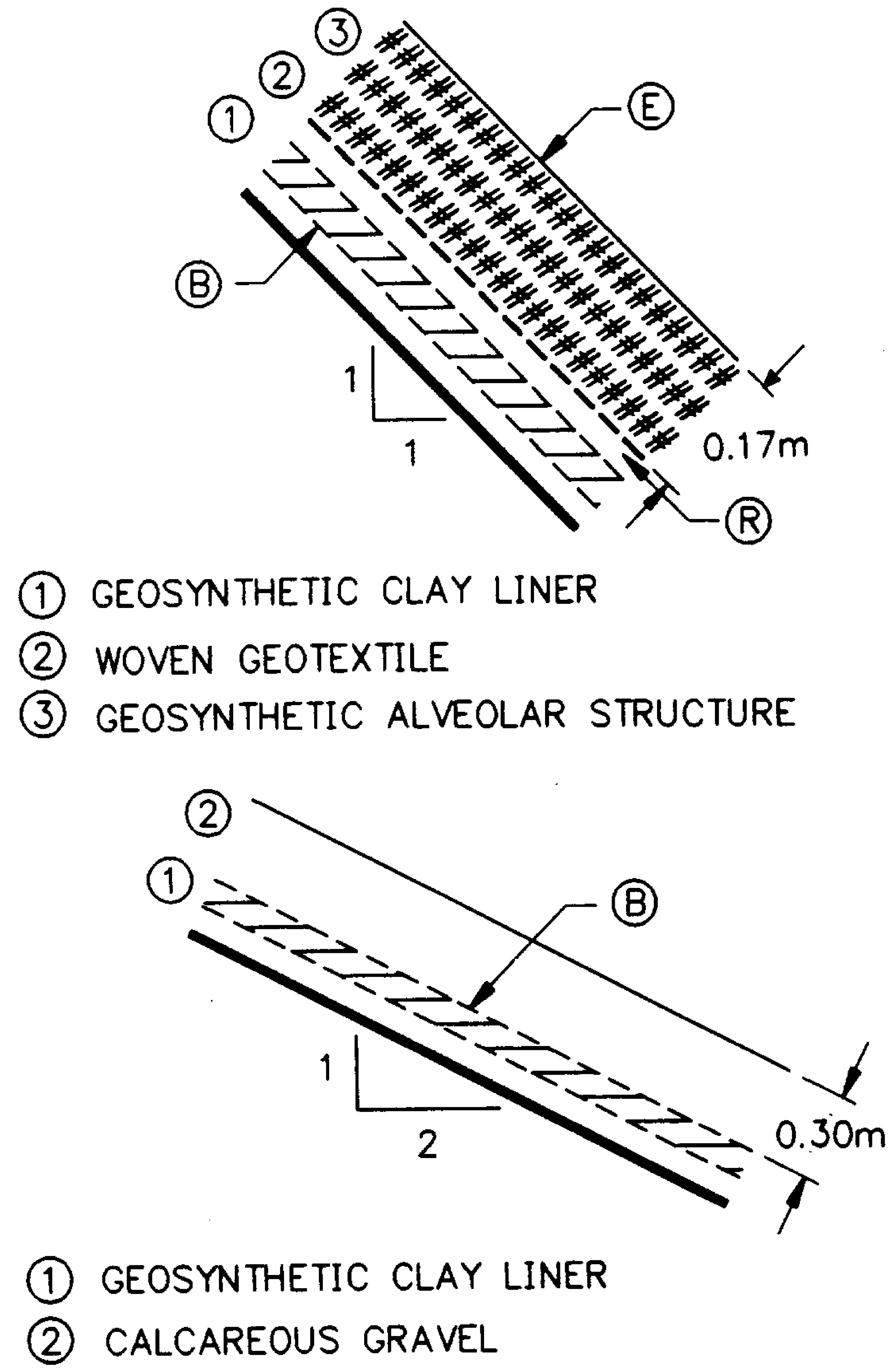

Figure 1. Instrumented lining systems on slope at the experimental site of Montreuil s/ Barse (France).

The displacements are measured on regularly spaced points on the slope, relatively to a first reference value. The spacing value between points (from 0.5 m to 0.7 m) depends on slope angle and the chosen number of points. Each point is bound with a simple cable protected by a tube in order to avoid displacement perturbation by waste displacement on it. Each set of cables of a profile both for a liner and its associated protective layer arrives in one measurement box. The human made measure is read with an accuracy of 0.001 m.

2.3 Intrumentation to monitor the tensile forces

For the HDPE geomembrane on slope 1/1, tensile forces are measured with electronic transducers. Five transducers were installed at the top of the 5 m wide band instrumented to monitor displacements. Each transducer is defined to measure a maximum tensile force of 20 kN/m.

The measure reading is human made through an electronic system and automatically translate on a digital incorparate screenplay.

3 PRELIMINARY RESULTS

At the present time waste still has not been placed in the cells. The first measurements deal with the behaviour of the bentonite membrane and its protective layer.

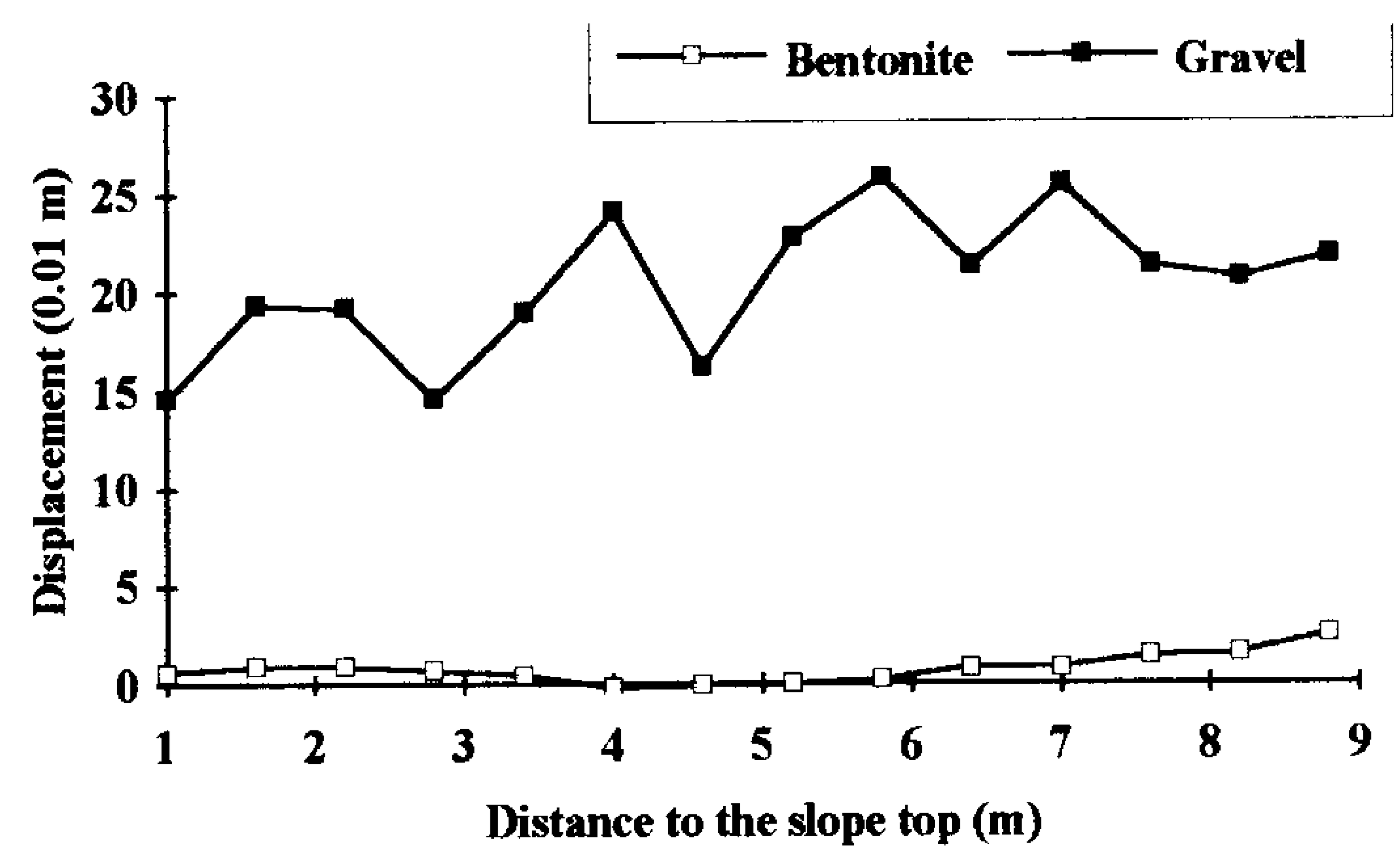

Figure 2. Lining system bentonite membrane and gravel : displacement state along the slope (1/2), 43 days after installation.

3.1 Bentonite membrane with granular protective layer

The distribution of displacement along the slope (1/2) has been drawn both for the bentonite membrane and the protective layer, 43 days after its installation (25/11/92) (Fig.2). Measurements taken until 500 days after the installation do not show significant modification. The most important observation is the great difference between displacements of the bentonite membrane which are in the range of 1 to 2 centimeters and the ones of the granular protective layer which are in the range of 15 to 25 centimeters, about ten times more.

The bentonite membrane seems to be mainly mobilized in the lower half of the slope. Average strain calculated between two points of measurement is 1 to 1.5%. At the top of the slope the bentonite membrane is not extended.

The displacement in the calcareous gravel protective layer is more or less in a linear relation with the distance to the top of the slope. It must be noted here that specific construction does not allow soil buttress at the toe.

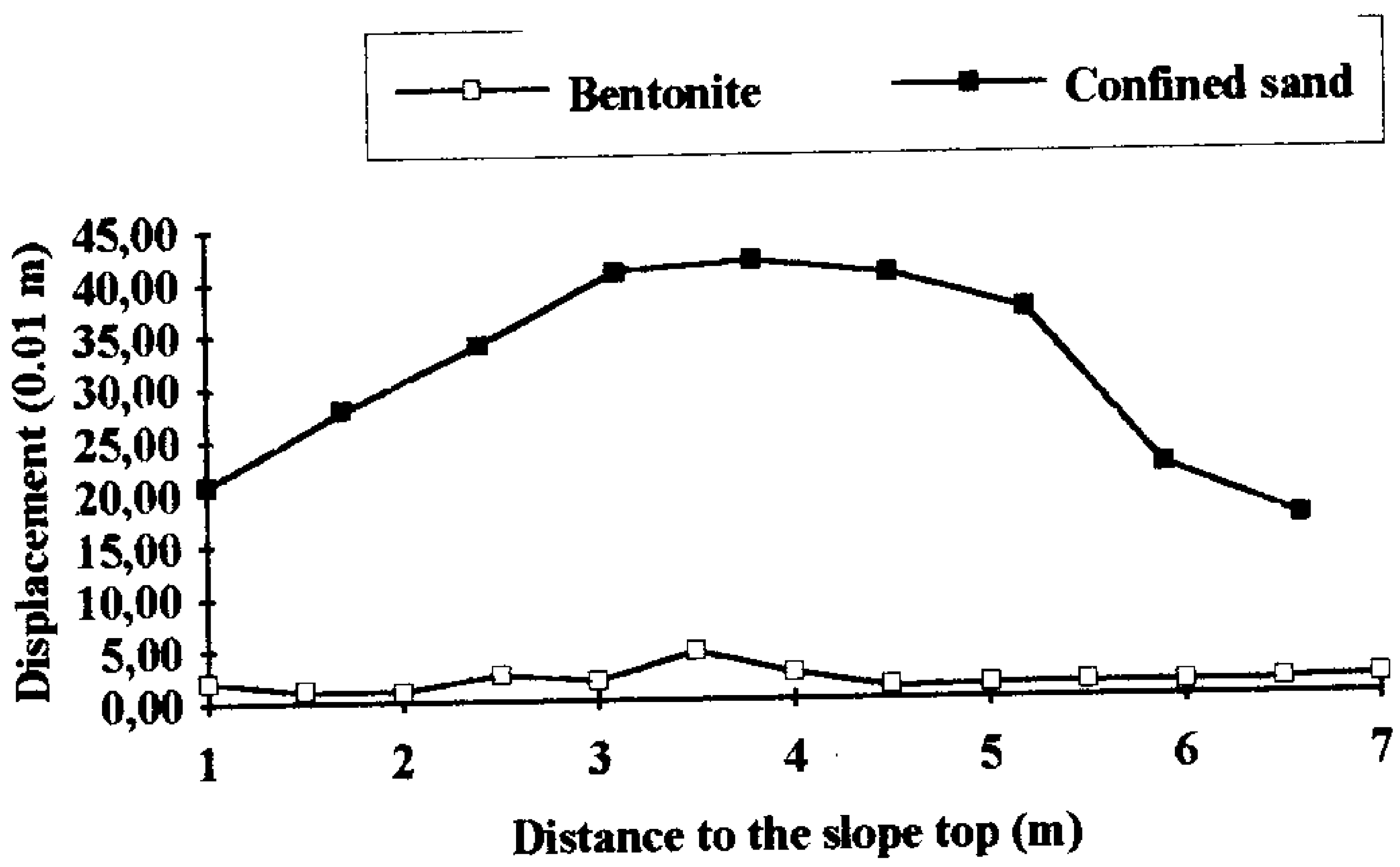

Figure 3. Lining system bentonite membrane - silty sand confined by alveolar geosynthetic : displacement state after installation.

3.2 Bentonite membrane with confined protective layer

First, the distribution of displacements along the slope (1/1) is shown both for the bentonite membrane and the silty sand confined by an alveolar structure at one date (14/10/92), 1 day after the installation (Fig.3).

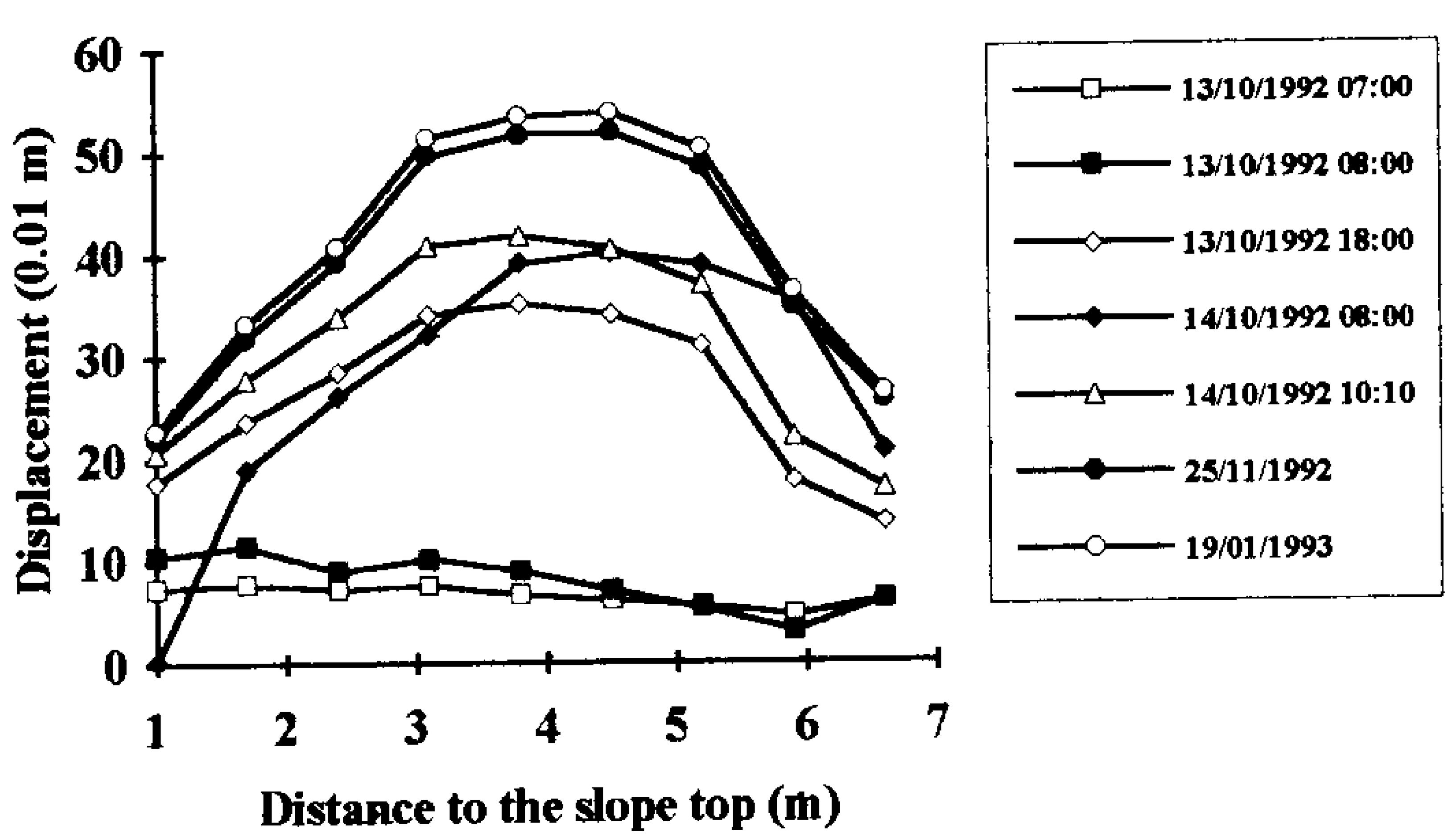

Figure 4. Displacements in time of the sand confined by an alveolar geosynthetic on slope (1/1).

Same observation as on the previous lining system can be made just after the installation. Displacements on the bentonite membrane are in the range of 1 to 5 centimeters while displacements on the confined silty sand are in the range of 20 to 40 centimeters, about ten times more.

Displacements on bentonite membrane at this time show a maximum close to the middle of the slope in a place where displacements of the confined silty sand change from increasing to decreasing. The maximum calculated strain between two points on the bentonite membrane is about 5.5%. The alveolar structure which confines the protective soil allows an equivalent soil buttress at the toe of the slope by developing tensile forces.

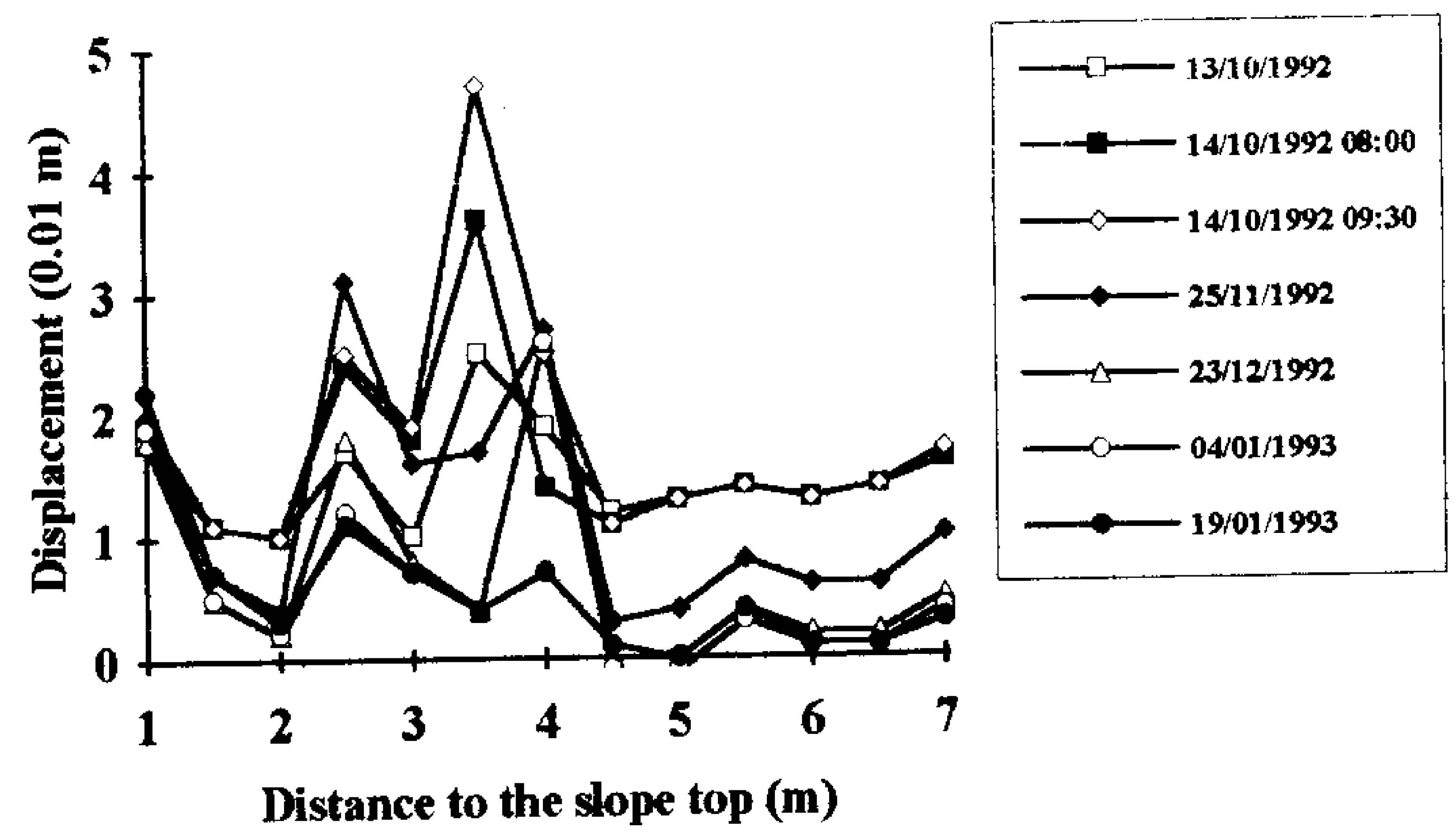

Figure 5. Displacements in time of bentonite membrane on slope (1/1).

Measurements between the installation day and the 100 days after the installation (19/01/93) give some results to be thought about. Displacements of the confined silty sand increase untill the 19/01/93, particularly in a significant manner untill the 25/11/92, 44 days days after installation (Fig.4). Further measurements in time confirm the stabilization. At the same time, after 2 days after installation (14/10/92) displacements on bentonite membrane significantly decrease (Fig.5). It could be assumed that the extrusion through the bentonite of the measurement points has occured because of the important displacements. This hypothesis must be confirmed by unearthing the cover to check the measurement points.

4 PERSPECTIVES

The monitoring system has to be completed when cells will be filled with domestic waste.

4.1 Vertical displacements of waste

The waste will be instrumented in the same profile as this one where lining system and protection displacements are, except for the HDPE welding profile. The cells will be filled by 1 m hight layers of waste. On each top of the 3 first ones one settlement cell device will be installed near the slope and one far from it (after the vertical line coming through the toe of the slope).

This system must give informations about displacements of waste along the protection layer of the lining system on slope and on free vertical displacements of waste. In such a way the displacements of each part having an influence on the lining system will be known as well as possible.

4.2 Laboratory tests

In order to characterize the friction along the slope some shear tests or inclined board tests will be completed. They concern the interface between the lining system (bentonite membrane and HDPE geomembrane) and their protection : silty sand on bentonite membrane and gravels on bentonite membrane ; silty sand in tyres on geotextile and HDPE geomembrane.

5 CONCLUSION

The current experimentation in Montreuil s/ Barse domestic waste site particularly deals with the problems of stability of lining systems on slope. The instrumentation has be designed to monitor the major parameters supposed to completely define the mechanical behaviour of the lining systems on slope.

The preliminary results which have been monitored before the waste filling show large displacements of the protective layer during the installation and the 50 first days after while the displacements of the liners are weak. The future monitoring will complete this knwoledge, particularly during waste placement and consolidation in time.

The installation of the lining system may be a critical phase for its stability and its long-term behaviour. The design methods of which a classical one is based on limit equilibrum analysis has to be improved through such completely instrumented experimentations managed in real conditions. All the informations which are assumed to be collected in our case will be interpreted to precise the installation conditions to be followed for each type of lining system and the real mechanical behaviour in time of the considered lining systems. Plus, they are supposed to be usefull to improve the design methods, particularly the one used through the software ETAGE set up by the *Laboratoire Central des Ponts et Chaussées* (Soyez et al. 1990) and based the slope stability analysis.

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