Slopes stabilization of loess and marl soils at semi-arid areas by using geo-cells - Case studies

A. Rosen
Volta Soil Stabilization Ltd., Israel

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ABSTRACT: The paper describes slopes stabilization cases of problematic soils, such as marl and loess, in a very dry area, by using three-dimensional geocells. Those areas suffer from small quantity of rain, strong windstorms, slow development of natural vegetation, strong radiation and other environmental problems, and the use of the geocells was a cost effective solution.

1 INTRODUCTION

The areas alongside the edge of the desert in Israel suffers from few critical problems:

- The weather is very dry.
- The rain period is very short, but may have strong showers.
- There are strong winds which cause wind erosion.
- There is almost no natural vegetation to protect the soil surface.
- The soils are very problematic, because of the high percentage of small particles which suffer from erosion.
- Any changes because of construction works can lead to un- predictable erosion which may cause an engineering failure.
- The erosion problems occur either in steep slopes or even in moderate slopes.

Any urban planning should take into consideration the erosion control. Solutions of high retaining walls are very expensive.

One of the solutions to protect the slopes from erosion was to install H.D.P.E geocells and to fill the cells with gravel.

Since there is possibility to adjust the number of cells per sq.m and the height of the cell wall to the slopes and the infill materials, this solution was cost effective and helped to prevent the erosion in few projects, few of them will be described at the paper hereunder.

2 SOIL AND WEATHER CONDITION

Israel is located at the eastern side of the Mediterranean. The climate is mostly dry. The rain period is very short (less than 3-4 months). Rain may appear in strong showers, sometimes within few hours each time. The intermission between the showers is very long, sometimes for few weeks, which cause the upper side of the soil to be dry and cracked with poor cohesion which can resist short storms which can hit the soil and cause rills.

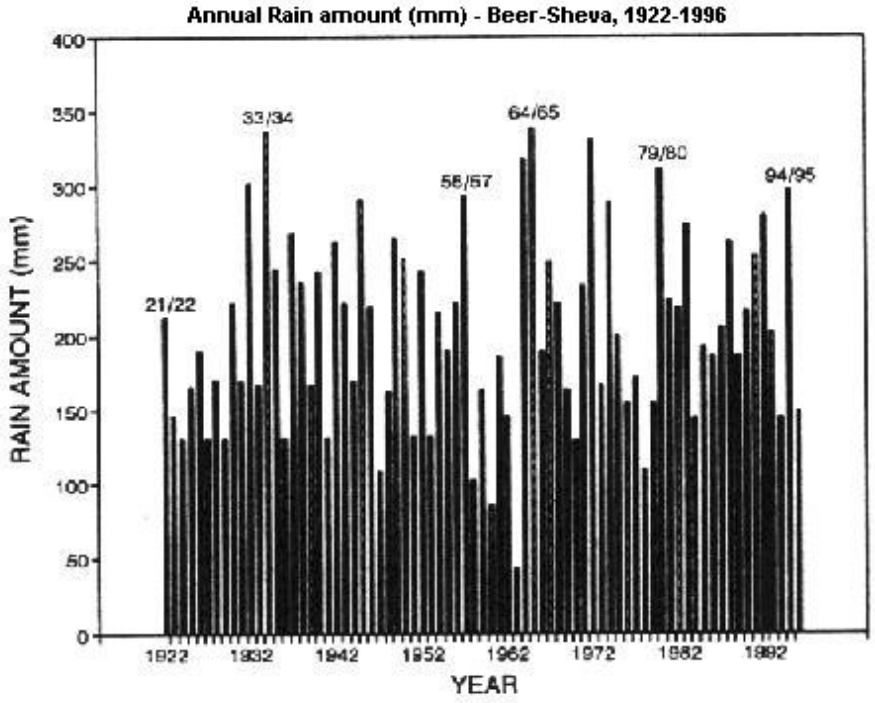

Figure 1.

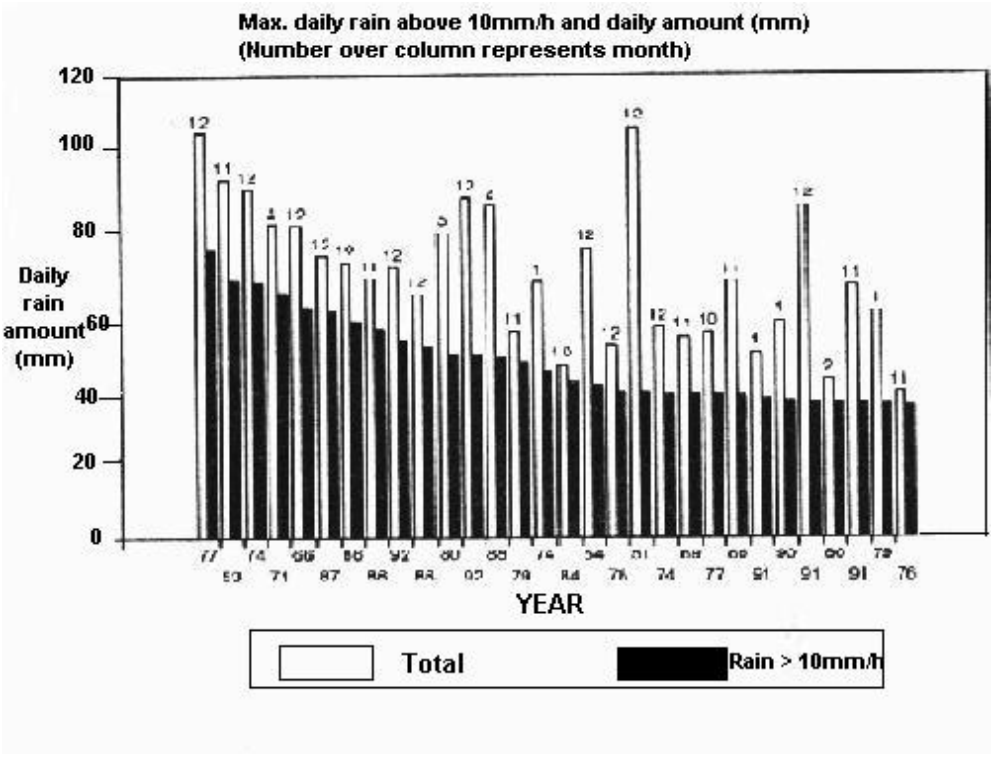

Figure 2.

The hot and the dry climate interrupt development of natural vegetation with roots which can protect and hold the soil against erosion.

The only possibility to develop vegetation is by irrigation and keeping more or less equal humidity of the soil.

Most of the soil types at the edge of the desert are loess (at the south of Israel) and marl (at the east of Israel). The loess consist of more than 87% small particles passing sieve #200 and 98% small particles sieve #100.

The soil in such dry environment is subject either to wind erosion during the long dry season or to surface flow, which cause deep grooves during the winter.

The marl also consist of more than 90% small particles which pass sieve #200 and is sensitive to changes of humidity which lead to sliding of soil and erosion.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

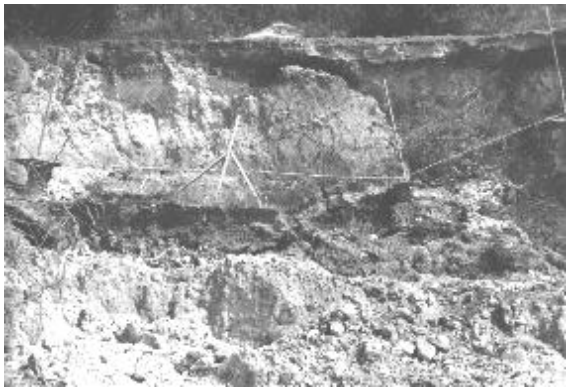

Figure 7.

3 ALTERNATIVE MANAGEMENT SOLUTIONS FOR EROSION CONTROL

In order to solve the problems of erosion, few alternatives had been offered:

- Concrete retaining walls.
- Installing of geocells filled with gravel.

- Installing of degradable coco blankets.

The retaining walls were postponed because of their costs. The degradable coco blankets were postponed because of the danger of fire.

The selected solution was the use of geocells which proved the long term solution with low costs.

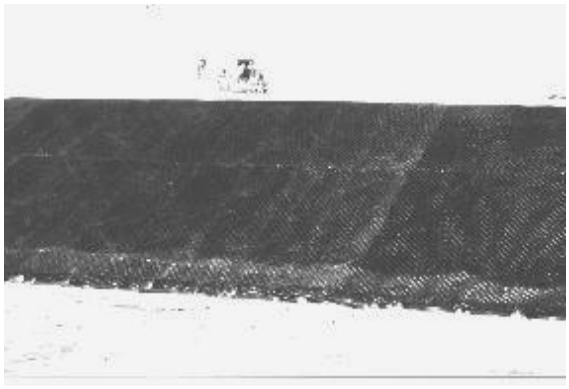

Figure 8.

4 THE GEOCELLS SOLUTION

The geocells – cellular confinement system is a three-dimensional lightweight and flexible material, made of high density polyethylene strips, ultrasonically bonded to form honeycomb. This is a geosynthetic product that is highly effective in solving many of the problems of drainage, soil stability and erosion control.

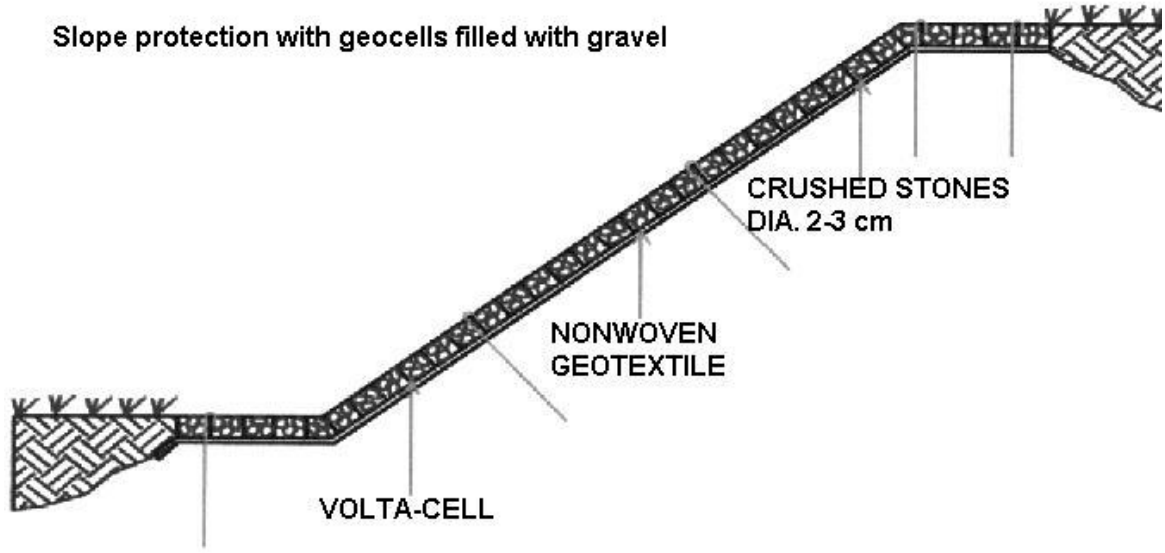

Figure 9.

5 THE INSTALLING SYSTEM

- The soil surface was leveled to final heights and slopes ready for laying.
- A non-woven geotextile was laid onto the surface of the slope and anchored. The pore size and the strength of the geotextile were adjusted to the structure of the soil.
- The geocells were anchored at the upper side of the slope and were expanded downward, for a full stretch, creating diamond shaped cells. Then the geocells were anchored at the bottom side and along the width and the length of the units.
- Each two adjacent units were joined with galvanized staples using a pneumatic stapler.
- The geocells were filled by pouring the gravel from the top downward into the cells until the cells were filled to the top.
- Inside the cells, in distance of 1-2m, trees were planted and were covered with gravel and irrigation pipes were installed.

Since the Volta-Cell cellular confinement system is manufactured in several heights and from 10 to 68 cells per sq.m, it was no problem to adjust the number of cells per sq.m and the height of the cell walls to the angle and the height of the slope and the size of the infill gravel. For example, in steep slopes, geocells with 49-68 cells/sq.m were used with good confinement. In moderate slopes, geocells with only 15-26 cells/sq.m were used, which helped to reduce installing costs.

6 GEOCELLS PROPERTIES

PROPERTIES	**VALUE**
Polymer material	H.D.P.E.
Sheet thickness (mm.)	1.25 mm $\pm$ 0.5
Number of cells per sq.m.	10, 15, 20, 26, 33, 40,49, 58, 68
Cell height (mm.)	50, 75, 100, 150, 200mm.
Carbon black	2%
Expanded dimensions of a standard unit*	Width: 2.44 m. Length 4.7 to 12.2 m
Collapsed dimensions of a standard unit*	3.35 x 0.13 m
Weight of a standard unit*	25 kg.
Minimum seam strength of a standard unit*	1000 N. (1000N. per 100 mm. of seam)
Color	Standard: black Others: upon request

Note: * Standard Unit: 40 cells per sq.m., cell height 100 mm.

7 THE RESULTS

A geocell confinement system filled with gravel effectively protects the surface of the slope for the following reasons:

- The gravel blocks the sudden blow of rainwater or the wearing effect of wind.
- The independent movement of particles resulting from the flow of water or the force of gravity is prevented.
- The system and the gravel slow the hydraulic flow within and beneath the cells.
- The system prevents piping in the soil and the development of grooves.
- The system and the gravel maintain a more or less constant moisture content in the soil, thereby preventing the phenomenon of swelling and settling of the soil and cracking.
- The system remains flexible and durable for a long time.
- The roots of the vegetation could be established and the gravel kept the needed humidity for them.

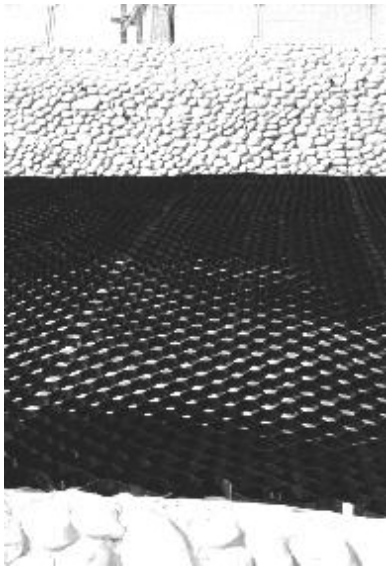

Figure 10.

Figure 11.

Figure 12.

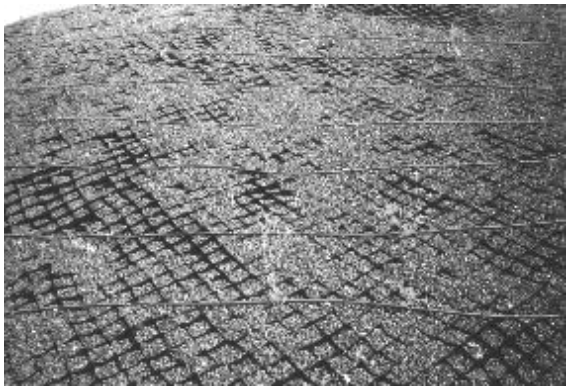

Figure 13.

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