Soils and highways laboratory: california bearing ratio

Engineering

The paper " Soils and Highways Laboratory: California Bearing Ratio " is a good example of a term paper on engineering and construction. This report presents the results of an experiment that was conducted to investigate the California Bearing Ratio (CBR) of engineering soil samples. The procedure comprised of; compaction of the soil sample into a standard CBR mould, placement of the mould on the plunger, application of the force at a uniform rate, and recording of the results at various intervals. The results obtained gave a CBR of 22. 58% at the penetration of 2. 5mm for a 60% Clay and 40% Sand soil sample evaluated at; the moisture content of 2. 13%, bulk density of 1. 57Mg/ m3 and a dry density of 1. 54Mg/ m3. These results serve as a useful tool for guiding policy-makers, programme managers and service providers in various aspects of engineering including service delivery issues to enable the public to receive comprehensive and effective infrastructures.

- INTRODUCTION:

In order to design a road, it’s important, to begin with, a sense of their sub-grade strength to support the load and an idea of which options are possible. Most successful and sustainable highway designs are usually built on the California Bearing Ratio (CBR) test, which is an empirical test relating to the performance of the subgrade under test compared with a standard curve. More than often, if the CBR value is high, then it implies that the thickness needed for construction of the road should be less, hence being less expensive, but if the CBR is less, then the thickness should be thick enough, in order to distribute the load over a wide area of that specific subgrade, which ensures that it doesn’t get deformed easily (Chakraborty & Das 2003, pp. 48-60). The particular test is conducted by measurement of the plunger

forces needed to penetrate a soil sample mould at penetrations of 2. 5mm and 5. 0mm, and then comparing them to those of a standard crushed rock, whose plunger forces at 2. 5mm is 13. 2kN, and at 5. 0mm is 20. 0kN (O'Flaherty 2002, pp. 20-40). In particular, the experiment involves; insertion of the soil sample into a steel mould (15mm diameter and a height of 178mm), and then compacting to a height of 127mm but, within specified moisture content and dry density. After compaction, the mould is then covered with annular surcharge weights proportional to the approximated mass of the elastic road on the soil layer on the real ground. The mould is then placed in the testing machine and plungers are made to penetrate the compacted soils at a rate of 1mm/minute, while the readings are made from the dial gauge at intervals of 0. 25mm, from 0. 0mm to 7. 5mm.

- PROCEDURE:
- The apparatus was set up with 6. 0kg of the soil sample having 60% Clay and 40% Sand being weighed to be used.
- The large particles soil sample was crushed and then sieved to have particles of about 20mm as a precondition of the test, as shown in Fig. 1 and 2
- The mould was then weighed before filling it with the soil sample, as in Fig. 3.
- The mould was then half filled before and 62 blows used to compact the sample.
- The mould was then top filled and another 62 blows used to compact it.

- The top of the mould was levelled and the mould with the sample was weighed.
- The mould was closed tightly for 24hours before conducting the test.
- Mould prepared before satisfying the condition was used on the CBR machine.
- The mould was then loaded and then the results were recorded after performing the necessary calibration of the equipment.
- At the end of the test, the soil sample was taken and used for the moisture content evaluation.

- RESULTS AND CALCULATIONS:

4. 1 Evaluation of the CBR: After calibration, the mean calibration was recorded to be 25. 48N/div. The penetration and the applied load were then recorded and tabulated as in Table 1 below. The plunger forces (Load) was then plotted against the penetration as shown in Graph 1. Penetration (mm)DivisionsPlunger force (kN) Penetration (mm)DivisionsPlunger force (kN)0. 0000. 000 4. 001413. 5920. 2530. 077 4. 251443. 6690. 50100. 255 4. 501483. 7710. 75200. 510 4. 751503. 8221. 00340. 866 5. 001533. 8981. 25491. 249 5. 251574. 0001. 50631. 605 5. 501604. 0761. 75892. 267 5. 751634. 1532. 001002. 548 6. 001664. 2292. 251072. 727 6. 251694. 3062. 501172. 981 6. 501714. 3572. 751243. 159 6. 751744. 4333. 001293. 287 7. 001774. 5103. 251333. 389 7. 251804. 5863. 501373. 491 7. 501824. 637Table 1: Penetration, Divisions and Plunger Force Values Graph 1: A Plot of Load vs. PenetrationFrom table 1 and graph 1 above, it can be established that, at a penetration of 2. 5mm, the plunger force is 2. 981kN and that of 5.

0mm is 3. 898kN. However, that of a standard crushed rock; the plunger force is 13. 2kN for a penetration of 2. 5mm and 20. 0kN for 5. 0mm. Therefore the top CBR can be calculated as below: At a penetration of 2. 5mm the CBR = (2. 981/13. 2) x 100%= 22. 58%At a penetration of 5. 0mm the CBR = (3. 898/20. 0) x 100%= 19. 49%From the above results the required value is 22. 58% which is the higher of the two values. 4. 2 Calculation of the Moisture Content: Mass of bucket (mc) = 210. 9gMass of bucket + Mass of wet soil (m2) = 560. 9 gMass of bucket + Mass of dry soil (m3) = 553. 6 gMass of moisture () = 560. 9-553. 6 = 7. 3 gMass of dry soil () = 553. 6-210. 9 = 342. 7 gMoisture content = (mass of moisture) / (mass of dried sample)Moisture content () = = 2. 13%4. 3 Evaluation of the dry density = Mass of mould + base = 5761. 4g = Mass of mould + base + compacted sample = 9370. 8gMass of compacted sample = = = 9370. 8-5761. 4= 3609. 4g = 3. 6094 kgVolume of the sample = = where is the mould diameter (152mm) and is the height (127mm)Then = 0. 002305 m3The bulk density is the ratio of the compacted sample to the volume of the sample, Therefore: The bulk density is 1565. 9 kg/m3 = 1. 57 Mg/m3. The dry density is the mass of dry solids per unit soil volume = = 1. 54 Mg/m3

1. DISCUSSION:

Generally, CBR values are evaluated at 2. 5mm as well as 5mm penetrations, but from the results, at the penetration of 2. 5mm the CBR values was higher than that of 5mm and hence it is taken as the value for the soil sample, none the less if the 5. 0mm could be higher than that of 2. 5mm then the whole experiment could be null and void, and hence repeated. However, if both the

results could be similar then the CBR value at the penetration of 5. 0mm could have been chosen for the design requirements. The CBR value of 22. 58% at the penetration of 2. 5mm implies that the soil sample tested is normal and high strength hence the thinner the layer of the sample can be utilized for the road construction in the state of California and that any increment in the load on the soil would get meet an increased resistance of the soil. CBR of a soil, in general, indicates to its strength and reliefs on the state of the sample at the juncture of its testing, hence the soil is expected to be tested in a very critical design of importance is that a given moisture content the CBR value increases with the dry density of the soil implying that there is an increase in the air as well as the moisture content in the soil (BSI 1990). This has an implication that the dry density to be selected for the design purposes should be corresponding to the lowest compaction expected in the field. The CBR of any given dry density of a soil sample depends on its moisture content. Also, for the CBR to be utilized for any design it ought to be evaluated at the highest expected moisture content. It needs to be noted that, prior to covering the soil with a pavement, its moisture content can alter along the year, hence the need for determination of the moisture content prior to its design. The experimental error that could affect the results comprise of; recording of wrong measurements especially during the calibration of the equipment.

6. CONCLUSION:

This experiment was designed to enable specialized engineers to recommend the required dry and wet density and consider moisture values before embarking on the road construction of the roads in the state of

California and could be used as a guideline for future reference in other projects in different geographical boundaries. The soil sample used had 60% clay and 40% sand and exhibited a CBR of 22. 58% at the penetration of 2. 5mm, thus was normal and strong, hence suitable for road construction.