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STRENGTH CHARACTERISTICS OF KUTTANAD SOIL TREATED WITH QUARRY DUST

P. Dhanya, M.Tech. Student, Thejus Engineering College, Vellarakkad, dhanya.pulpayil@gmail.com
K. Ramya, Assistant Professor, Thejus Engineering College, Vellarakkad, ramyakmadhavan@gmail.com

ABSTRACT: Kuttanad region of Kerala, India is a unique agricultural area in the world. The soil here is highly problematic in nature. Quarry dust produced in aggregate crushing industry is a waste product which may cause serious environmental problems and its utilization in stabilization of this soil is the best way to dispose it. This paper presents the variation of properties of Kuttanad soil when mixed with different percentages (0%, 5%, 10%, 15% upto 30%) of quarry dust and the results shows that upon addition of quarry dust the soil properties get modified except the CBR which increases and then decreases.

INTRODUCTION

Kuttanad region in the state of Kerala, India lies 0.6-2.2 m below mean sea level and during most of the time major portion of the region is in submerged condition. These soils are with low strength which worsens the ability of the deposit to support even moderate loads. A large number of foundation failures have been reported in this soil due to its poor strength properties. The increased population growth has become mandatory to construct on soft grounds. So in order to construct structures above these soils, we have to modify them. Through soil modification or stabilization the goals like increasing soil strength, geotechnical properties and bearing capacity, preventing structure subsidence, reducing soil plasticity index can be achieved. Fine soils behavior should be studied well before deciding on the method of improvement. The selection of an appropriate method depends on effectiveness of the method, ground characteristics and associated cost.

Quarry dust is an industrial waste produced as by-product during crushing of large size stones during production of coarse aggregates. Large number of crushing units is available in Kerala which produces large quantity of quarry dust. These wastes create a lot of geoenvironmental problems for their disposal and so its utilization as soil stabilization admixture is a best way to dispose it and will be very effective in terms of cost.

The main objective of this study is to improve the geotechnical property of low strength Kuttanad soil by making use of locally available waste material and thus reduce the pollution problems and also the construction cost. Here the characteristics of Kuttanad soil and quarry dust were studied and the index and engineering properties of soil mixed with different percentages (0%, 5%, 10%, 15% upto 30%) of quarry dust were determined to find the optimum percentage of dust needed to stabilize the Kuttanad soil.

LITERATURE REVIEW

Paul et al. (2014), used eggshell powder and quarry dust as the wastes, to combine with soil so that the properties of clay soil were investigated in different mixture proportions. The conclusion drawn from this investigation is that the combination of quarry dust and egg shell powder is more effective than the addition of quarry dust/ egg shell powder alone for the improvement of properties of clay. Sabat (2012), conducted some laboratory tests to study the effect of lime on Atterberg's limit, MDD, OMC, shear strength and durability of quarry dust stabilized expansive soil mixes Venkateswarlu (2015), conducted various tests to find the variation of index and engineering properties of expansive soil when it is mixed with different percentages (0%, 5%, 10% and 15%) of quarry dust. From the above experimental analysis it is found that quarry dust up to 10% can be utilized for strengthening the expansive soil with a substantial save in cost of construction. Muntohar et al. (2013), conducted compaction, UCS, split tensile strength, unconsolidated/undrained triaxial and CBR tests to examines the influence of the plastic-waste fiber (polypropylene plastic waste) to improve the engineering properties of the lime/rice husk ash-stabilized soils. It was observed from testing that the engineering properties of fiber/lime/RHA soil vary and depend on the fiber content. Adding plastic-waste fiber enhanced the residual strength of the stabilized soil. Neenu and Sasidharan (2012), conducted compaction test (air dried sample passing through 20mm IS sieve) and unconsolidated undrained triaxial test (oven dry soil passing through 425µ sieve) to study the efficacy of using rice husk ash in presence of lime for stabilizing Kuttanad clay. Results show that MDD increases with increase in percentage of RHA and lime. The maximum strength was obtained at 15% RHA and 4% lime. Beyond that strength decreases with increase in lime. The strength improvement is due to the formation o cementitious material formed by pozzolanic reaction between $Ca(OH)_2$ and

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SiO_2 present in the lime RHA Kuttanad clay mix. Ghausuddin and Koranne (2011), conducted a series of test viz. compaction test & California bearing ratio tests to analyze the replacement of weak earth material with quarry dust using polypropylene fibers as reinforcements and to investigate the influence of selected fiber parameters i.e., content and length on the strength and ductility behavior of soil-quarry dust mixtures. The inclusion of randomly oriented fibers greatly influences the performance of soil quarry dust mix. Kumar and Biradar (2014), carried out Atterberg limit and compaction test on both unmodified and modified soil. California bearing ratio (CBR) test was performed to determine the strength properties of the soil–quarry dust mixtures. Quarry dust was added to soil in different proportions for the modification of soil. The addition of the quarry dust to the soil reduces the clay content and thus increases in the percentage of coarser particles, reduces the LL and PI of soil. OMC of soil is decreased with increase in percentages of quarry dust. MDD of soil is increased by addition of quarry dust. Mariamma and Rekhasree (2014), conducted CBR test on soil to study the behavior of waste plastic chip reinforced stone dust over Kuttanad clay. Here they used 3 additives like stone dust, geotextile (non wven coir geotextile) and plastic chips (2types- Type 1: random mixture of high density polyethylene and polypropylene, Type 2: mixture of polypropylene and polycarbonate in ratio 80:20). Addition of waste plastic chips inclusion in fly ash/stone dust overlaying Kuttanad soil subgrade results in an increase in CBR value. A higher bearing ratio was obtained for reinforced stone dust overlaying Kuttanad clay. For both types of plastic chips, higher value of CBR is obtained when non woven coir geotextile is used in between the soil and fly ash/stone dust layer. For stone dust overlying Kuttanad soil, reinforcement with type 2 plastic chips with non woven geotextile was given higher value of CBR at 2% of plastic chips. For fly ash overlaying Kuttanad clay, reinforcement with type 2 plastic chips with non woven geotextile was given higher value of CBR at 2% plastic chips. Soumya and Sruthy (2014), conducted compaction test, unconfined compressive strength test and consolidation test to study the effect of coconut shell powder on the strength and settlement characteristics of Kuttanad clay. MDD and OMC increases with increase in powder. Increase in dry density may be due to fine additives which fill voids present in soil, thereby increasing density. After a percentage dry density decreases due to the segregation of coconut shell powder after a certain limit.UCS increases with increase in coconut shell powder upto an optimum and then decreases in strength. This decrease is observed due to changes in soil matrix resulting from excess coconut shell powder. There was a reduction in settlement characterists of Kuttanad clay on addition of coconut shell powder. Sabat and Bose (2013), have been discussed the combined effects of two industrial wastes fly ash and quarry dust in proportion of 1:2 and up to 75% of its dry mass on compaction characteristics, unconfined compressive strength, California bearing ratio (CBR), shear strength parameters and swelling pressure of an expansive soil.

MATERIALS USED

Soil Sample

The soil used in this study was collected from Kainakary region of Kuttanad in Alappuzha district, Kerala, India. The sample was thoroughly air dried, weighed and stored in polythene gunny bags at room temperature. The index and engineering property of the soil was thoroughly studied in the laboratory. The soil was tested for liquid limit, plastic limit, compaction characteristics, California bearing ratio test etc. with different percentage of quarry dust. The soil properties based on experiments conducted are given in Table 1.

Fig. 1 Kuttanad soil sample

Table 1 Soil properties based on experiments conducted.

Soil property	Value
Natural water content (%)	115
Organic matter (%)	8.3
pH	5.16
Specific gravity	2.26
Differential free swell (%)	20
Percentage of gravel (%)	0
Percentage of sand (%)	26.7
Percentage of silt (%)	53.5
Percentage of clay (%)	19.8
Liquid limit (%)	56
Plastic limit (%)	37.5
Plasticity index (%)	18.5
Shrinkage limit (%)	30.6
Soil classification	MH
Max. dry density (kN/m^3)	14.81
Optimum moisture content (%)	28
California bearing ratio (Unsoaked) (%)	1.9

Quarry Dust

Quarry Dust for this study was collected from Vellarakkad, Thrissur District of Kerala, India. The properties of the quarry dust were determined as per IS codes and are presented in Table 2.

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Fig. 2 Quarry dust

Table 2 Quarry dust properties based on experiments conducted

Quarry dust property	Value
Specific gravity	2.5
Percentage of gravel (%)	0
Percentage of sand (%)	92.3
Percentage of silt and clay (%)	7.7
Coefficient of uniformity	5.1
Coefficient of curvature	1.2
Liquid limit (%)	Nil
Plastic limit (%)	N.P
Plasticity index (%)	N.P
Max. dry density (kN/m^3)	18.93
Optimum moisture content (%)	8.8

EXPERIMENTAL INVESTIGATION

For determining the variations on different properties of Kuttanad soil, the soil was mixed with the quarry dust from 0% to 30% at an increment of 5%. A total of 7 mixes were prepared. Specific gravity test, liquid limit tests, plastic limit tests, modified proctor compaction tests and unsoaked CBR tests were conducted on these mixes as per Indian Standard codes for finding optimum percentage of quarry dust material.

RESULTS AND DISCUSSIONS

The experiments were conducted with varying percentage of quarry dust and the obtained results were shown below. From the experiments conducted, 25% was obtained as optimum percentage of quarry dust.

Effect of Quarry Dust on Atterberg's Limits

The liquid limit (LL) decreases from 56% to 26% (Fig. 3) and on the other hand plastic limit (PL) of Kuttanad soil decreases from 37.5% to 22.2% (Fig. 3) and plasticity index (PI) decreases from 18.5% to 3.8% (Fig. 3) with increase in percentage of quarry dust.

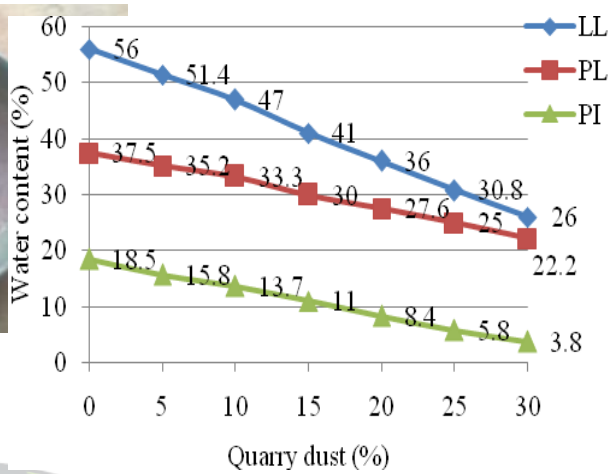

Fig. 3 Variation of LL, PL and PI with increase in percentage of Quarry Dust

Effect of quarry dust on compaction characteristics

The optimum moisture content of Kuttanad soil was found to decrease from 28% to 16% and subsequently the maximum dry density increases from 14.81kN/m3 to 17.65kN/m3 on addition of quarry dust as shown in the Figs. 4 and 5.

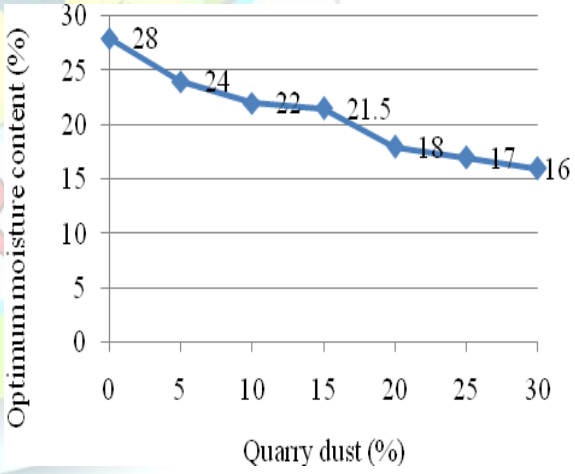

Fig. 4 Variation of optimum moisture content with increase in percentage of Quarry Dust

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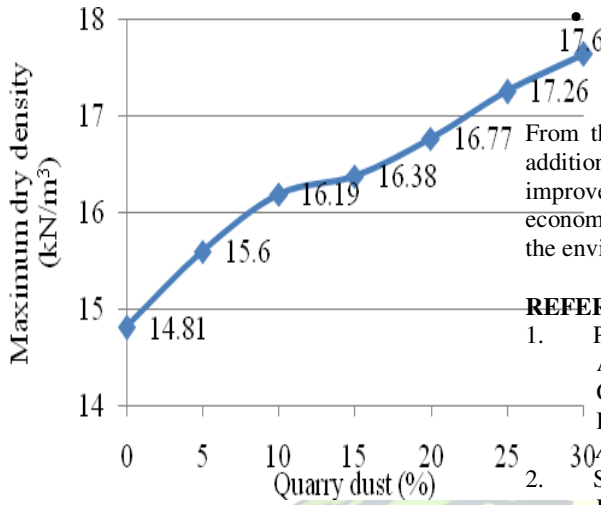

Fig. 5 Variation of maximum dry density with increase in percentage of Quarry Dust

Effect of Quarry Dust on CBR Results

The CBR value of soil goes on increases as percentage of quarry dust increases upto 25%, furthermore increase in percentage of quarry dust reduces the CBR value as shown in Fig. 6.

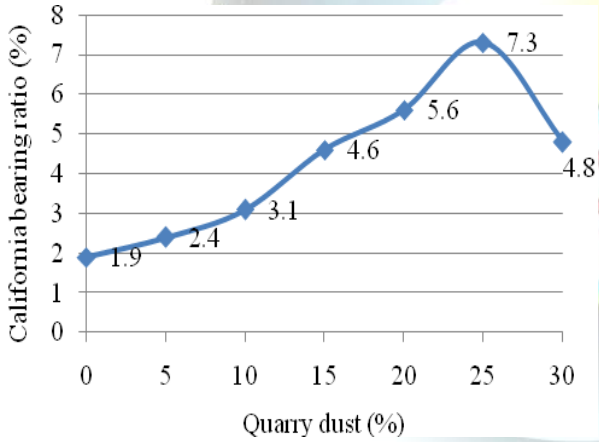

Fig. 6 Variation of CBR with increase in percentage of Quarry Dust

CONCLUSIONS

The following conclusions can be drawn on the basis of the result obtained from this investigation.

- It was found that the liquid limit, plastic limit and plasticity index decreases irrespective of the percentage addition of quarry dust.
- It was noticed that there had an increase in maximum dry density and decrease in optimum moisture content with increase in percentage of quarry dust.
- It was found that the CBR value goes on increasing as percentage of quarry dust increases upto 25%, and then decreases on further addition.

From the above observation we come to a conclusion that addition of about 25% of quarry dust in Kuttanad soil can improve soil properties which enables it to be used economically for the improvement of soil and thus reducing the environmental problems.

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