Effect of Quarry Sand on the Strength Characteristics of Kaolinite

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***Abstract* --Kaolinite clay is a type of clay which posses low bearing strength and high compressibility. So, in order to improve the bearing strength of kaolinite clay stabilization should be done. Quarry sand is a waste product which is used as an effective stabilizing material. This paper focuses the effect of quarry sand on the strength properties of kaolinite clay. The tests such as compaction and unconfined compression tests were conducted on clay with different percentage of quarry sand i.e.5,10, 15,20,25 and 30% . The results concluded that maximum dry density was increased by the addition of quarry sand. The optimum moisture content decreases by increasing percentage of quarry sand. Unconfined compressive strength was improved by the addition of quarry sand. On the second phase of the thesis the effect of particle size of quarry sand in the stabilization of clay were studied. The results were concluded that the strength of quarry sand stabilized kaolinite was mostly contributed by coarse particles in the quarry sand.**

Keywords: Kaolinite , Quarry sand, Bearing strength, compressibility, Compaction, Unconfined compressive strength, Maximum dry density, Optimum moisture content

I. INTRODUCTION

Increase in population leads to the reduction of available land. So the construction of buildings and other civil engineering structures have to be carried out on weak soil. Kaolin, also called china clay is a soft white clay . In its natural state kaolin is a white, soft powder consisting principally of the mineral kaolinite, which, under the electron microscope, is seen to consist of roughly hexagonal, platy crystals ranging in size from about 0.1 micrometre to 10 micrometres or even larger. Owing to such soil of low bearing strength and high compressibility, it is necessary to improve the strength of weak clays. The usually adopted methods are stabilization methods. Soil stabilization a general term for any physical, chemical, biological, or combined method of changing a natural soil to meet an engineering purpose. Soil stabilization technique is well developed and extensively applied in the improvement of engineering properties of foundation soil. Quarry dust can be effectively used in stabilization of weak soils. Quarry dust is a waste product from quarries, disposal of which is a problem faced nowadays and it is a cheap material. The strength improvement in the quarry dust stabilized soil is due the high specific gravity and angle of internal friction of the quarry dust.

II. MATERIALS

A. Kaolinite

Kaolinite clay sample of white colour was collected from English Indian Clay Limited, Kochuveli, Thiruvananthapuram. The soil sample was collected in polythene bags. Engineering properties of this soil were foundout from the lab tests and are listed in Table I.

TABLE.I. PROPERTIES OF KAOLINITE CLAY

Properties	Value
Colour	White
Liquid limit	34.9%
Plastic limit	23.8%
Shrinkage limit	21.9%
Plasticity index	11.2%
Specific gravity	2.6
Clay content	60%
Silt content	35.8%
Sand content	4.2%
Unconfined compressive strength	49.2kN/m^2
Shear strength	24.6kN/m^2
Maximum dry density	14.3kN/m^3
Optimum moisture content	30.5%

B. Quarry sand

Quarry dust was collected from local quarry at Attingal, Thiruvananthapuram. The particle size distribution of quarry dust is shown in Fig.1.

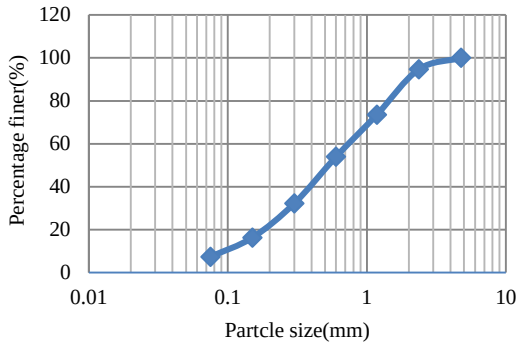

Fig. 1. Particle size distribution curve of quarry dust

Quarry dust has been sieved through 4.75 mm sieve and 75 micron sieve . So the sand sized particles were used for stabilization. The material was named as quarry sand. Tests such as sieve analysis, specific gravity and direct shear test were carried out in quarry dust. Properties of quarry sand are listed in Table.II.

TABLE.II. PROPERTIES OF QUARRY SAND

Parameter	Value
Shear strength(kN/m^2)	14
Angle of internal friction (degrees)	43
Specific gravity	2.7
Sand content	92.6%
Silt and clay content	7.4%

III. METHODOLOGY

A. Compaction

Compaction tests were done according to (IS:2720(Part 4)-1980) to find the optimum moisture content and maximum dry density. Air dried samples passing through 4.75mm sieve was mixed with 5% of quarry sand by the weight of dry soil. Then the optimum moisture content and maximum dry density were calculated. Such like that quarry sand was added in different percentages varies from 10% to 30% with a constant addition of 5%. From the tests optimum moisture content and maximum dry density of each composites were found out. On the second phase of the thesis compaction tests are done to study the effect of particle size. For that the quarry sand was graded into coarse sand, medium sand and fine sand. First of all 10% of coarse sand was mixed to the soil and compaction tests were carriedout. The maximun dry density and optimum moisture content were foundout. Like that 20% and 30% coarse sand was added and maximum dry densities and optimum moisture content were calculated. Then medium sand and fine sand were added in 10, 20 and 30% to soil. From the results the effect of particle size on the density characteristics were studied.

B. Unconfined Compressive Strength

Unconfined compressive strength tests are done according to **(**IS: 2720(Part 10) – 1991). UCC specimens are prepared at maximum dry density and optimum moisture content. Air dried samples passing through 4.75mm sieve was mixed with 5,10,15,20,25 and 30 % of quarry sand by the weight of dry soil and UCC tests were done. On the second phase of the thesis UCC tests were done to study the effect of particle size. So coarse, medium and fine sand was mixed in 10, 20and 30% to soil and UCC strength tests were conducted at corresponding optimum moisture contents and maximum dry densities.

IV. RESULTS AND DISCUSSIONS

A. Quarry Sand-Soil Composite

Compaction :A series of compaction tests were conducted to study the effects of quarry sand on the MDD and OMC. The variation of maximum dry density and optimum moisture content by the addition of quarry sand (0%,5%,10%,15%,20%,25% and 30%) was given in Fig.2. and Fig.3. respectively.

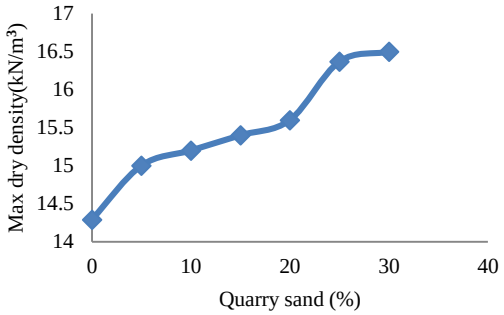

Fig.2. Variation of maximum dry density with different percentage of quarry sand

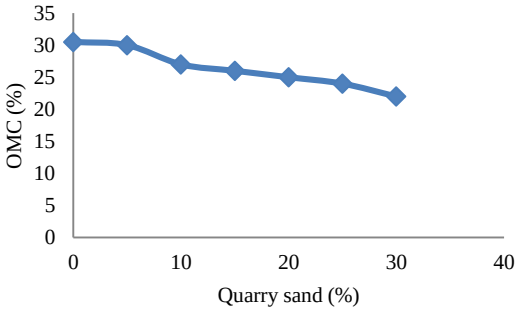

Fig.3. Variation of OMC with different percentage of quarry sand

From the Figures, it can be seen that there is a decrease in OMC an increase in MDD value with increase in percentage of quarry sand. The OMC of stabilized soil decreases 1.39 times when quarry sand is increased from 0 to 30%. The reason of such behavior is due to the replacement of soil particles with quarry sand cause the attraction for water molecules decreases. Hence, OMC decreases. MDD increases by the addition of quarry sand, because the specific gravity of quarry sand is higher than the specific gravity of soil. When we replace a low specific gravity material , the specific gravity of the composite will be greater than the low specific gravity material. So the specific gravity of soil-quarry sand composite will be greater than 2.6. The MDD of stabilized soil increases 1.17 times when quarry sand is increased from 0 to 30%.

Unconfined Compression Strength: The variation of UCC Strength tests on kaolinite clay treated with different percentage of quarry sand (0%,5%,10%,15%,20%,25% and 30%) are shown in Fig.4.

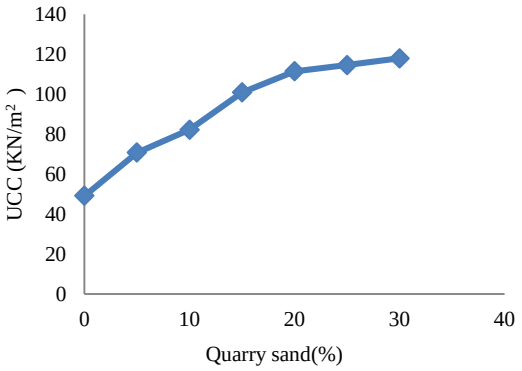

Fig.4. Variation of UCS with different percentage of quarry sand

From the figure it can be seen that with increase in percentage of quarry sand, the UCC Strength of soil goes on increasing. This is mainly because of the high specific gravity and angle of internal friction of the quarry sand .The UCC Strength of stabilized soil is increased 2.4 times than the unstabilized soil.

B. Coarse Quarry Sand-Soil Composite

Compaction: The variation of maximum dry density and optimum moisture content by the addition of coarse quarry sand (0%,10%,20%,30%) was given in Fig.5. and Fig.6. respectively.

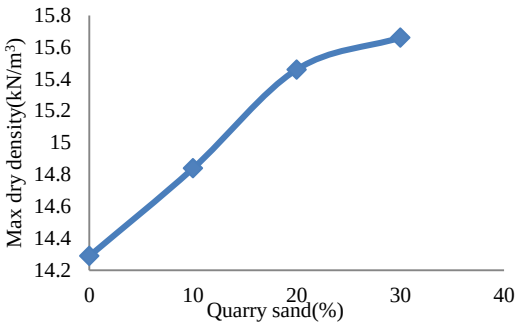

Fig.5. Variation of maximum dry density with varying percentage of fibre content

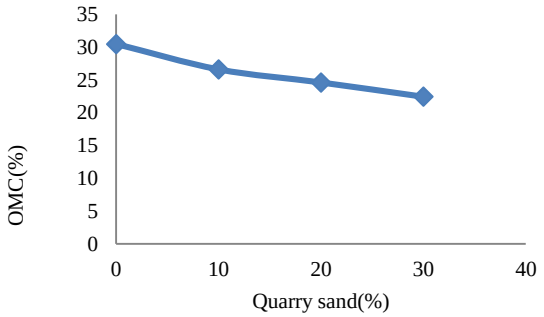

Fig.6.Variation of OMC with varying percentage of fibre content

From the figures, it can be seen that there is a decrease in OMC and increase in MDD with increase in percentage of coarse quarry sand. The reason of such behavior is, due to the replacement of soil particles by quarry sand which has less attraction for water molecules . MDD increases by the addition of quarry sand, because the specific gravity of coarse quarry sand (2.73) is higher than the specific gravity of soil.

Unconfined Compression Strength: The variation of UCC strength tests on kaolinite clay treated with different percentage of coarse quarry sand (0%,10%,20%,30%) are shown in Fig.7.

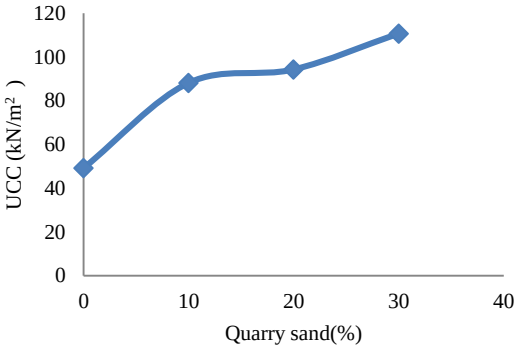

Fig.7. Variation of UCS with different percentage of quarry sand

From the figure it can be seen that with increase in percentage of quarry sand, the UCC strength of soil goes on increasing. This is mainly because of the high specific gravity (2.73) of coarse quarry sand .The UCC strength value increased about 2.25 times than that of unstabilized soil.

C. Medium Quarry Sand-Soil Composite

Compaction: The variation of maximum dry density and optimum moisture content by the addition of medium quarry sand (0%,10%,20%,30%) was given in Fig.8. and Fig.9. respectively.

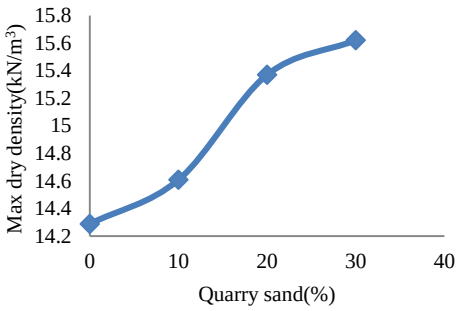

Fig.8. variation of maximum dry density with varying percentage of quarry sand

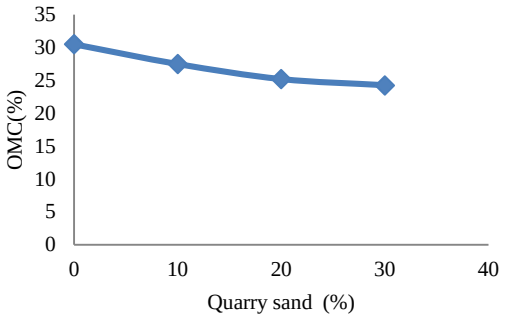

Fig.9. Variation of OMC with varying percentage of quarry sand

From thefigure, it can be seen that there is a decrease in OMC and increase in MDD value with increase in percentage of medium quarry sand. The reason of such behavior is, due to the replacement of soil particles by quarry sand which has less attraction for water molecules . MDD increases by the addition of quarry sand, because the specific gravity (2.68) of medium quarry sand is higher than the specific gravity of soil

Unconfined Compression Strength : The variation of UCC strength tests on kaolinite clay treated with different percentage of medium quarry sand (0%,10%,20%,30%) are shown in Fig.10.

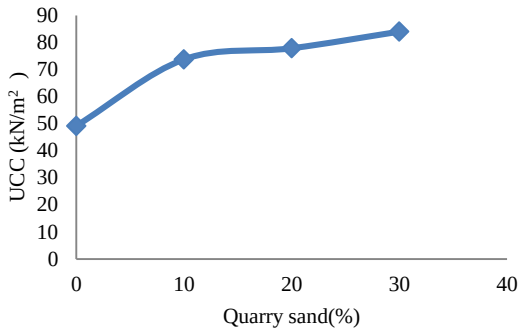

Fig.10. Variation of UCS with increase in medium quarry sand

From the figure it can be seen that with increase in percentage of quarry sand, the UCS of soil goes on increasing. This is mainly because of the high specific gravity (2.68) of the medium quarry sand .The UCC strength value increased about 1.7 times by the addition of 30% medium quarry sand.

D. Fine Quarry Sand-Soil Composite

Compaction: The variation of maximum dry density and optimum moisture content by the addition of medium quarry sand (0%,10%,20%,30%) was given in Fig.11. and Fig.12. respectively.

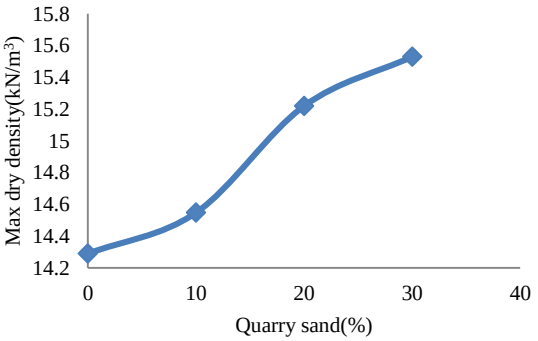

Fig.11. Variation of maximum dry density with varying percentage of fine quarry sand

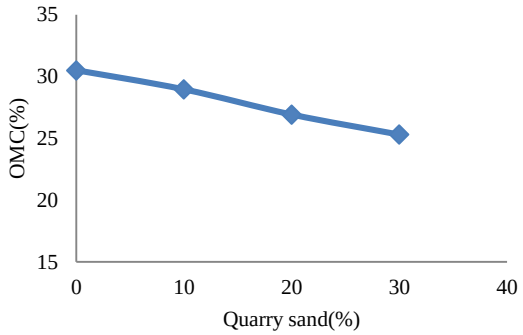

Fig.12. Variation of OMC with varying percentage of fine quarry sand

From the results, it can be seen that there is a decrease in OMC and increase in MDD value with increase in percentage of fine quarry sand.

Unconfined Compression Strength : The variation of UCC strength tests on kaolinite clay treated with different percentage of fine quarry sand (0%,10%,20%,30%) are shown in Fig.13.

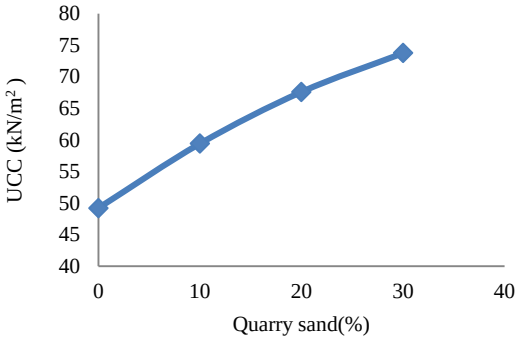

Fig.13. Variation of UCS with different percentage of fine quarry sand

From the figure it can be seen that with increase in percentage of fine quarry sand, the UCS of soil goes on increasing. This is mainly because of the high specific gravity (2.63) of the fine quarry sand compared to soil. The UCC strength value increased about 1.5 times by the addition of 30% fine quarry sand.

OMC decreases with increase in size. The comparison of variation of OMC with different sizes of quarry sand is shown in Fig.14. Fine sand have larger surface area so it absorbs water .But coarse particles absorb very less amount of water.

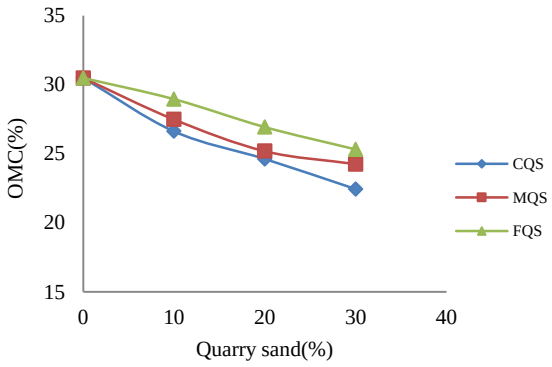

Fig.14. The comparison of variation of OMC with different sizes of quarry sand

Maximum dry density is directly related to size of quarry sand. The comparison of variation of MDD with different sizes of quarry sand is shown in Fig.15. Fine quarry sand shows lower specific gravity (2.63) than medium (2.68) and coarse quarry sand (2.73) particles. So the maximum dry density of soil composite due to coarse quarry sand is slightly higher than fine quarry sand.

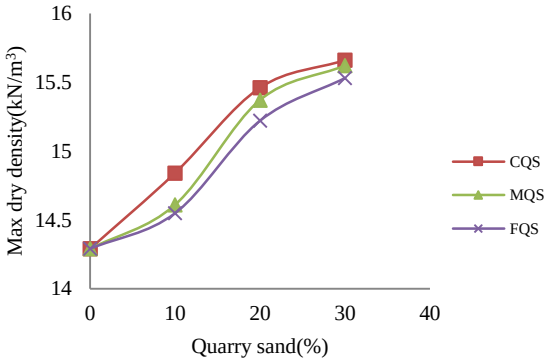

Fig.15. The comparison of variation of MDD with different sizes of quarry sand

Coarse quarry sand shows lager values of UCC. The comparison of variation of MDD with different sizes of quarry sand is shown in Fig.16. The specific gravity of coarse particles are higher than medium and fine particles.

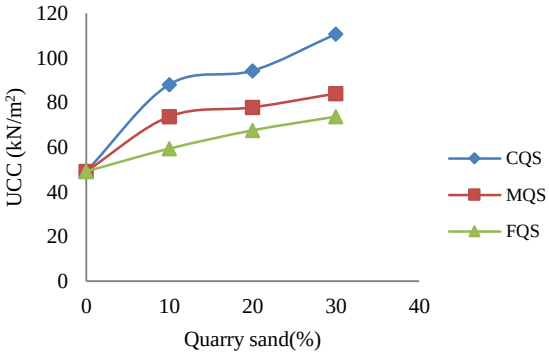

Fig.16. The comparison of variation of MDD with different sizes of quarry sand

I. CONCLUSION

There is an increase of maximum dry density (MDD) values for the addition of 30% quarry sand, because the specific gravity of quarry sand is greater than Kaolinite clay. OMC goes on decreasing with increase in percentage of addition of quarry sand. The UCS goes on increasing with increase in percentage of addition of quarry sand. UCS results of stabilized soil with 30% quarry sand was increased 3.1 times than the unstabilized soil.

Maximum dry density increases with increase in percentage of coarse, medium and fine quarry sand. OMC decreases with increase in percentage of coarse, medium and fine quarry sand. Maximum dry density increases with the increase in particle size . OMC will decrease with increase in particle size . Soil mixed with coarse sand shows the maximum value of UCC compared to medium and fine quarry sand. UCC increases with respect to the size of the quarry sand.

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