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CBR test on fibre reinforced silty sand

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Abstract. Geosynthetic fibres are an established family of geomaterials used in a wide variety of civil engineering applications such as pavement systems. In pavement design, CBR ratio count as an important parameter. This study aims to investigate effect of fibre inclusion on CBR ratio. A series of laboratory investigation were carried out to evaluate effects of reinforcing the sub grade soil in pavement system with randomly distributed plastic fibres. In this study, one type of soil (i.e silty sand) and two type of fibre were used. CBR test were conducted on unreinforced samples as well as reinforced ones at different fibre contents (i.e. 0.1%, 0.3%) and different fibre length (i.e. 10mm , 20 mm and 40mm).The results of CBR test showed that the CBR ratio for reinforced silty sand increased even more than two times in some cases as fibre content and fibre length increased. The results proved that application of short randomly distributed fibre is a good method to apply in practical projects.

Keywords: CBR, Silty sand, Fibre.

1 Introduction

CBR test is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of subgrade soil for design of flexible pavement. CBR tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the subgrade soil. Applications of soil strengthening or stabilization range from the mitigation of complex slope hazards to enhancing the subgrade stability. Together with the many applications for improving soil, there are several widely varied methods. Mixing of randomly oriented fibres to a soil sample may be considered same as an admixtures used to stabilize soil. Material used to make fibres for reinforcement may be obtained from paper, metal, nylon, polyester and other materials having widely varied physical properties. There have been numerous past papers published on the topic of fibre strengthening of soils. Examples include Lee et al., 1973, Hoare,1979, Andersland and Khattac,1979, Freitag,1986, Gray and Ohashi, 1983, Gray and Rafeai, 1986, Maher and Gray 1990, Maher and Ho, 1994, Michalowski and Zhao 2002, Ranjan et al. 1996, Kaniraj and Havanagi 2001, Consoli et al. 2009.

All of the papers listed above have generally shown that; strength of the soil was improved by fibre reinforcement. The investigation on silty soil is very limited. The purpose of this survey is to evaluate of CBR values of silty sand induced by fibre inclusion. The CBR tests were conducted as per ASTM D1883 on the selected soils with and without reinforcement to investigate the influence of length and fibre content on CBR values. Moreover, the obtained CBR values were taken as indication of improvement in the soil strength due to fibre reinforcement. For different length and fibre contents, the dry weight required to fill the CBR mould was calculated based upon maximum dry densities of the soil and the volume of the mould. The water corresponding to Optimum Moisture Content (OMC) was put and mixed thoroughly. The water was added prior to fibre to prevent floating problems.

2 Material

Composite soils consist of two parts. The first part is soil part which can be dealt as pure soil. The second part is reinforcement part which can be made up of any material which helps soil to have better mechanical performance.

2.1 Soil Type

The soil type in this study was Western Australian Sand. The Particle Size Distribution (PSD) of used sand is presented in Figure 1. This type of sand is widely used in industrial projects and research activities in Western Australia. Five percentage of silt also was used to reconstruct mixture.

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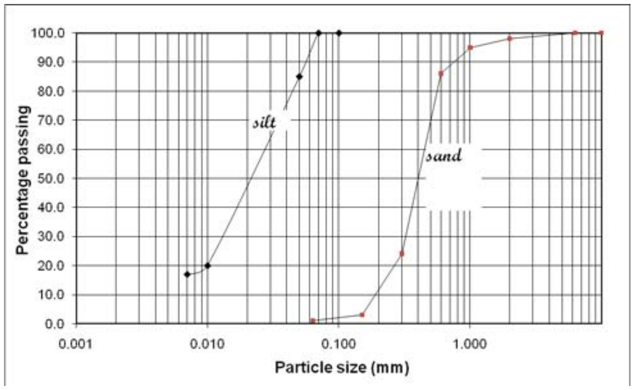

Fig. 1 Sand Particle Distribution

2.2 Fibre Type

Natural fibre and plastic fibre were used in this investigation. The main advantage of natural fibre (see Figure 2) is that it is cost-effective. In addition, it can be sourced locally and is easily prepared for industrial projects. The second type of fibre used was plastic (as shown in Figure 3), which has excellent energy absorption capabilities. The main advantage of this fibre is in its positive capabilities regarding soil interaction. The interlock forces of the plastic fibres were expected to be considerably higher than those of natural fibre, due to skin friction, thus allowing a more effective load transfer.

Fig. 2 Natural fibre

Fig. 3 Plastic fibre

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3. Test program

A series of CBR tests have been conducted on reinforced sandy composite. Reinforced samples prepared by putting plastic and natural fibre inside sand.

3.1 CBR Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. CBR test may be conducted in remoulded or undisturbed sample. Test consists of causing a cylindrical plunger of 50mm diameter to penetrate a pavement component material at 1.25mm/minute. The loads for 2.5mm and 5mm are recorded. This load is expressed as a percentage of standard load value at a respective deformation level to obtain CBR value. (Chegenizadeh and Nikraz, 2011)

3.2 Main Equipments

- Mould
- Steel Cutting collar
- Spacer Disc
- Surcharge weight
- Dial gauges
- IS Sieves
- Penetration Plunger
- Loading Machine
- Miscellaneous Apparatus

Figure 4 shows the mechanism of CBR test machine.

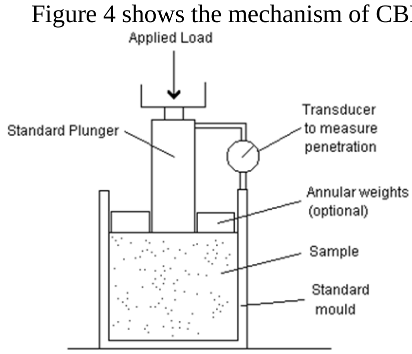

Figure. 4 Mechanism of CBR Test Machine(Gray,1983)

4. Test Methodology and Procedure

The sample was sieved through 20mm sieve. 5kg of the sample of soil specimen was taken. Water was added to the soil in the quantity such that optimum moisture content or field moisture content was reached. Then soil and water were mixed thoroughly. Spacer disc was placed over the base plate at the bottom of mould and a coarse filter paper was placed over the spacer disc. The prepared soil water mix was divided into five. The mould was cleaned and oil was applied. Then was filled one fifth of the mould with the prepared soil. That layer was compacted by giving 56 evenly distributed blows using a hammer of weight 4.89kg. The top layer of the compacted soil was scratched. Again second layer was filled and process was repeated. After 3rd layer, collar was also attached to the mould and process was continued. After fifth layer collar was removed and excess soil was struck off. The base plate was removed and the mould was inverted. Then it was clamped to base plate. Then the normal load was applied and CBR values recorded. (Chegenizadeh and Nikraz, 2011) The fibre content and length were varied during the tests. Fibre contents were selected as 0.1%, 0.2% and 0.3%. On other hand, fibre lengths were varied from 10mm up to 40mm. For both fibre types (i.e. plastic and natural) same procedure applied.

5. Results and discussions

The CBR tests were performed in order to determine effect of fibre inclusion on CBR values of reinforced silty sand. Figure 5 shows the CBR values obtained from the tests at different plastic fibre length and content. The maximum CBR value was obtained for a length of 40mm and 0.3 percentage fibre content, which proved that fibre length and fibre content directly affect the CBR values.

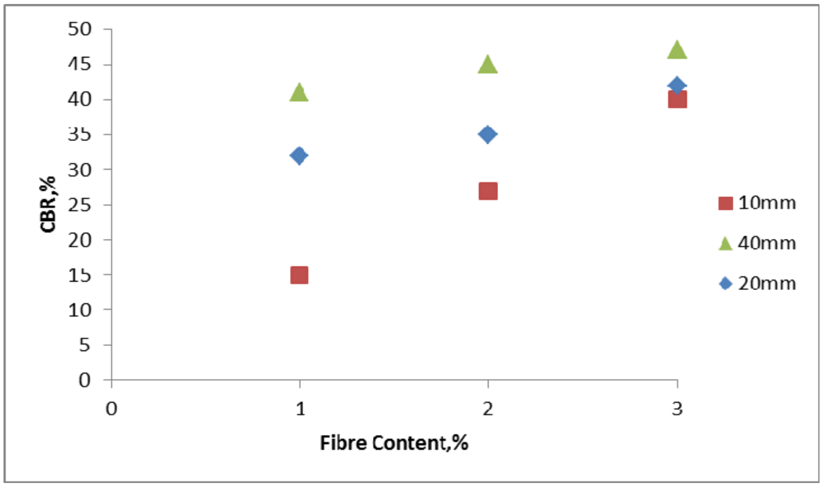

Figure. 5 results of CBR test for plastic fibre

Same procedure applied for natural fibre. Figure 6 shows the effect of fibre length and content on CBR values.

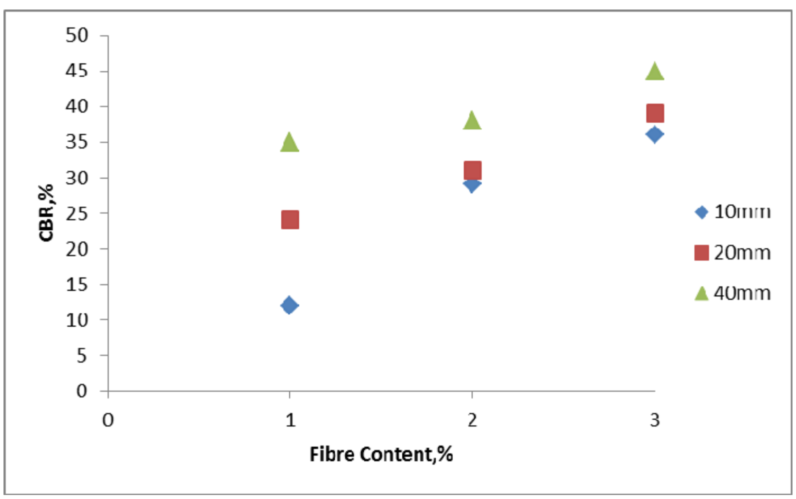

Figure. 6 results of CBR test for natural fibre

Maximum value of CBR values for natural fibre was obtained in fibre content of 0.3% and length of 40mm. The CBR values for natural fibre were less than plastic fibre. However, the results for both types of fibre proved that fibre inclusion will be recommended for practical projects especially in pavement engineering projects.

6. Conclusion

Two important parameters were well investigated in this paper. The first parameter was fibre content and the second one was aspect ratio. The effect of these two parameters studied on CBR values. Two types of fibre used in this study (i.e. plastic and natural). Following results were derived:

- Increasing in fibre percentage increased CBR values in sandy samples for both natural and plastic fibre. In natural fibre increasing fibre content from 0.1 to 0.3% increased CBR values by 50%. CBR values showed increament of more than 60% in increasing same amount (i.e. three times) of fibre content.

- The results proved that with increasing in fibre length, the CBR values of composite sandy soil were increased for both kinds of fibre. For increament of fibre length by three times, CBR value increased by two times for both fibres.

- CBR values for case of natural fibre was less than those plastic fibre. That shows plastic would be better solution for subgrade material..

- Short and randomly fibre inclusion showed to be reliable in industry projects as it helps to minimize the cost of projects.

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