DESIGN OF FLEXIBLE PAVEMENT USING GEOCELL

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Abstract : Geocell reinforcement is a judicious combination of reduction of thickness and improvement of the life time of the pavement in terms of million standard axle (msa) and Bearing capacity of the soil . Geocells acts as a rigid mattress and are light weight with strong three dimensional cellular confinement system which greatly reduces the lateral movement of confined soil particles. The walls of the geocells are specially textured on both the sides for better soil-cell wall interaction and the perforated walls are provided to reduce the pore water pressure. This paper concerned with the design of pavement reinforced with geocell and its cost comparison with conventional flexible pavement.

***IndexTerms* – Soil Confinement, Thickness Reduction, Durability, Light Weight, Perforated Walls.**

I. INTRODUCTION

The performance of highway pavements is governed by the strength and stiffness of the pavement layers. Soft ground for low land filled sites cause several problems included ground subsidence, sliding of slope, and settlement of foundation because their tensile strength is weaker than that of ordinary grounds. When soil is overstressed, it can cause excessive subsidence or shear failure of soil. Therefore geotechnical and structural engineers who design foundation evaluate bearing capacity of soil and, extremely soft ground, apply techniques to reinforce the bearing capacity. Among different techniques to reinforce a soft ground, geotextile reinforcement confines horizontal movement and creates friction by installing continuous board type or belt typeelement.Especially, Geocell which is developed by geotextile for protection and stabilization applications increases tensile strength and improves bearing capacity of soft ground. Geocell is used to reinforce an embankment, subbase, foundation, retaining wall and subsoil below roads because it has a roll to maximize a shearing strength and bearing capacity in soft ground.The cost and duration of construction are dependent on the availability of aggregate for construction. The scarcity of natural resources often delays the project or escalates the cost due to large lead distances from the borrow areas.Hence it is essential to look at alternatives to achieve improved quality of pavements using new materials and reduce natural material usage.Geocells are a new standard in road base reinforcement and ground improvement. It is designed for heavy-duty road pavements, such as highways, railways, ports and working platforms. Geocells are three dimensional honeycombs of polymeric strips filled with granular material (sand, recycled asphalt, local soils). This cellular confinement system prevents movement of infill and distributes loads over a wide area – which increases the strength and stiffness of a pavement layer. This makes geocells an ideal solution for all types of soil stabilization and ground reinforcement.

II. OBJECTIVE

- Maintenance of paved and unpaved roads and highways has been a major issue for all road owner authorities. When the roads are not appropriately designed and constructed, life of the roads drastically reduces causing disruption of the traffic.
- To improve the performance of the pavement, Geocells in-filled with sand as subgrade, reducing settlements, formation of reflective crack and potholes.
- Besides, use of geocells not only reduces the thickness of the pavement section but also significantly reduces downtime due to maintenance.
- It also reduces the cost of the pavement during the construction.

SCOPE

Engineering:

- Reduces the asphalt sub-base thickness due to the improved modulus of the base.

- Replace the base layer infill with sub-base quality infill.
- Provide long-term confinement and compaction throughout the design-life of the road.

Economic:

- Utilize lower cost infill material (Sub-base quality) to replace base quality aggregate.
- Cost effective – lowers construction costs.
- Lowers lifecycle cost due to reduced maintenance.

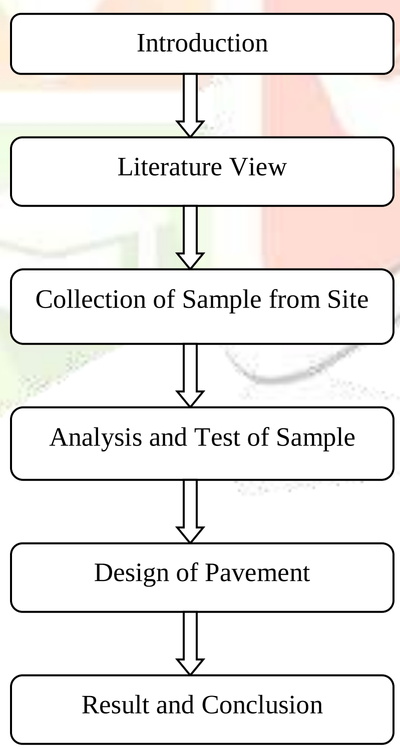
Environmental:

- Improved pavement lifespan reduces rehabilitation work and downtime.
- Implementing sustainable technology saves natural resources.

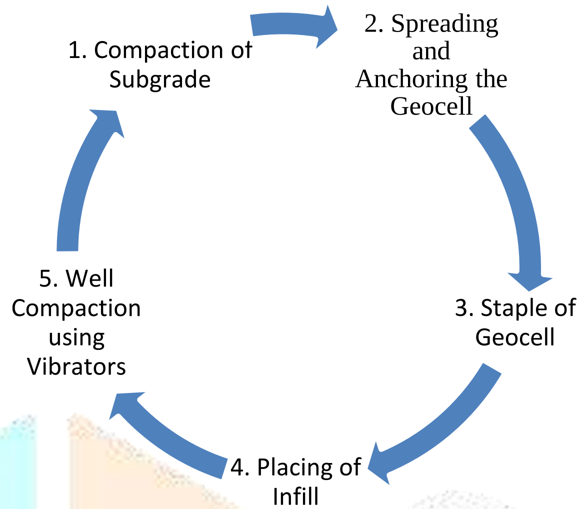
III. LITERATURE VIEW

Empirical recommendations for the modulus of different layers in terms of the thickness of the layers and the CBR value were made by Huang(2004) and IRC-37(2001). A number of researches have investigated the fundamental properties of the soil reinforced with geocells(Bathrust and rajagopal 1993, Rajagopal et al.1999). Pokharelet al (2009) found through experimental evaluation that the performance of the geocell reinforced bases depend upon the elastic modulus of the geocell. The geocell with a higher elastic modulus had a higher bearing capacity and stiffness of the reinforced base.Rajagopalet al(2005, IIT Madras) studied about the role of geocell layers in improving the quality of pavement. Stress analysis programs and both field as well as lab tests were conducted for this purpose. A trial construction was carried out for a certain length of 2m and the pavement performance was evaluated . It was observed that the reinforced section maintain a good level surface where as the unreinforced section had surface depressions.

METHODOLOGY



IV. PROCESS OF INSTALLATION OF GEOCELL PAVEMENT



1. PLANNING OF INSTALLATION

When planning installation, attention should be given to ensuring that all equipment and tools required for installation are available. In addition, sufficient personnel should be employed on the installation work. Adequate precautions should also be taken to ensure the safety of personnel. Geocell perform better when installed on even, well prepared surfaces. Prior to installing geocell, it is advised that the slope surface is made level and even. Any sharp objects and stones that are much larger than the intended fill material should be removed. If necessary, to achieve a level surface, compaction of the slope surface should be undertaken. IF required, a suitable geotextile may be used as a separator between the geocell and the slope surface. Some of the other matters to be consider when planning installation includes:

- Desired shapes and size of the cells
- Methods for compacting the slope surface(During surface preparation)
- Anchoring details, to prevent excessive down-slope movement
- Methods for fixing the cells
- Methods for compacting the infill material into the cells, if required.

2. SITE PREPARATION

Geocell perform better when installed on even, well prepared surfaces. Prior to installing geocell, it is advised that the slope surface is made level and even. Any sharp objects and stones that are much larger than the intended fill material should be removed. If necessary, to achieve a level surface, compaction of the slope surface should be undertaken.IF required, a suitable geotextile may be used as a separator between the geocell and the slope surface.

3. EXPANDING THE GEOCELL AND ANCHORING

Onsite, the geocell must be expanded and tailored to the desired dimension and shapes. To achieve optimum results, it is advised that, it is expanded to the pre designed shapes and sizes. If no pre-designed shapes and sizes are available, it may be advised to expand tha uniform shapes and sizes throughout. To enable the installation with ease, it is often necessary to secure the product along one side of the slope, using a suitable fixing method. The fixing pins which may be used during installation can be used. Ultimately, the fixing pin selection is the designer's responsibility. Once the product has been fixed on one side, it can then be expanded, along the length of the slope, until the desired shapes and sizes are achieved. If the geocell panel is too long, it can be cut to size using a pair of scissors. However, if more than one panel of geocell is to be installed on the same surface the panels can be joined together by stapling and further pinning. To retain the cell shapes and sizes, before infilling, it needs to be pinned down to the installation surface using appropriate methods. It is advised that the product is pinned down at every single cell around the perimeter and a staggered 1m centers down and across the slope.

4. INFILLING OF GEOCELL

After geocell has been fixed and anchored in place, in-filling of the cells may be carried out. For general convenience, it may be advisable to commence in-filling from the toe (bottom) of the slope. The in-filled cells, at the lower part of the slope, will provide a platform for in-filling the upper cells. If required the in-fill can be compacted into place using an appropriate method, which should not damage the fabric of geocell. It is very important to ensure that geocell is completely covered, after in-filling. Prolonged exposure to sunlight will directly affect the product longevity.

Fig 1. Geocell

Fig 2. Placing of Geocell

Fig 3. Infilling of Geocell

Fig 4. Formation of Subgrade

Fig 5. Formation of Base layer

Fig 6. Surface Course

VI. RESULTS ON SAMPLE

NAME OF TEST	RESULT	IS CODE REFERENCE
Specific Gravity of Soil	2.35	IS: 2720(part 14)
Specific Gravity of Bitumen	3.30	IS: 1202-1978
Penetration test of Bitumen	16	IS: 1203-1978
Determination on Water Content of Soil		IS: 1211-1978

Standard Proctor Compaction Test	**1.892**	**IS: 2720(part 7 & Part8)1965**
Water Absorption and Specific Gravity of Aggregate	**0.41% and 3.08**	**IS: 2386(part 3) and IS: 2720 (part 3)-1980**
CBR test on Soil	**4.82**	**IS: 2720(part 16)**

VII. DESIGN OF GEOCELL FLEXIBLE PAVEMENT- BASE DATA

By using this Base-Data, the Thickness of Geocell Flexible Pavement is determined by IITPAVE or KENPAVE Softawres.

Name of Work	**Chennai-Tirutani Road**
Carriage way Width	**Undivided Three Lane**
Classification of Road	**SH**
Design Life	**15**
Initial Traffic in both Directions (CVD)	**3680**
Traffic Growth	**5**
Terrain	**Plain**
CBR of Subgrade	**4.82**
Whether subgrade to be replace with burrow material	**No**
List of Bituminous Layers	**5**
Design Traffic	**N = {365×[(1+r)^n – 1] × A × D × F} ÷ r**
For 15 years	**={(365×[(1+0.05)^15]-1) × 3680 × 0.45 × 4.5} = 58.64 msa**

HORIZONTAL TENSILE STRAIN AT THE BOTTOM OF THE BITUMINOUS LAYERS:

Calculation of Tensile Strain:

$N_r = 2.21 \times 10^{-4} \times \{1/\varepsilon t\}$^3.89 × [1/MR]^0.854

ε_t = 308.84E-06 **(Allowable Tensile Strain)**

VERTICAL COMPRESSIVE STRAIN AT THE BOTTOM OF THE GRANULAR SUBBASE:

Calculation of Vertical Strain:

N = 4.1656*10^-8*(1/εv)^4.5337 for 80% reliability

N = 1.41*10^-8*(1/εv)^4.5337 for 90% reliability

ε_v = 347.39E-06 **(Allowable Vertical Strain)**

The Thickness of Geocell Flexible Pavement is tabulated as below:

GSB	WMM	DBM	BC
210+250(Subgrade + Geocell)	0	80	30

VIII. ADVANTAGES AND DISADVANTAGES OF GEICELL PAVEMNET

GEOCELL

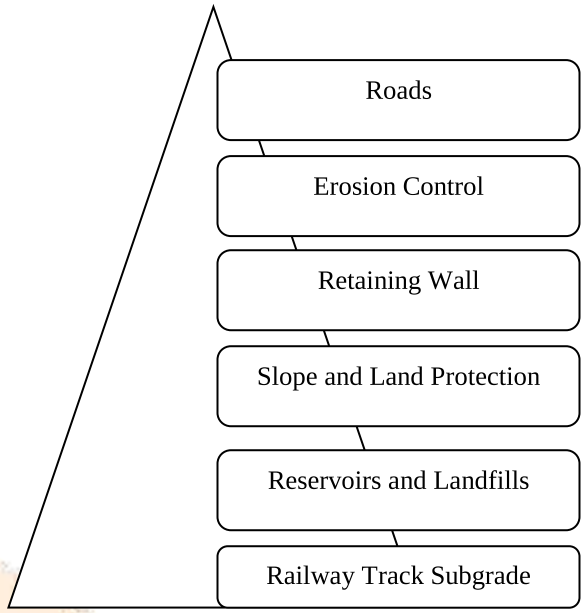
ADVANTAGES

- Provide Durable Protection to Impervious Layers
- Allow significant Subgrade Deformation without loss of Structural Integrity.
- Easy to Transport and Install.
- High resistance to Tensile Stresses, Tearing, Punching, fatigues.
- Environmentally Friendly material.
- Light weight, Low cost, high Durability.
- It is very **economical** in use compare to other products.
- They increase the reliability of structure, life of structure.
- These walls are typically **perforated** so as to allow **for drainage from one cell to another.**
- It **increases frictional resistance** against the infill soil from displacement.
- It **reduces demand** for aggregate and bituminous binder

DISADVANTAGES

- Long-term performance of the particular formulated resin being used to make the geocell must be assured by using **proper additives** including antioxidants, ultra-voilet screeners and fillers.
- Handling, storage and installation must be assured by **careful quality control** and quality assurance.
- **Insufficient materials** leads to **delay** of construction.

IX. APPLICATIONS OF GEOCELL



X. CONCLUSION

The use of geocell layer in flexible pavement increases the **structural stiffness** of the pavement system. It is found to reduce the thickness of about **27.3%** compared with conventional pavement. The cost and duration of the construction depends upon the availability of material at the site. It improves the **performance** and **increase the service life**.Cost report are also attached then its clearly viewed that Cost of the pavement found to be lower even with the use expensive geocell layer than the conventional flexible pavement.

RESULTS	**FLEXIBLE PAVEMENT**				**GEOCELL PAVEMENT**			
	GSB	**WMM**	**DBM**	**BC**	**GSB**	**WMM**	**DBM**	**BC**
Thickness (mm)	345	250	90	40	210+250 (SUBGRADE+GEOCELL)	0	80	30
Volume (kg) (2.5 * 2 * 2) cu.ft Model	385.048	279.4	100.52	44.7064	213+279.415	0	85.18	34.07
Allowable Tensile Strain (309 micro strain)	Actual=304 micro strain				Actual=305 micro strain			
Allowable Compressive Strain (347 micro strain)	Actual=345 micro strain				Actual=347 micro strain			

XI. REFERENCE

- ChandanBasu&Jitendra Kumar Soni, Design approach for geocell reinforced flexible pavement.
- K.Rajagopal (IIT Madras), Geosynthetics in Flexible pavement and carbon foot print Analysis, pp 2-56.
- Design of flexible pavements IRC 37:2012
- Indian Road Congress-37 (2001) Guideliness for the Design of Flexible Pavements(2nd revision), The Indian Road Congress, New Delhi, India.
- Krishnaswamy, N.R, Rajagopal, K. and Madhavi Latha, G, (2000), Model studies on geocell supported embankments constructed over a soft clay foundation, Geotechnical Testing Journal, 123(1): 45-54.Presto Geosystem for Material specifications**.**