Applications of EPS Geo-foam and Geo-membranes in Construction Industry – Bridges, Embankments

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Abstract. This paper mainly concentrates on the uses and applications of EPS geo-foams and geo-membranes in construction industry like Bridges and Embankments over weak soil (compressible soils). If any external load is acting on weak soil, it will undergo settlement and the soil will be compressed. To overcome these settlements and compression of the weak soils, in this research we suggest EPS geo-foams. The EPS means “Expanded Poly Styrene”, it is a light weight material which is 1% weight of soil and it is less than 10% weight of other light weight materials and it is available in different densities. It has high compressive resistance and it reduces settlement of weak soil. It is generally used as a soil fill replacement material. If the soil contains any moisture content, the geo membrane acts like a water barrier for the geo-foam material. Geo-membrane is a thin continues polymeric sheets and it is a geo synthetic material, it is generally used in construction industry and geotechnical applications. If we place different types of densities of EPS geo-foam blocks and geo-membranes over weak soil in bridges and embankments, the soil behaviour is changing and attaining stability. Finally based upon the behaviour of weak soil we conclude that, at which density of the EPS blocks the soil attain more strength and how other strength parameters has been related to density by conducting the different tests.

Keywords: EPS Geo-foam, Geo-membrane, Weak soil, compressive resistance, settlement, soil fill replacement.

1. Introduction

Now a days all countries are developing more rapidly in the construction side. To construct any structure on weak soil, if the soil is not suitable for construction, then there is a need to go for alternative materials [3]. Especially while the construction of the structures like Bridges and Embankments, it is mandatory that the soil should have enough strength (Bearing capacity) to with stand the external loads and when we required to construct heavy structures like bridges and embankments on weak soils one need to increase the strength and stability of the soil. Stabilizing of soils is not economical and it requires more time [7, 8]. In this research we suggest the best alternative material is EPS geo-foam means “Expanded Poly Styrene” generally called as “Thermocol” is used in the weak soils to get more stability [10]. It contains 95% of air and the strength of EPS is related to the density of EPS geo-foam. In foreign countries they were used these EPS blocks in the construction of Bridges and embankments to increase the strength and stability of the weak soils and to decrease the settlements of the soils under loading. The usage of these EPS geo-foams in Bridge abutments is best economical alternative than a piled
embankment inside the abutment. We can use different qualities of EPS geo-foams based on the requirement in the soils. Generally by placing different densities over weak soil and comparing the behavior of weak soil based on the results obtained [11].

2. Materials and Properties

2.1. EPS Geo-foam

EPS Geo-foam blocks means Expanded Poly-Styrene Geo-foam blocks, which is a geo-synthetic material generally used for packaging and insulation purposes over compressible soils, but now a days it is also used in the construction field [6]. The EPS geo-foams can be used in the bridge abutments and the construction of embankments to increase the strength and stability of the weak soils. The use of EPS geo-foam over weak soils was best suggestion because it was found to be the most economical geotechnical solution for the project [5]. EPS geo-foam blocks were therefore used to make up the filling inside the abutments and the embankments while the extension of highways. The EPS geo-foam weight is very less, it can carry easily without any special equipment and can be available in different shapes and densities.

![Fig: 1 EPS Geo-foam](image)

| Property               | Value |
|------------------------|-------|
| Density (kg/m³)        | 15.8  |
| Compressive strength (K Pa) | 27    |
| Flexural strength (K Pa) | 168   |
| Water Absorption (%)   | 3.84  |
| Density (kg/m³)        | 15.8  |

2.2. Geo-membrane

A geo-membrane is a very less permeable membrane, it will not allow water through it and act like a barrier for other material which is placed over geo membrane [4]. It is majorly used over weak soil and it is act like a barrier between soil and EPS geo-foam. The main purpose of these geo membranes is to hold the EPS geo-foam blocks on the soil and to minimize the passage of the water through it. And by placing these geo membranes on the side fills we can mitigate the settlement and sliding of the soil.
### Table 2: Properties of Geo membrane

| Property          | Value            |
|-------------------|------------------|
| Thickness         | 12-100 miles     |
| Specific gravity  | 0.9 -1.6         |
| Tear resistance   | 4-32 pounds      |
| Impact resistance | 0.5-13 ft-lb     |
| Puncture resistance | 10-100 pounds  |

2.3. Compressible soils

Weak soils generally called as “compressible soils” such as clay or silty clay soil having low bearing capacity. When loads act on this type of soils it undergoes easily settlement [2]. To increase the properties of weak soil instead of stabilizing, if we place geo-foam members over weak soil it will give best results more than stabilizing techniques and the cost of the usage of these EPS blocks in the soils is very less compared to the stabilization of the soil by using any stabilizing materials [9]. The below figure shows the properties of weak soil.
Table: 3 Properties of soil

| Property       | Value |
|----------------|-------|
| Liquid limit   | 62%   |
| Plastic limit  | 41%   |
| Plasticity index | 22%   |
| Specific gravity | 2.34  |

3. Test Results and Comparison

3.1. Density
EPS geo-foam densities are taken as 10, 12, 14, 16, 18, 20kg/m³ and comparing the stability of soil at various densities. The stability of soil depends upon the compressive strength and shear strength values. The test results are shown in the following graph. The below graph shows the variation between different density values of EPS geo-foam to the other strength parameters of EPS geo-foam after placing over weak.

Fig 4: Comparing of Compressive strength, shear strength values with different density values of EPS geo-foam.

3.2. California Bearing Ratio Test
The CBR test is generally used for evaluating the sub grade strength of the roads and pavements. But in case of construction of structures over weak soil by placing EPS geo-foam, we need to perform CBR ratio test on geo-foam to find the penetration strength [1]. CBR ratio test has been performed on different densities of geo-foam as 10, 15, 20, 25 kg/m³. By placing EPS geo-foam in cylindrical sections of CBR mould. The CBR test is penetrated into EPS geo-foam with a standard rate of 1.28 mm/min as per ASTM D1883 [12]. This test is performed on different densities and obtained different CBR ratio values. Finally graph is drawn between density and CBR ratio values as shown as below.
3.3. Compression Test

Compressive strength is the test which is performed on geo-foam to find the ability, to carry the loads without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. The compression test will be conducted for the calculation of compressive strength of the soil by placing densities of EPS geo-foam as 12, 14, 16, 18, 20 kg/m³ over the weak soil. EPS geo-foam blocks with compressive strength of 25 kN/m² at 4% deformation constituted large part of the filling. Higher strength blocks were also used at selected sections and these had a strength of 28 kN/m² at 5% deformation. The results are shown in the below graph.
3.4. Shear Strength

Shear strength is the maximum internal resistance to shearing stresses and a consequent tendency for shear deformation. It has been tested over different densities as 14, 16, 18, 20 kg/m$^3$ of EPS geo-foam under tri-axial testing. EPS geo-foam blocks with shear strength of 45 kpa at 5% deformation constituted large part of the filling. Higher strength blocks were also used at selected sections and these had a strength of 62 kpa at 5% deformation. Below figure shows the test result values.

![Fig 8: Comparing of strength parameters with different density values of EPS geo-foam.](image)

4. Conclusion

The following are the list of the conclusions drawn from the above investigation,

- Based upon above results, we can conclude that the weak soil can get strength by using these EPS Geo-foams and Geo membranes.
- This technique is more economical compared to the stabilization of soil by using stabilized materials, because the cost of Thermocol is very less compared to the stabilizing materials.
- Behavior of weak soil depends upon the different density values of geo-foam used in the construction.
- It is clear that from the above test results, density of EPS Geo-foam should be not less than 15.
- If the density of Geo-foam is less than 15 then there is no effect of these EPS Geo-foams in the strength properties of the soil.
- A full pledge inspection of the embankment during construction plays vital role in the quality checking. Overall, the lightweight fill in bridge abutments and embankments are safe with regard to settlement and stability concerns.
- Construction of bridge abutments and highway embankments over soft soil using expanded polystyrene (EPS) block (geo-foam block) to decrease consolidation settlement is a recent technology and has been implemented by various countries around the world.
- By using EPS blocks, bridge abutments, infrastructural embankments and extension of highways can now be done cheaply and quickly without unnecessary embankment slopes. This was implemented in the southeast of the Netherlands.
- If the density value is less than 15 the strength will not increase more, if the value is more than 20 the compressive strength, shear strength and CBR ratio values increases and it is best for any type of construction.

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