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Laboratory Studies on the Effectiveness of Quarry Dust and Bottom Ash with Treated Marine Clay for Adaptable Flexible Pavement Sub-Grade

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Keywords: Stabilization, Marine Clay (MC), Bottom Ash (BA), Quarry Dust (QD), OMC, MDD, CBR

Abstract. The soil found on the seabed is classed as Marine clay. The major proportion of marine soil is clay so it is generally referred as marine clay (MC). The MC is often weak and lacks stability in heavy loads. This research is concerned with the potential of BA (Bottom ash) and QD (Quarry dust) as soil stabilizers based on resistance enhancement. Soil stabilization points to make strides the geotechnical features of the MC. The engineering properties of MC have been built-up, such as grain size distribution, particle density and soil plasticity. The soil sample was blended and compacted with various quantities of the BA and QD i.e. 2.5%, 5%, 7.5%, 10% 12.5% and 15% for compaction and strength test. The dry-weight method was utilized to prepare the samples. A standard Proctor test was run to determine the stabilized floor OMC and MDD. In the interim, the CBR was conducted to obtain the strength of the stabilized soil. Test results indicate that the MDD of the MC has been improved by 0.19 (g/cc) on addition of 10% BA and it has been improved by 0.246 (g/cc) when 10% QD is added when compared with untreated MC. Laboratory analyses of the cyclic plate load test revealed the ultimate load carrying capacity of the treated MC model flexible pavement has been increased by 349.9% at OMC when compared with untreated MC model flexible pavement.

Introduction

Many parts of the world, such as India, the United States, Egypt, etc., are struggling with construction issues due to clay soil.

The study is focused on the following points:

1. Advancement of locally accessible soil utilizing a few eco-friendly and cheap squander materials.
2. Assessment of quality characteristics of virgin as well as mixed soil utilizing diverse extents of QD and BA.
3. Assurance of fitting QD and BA substance proportion can accomplish the greatest pick up in quality of soil.

Wide run of soil alteration strategies are accessible based on the sort of soil and its characteristics, sort of the development, time accessible, related taken a toll. It has been watched that mechanical by-products can cause exceptional alter within the soil properties in terms of quality characteristics, thickness, sharpness etc., parched too serves rural benefits by increasing crop yield. It may be a well-established truth that the stack coming from the superstructure is eventually borne by the soil. The sandy soil has the property of liquefaction while sweeping soil imbibes part of water posturing danger to little structures, canal-linings, asphalts. Subsequently when an inadmissible condition is met, conceivable elective arrangement can be either of • Forsake the site • Expel and supplant the soil • Overhaul the arranged structure accordingly • Treat the soil to alter its properties or Ground Improvement The final strategy recorded over is known as Ground Improvement Technique or Geotechnical Engineering Practice which is used in this work.

Objectives of the study

- To decide the properties of MC, BA and QD,
- To assess the performance of Raw MC with the addition of BA and its suitability for sub-grades of flexible pavements.
- To assess the performance of BA stabilized MC with the addition of QD and its suitability for sub-grades of flexible pavements.

Materials and Methods

Marine clay (MC). The MCs largely found within the states of West Bengal, Orissa, Andhra Pradesh, Tamilnadu, Kerala, Karnataka, Maharashtra and some parts of Gujarat.
The MC used in this work has been collected near sea coast, Kakinada, Andhra Pradesh
The volume changes of soils are occurs due to variations in moisture content present in the soil. Amid dry-season, a shrinkage crack may occurs close the surface, expanding to profundity of around 1.5m, demonstrating for compressibility.

Furnace BA (FBA). Furnace BA (FBA) is composed of agglomerated fly fiery debris collected at the furnace bottom or combustion chamber of the power station boiler. The grain size of furnace BA ranges from fine sand to fine gravel (more prominent than 5 mm size).
There are two types of BA
A) Dry BA: The ash is in a solid state at the furnace bottom
B) Wet BA: The ash refers to the molten state of the ash which leaves the furnace as a liquid.

BA (Bottom ash) Properties. The BA used in this work has been collected form VTPC (Vijayawada Thermal Power Corporation). Fly fiery debris is, therefore, ideal for backfilling retaining walls or for building dikes over delicate soils since of its:
High internal angle of friction, Low unit mass, Low compressibility, diminished settlement when utilized as fill fabric, Ease of compaction and self-hardening properties, coming about in a conceivable decrease in fill pressures on structures.
To use BA in embankment fill, attention should be paid to the control of:

- Erosion caused by surface runoff and internal piping, dust and leaching,
- Care should be taken with the use of acidic BA in backfill against concrete structures to ensure that they do not attack the concrete.

QD (Quarry dust). The QD brought from Padmavathi crusher present at Yeleswaram from 40 Km away Kakinada.

Remedial measures to overcome issues of marine clay soils. If soil incorporates high deformation, the preventive measures are required. These measures can be broadly classified into the following categories:

- Avoiding highly compressible soils
- Alterations to these soils

In case of Asphalt sub-grade, stabilization procedures can be adopted using different mechanical squander considering the economy additionally chemical added substances for simple blending and early comes about. The support strategies moreover play imperative part in progressing the stack carrying capacity of the marine clay beds.

Soil Replacement. It consists of replacing the weak marine clay by using the rich soils available within the vicinity. So that the allowable bearing pressure of the foundation bed or sub-grade of the flexible pavement can be improved and also the deformations can be controlled up to some extent.

Sand Cushion Method. In this method, the whole profundity of the marine clay stratum or a portion thereof is expelled and supplanted with a sand pad, compacted to the desired density and thickness. The deformation varies inversely as the thickness of the sand layer and directly as the density of the sand. Arrangement of sand pad is likely based on the suspicion that it would retain upward and lateral deformations. The sand pad strategy in this way bristles with serious restrictions especially when it is embraced in profound strata. Foundation engineers regularly recommend a few subjective thicknesses for sand cushion.

Stabilization of Marine Clay. Soil stabilization could be a strategy where natural or manmade additives or folios are utilized to make strides the properties of soils. Chemical added substances, such as lime, cement, Rice Husk Fiery debris, Fly fiery debris and other chemical compounds have been utilized in marine clays stabilization for numerous a long time with different degrees of success.

Compositional variety through ionic or isomorphism substitution inside the clay mineral crystal lattice can take off the structural unit with a net negative charge. The presence of this net negative charge implies that soluble cations can be pulled in or adsorbed on to the surface of the clay mineral auxiliary units without modifying the essential structure of the clay mineral. The most common soluble cations are Na+, K+, Ca2+, Mg2+, H+, and NH4+.

Cation exchange capacity (C.E.C.) is measured in terms of milli-equivalent of the atomic weight of solvent/100 gram of the dry solid, which varies widely for various types of clay minerals.

Laboratory test results & Discussions

The impact of diverse materials on the compaction and CBR properties were discussed in this article. In the laboratory, index tests, swell tests, strength tests were conducted by supplanting MC partially by BA and QD at distinctive rates with a view to determine the supplanting extents. The CBR values of the untreated and treated MC were determined at the respective OMC of the various mixes obtained from the IS modified compaction test.

The impact on the addition of BA and QD on compaction, CBR, swelling, strength properties and Atterberg limits of MC were discussed in detail in the following sections.

Effect of BA on Compaction properties of MC. Individual influence of BA on the compaction properties of MC as observed in the laboratory testing by replacing MC with BA partially by 2.5%, 5%, 7.5%, 10% and 12.5% respectively.

The ideal percentages of distinct individual additives observed during the laboratory experimentation appeared below.

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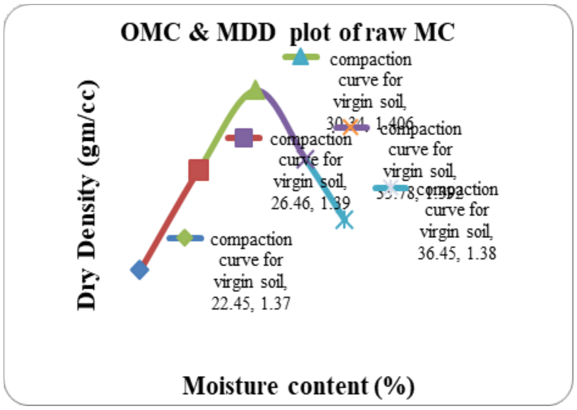

Fig 1. Compaction properties of raw MC

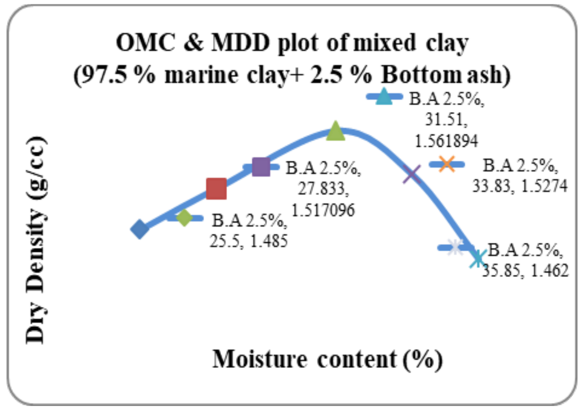

Fig 2. Compaction properties of 2.5% BA treated MC

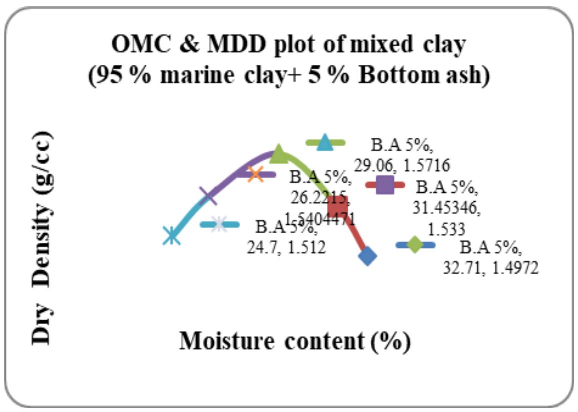

Fig 3. Compaction properties of 5% BA treated MC

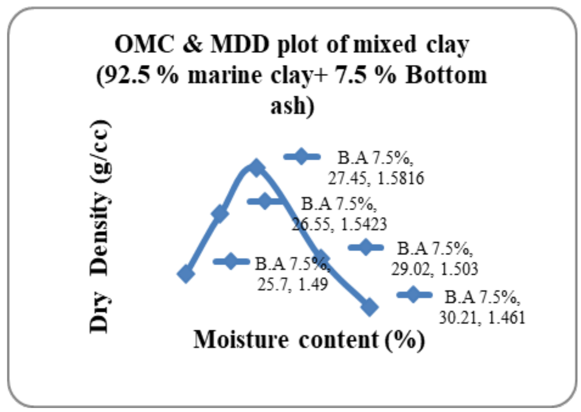

Fig 4. Compaction properties of 7.5% BA treated MC

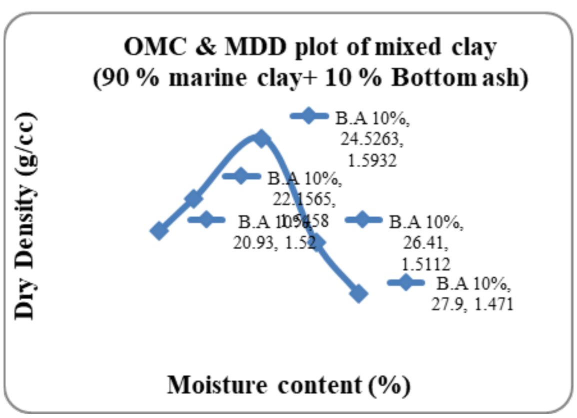

Fig 5. Compaction properties of 10% BA treated MC

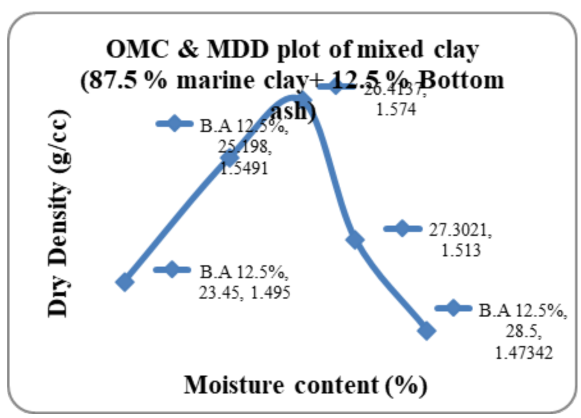

Fig 6. Compaction properties of 12.5% BA treated MC

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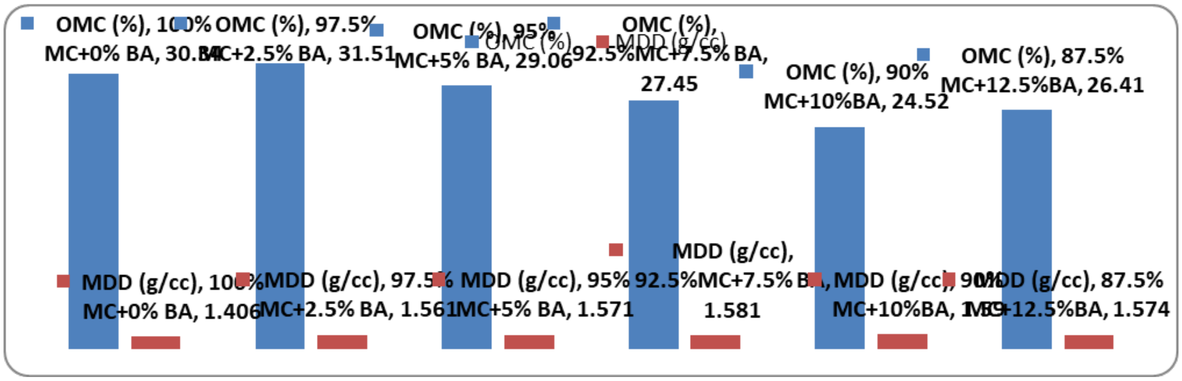

Fig 7. OMC & MDD Values for Different Percentages of BA Treated MC

Of all the different combinations of BA tried in this investigation, it was observed that optimum is found to be obtained at 10% BA. However, more than the adding of 10%, there is lowering the MDD values of treated MC.

Effect of BA on CBR of MC. CBR values of distinct blended percentages of MC and BA using OMC obtained from standard proctor tests are determined. The soaked CBR test is done. Variation in CBR of raw MC and MC with 7.5%, 10%, 12.5% partial replacement by BA is presented in the following figures.

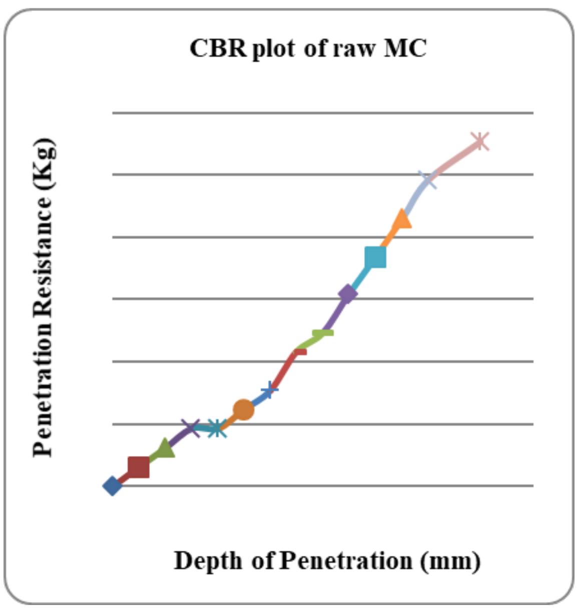

Fig 8. CBR for untreated Marine Clay

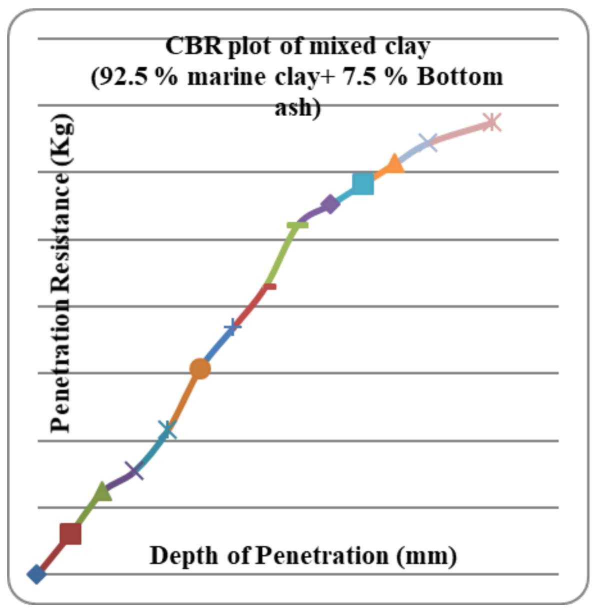

Fig 9. CBR of 7.5% BA treated MC

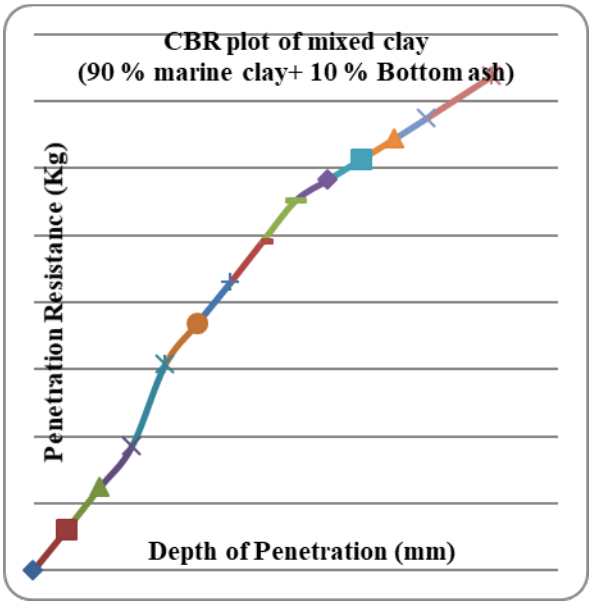

Fig10.CBR of 10% BA treated MC

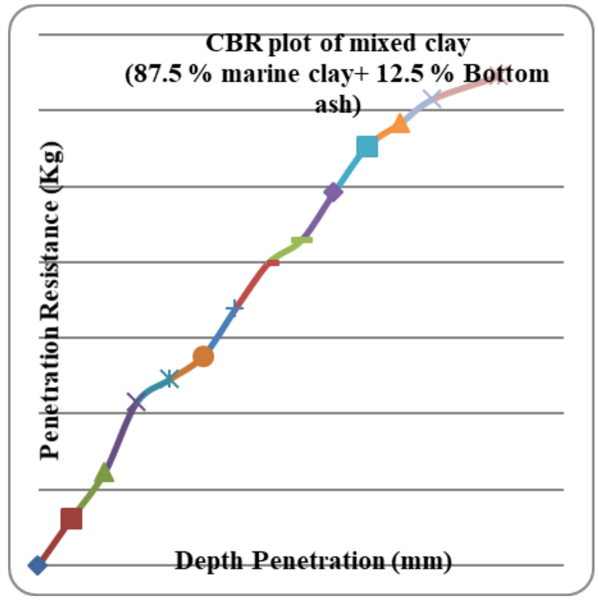

Fig 11. CBR of 12.5% BA treated MC

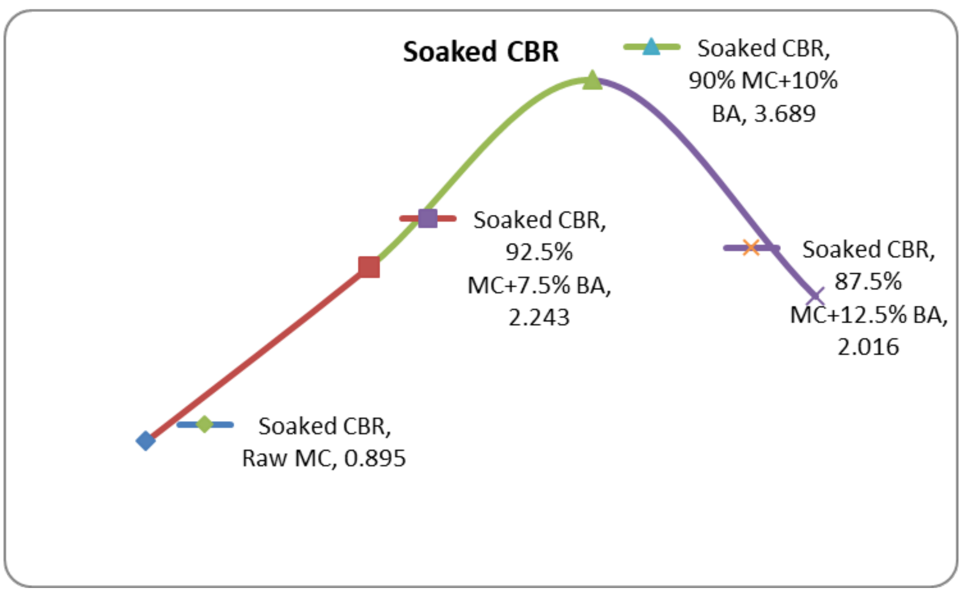

Fig 12. CBR Values for Different Percentages of BA Treated MC

It was observed that optimum CBR is found to be obtained at 10% BA. However, other combinations of the adding of BA, there is a decrease in CBR values of treated MC. The stabilized MC i.e., raw MC with 10% replacement with BA is further evaluated for the compaction properties and CBR by the addition of QD at various proportions.

Effect of QD on Compaction properties of stabilized MC (90% MC+10% BA). nfluence of QD on the compaction properties of stabilized MC as observed in the laboratory testing by replacing stabilized MC with QD partially by 5%, 10% and 15% respectively.

The ideal distinct additives observed during the laboratory experimentation appeared below.

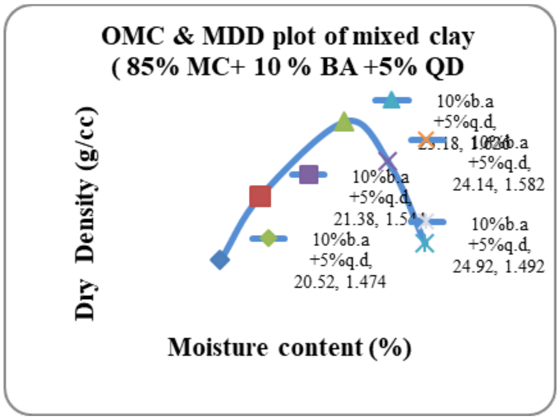

Fig 13. Compaction properties of 5% QD treated stabilized MC

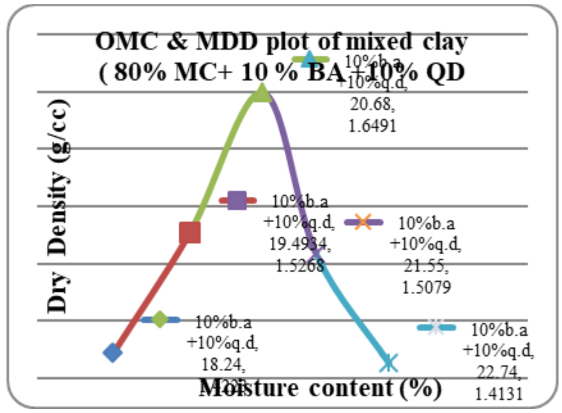

Fig 14. Compaction properties of 10% QD treated stabilized MC

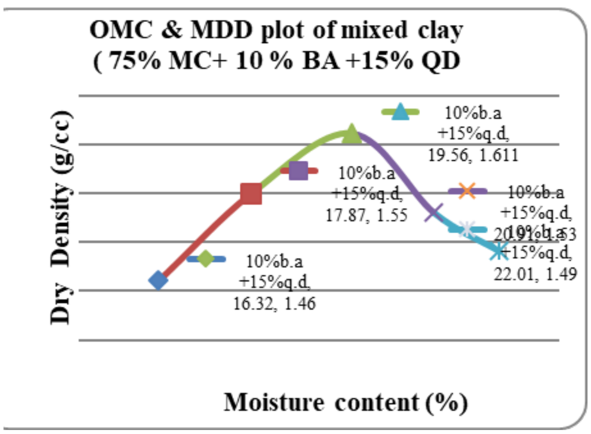

Fig 15. Compaction properties of 15% QD treated stabilized MC

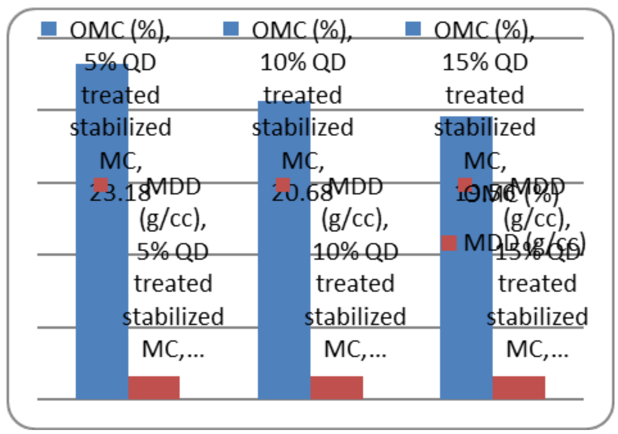

Fig 16. OMC & MDD Values for Different Percentages of QD Treated stabilized MC

Effect of QD on CBR of stabilized MC (90% MC+10% BA). CBR values of various mixes of 10% QD treated stabilized MC are calculated. The soaked CBR value is determined. Variation in CBR of stabilized MC and MC with 7.5%, 10%, 12.5% partial replacement by QD is presented in the following figures.

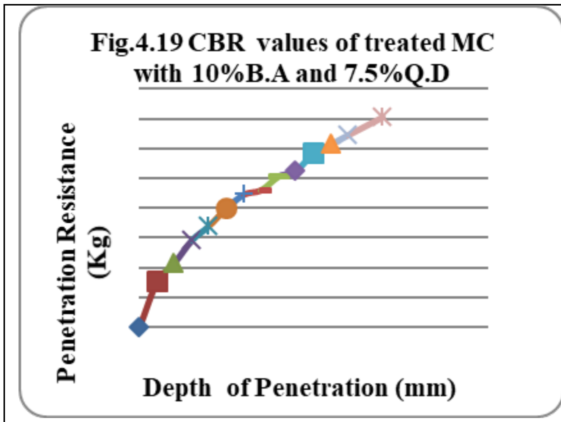

Fig 17. CBR of 7.5% QD treated stabilized MC

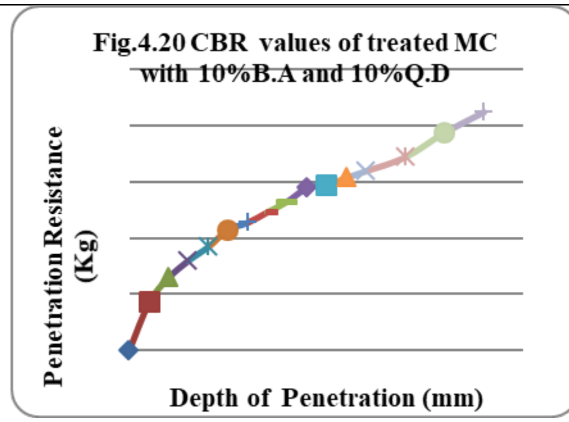

Fig 18. CBR of 10% QD treated stabilized MC

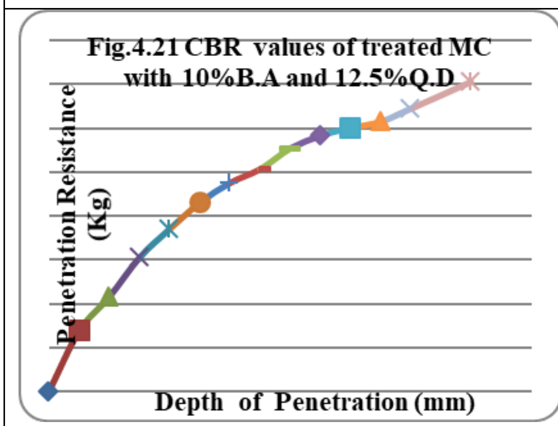

Fig 20. CBR of 12.5% QD treated stabilized MC

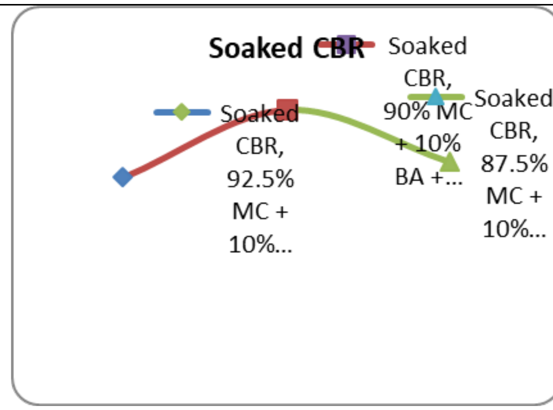

Fig 21. CBR Values for Different Percentages of QD Treated stabilized MC

Properties of BA, QD, Untreated and Treated MC

Table.1 Comparison of physical properties of MC, BA and QD before and after treatment

Sl.No	Property		BA	QD	Untreated (Raw) MC	Treated MC (10% BA)	Treated MC (10% BA+ 10% QD)
1	**Grain size distribution**						
	Gravel (%)		-	16.36	0	-	3.2
	Sand (%)		86	83.18	1.2	9.6	17.8
	Fines	Silt (%)	10	0.46	4	4.3	4.1
		Clay (%)	4	0	94.8	86.1	74.9
2	**AtterBerg limits**						
	Liquid Limit (%)		NON PLASIC	NON PLASIC	64.52	44.52	36
	Plastic Limit (%)				30.12	27.96	24.09

	Plastic Index (%)			34.40	16.58	11.91
3	Soil Classification	SW	SW	CH	CI	CI
4	Specific Gravity	2.21	2.87	2.4	2.58	2.62
5	**Compaction properties**					
	Optimum Moisture Content (%)	23	13.4	30.34	24.52	20.68
	Maximum Dry Density (g/cc)	1.53	1.94	1.4	1.59	1.64
6	Cohesion (kN/m^2)	7.2	4.8	120	65	25
7	Angle of Internal Friction (°)	9	16	3.5	6	8
8	CBR Value (soaked) (%)	3.59	8.96	0.89	3.68	7.84

Summary

The following conclusions are drawn based on the results of the laboratory testing.

- It is found from the test results that the O.M.C of the M.C has been diminished by 5.82% in addition to 10% BA and it has been further diminished by 9.66% when 10% Q D is added when compared with untreated MC.

- It is found from the test results that the M.D.D of the MC has been improved by 0.19 (g/cc) in addition to 10% BA and it has been improved by 0.246 (g/cc) when 10% QD is added when compared with untreated MC.

- It is observed from the test results that the C.B.R. the value of the MC has been increased by 412.17% in addition to 10% BA and it has been further improved by 880.89% when 10% QD is added when compared with untreated MC.

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