A CASE STUDY ON THE DESIGN OF GEOCELL REINFORCED FLEXIBLE PAVEMENT

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Abstract - *Roads are inevitable medium for transportation. Nowadays, many of the flexible pavement structures fail to meet their design life due to unequal settlement and disintegration of layers. Pot holes or cracter are the major problem. In this study, we focus on design of flexible pavement to improve the strength and stiffness of sub base layer of flexible pavement by using geocell confinement. Geocell is a 3D honey combed polymer matrices formed by interconnected cells. Three types of infill materials used here are quarry waste, clay and aggregate. The test result shows that geocell confinement can reduce the permanent deformation of settlement and increase the elastic deformation of granular bases.*

Key Words: **Geocell, Roads, Geosynthetics, Flexible pavement, Reinforcement.**

1. INTRODUCTION

Many roads have a prime problem like lack of soil stability, disintegration, settlement and so on. Disintegration is the process of progressive breaking up of the pavement into small, loose pieces. Due to continuous vehicle movement, and poor drainage, peeling off of bitumen surface takes place, causing migration of the gravel below it to other areas. Passing over the time it can gradually reduce the level of pavement and create ruts, dips, and holes in the driveway. Sustainable paved road can help to face these challenges by improving the long-term road strength and rigidity. Geocell, a cellular confinement. The cells are filled with the selected infill material, the proper bond between the cell and infill material can improve pavement strength by lateral vertical confinement. Hence, frictional resistance between the infill and cell wall increases and prevent restrained soil from moving upward outside the loading area. Geocells can be installed easily and requirement of skilled labour is not there. Easily transportable as flat strips welded width-wise at regular intervals. They can be installed in any weather condition; geocells substantially reduce construction time and maintenance cost by improving the longevity of the road / pavement. Considering all the above, HDPE geocells help to reduce carbon foot-print; since carbon black is an essential ingredient of the HDPE.

2. Objective

- Case study on existing road condition.
- Design the thickness of flexible pavement.
- To design the geocell reinforced flexible pavement
- To study and compare the behaviour of geocell flexible pavements with conventional pavement.

3. Materials and Tests

3.1 Geocell

Geocells are a type of geosynthesis made or manufactured in the form of three-dimensional interconnected cells(honeycomb structures), which effectively provide lateral confinement to the infill material thereby increasing the modulus and bearing capacity of the base course. These are widely used as material for soil reinforcement in projects such as slopes, retaining walls, landfills, foundations, etc., in all these cases the geocell reinforcement is under static loading whereas the geocells used for pavements are under repeated loading. Geocells that are available in the market are made of high-density polyethylene(HDPE) and novel polymeric alloy(NPA). Geocells come in different shapes and sizes.

3.2 Advantages

- Increase sub-grade CBR
- High modulus improvement factor(MIF)
- Reduce layer thickness-including bitumen or surface layer
- Reduce vertical stress
- Decrease differential settlement
- Allow more traffic and heavier axle loads
- Reduces construction costs- for infill
- Reduce maintenance costs- fewer overlays and longer rehabilitation cycles
- Lower total costs- by extending pavement design

The geocell confinement increases for each layer, which enables a reduction in pavement thickness while decreasing the road maintenance. Also, the construction cost can be reduced by utilizing locally available marginal soil and/or recycled materials as the infill.

3.3 Infill materials (base course materials)

In this study, three different types of materials were used as infill materials, viz., quarry waste, clay, and aggregates, the most suitable one was selected after experimental studies. After crushing, the materials which are unsuitable for construction works as they are too fine, irregular, or flaky are discarded; this discarded materials are known as quarry waste. Quarry waste used was collected from Parackal Granites Kerala Pvt. Ltd., Adivad. It was checked whether the quarry waste can be used as an infill for the geocell, thereby the sustainable use of quarry waste is also possible. The clay used was collected from Nedumudy, Alappuzha. Clay was selected to check if it can be used as an infill for the geocell so that the geocell reinforced pavements can be applied in regions with clayey type soil like in Alappuzha. Aggregate of size 20 mm was purchased from the market as it is of standard size and available in the market. The quarry waste used for the tests were sieved through 1.18 mm sieve. Standard proctor test was conducted for quarry waste and clay; and the optimum moisture content(OMC) was obtained as 9% for quarry waste and 24% for clay. The aggregate used is a well graded base course material and are used for the pavement constructions. It had a specific gravity of 2.61, moisture content of 0.8% and abrasion value of 39.48%. OMC for aggregate=10% from standard proctor test.

4. Design

4.1 Design of flexible pavement

The site we selected for the design of flexible pavement is Muvattupuzha town by-pass road. Design parameters and further calculations are made in accordance of IRC;2001, IRC2012 and IIT Pave. Details regarding the design are collected from Muvattupuzha road sub division PWD.

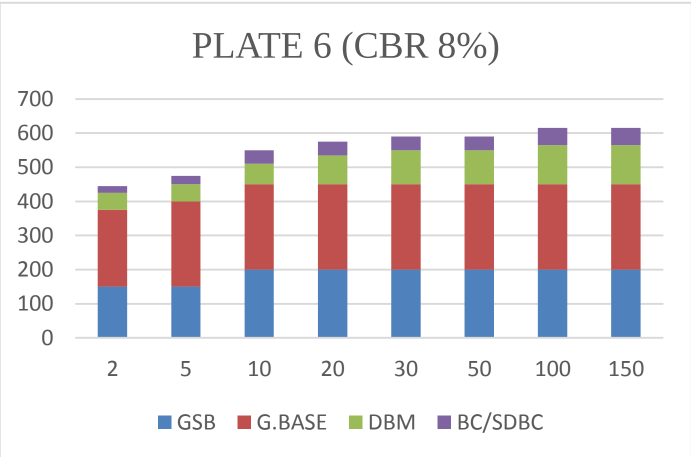

Chart- 1: CBR Value

4.1.1 Pavement design

Design Temperature=35^0C. It is recommended for use for traffic up to 30msa where normal bituminous mixes VG 30 bitumen can be used. Type of bitumen= BC and DBM for VG30 bitumen.MR bituminous layer = 1700 Mpa. Effective CBR of the subgrade = 8% ,Design resilient modulus of the compacted subgrade, $M_{R(MPa)}$ = 65.53 MPa. Resilient modulus of granular layer, M_{Rgsb} = 204.85MPa. Realibility factor=80%. Allowable horizontal tensile strain in bituminous layer ε_t = 245.99 * 10^{-6} .Allowable vertical tensile strain in bituminous layer ε_v = 490.11 * 10^{-6}.

Road Name	Muvattupuzha town by pass road
Length	2.276
CBR Value	7.8
Design CBR value	8
Characteristic deflection(mm)	1.229
Overlay thickness	100mm DBM+40 mm BC
Traffic (Msa	42.159
Proposed pavement thickness(mm)(IRC:37-2012)	BC -40 DBM -140 G.BASE-250 GSB -200

Table -1: Design of flexible pavement

Design of flexible pavement is done as per the recommendations made in IRC:37(2012).

4.1.2 Analysis Result

As per IRC 37:2012, vertical subgrade strain (epZ) should be less than the permissible value for the design traffic. Critical vertical tensile strain=470.3*10^{-6} < 490.11x 10^{-6}. From plate 6, CBR 8% pavement thickness should be BC = 40 mm, DBM = 140 mm, WMM = 250 mm, GSB = 200 mm is to be provided. If any variation is observed during construction regarding the CBR/ dry density/ field moisture, the design has to be modified in accordance with IRC37. Strict monitoring is necessary.

4.2 Design of geocell flexible pavement

Plate load test is carried out to determine the settlement under loading. Pavement is designed for CBR 8% and 42.159 traffic msa. Modulus improvement factor obtained = 2.8 by (plate load test).

Reinforced flexible pavement	BC	DBM	Base	Sub base	Total thickness(mm)
	40	70	250	200	560

Table-2: Design of reinforced flexible pavement

4.3 Calculation of elastic modulus and poisson's ratio

Elastic modulus and poisson's ratio are calculated according to IRC:37-2001

layer	Elastic modulus (Mpa)	Poisson's ratio	layer	Elastic modulus of geocell reinforcement
Asphalt layer (BC+DBM)	905.77	0.4	Asphalt layer	960.43
Base layer	345.51	0.4	Geocell reinforced Base layer	345.51
Sub-base layer	144.53	0.4	Sub base	144.32
subgrade	66.60	0.4	Subgrade	66.45

Table-3: Elastic modulus and poisons ratio

Poisson's ratio for both the granular layer as well as subgrade layer are taken as 0.4 .

5. Conclusion

In this project, a comparative study on the design of geocell reinforced flexible pavements with the conventional flexible pavements; and experimental analysis of usage of 3 different materials as an infill for geocell was carried out. In our studies, it shows that an increase in bearing capacity, and structural stiffness of the pavement system is achieved by the use of geocell layer in flexible pavements, also it reduces the deformation of embankments due to settlements. It is found that the layer thickness of the pavement system can be reduced to as much as 50% and which leads to speedy construction and low construction cost. The performance of the pavement can be improved with the increase in stiffness which also gives long service life.

The geocell reinforced flexible pavement with aggregate as infill material is having a higher percentage of elastic deformation than that with clay or quarry waste. Quarry waste requires mixing with geocell waste pieces to use as a infill material. From these findings, it can be concluded that, the geocells used along with aggregate as infill give more strength and stability to the flexible pavements.

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