" USE OF GEOCELLS TO PREVENT SOIL EROSION "

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ABSTRACT

This project delves into the field of application of Geocells in India to prevent erosion along the slopes. A report by the United Nations Convention to Combat Desertification (UNCCD) tells us that about 33% of India's total land area was undergoing degradation in 2011-12. Considering the vast potential that our country has in the field of Agriculture, and the propensity of disasters to take place along eroded slopes, this is a matter of concern. This project elaborates on the use of Geocells to eliminate the problem of erosion along the slopes, minimizing disasters like landslides and making infrastructure development sustainable. Cellular confinement systems —also known as geocells—are widely used in construction for erosion control, soil stabilization on flat ground and steep slopes, channel protection, and structural reinforcement for load support and earth retention. Geocell products are three-dimensional, expandable panels made from high-density polyethylene (HDPE), polyester or another polymer material. When expanded during installation, the interconnected strips form the walls of a flexible, three-dimensional cellular structure into which specified initial materials are placed and compacted. This creates a free-draining system that holds initial materials in place and prevents mass movements by providing confinement through tensile reinforcement. Cellular confinement systems improve the structural and functional behavior of soils and aggregate materials.

It is also Cellular Confinement Solutions and the technology is growing ever since. After different experiments, some polymer based alloys have been designed that are strong enough for load and good enough for the technology. The alloy and other different materials are in use for making strong Highways and even Railways in different parts of the world. The use of Geocell is also very significant in slope protection. It is one of the most popular methods for the earth retention walls in the modern civil engineering methods.

Key words: Cellular Confinement Systems, Erosion, Geocells, Slopes, Polymer.

I. INTRODUCTION

Cellular Confinement Systems are popularly known as "Geocells". Geocells are strong, lightweight, three dimensional systems fabricated from ultrasonically-welded High Density Polyethylene (HDPE) strips that are expandable on-site to form a honeycomb-like structure (Fig. 1).Geocells are filled with compact non-cohesive soils which are confined within the cellular walls. The composite forms a rigid to semi-rigid structure. The depth of the geocells as well as the size of each cellular unit can vary as per design requirements Research and development of cellular confinement systems (CCS) began with the U.S. Army Corps of Engineers in 1975 to devise a method for building tactical roads over soft ground. Engineers found that sand-confinement systems

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performed better than conventional crushed stone sections and they could provide an expedient construction technique for access roads over soft ground, without being adversely affected by wet weather conditions. The US Army Corps of Engineers in Vicksburg, Mississippi (1981) experimented with a number of confining systems, from plastic pipe mats, to slotted aluminum sheets to prefabricated polymeric systems called sand grids and then, cellular confinement systems. Today cellular confinement systems are typically made from strips 50–200 mm wide, ultrasonically welded at intervals along their width. The CCS is folded and shipped to the job site in a collapsed configuration. Efforts for civilian commercialization of the cellular confinement system by the Presto Products Company, led to the Geoweb. This cellular confinement system was made from high density polyethylene (HDPE), relatively strong, lightweight and suitable for geosynthetic extruding manufacturing. The cellular confinement system was used for load support, slope erosion control and channel lining and earth retention applications in the United States and Canada in the early 1980s. Geocells with soil or concrete infilling provide an effective erosion protection system. Geocells filled with concrete can be shaped to form waterways to route storm water along slopes and embankments to prevent formation of gullies and ruts which can weaken the earth structure. Soil degradation in India is estimated to be occurring on 147 million hectares (Mha) of land, including 94 Mha from water erosion, 16 Mha from acidification, 14 Mha from flooding, 9 Mha from wind erosion, 6 Mha from salinity, and 7 Mha from a combination of factors. This is extremely serious because India supports 18% of the world's human population and 15% of the world's livestock population, but has only 2.4% of the world's land area. Despite its low proportional land area, India ranks second worldwide in farm output. Agriculture, forestry, and fisheries account for 17% of the gross domestic product and employs about 50% of the total workforce of the country. Causes of soil degradation are both natural and human-induced. Natural causes include earthquakes, tsunamis, droughts, avalanches, landslides, volcanic eruptions, floods, tornadoes, and wildfires. Human-induced soil degradation results from land clearing and deforestation, inappropriate agricultural practices, improper management of industrial effluents and wastes, over-grazing, careless management of forests, surface mining, urban sprawl, and commercial/industrial development. Inappropriate agricultural practices include excessive tillage and use of heavy machinery, excessive and unbalanced use of inorganic fertilizers, poor irrigation and water management techniques, pesticide overuse, inadequate crop residue and/or organic carbon inputs, and poor crop cycle planning. Some underlying social causes of soil degradation in India are land shortage, decline in per capita land availability, economic pressure on land, land tenancy, poverty, and population increase. In this review of land degradation in India, we summarize (1) the main causes of soil degradation in different agro-climatic regions; (2) research results documenting both soil degradation and soil health improvement in various agricultural systems; and (3) potential solutions to improve soil health in different regions using a variety of conservation agricultural approaches.

II. MATERIALS PROPERTIES

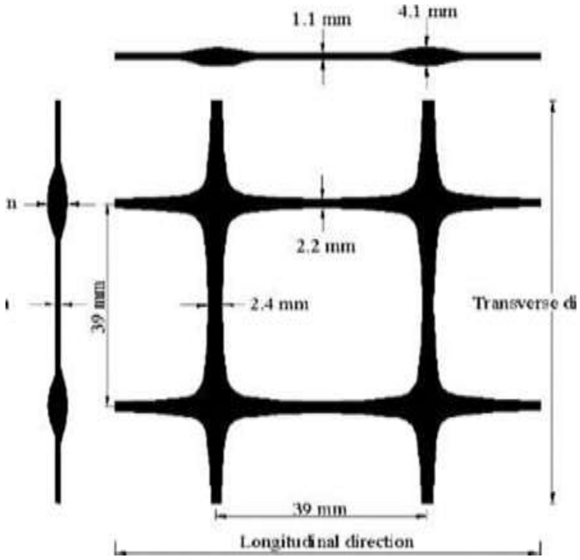
3.3.1. Presto's GEOWEB Systems:

How doGeocells Work to Stabilize Soils?

Through an interconnected honeycomb-like network, 3D geocells confine and stabilize soils that would otherwise be unstable under loading. Geocells are efficient and economical for fast-built unpaved roadways and retaining walls, erosion control of slopes, and stormwater control in channels.

3.3.2 The Original Geocell Soil Stabilization System

Presto Geosystems invented geocells in the late 1970s and has been leading geocell technology ever since with important product advancements, design, and construction accessories for higher performance and faster installation. Presto's GEOWEB system is the industry's 'most complete geocell system' designed with fully engineered components to withstand the most challenging site problems. Made from robust high-density polyethylene (HDPE) since conception, GEOWEB geocells offer the highest, longest-lasting, and most proven performance of any geocell system in civil applications.



. 3.3.3. TopSoil

Topsoil is the upper, outermost layer of soil, usually the top 5–10 inches (13–25 cm). It has the highest concentration of organic matter and microorganisms and is where most of the Earth's biological soil activity occurs. Topsoil is composed of mineral particles, organic matter, water, and air. Organic matter varies in quantity on different soils. The strength of soil structure decreases with the presence of organic matter, creating weak bearing capacities. Organic matter condenses and settles in different ways under certain conditions, such as roadbeds and foundations. The structure becomes affected once the soil is dehydrated. Dehydrated topsoil volume substantially decreases and may suffer wind rosion.

Soil properties	Values
Clay (%)	13
Silt (%)	17
Sand (%)	70
Carbon (%)	0.599
C/N ratio	13.011
OM (%)	1.0773
Total nitrogen (%)	0.046
Total phosphorus (ppm)	33.206
Total potassium ($\mu eq \cdot K \cdot g^{-1}$)	1.2153
Exchangeable calcium ($\mu eq \cdot K \cdot g^{-1}$)	19.254
Exchangeable magnesium ($\mu eq \cdot K \cdot g^{-1}$)	28.964
Moisture content (%)	4.163
Field capacity (%)	20
Wilting capacity (%)	10
Bulk density (g/cm^3)	1.59
pH	5.2

III. RESULTS AND DISCUSSION

A Cellular Confinement System when infilled with compacted soil creates a new composite entity that possesses enhanced mechanical and geotechnical properties. When the soil contained within a CCS is subjected to pressure, as in the case of a load support application, it causes lateral stresses on perimeter cell walls. The 3D zone of confinement reduces the lateral movement of soil particles while vertical loading on the contained infill results in high lateral stress and resistance on the cell-soil interface. These increase the shear strength of the confined soil, which Creates a stiff mattress or slab to distribute the load over a wider area Reduces punching of soft soil.Increases shear resistance and bearing capacity Decreases deformation Confinement from adjacent cells provides additional resistance against the loaded cell through passive resistance, while lateral expansion of the infill is restricted by high hoop strength. Compaction is maintained by the confinement, resulting in long-term reinforcement. On site, the geocell sections are fastened together and placed directly on the subsoil's surface or on a geotextile filter placed on the subgrade surface and propped open in an accordion-like fashion with an external stretcher assembly. The sections expand to an area of several tens of meters and consist of hundreds of individual cells, depending on the section and cell size. They are then filled with various infill materials, such as soil, sand, aggregate or recycled materials and then compacted using vibratory compactors. Surface layers many be of asphalt or unbound gravel materials.

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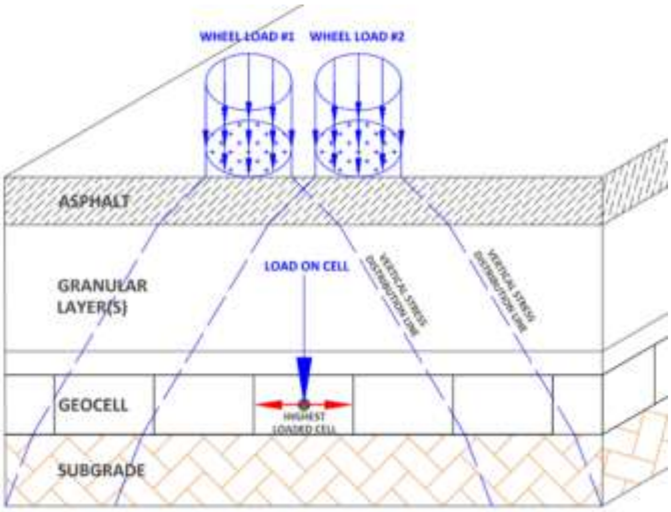
Test.1 – How can I validate my design will not reach its failure point before the end of the design life? How can i ensure achieving this result at minimum cost?

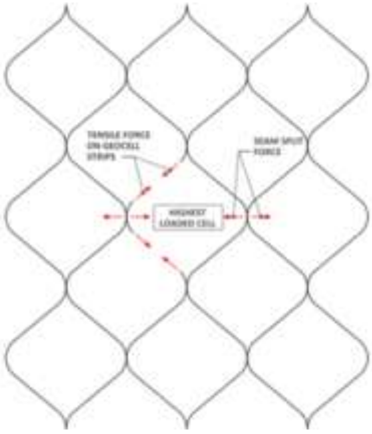
Lets examine a load support incident to anwer this question.



We can see at the pic above that part of any vertical load on any of the cells is transferred to lateral load turning to hoop stress on the cell wall.

Therefore, the cell integrity is dependent on cell hoop stress. Consists of:

Tensile Force on Geocell Strips .Effective actual force on seam



Therefore the structural Engineering solution will consist of Stresses cause strains on the designated structure.

Calculate the accumulative strains (deformations) throughout the design life.

Measure: Accumulative deformations < Calculated Failure Point.

Calculated Failure Point is dependent on the application (1%-3%).

Test.2 – Which Lab tests results can assure that my project will not fail prematurely?

There are couple of existing geocell stiffness tests to answer this question.

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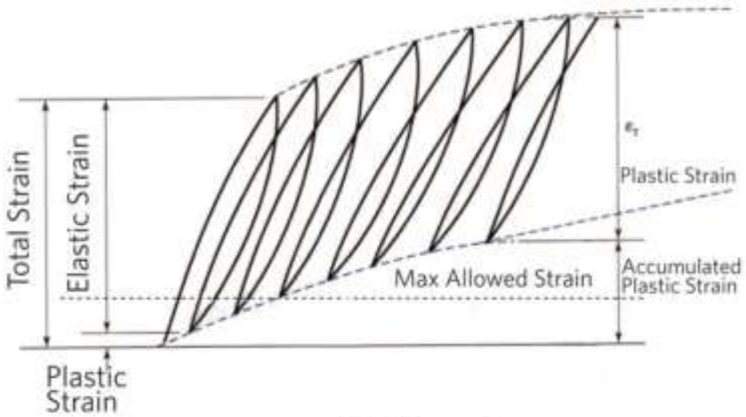
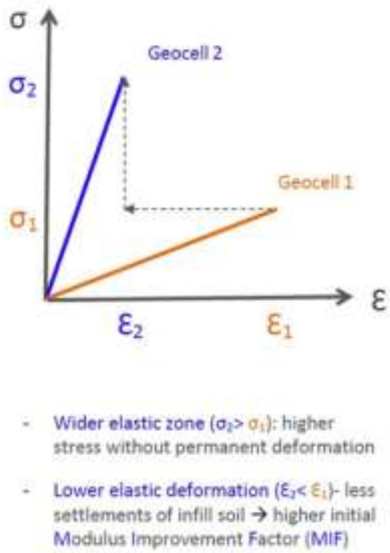
Elastic (Dynamic) Modulus Range: Test ability to apply accumulated loads on geocell walls prior to plastic deformation Plastic (Permanent) Modulus Range:Verify that accumulated plastic deformation does not reach failure point during project design life.



Elastic Recovery Curve

Elastic (Dynamic) Modulus Test.

Elasticity is tested by DMA (Dynamic Mechanical Analysis).This method is widely used in the automotive, electronic, military and aero-space industries.This test is adjusted to the needs of each specific industry. Lately, this method was adopted to geocells as well.



Plastic (Permanent) Deformation Test:

Based on: ASTM D-6992 (SIM) –Stepped Isothermal Method, modified for geocells

Concept: Accelerate time by temperature under typical applied geocell load per application type.

Note: The structural failure point is defined as the accumulated plastic deformation caused by the accumulated stresses applied to it.

Test.3 – How to evaluate the actual geocell strength?

Geocell Tensile Strength Test:

Based on ISO 10319:2015; modified test specimen is in-situ product sample.Test specimen must include the entire perforation pattern. if pattern is symmetric, then 1/2 the cell length ,if not, then entire cell size.

Testing: a longitudinal force is applied at a constant strain rate (according to the relevant applications) – until the specimen yields.

Geocell Seam Strength Test:

Weld Splitting Test – based on ISO 13426-1 (Part 1 Method C).

Typical size of cell opening in field (cell width-to-length) creates an angle of 95^0±7%. The test should simulate this opening angle.

Simulation of actual in-situ forces can be achieved by using a jig apparatus (shown in picture).

To sum up, our suggested approach is Measure the forces applied on the Geocell in your design. Verify the Geocell Geometry is retained for the entire design life

IV. CONCLUSION

1. Considering the vast potential of India's land in the field of agriculture, geosynthetics assume paramount importance.
2. It is a modern and sustainable method to prevent soil erosion along the slopes.
3. Available in different sizes and dimensions, geocells can be used in different environmental and geological conditions
4. There is a need of garnering the attention of stakeholders to manufacture geosynthetics locally.

5. The use of geocells can greatly reduce the ongoing land degradation problem in India.
6. In areas that experience heavy rain, for example, the North-East region, geocells can be used to protect roads and railway lines by reinforcing the slopes beneath them.

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