SUSTAINABLE ROAD CONSTRUCTION WITH COMPRESSED STABILIZED EARTH

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Abstract: Heat island effect has been given significant recognition in LEED certification process. The idea is to reduce the heat island effect to minimize impacts on micro climates and human and wild life habitats. In this context, it is useful to have roads with Solar Reflectance Index of more than 29% and also less than 50% impervious. Cement stabilized earth has the potential to satisfy this requirement as an alternative to asphalt paved roads. This paper describes some field experience gained while constructing a cement stabilized earth road with adequate strength and durability.

1. Introduction

The use of dark non – reflective surfaces for parking areas, walkways and access roads contributes to the heat island effect by absorbing sun's warmth, which then radiates into the surroundings. Because of heat island effect, ambient temperatures in urban areas could be artificially elevated by about 1.5^{o}C to 5^{o}C compared to suburban and undeveloped areas. In this context, under sustainable sites credit 7.1of LEED, emphasis is placed on reducing the heat island effect that can be caused by hard cape materials. It is recommended to have such strategies for at least 50% of the site hardscape [1]. Therefore, development of an alternative material that can be successfully used for car parking areas, access roads and walkways will be extremely useful.

2. Soil stabilization with cement

Laterite soil available in tropical climatic condition is an ideal material for stabilization with cement. Generally, 7 -14 % cement by volume is recommended [2]. The thickness of the base recommended is 100 – 150 mm. The soils with less that 35% clay and silt content could give good results.
The important characteristic of stabilization with cement is that the relatively high strengths which may be obtained with dry compacted soils are retained by the mixtures when they become wet. When the unconfined compressive strength of cement stabilized soil is more than 1.5 N/mm^2, the corresponding CBR value will be 100% or more [3]. A compressive strength of 1.7 N/mm^2 is recommended in Kadyali and Lal [4]. Since the strength characteristics and performance has been found to be adequate with many previous trials, it was decided to have a detailed study addressing various construction related issues. Such experience would allow the wider use of this technique for projects intended to achieve a greater degree of sustainability.

3. The objective and methodology

The main objective of this field trial was to achieve a road and also with acceptable performance with very good durability characteristics. In order to achieve this objective, the field trials were carried out with different cement percentage and addition of chips. The mixes that gave good constructability, strength and durability have been recommended for future applications.

4. The thickness of road base material

Since the road was intended for heavy traffic loads such as containers, a suitable base thickness had to be selected. According to the Road Note 29 [5], it is possible to allow 1 x 10^6 cumulative axles when the thickness of the base is more than 150 mm. Hence, a decision was taken to maintain a minimum thickness of 150 mm when the base and the wearing course thickness were combined.

5. The soil cement mixes

In a cement stabilized road, there are two requirements to be fulfilled. One is the strength. The other is the durability. In order to address these two issues in a cost effective manner, a decision was taken to complete the road in two main layers. The lower layer laid on well compacted soil was intended to provide sufficient strength. The upper layer was intended to provide a good wearing surface while ensuring a light colour surface and also contribute to the strength of the base.

5.1. The soil composition

It was found that the clay content of the soil that was available at the site due to earthwork associated with landscaping and road work has clay and silt content of about 40%. Therefore, a soil with lower clay and silt content had to be brought to adjust the composition. The resulting mix had a clay and silt content in between 30 - 35 %. In order to facilitate proper mixing, soil was sieved using a 25 mm mesh and then kept covered as shown in Figure 1 to control the moisture content.

Figure 1: Selected soil is stored with a cover to ensure proper moisture content

5.2. The cement content

For the selection of cement content, reliance was placed on the results obtained with laterite soils stabilized with cement for rammed earth concentration. A compressive strength of about 2.5 N/mm^2 could be obtained with 10% cement with a wet strength of about 1.5 N/mm^2 [6]. The cement and soil was mixed with a drum type concrete mixer as shown in Figure 2.

Figure 2: Cement and soil mixed with desired ratio

5.3. The compaction

In cement stabilized soil, the level of compaction is very important for the strength characteristics. A compaction ratio in excess of 1.7 would be ideal. A minimum compaction ratio of 1.65 has been specified by Jayasinghe [7]. It was found that a 5 tonne roller shown in Figure 3 could provide a compaction ratio of excess of 1.7 after four passes. The thickness of the base was maintained between 75 – 100 mm after compaction.

Figure 3: Five Ton roller was used for compaction

5.4. The wearing course

For this road, the durability was very important. For this, the wearing course was completed with a cement, soil and aggregate mix. The aggregate was 6 – 8 mm ships. The addition of chips was useful in improving the resistance to driving rain while ensuring adequate abrasion resistance to moving vehicles. After few trials, it was found that a mix of 1:4:4 cement, soil and aggregate could ensure a surface that would be free of shrinkage cracks. A thickness of 100 -150 mm was maintained for this wearing course while ensuring the required camber. The finished wearing surface is shown in Figure 4. Due to formation of a light colour dust, it could maintain a light colour thus fulfilling the requirement as Solar Reflective Index.

Figure 4: The light colour road surface without significant cracks

5.5. The drainage

In a road of this nature, it is important to ensure good drainage. This was achieved by using precast concrete half round drains laid on part of the road construction as shown in Figure 5.

Figure 5: Arrangement used for drains

6. The long term performance

The road has retained its light colour during its usage. The reason is that the chips would become exposed as the road is used and hence the colour of the road would be light thus facilitating a high solar Reflectance Index as the road is used. Since a small degree of wearing would occur with time, the road was able to maintain its light color without much maintenance. Figures 6 to 8 indicate the present situation of the road and parking areas after nearly three years of operation.

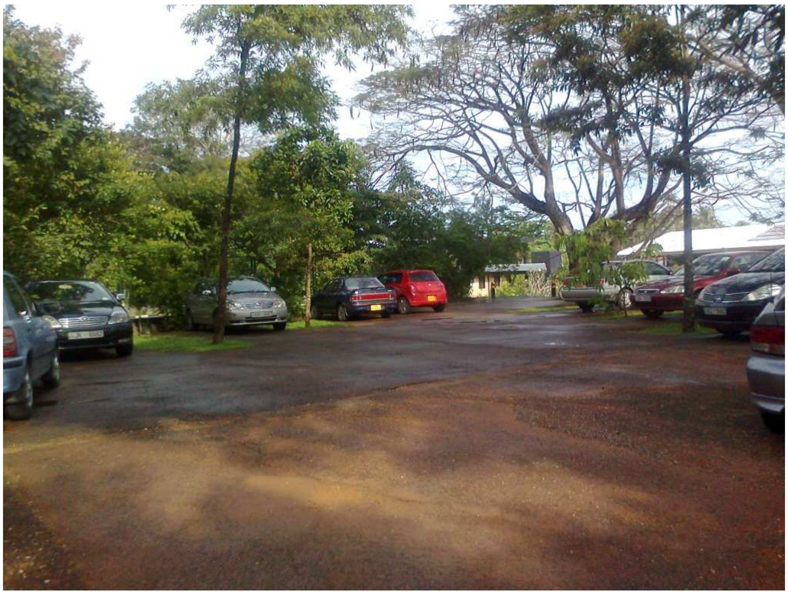

Figure 6: The parking area provided with many trees

Figure 7: One of the main access road

Figure 8: Gradual erosion that has exposed aggregates mixed in wearing course

7. Conclusion

The minimization of the effect of heat island is an important concept when planning built environments. The solution proposed in white concrete or gray concrete hard tops. The alternative proposed is cement stabilized soil bases finished with light colour aggregates. When combined with strategically planned vegetation, such roads can provide a good solution for minimization of heat island effect in a cost effective and environmentally friendly manner. Some of the key advantages would be the use of soil that is available at the site thus promoting the minimization of waste material generation while reducing the need for new material

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