Improvement of Subgrade Soil Properties Using Admixtiture (Quarry Dust) and Woven Geotextile

Appari Avinash, B Santoshi Matha

Introduction on sub grade layer:
Low volume paved and unpaved roads usually serve as access roads to rural areas, towns and districts. They play a very important role in rural economy, resource industries (forest, mining) and transportation to agricultural production areas. When low volume roads are built on poor subgrade soils, large deformations can occur, which increase maintenance cost and lead to interruption of traffic service. Leng (2002) states that in general, deterioration of unpaved and paved roads is faster than road replacement. The increasing material and construction costs, make it important to explore alternative construction methods with longer service life but at the same time cost efficient. The objective of pavement design is to provide a structural and economical combination of materials to carry traffic in a given climate over the existing soil conditions for a specified time interval. In which subgrade is the lower most layer in the earth’s surface which is the native material underneath a constructed road, Generally subgrade is compacted before laying a pavement as it is the lower layer and it should have the bearing capacity to sustain the entire pavement.

Geo-synthetics have been found to be a cost effective alternative to improve poor sub- soils in adverse locations, especially in situations where there may be non-uniform quality and/or non-availability of desired soils with applications in almost all geotechnical engineering projects such as airport and highway pavements. In India Ghosal and Son (1989) reported the first major use of a nonwoven fabric in a heavy duty yard in Haldia, it was found to decrease the pavement thickness by 30%.

Geo-grid, a type of geo-synthetic reinforcement is gaining acceptance as an effective way of improving on the properties of naturally occurring soils for road pavement construction. Venkatappa Rao and Banerjee (1997) reported that bi-oriented geo-grids have been successfully utilized in Maharashtra in the State Highways for strengthening road pavements in black cotton soil. Gupta (2009) argues that the purpose of geo-synthetic reinforcement in flexible pavements is to extend a pavement’s lifespan or to enable the construction of a pavement with a reduced quantity of base course material without sacrificing pavement performance. The Ghanaian engineering community is in the process of getting acquainted with geo-grids through research work and conferences. In many tropical countries like Ghana, lateritic subgrades are common and often rejected after proof rolling during construction due to poor strength. Cost associated with poor subgrades include relatively larger sub-base and base thicknesses, right-of-way purchases as a result of relocation of road corridors and eventually longer construction periods with associated opportunity costs.

II. Types of Pavements

Types of Pavements:
- Flexible Pavements (upper layers of asphalt)
- Rigid Pavements (upper layers of concrete)
• Composite pavements.

**Flexible Pavements:** Flexible pavements consist of a number of layers.

- **Conventional flexible pavements:**
  - Adjusts to limited differential settlement
  - Easily, quickly constructed and repaired
  - Additional thickness can be added

**Types of Admixtures:**
There are many admixtures which are been use in replacement off in aggregate to increase the strength. Commonly used admixtures are:

1. Quarry dust
2. Flyash
3. Steel slag
4. Brick dust

**Showing the Physical Properties of Quarry Dust and Natural Sand**

<table>
<thead>
<tr>
<th>Property</th>
<th>Quarry Dust (%)</th>
<th>Natural Sand (%)</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.54-2.6</td>
<td>2.6</td>
<td>IS2386(part-III)-1963</td>
</tr>
<tr>
<td>Bulk density (kg/m³)</td>
<td>1720-1810</td>
<td>1460</td>
<td>IS2386(part-III)-1963</td>
</tr>
<tr>
<td>Absorption (%)</td>
<td>1.20-1.50</td>
<td>Nil</td>
<td>IS2386(part-III)-1963</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>Nil</td>
<td>1.50</td>
<td>IS2386(part-III)-1963</td>
</tr>
<tr>
<td>Fine particles less than 0.075 mm (%)</td>
<td>12-15</td>
<td>6</td>
<td>IS2386(part-III)-1963</td>
</tr>
<tr>
<td>Sieve analysis</td>
<td>Zone II</td>
<td>Zone II</td>
<td>IS383-1970</td>
</tr>
</tbody>
</table>

**Showing the Typical Chemical Properties of Quarry Dust and Natural Sand**

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Quarry Dust (%)</th>
<th>Natural Sand (%)</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>62.48</td>
<td>80.78</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>18.72</td>
<td>10.52</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>6.54</td>
<td>1.75</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>CaO</td>
<td>4.83</td>
<td>3.21</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>MgO</td>
<td>2.56</td>
<td>0.77</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>Na₂O₃</td>
<td>Nil</td>
<td>1.37</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>K₂O</td>
<td>3.18</td>
<td>1.23</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>TiO₂</td>
<td>1.21</td>
<td>Nil</td>
<td>IS4032-1968</td>
</tr>
<tr>
<td>Loss of ignition</td>
<td>0.48</td>
<td>0.37</td>
<td>IS4032-1968</td>
</tr>
</tbody>
</table>

**Advantages of Quarry Dust:**

The Specific gravity depends on the nature of the rock from which it is processed and the variation is less...
Disadvantages of Quarry Dust:

Shrinkage is more in when compared to that of the natural river sand. Water absorption is present so that increase the water addition to the dry mix.

Geo-textile Membranes:

A geo-textile is defined as a permeable geo-synthetic made of textile materials. The Geo-synthetics industry has expanded rapidly in recent years, and the number and types of geo-textiles manufactured with a specific focus in roadway design has increased dramatically. This increase has resulted in many new performance-enhancing and cost-saving design alternatives for roadways. The use of geo-textiles in pavement applications has addressed five main functions: separation, filtration, drainage, reinforcement, and mitigation of crack propagation. Depending on the type of geo-textile and its location within the pavement system, geo-textiles can perform one or more of these various functions simultaneously as part of an overarching application. The polymers used in the manufacture of geo-textile fibers include the following, listed in order of decreasing use: polypropylene (~85%), polyester (~12%), polyethylene (~2%), and polyamide (~1%). The most common types of filaments used in the manufacture of geo-textiles include monofilament, multifilament, staple filament, and slit-film. If fibers are twisted or spun together, they are known as yarn.

Nonwoven Geo-textiles:

Nonwoven geo-textiles are manufactured by placing and orienting the filaments or fibers onto a conveyor belt, which are subsequently bonded by needle punching or by melt bonding. The nonwoven geo-textiles have tremendously different engineering properties than the wovengeo-textiles. The type of polymer will also influence significantly the engineering properties of these products.

View of different types of Geo-textiles

Separation:

Separation is the introduction of a flexible porous geo-textile placed between dissimilar materials so that the integrity and the functioning of both materials remains intact for the life of the structure or is improved. A geo-textile placed between the aggregate and the subgrade acts as a separator, minimizing contamination of the aggregate base by the subgrade.

Pavement without geo-textile showing intrusion into the base coarse

Pavement without geo-textile showing reduction of base contamination

Figure 1.6: Pavement With and Without Geo-Textile
LITERATURE REVIEW

Studies of Various Authors Improving Strength of Soft Subgrade:

Lacuoture and Gonzalez et al. [1995] He conducted comprehensive study of the Terrazymes oil stabilizer product and its effectiveness on sub-base and sub-grades oils. The reactions of this oils treated with the enzyme was observed and recorded compared to the untreated control. Samples, the variation in properties was observed over a short period only and it was found that incohesive soils showed no major variation in properties during the early days but the soil showed improved performance progressively.

Hitam and Yousof et al. [1998] He conducted field studies on improvement of plantation roads. The road was unpaved and it affects badly due to adverse weather conditions. Terrazyme was treated to 27.2 km of the road and the sections were then monitored on the surface erosion for two monsoon seasons. No damage was noticed and there searches have concluded that Terrazyme stabilization can convert the road to all-weather roads that has minimum destruction in hot and wet seasons.

Sharma et al. [2001] He has conducted laboratory studies on use of Bio-Enzyme stabilization of three types of soils namely, clay of high plasticity, clay of low plasticity and silt of low plasticity. It was found that soil shows a margin in CBV value and substantiates reduction in saturation moisture after four weeks of stabilization. The soil shows a marginal improvement in unconfined compressive strength, direct tensile strength and fatigue strength.

Isaac et al. [2003] He have done experimental studies in the area of Bioenzymatics oil stabilization in the laboratory for different types of soils from Kerala. The soil samples were laterite, clay and sand. These samples were tested for grain size analysis and Atterberg’s limit. The optimum moisture content of the soil was determined from modified compaction test. The soil was treated with different dosage of enzyme. CBR test were conducted on each soil samples at different curing period under soaked condition. From the study they found that Terrazyme.

METHODOLOGY AND EXPERIMENTAL STUDY

The following methodology is undertaken and various combinations of tests were conducted for both un-modified and modified soil in order to complete the task.

Figure 3.1: Methodology for project

- Identification of soil
- Index properties of soil
- Selection of admixtures
- Physical properties
- Experimental tests on soil + admixtures
- Selection of reinforced
- Experimental tests on soil + admixture + reinforced
- Analysis of lab tests
- Results and conclusion
Material Study:
In this experiment, we are evaluating the index properties of soil in which the materials used are an unmodified Red soil which is collected near Sanketika College, palem. Quarry Dust which is collected from Gonnovanipalem quarry. It consists mainly of sand size particles (89%). Geo-textile of 200 GSM woven 1.6mm thick (+1-20%) and holding in position in the foundation trench in between the sand layers including overlapping of 100mm forevery joint.

Test on Materials:
The following parameters are studied in experimental work
- Specific gravity of soil
- Grainsizedistribution of soil
- Compactioncharacteristicsof soil
- Californiabearingratio (CBR) of soil.

Results and Discussion:

Result On Soil And Admixture:
In this experiment, we are evaluating the index properties of soil in which the materials used are an unmodified Red soil which is collected near Sanketika College, palem. Quarry dust which is collected from Gonnovanipalem quarry.

Presentation of Test Results:
Naturally available red soils are mixed with admixtures like Quarry dust at varying percentages to the dry weights of soils. Experiments are conducted on the samples blended with these admixtures to determine the index and engineering properties of the modified soils.

Properties of Unmodified Soil and Admixtures:

<table>
<thead>
<tr>
<th>Properties</th>
<th>Soil</th>
<th>Quarry dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>1.9</td>
<td>2.4</td>
</tr>
<tr>
<td>WL(%)</td>
<td>21.5</td>
<td>NP</td>
</tr>
<tr>
<td>WP(%)</td>
<td>12.01</td>
<td>NP</td>
</tr>
<tr>
<td>P.I(%)</td>
<td>9.49</td>
<td>NP</td>
</tr>
<tr>
<td>Gravelsizeparticles(%)</td>
<td>2.82</td>
<td>1.78</td>
</tr>
<tr>
<td>Sandsizeparticles(%)</td>
<td>22.62</td>
<td>89</td>
</tr>
<tr>
<td>Finessizeparticles(%)</td>
<td>71</td>
<td>5</td>
</tr>
<tr>
<td>ISCS</td>
<td>CI</td>
<td>SP</td>
</tr>
<tr>
<td>γd(kN/m²)</td>
<td>18.94</td>
<td>26.5</td>
</tr>
<tr>
<td>WO(%)</td>
<td>14.3</td>
<td>10.6</td>
</tr>
<tr>
<td>SC(%)</td>
<td>1.74</td>
<td>-</td>
</tr>
<tr>
<td>UC(%)</td>
<td>2.8</td>
<td>-</td>
</tr>
</tbody>
</table>
CONCLUSIONS

Conclusions that are studied from the course of study include the following:

1. The effect of all the admixtures on various properties is significant in general and of geo-textile in particular. Among two admixtures it is observed that workability of geo-textile membrane is better than quarry dust.

2. The liquid limit of soil with quarry dust gradually decreases from 5% to 25% when compared with soil with zero percentage of quarry dust. The decrease in liquid limit is 1.3%, 1.7%, 5%, 6.61% and 7.21%.

3. The plastic limit of soil with quarry dust gradually decreases from 5% to 25% when compared with soil with zero percentage of quarry dust. The decrease in liquid limit is 0.89%, 0.39%, 2.45%, 3.76% and 4%.

4. The plasticity index of soil with quarry dust gradually decreases from 5% to 25% when compared with soil with zero percentage of quarry dust. The decrease in liquid limit is 1.04%, 1.25%, 2.55%, 2.85% and 3.21%.

5. The water content of soil with quarry dust gradually decreases from 5% to 25% when compared with soil with increase in percentage of quarry dust. The optimum moisture content was attained at 15% with 21.66%. The decreases in water content with respect to OMC is 3.36%, 2.05%, 0.69%, till 15% and a gradual increase in water content with respect to OMC is 1.14% and 1.18%.

6. The dry density of soil with quarry dust gradually decreases from 5% to 25% when compared with soil with increase in percentage of quarry dust. The MDD is attained at 20%. The decrease in dry density with respect to MDD is 3.75%, 3.47%, 2.80%, 2.60% and 0.8%.

7. The void ratio of soil with quarry dust is gradually decreasing with a percentage of 5% to 25%. The decrease of void ratio of soil is 0.041%, 0.0876%, 0.1159%, 0.1762%, 0.0199%.

8. The un-soaked CBR value with a modified soil gradually decreases with addition of quarry dust from 5% to 25%, the decrease of CBR value from the figure is 4.22%, 2.1%, 1.41%, 0.13%.
9. The un-soaked CBR value with a modified soil gradually decreases with addition of quarry dust and geo-textile membranes from 5% to 25%, the decrease of CBR value from the figure is 5.35%, 3.93%, 2.97%, 1.83%.

References


