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STRENGTH IMPROVEMENT OF SUBGRADE SOIL USING CERAMIC WASTE POWDER TREATED WITH COIR FIBRE

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ABSTRACT : The performance of a pavement is very responsive to the characteristics of soil sub grade. The economic design of pavement results in saving countries economy. The construction of roads in most of the places across the world faces major problems due to weak sub grade soil. Sub grade being the support for the whole pavement, it needs the utmost care in its construction. During last few decades' research has been conducted on various aspects of low volume roads resulting in innovative and unconventional approaches of road constructions. Many suggestions have been put forward by various scientists to improve the subgrade.Usually adopted methods are stabilization methods. Use of waste material and natural fiber for improving soil property is advantageous because they are cheap, locally available and eco-friendly. In this study, the stabilizing effect of Natural fiber (coconut coir) and ceramic waste powder on soil properties has been studied. Over the last decade the use of waste material and fiber has recorded a tremendous increase. Keeping this in view an experimental study is conducted on locally available i.e. clayey soil mixed with varying percentage of coir fiber and ceramic waste powder. Long term performance of pavement structures often depends on the stability of the underlying soils. Conventional waste disposal methods are found to be inadequate. The existing soil at a particular location may not be suitable for the construction due to poor bearing capacity and higher compressibility or even sometimes excessive swelling. For sustainable development use of waste material should been encouraged.It is crucial for highway engineers to develop a sub grade.

Key Words: Ceramic dust,,California Bearing Ratio,cohesion,coir fibre

1. INTRODUCTION

Keeping in mind the large geographical area of India (3,287,240 sq. km) and population of India (125 million approx.) the vast network of road is required. Soil being the cheapest and readily available construction material, has been Popular with the civil Engineers, even though it being poor properties. It has been the constant endeavor of research workers to put forth innovative ideas to improve its mechanical properties to suit the requirements of engineering students. The construction of road imposes a heavy pressure on limited resources like suitable earth,

stone aggregates binders etc. For sustainable development use of locally available materials, waste material should be encouraged in order to save the natural resources for future generation. There are many types of waste material found in India like coal ash, stone quarry, plastics, recycled aggregate, geosynthetic materials and polythene bags etc but coconut coir fiber is used in this research paper. In future many roads and highways will be constructed near the Chandigarh. Coconut coir fiber may be utilized in these highways projects.Coir or coconut fiber belongs to the group of hard structural fibers. It is an important commercial product obtained from the husk of coconut. The coir fiber is elastic enough to twist without breaking and it holds a curl as though permanently waved. Shorter mattress fibers are separated from the long bristle fibers which are in turn a waste in the coir fiber industry. So this coir fiber waste can be used in stabilization of soil and thus it can be effectively disposed off. The inclusion of fibers had a significant influence on the engineering behavior of soil-coir mixtures. The addition of randomly distributed polypropylene fibers resulted in substantially reducing the consolidation settlement of the clay soil. Length of fibers has an insignificant effect on this soil characteristic, whereas fiber contents proved more influential and effective. Addition of fiber resulted in decrease in plasticity and increase in hydraulic conductivity. As a result there has been a growing interest in soil/fiber reinforcement. The work has been done on strength deformation behavior of fiber reinforced soil and it has been established beyond doubt that addition of fiber in soil improves the overall engineering performance of soil. Fiber mixed with soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Fiber mixed with soil is effective in all types of soils (i.e. sand, silt and clay). The main advantage of coir material is this it is locally available and is very cheap. This is biodegradable and hence do not create disposal problem in environment. Ceramic waste are generated in ceramic industries with an important impact on environment and humans. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Indian ceramic production is 100 Million ton per year. In ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present. However, the ceramic waste is durable, hard and highly resistant to biological, chemical, and physical degradation forces. The Ceramic industries are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the ceramic waste.

2. LITERATURE REVIEW

Many Studies have also shown that durability of natural fiber can be improved using coating of fiber with Phenol and Bitumen. Many studies have been conducted relating to the behaviour of soil reinforced with randomly distributed fiber. Gray and Ohashi (1983)[1] conducted a series of direct shear tests on dry sand reinforced with different synthetic, natural and metallic fiber to evaluate the effects of parameters such as fiber orientation, fiber content, fiber area ratios, and fiber stiffness on contribution to shear strength. Based on the test results they concluded that and increase in shear strength is directly proportional to the fiber area ratios and shear strength envelopes for fiber- reinforced sand clearly shows the existence of a threshold confining stress below which the fiber tries to slip or pull out. Various types of randomly distributed elements such as polymeric mesh elements, synthetic fiber (Gray and Al Refeai 1986[2], Mahar and Gray 1990[11], Ranjan et. Al, 1996[3], Charan 1995[4], Michalowski and Cermak, 2003[5], Gosavi et al., 2004[6], Rao et al., 2006[7], Chanda et al. 2008 and Singh 2011[8] metallic fiber (Fatani et al.1999)[9] and discontinuous multi oriented polypropylene elements (Lawton et.al, 1993)[10] have been used to reinforce soil and it has been shown that the addition of randomly distributed elements to soils contributes to the increase in strength and stiffness.

Dr. Soosan George .T analysed the effect of quarry dust in stabilizing sub grade layers of pavements. Initially stabilization of clayey soil was done using sand. Now a days availability of sand is less as sand mixing resulted in various environmental hazards. Coir fiber waste also needs care in disposal. Alice T V and Mini M .I studied that inclusion of fibers had a significant influence on the engineering behavior of soil fly ash mixtures. And their findings were published in their paper "Improvement of kaolinite clay sub grade using coir fiber waste". P. R Ronald Ross,J.Paramanandham,P Tenmozhi,K S Abiramy

Ceramic waste are generated in ceramic industrieswith an important impact on environment andhumans. The use of the replacement materials offercost reduction, energy savings, arguably superiorproducts, and fewer hazards in the environment.Indian ceramic production is 100 Million ton peryear. In ceramic industry, about 15%-30% wastematerial generated from the total production. Thiswaste is not recycled in any form at present.However, the ceramic waste is durable, hard andhighly resistant to biological, chemical, and physicaldegradation forces. The Ceramic industries aredumping the powder in any nearby pit or vacantspaces, near their unit although notified areas havebeen marked for dumping. This leads to seriousenvironmental and dust pollution and occupation of avast area of land, especially after the powder dries upso it is necessary to dispose the Ceramic production in Bilecik- Eskisehir-Kütahya region makes 43.2% of total ceramic production in Turkey (Saatcioglu, 2010). environmental pollution, CW aggregates can be used in pavement design for sustainable environment. There are few studies in the literature related using CW waste in concrete and HMA as Due to results, the workability is reduced by ceramic waste addition in specimens. Also, the compressive strength in concrete with CW increased with increasing CW ratio (Torkittikul and Chaipanich, 2010). Pacheco et.al., researched the feasibility of ceramic waste usage in concrete as aggregates. The construction of roads not only helps to consume bulk quantities of ceramic waste powder solving its disposal problems to certain extent but also satisfies the construction requirements.Engineers are facing greater challenges in containing the degradation of land and atmospheric pollution caused by ever mounting deposits ofceramic wastes.Dr.Praveen Kumar and Shalendra Pratap Singh studied the influence of various reinforced flyash parsmeters through static and dynamic load tests and semi field tests.It was planned to observe the effect of reinforcement such as polypropylene fibers,geogrids ,geotextile etc.Akshaya Kumar Sabat had studied the use of waste ceramic dust in strengthening the subgrade of flexible pavements to save the cost of construction and the results were given in their paper "Stabilization of expansive soil using waste ceramic dust."

3. OBJECTIVES OF THE STUDY The main objective of the project is to reduce maintenance cost and increase pavement longevity of roads in rural roads using Coir fibre. The precise objectives is to to review the literature on coir fibre reinforced rural roads treated with ceramic waste powder.

4. MATERIALS USED

Soil sample : soil sample to be treated was collected from a paddy field near Nilamel,Kollam.

Table 1.Soil Properties

PROPERTY	VALUE
Specific Gravity	2.20
Uniformity Coefficient	6.67
Coefficient of Curvature	0.9375
% of gravel	17%
% of sand	80%
% of clay	3%
Liquid Limit (%)	53
Plastic Limit (%)	30
Plasticity Index (%)	32

Ceramic waste powder: The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pit refill, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use of ceramic waste produced. Ceramic waste was collected from "The Kerala ceramics ltd, Kundara, Kollam.

Table 2 Chemical Property of ceramic waste Powder

Materials	Ceramic Powder %
Silicon Dioxide(SiO2)%	78.2
AluminiumOxide(Al2O3)%	0.82
Iron Oxide (Fe2O3)%	
Calcium Oxide(CaO)%	1.52
Magnesium Oxide (MgO)%	3.58
Chloride (CL)%	0.31
Sulphur as Sulphur Trioxide (SO3)	0.065

Fig.2. Appearance of cocunut Coir fibre

Fig.2. Ceramic waste powder

Coir fibre

Table 3 Physical and engineering properties of coir

Specific Gravity	0.71
Cut length	20-30mm
diameter	0.2-0.3mm
colour	brown

5. METHODOLOGY

Soil sample was collected from Nilamel,Kollam . The geotechnical properties of soil such as specific gravity, soil classification, consistency limits, compaction characteristics, California bearing ratio (CBR) test,undrained direct shear test etc were tested as per Indian Standard Specification. For conducting different test soil was mixed with the ceramic dust from 0 to 30% with increment of 5% ,its optimum % is found out. Different amounts of coir when added to the same soil & ceramics dust & varying effects were studied.

5. RESULTS AND DISCUSSIONS

The results of liquid limit tests on expansive soil treated with different percentage of ceramic dust are shown in Figure1. From the figure it can be seen that with increase in percentage of ceramic dust the liquid limit of soil goes on decreasing.It decreases from 53 to 26% when ceramic dust is added from 0 to 30%.

plasticity index decreases from 32% to 15% when ceramic dust is increased from 0 to30%.

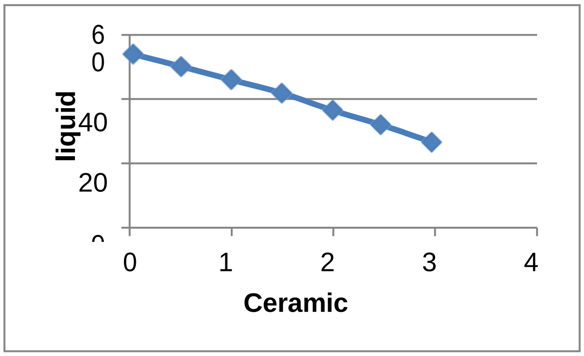


Fig 3. Variation of liquid limit with percentage of ceramic dust

The results of plastic limit tests on soil treated with different percentage of ceramicdust are shown in Figure 2. From the figure it can be seen that with increase in percentage of ceramic dust ,plastic limit goes on decreasing.

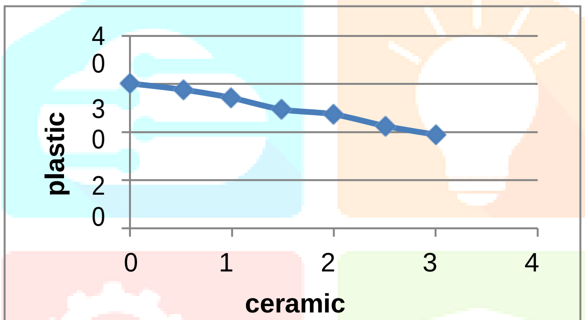


Fig 4. Variation of plastic limit with percentage of ceramic dust

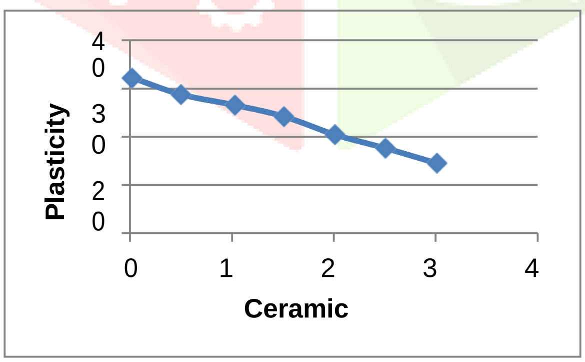


Figure 5: Variation of Plasticity index with percentage of Ceramic dust

From the figure it can be observed that the plasticity index goes on decreasing with addition of ceramicdust. The

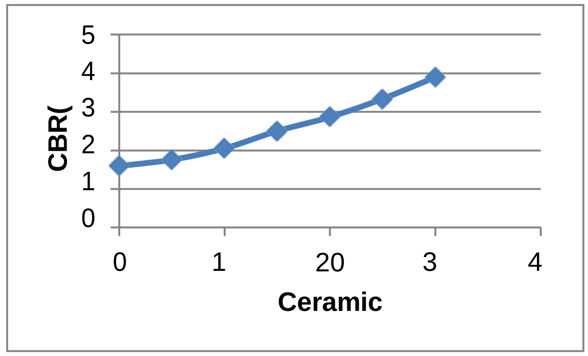


Figure 6: Variation of Soaked CBR with percentage of Ceramic dust

The results of soaked CBR tests on soil treated with different percentage ofceramic dust are shown in Figure 8. From the figure it can be seen that with increase inpercentage of ceramic dust, the soaked CBR of soil goes on increasing. The soaked CBRincreases from 1.6% to 4% when ceramic dust is increased from 0 to 30%. There is 150%increase in soaked CBR of soil at this percentage of ceramic dust as compared to untreated soil.As MDD increases with increase in the percentage of ceramic dust, it results in increase in boththe UCS and soaked CBR values of the soil.

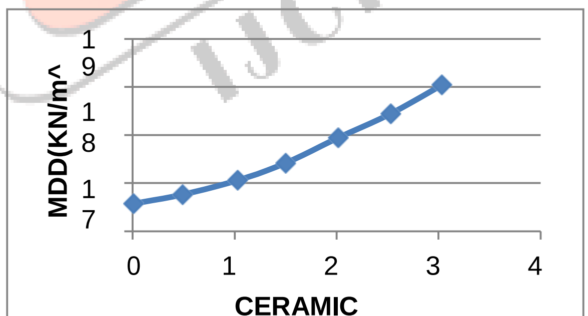


Figure 9: Variation of MDD with percentage of Ceramic dust

The results of standard Proctor tests on soil treated with different percentage of ceramic dust are shown in Figures 9 and 10. Figure 9 shows the variation MDD with percentage ofceramic dust. With increase in percentage of ceramic dust, the MDD of soil goes on increasing.The MDD increases from 15.6 kN/m3 to18.1 kN/m3 when ceramic dust is increased from 0 to30%

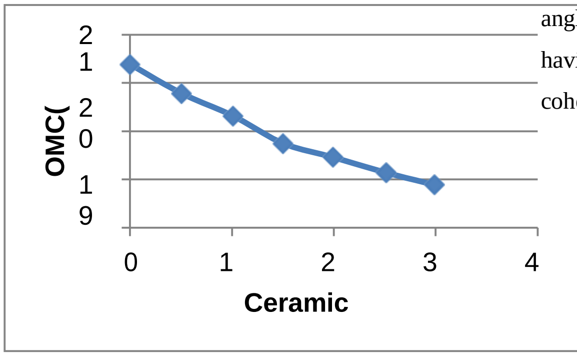


Figure 10: Variation of OMC with percentage of Ceramic dust

With increase in percentage of ceramic dust, the OMC of soil goes on decreasing. The OMC decreases from20.4% to 17.6% when ceramic dust is increased from 0 to 30%. The reason of such behavior is,due to replacement of ceramic dust particles with soil particles the attraction for water molecules decreases hence, OMC decreases.

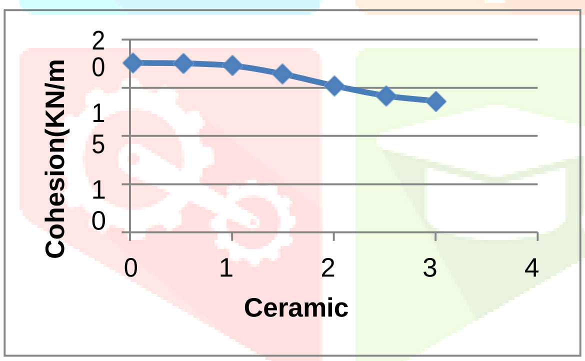
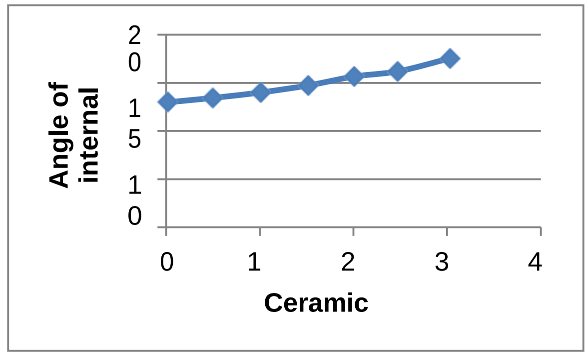


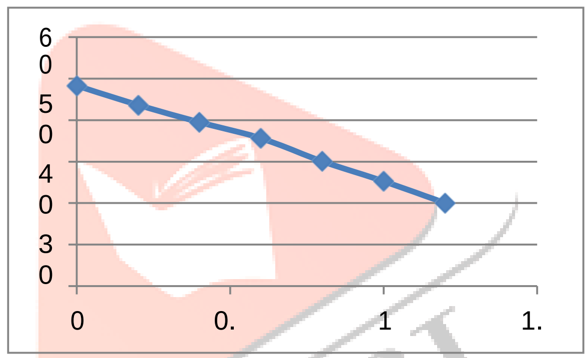
Figure 11: Variation of Cohesion with percentage of Ceramic dust

The result of shear tests are shown in Figures 9 and 10 .From the Figure 9 it is observed thatwith increase in percentage of ceramic dust, the cohesion of soil goes on decreasing. The cohesion decreases from 18 kN/m2 to13.5 kN/m2 when ceramic dust is increased from 0 to 30%.

From the Figure 12 it is observed that with increase in percentage of ceramic dust, the angle of internal friction of soil goes on increasing. The angle of internal friction increases from 13 to17.7 when ceramic dust is increased from 0 to 30%. The reason of such behavior is the replacement of soil particles which have very high cohesion (18 kN/m2) and low angle of internalfriction (13) with ceramic dust particles, having very high angle of internal friction(39) and low cohesion(8KN/m^2)

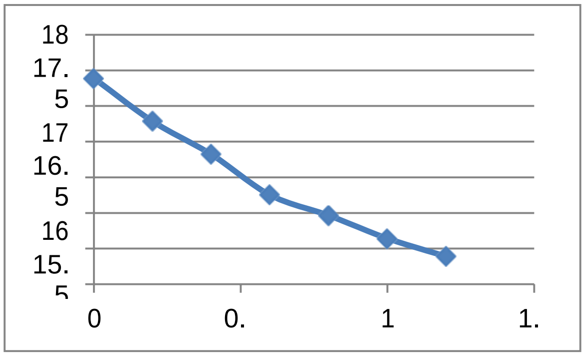


Effect of coir content on liquid limit

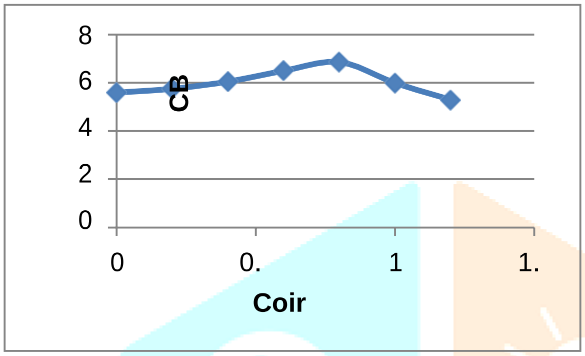


Effect of coir content on compaction

Compaction tests were carried out on the soil sample by varying the coconut coir dosage (0-1.2 %) and 30% of ceramic dust powder. From the results obtained, it can be inferred that as coir content increases maximum dry density (MDD) decreases. Density of soil decreases because the heavier particles of the soil are replaced by coir which is light in weight. But with increase in coir content, optimum moisture content (OMC) increases as coir fibre absorbs more water.



Effect of coir content on CBR



California Bearing Ratio test is mainly done to evaluate the sub-grade soil strength and this value can be used for pavement design. With increase in coir content, CBR value of the soil also increases. When coir is added to the soil it provides certain amount of shear strength to the soil. This increase is less due to lack of chemical reaction between coir and soil.

6. CONCLUSIONS

Based upon the results obtained from laboratory tests following conclusions can be drawn:

1. The liquid limit, plastic limit and plasticity index go on decreasing irrespective of thepercentage of addition of ceramic dust.
2. The addition of 30% ceramic dust changes the soil from CH group to CL group
3. The MDD goes on increasing and OMC goes on decreasing with increase inpercentage of addition of ceramic dust.
4. The UCS goes on increasing with increase in percentage of addition of ceramic dust..
5. The soaked CBR goes on increasing with increase in percentage of addition of ceramic dust. There is 150% increase in soaked CBR value as compared to untreated soil, when 30% ceramic dust was added.
6. The cohesion value goes on decreasing and angle of internal friction goes onincreasing with increase in percentage of addition of ceramic dust.

7 .From Compaction test results it can be inferred that with the increase in coir content, maximum dry density decreases and optimum moisture content increases.

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