OPTIUM STABILIZATION REQUIREMENT OF IMO CLAYSHALE

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ABSTRACT

Clayshale is one of the problematic soils often encountered in civil engineering construction and is notable for its low shear strength when wet and rapid deterioration on exposure to weather .

The geo-technical and engineering properties of samples of Imo clayshale collected from Nsugbe – Omo (along Onitsha – Nsukka road in the eastern part of Nigeria) were investigated. When the existing standards in civil engineering practice such as Road Note 29, Western Nigeria Road specification, Nigeria Board of Road Research Institute, (NBRRI), the soil proves highly inadequate for road construction from strength criteria. Also index properties suggest that the sample is a potentially high swelling clay.

In order to reduce the expansiveness of this sample and also increase the strength, stabilization by additives was employed.Cement, Lime and flyash were utilized at various percentages. Stabilized samples were tested in accordance with BS 1924 (1975) .

It was observed that flyash -stabilization – Imo clayshale is inadequate for civil engineering construction both from strength criteria and index properties. It was also observed from the results that 8% lime,15%lime, mixture of 6%lime and 8% flyash, and 15% cement are suitable for road construction on the basis of strength criterion.

INTRODUCTION

Soil has proved to be the most highly indispensable singular material in construction industry. It remains highly variable and complex in nature. When the engineer comes face to face with such a situation that soil proves to be incapable of functioning for the purpose for which it is employed a number of option of what to do are put into consideration.

■ Redesign of the structure so that the soil can carry the load to be imposed. This, most of the time is impracticable, as the maximum load allowable for such deposit may be too low that it becomes unrealistic to put appreciable structure on such a soil.

■ Removal of the entire soil from a tested borrow pit; this is uneconomical when the deposit is considerably large.

■ Improving its physiochemical and geo-technical properties: this technique over the years has proved to be the most practicable in terms of cost and engineering judgement. The latter is referred to as SOIL STABILIZATION. " To alter its physical properties, increase its strength and durability and thus provide a satisfactory foundation and walling material" Ola (1983).

There are number of ways stabilization of soil can be effected. The result of a method will depend strongly upon such factors as the properties of the soil, state of occurrence and environment factors. Stabilization may be mechanical or chemical or by chlorides additions. Mechanical stabilization will work best on cohesionless deposits. Chlorides too is to improve the cohesion therefore the work focuses on the use of chemical additives like cement, lime or flyash since the material is cohesive.

The aim of the work is to be able to give an adequate recommendation on the type of stabilizer and the percentage that will be adequate for different purpose in terms of strength development. The mineralogical test were not covered as have been widely reported but tests such as the Atterberg limit, sieve analysis, free swell and unconfined compressive strength tests were performed on the natural deposits and on the stabilized sample.

What led to the recent study of the deposit was the damage of the bridge at 38km from Onitsha (between Aguleri and Omo) believed to be as a result of the expansion of Imo clayshale deposit underlying it.

REVIEW OF PAST WORK

Imo clayshale is located within a terrain containing the lower Orle and Owan rivers and the upper Oha river/clay-shale, 120 to 180 metres thick overlying thin sand stones in shale belonging to the transitional group (Tahal consultant Nig. Ltd,1977). ACKROYD (1967), recognised the presence of Imo clayshale in the South Eastern basin of Nigeria and that the prevailing rainfall of the areas exceeds 1500m which does not favour the concretionary formation because of strong leaching.

Clayshales had also been grouped as argillaceous material predominantly less than 0.002mm size and compressive strength less that 12.5mn/m^2(Maclean and Gribble 1979) . It behaves like rock, but on exposure to water or moisture it softens and expands. For this unstable character, a lot of havoc results when underlying a building or pavement. Imo clayshale derives its name from the fact that the deposit was first recognised along the Imo river channel. The deposit attains a thickness of about 500metres along the river channel between Umuahi and Okigwe (Simpson, 1954 and Wilson and Bain, 1928) and rests conformably on the Nsukka formation.

The predominant clay minerals in Imo clayshale had also been identified as illite and with notable percentages of kaolinite and smectites Chimley et la, 1979) . kulamand (1977), conceded that 6%hydrated lime,14% portland cement and 25% flyash give option condition by imparting acceptable strength level to the clayshales found in Oklahoma, United State of America.

EXPERIMENTAL INVESTIGATION

The following tests were performed on the natural soil; cement- stabilized soil, lime – stabilized soil, flyash – stabilized soil, Atterberg limits swelling, proctor compaction, unconfined compression strength and California Bearing Ratio. The test on the natural sample were performed generally in accordance with the relevant section of British Stardard Specification BS 1377 (1975), while the test on the stabilized test were performed in accordance with relevance sector of BS 1924 (1975) with exception of free swell test carried out as adopted by Balogun (1991) .

$$\text{Free Swell} = \frac{(v-v^1)}{V^1} \times 100\%$$

Where v is the volume of soil mixture after swelling and v^1 is the volume of soil mixture before swelling (i.e. 10cc).

The percentage of the stabilizer by weight were varied from 2% to 15% and tested to determine the optimum.

RESULTS

The physical properties of natural Imo clayshale are given in Table I. From the sieves analysis results 94.5% of sample used for the test passed No .200 B. S sieves while about 47% was found to be of clay size. The result all laboratory tests are given in tables 2, 3, 4, 5, and 6.

Table 1.

Physical Properties of the Natural Imo Clayshale

Moisture Content	45.50%
Specific Gravity	2.61%
Liquid Limit	103. 00%
Plastic Limit	6.65%
Plasticity Index	96.35%
Linear Shrinkage	17.10%
Free Swell	45.00%
Proctor Maximum Dry Density (M.D.D)	1293.00kg/m^3
Option Moisture Content (O.M.C)	29.80%
Unconfined Compressive Strength (U.C.S.) measured at MDD	46.0%km/m^2
California Bearing Ratio (C. B. R)	
Unsoaked	0.72%
Soaked	0.65%

DISCUSSION OF RESULTS

Atterberg limits

Table 2 and figure 3 show the variation of the Atterberg limits of Imo clayshale with cement, lime and flyash. From the Table of results, cement at 15% brings the plasticity index and liquid limit to 48.03% and 82.2% respectively. Lime at 6% records plasticity index and liquid limit of 17.6% and 54. 6% respectively and at 15% lime it was no longer plastic. Flyash at 15% has plasticity index and liquid limit of 45.2%and 69.4% respectively.

According to Gromko (1974), plasticity index higher that 35%and liquid limit higher than 60% is considered high. When linear shrinkage is less than 6% it is non critical (Gromko, 1974 and Ola,1983). At 6% lime the linear shrinkage is 5% and at 8% it reduced to 3%. Thus 6% lime produce the desired results in reducing the plasticity index, liquid limit and shrinkage.

Compaction Characteristics.

The proctor maximum dry density (MDD) variation with additive is as shown in Figure 5. With lime and flyash the MDD decreases as shown in Table 4 although there was an initial slight increase at 2% but as the percentage increases the MDD also increase in value. Both lime and flyash record a considerable increase in O.M.C up 8% contents while cement increases at 2% and reduces on further increase in cement content. Lime and cement increase the unconfined compressive strength while the effect of flyash on clayshale seems unsatisfactory. At 15% cement, the unconfined compressive strength (U.C.S) is 171 kN/m^2, lime at 15% reach 124kN/m^2, Although when soaked for 7 days lime at 10% the U.C.S was found to be 192kN/m^2 but at 14 days reduces to 96kN/m^2.

CBR RESULTS

The result is as shown in Table 6, the highest C.B.R is with 15% cement with CBR 14.22% and 15% lime with 10.22% CBR. For sub-grade of road 8% cement, 4% lime will produce a desirable result.

Other test performed was on mixture of lime and flyash as proposed by kulamad (1977) that 6% lime and 8% flyash mixture produces desirable results on the Oklahoma clayshales. This was marginally okay with liquid limit of 67%,plasticity index 34% linear shrinkage 13.22%, MDD is 1264kg/m^3, O.M.C 30.4%, U.L .S 180km/m^2 and C.B.R 7.04%. Thus,on the basis of strength Imo claysale is considered okay for subgrade but it is not a fine result from Atterberg limits view point.

CONCLUSIONS

The sample behaves in a very similar manner to that of Sokoto soft clayshale (Ola, 1983) though denser, harder and with less pronounced swelling nonetheless it can still be classified as soft sample, highly plastic and of very high swelling potential.

From Salter (1988), Road Note 29, Watson (1989), Madedor (1982), NBRRI (1983) and Western State Specification for road and bridges (1965) the following conclusions were reached for Imo clayshale.

1. When Imo clayshale is encountered on the site designers should not jump to the conclusion that it must be removed since additive can be employed to stabilize it to meet the required degree of stability for sub-grade.
2. None of the stabilizer employed is able to produce the minimum required CBR of 30% of sub-base.
3. Although 10% CBR is minimum for major road sub-grade in Nigeria, for minor road, 8% cement, 4% lime and a mixture 6% lime and 8% flyash will be adequate if properly cured as allowed in practice.
4. Looking critically at the selection of care materials in earth dam, 6% or maximum of 8% lime will produce the required properties based on the index properties and particle size distribution (Terzaghi and Peck,1967).
5. For building it is generally believed in geotechnics that a heavy load will curtail swelling but it will not work on clayshale since it will fail in strength even at lower water table, Therefore pilling may be required when a massive deposit of clayshale is encountered.

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TABLE 2 LINEAR SHRINKAGE

Stabilizer	Percentage	Linear Shrikable (%)
Cement	0	17.1
	4	16.2
	8	15.6
	15	14.0
Lime	4	11.0
	6	5.0
	8	3.0
	15	non plastic
	4	15.75
Flayash	6	17.50
	8	18.00
	15	

TABLE 3 INDEX PROPERTIES OR ATTERBERG LIMITS

Stabilizer	Percentage	Liquid Limit%	Plastic Limit %	Plasticity Index %
Cement	0	103.0	6.65	96.35
	2	91.5	9.4	82.1
	4	87.5	27.5	60.0
	6	85.5	29.2	56.3
	8	82.2	30.17	52.03
	15	82.2	33.9	48.03
Lime	2	65.2	10.0	55.2
	4	59.7	13.5	46.2
	6	54.6	37.0	17.6
	8	53.5	46.15	7.35
	15	-	-	non plastic
Flayash	2	76.3	13.8	62.5
	4	76.5	18.0	58.5
	6	74.0	19.5	54.5
	8	76.0	20.1	55.9
	15	69.4	24.2	45.7

TABLE 4 COMPACTION SUMMARY

Stabilizer	Percentage	Max. Dry Density	O.M.C %
	0	1293.0kg/m3	29.80
Cement	2	1239.0"	35.60
	4	1262.0"	33.20
	6	1269.0"	31.70
	8	1284.0"	30.40
	15	1296.4"	29.30
Lime	2	1290.2"	30.60
	4	1276.2"	33.60
	6	1250.0"	35.80
	8	1217.0"	36.15
	15	1235.0"	33.95
Flayash	2	1298.0"	28.60
	4	1266.0"	32.60
	6	1266.0"	33.30
	8	1266.0"	35.00
	15	1254.0"	35.00

TABLE 5 UNCONFINED COMPRESSIVE STRENGTH U.C.S.

Stabilizer	Percentage %	U. C. S. KN/M2
	0	46.0
Cement	2	56.4
	4	71.0
	6	101.0
	8	130.0
	15	171.0
Lime	2	59.0
	4	66.7
	6	67.0
	8	68.0
	15	124.0
Flayash	2	80.0
	4	36.0
	6	44.0
	8	48.0
	15	60.0
6% Lime and 8% Flyash		280km/m2

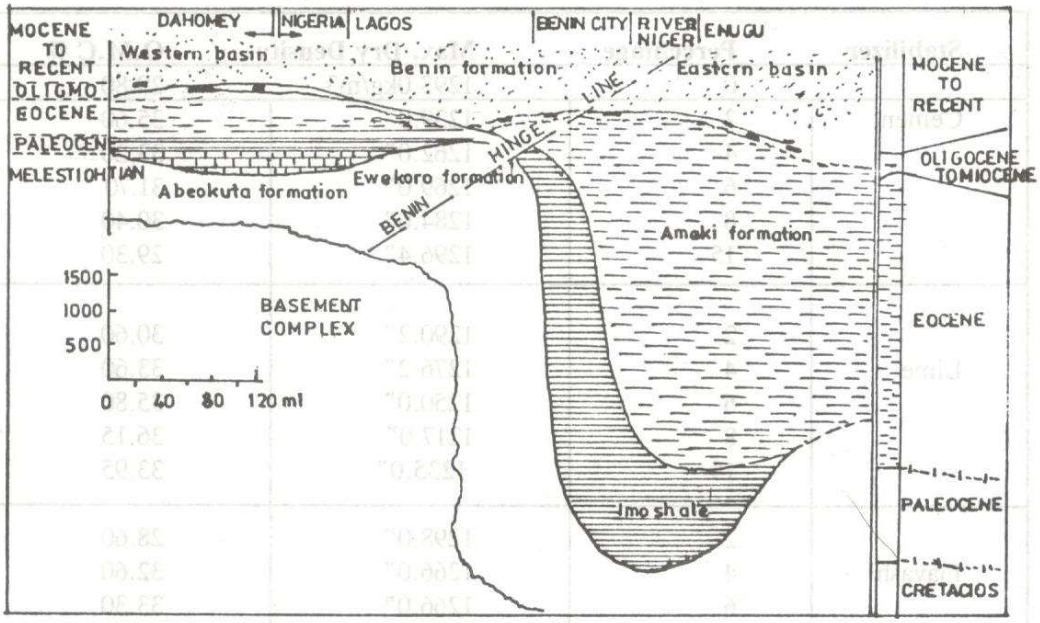

Fig-1 : GENERALISED TERTIARY STRATIGRAPHY OF SOUTHERN NIGERIA (AFTER ADEGOKE 1959)

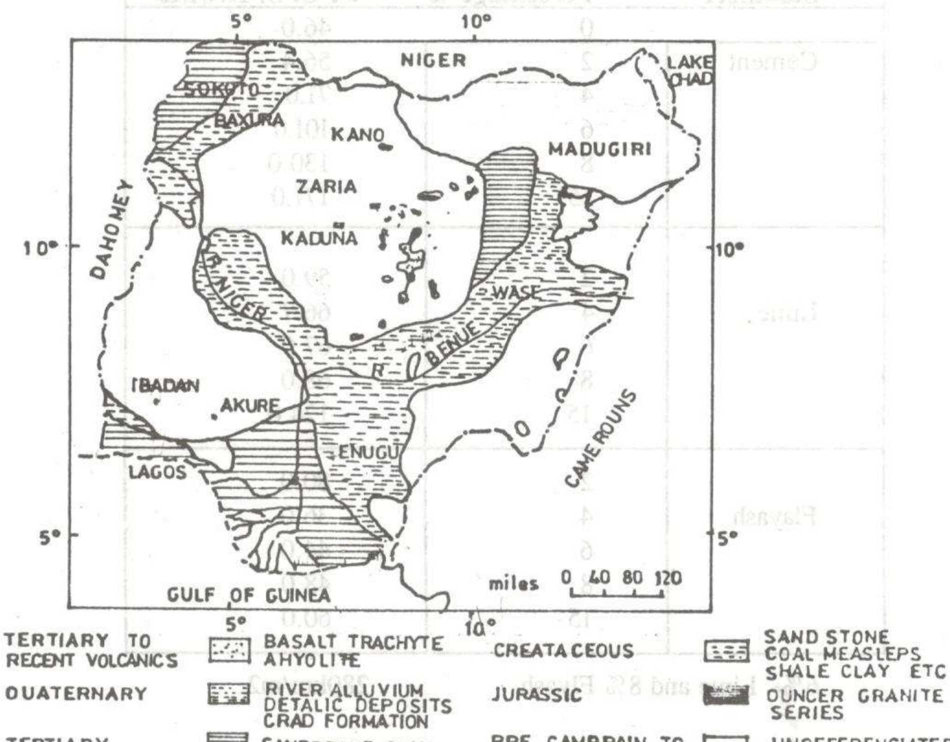

Fig. 2 : SIMPLIED GEOLOGICAL MAP OF NIGERIA

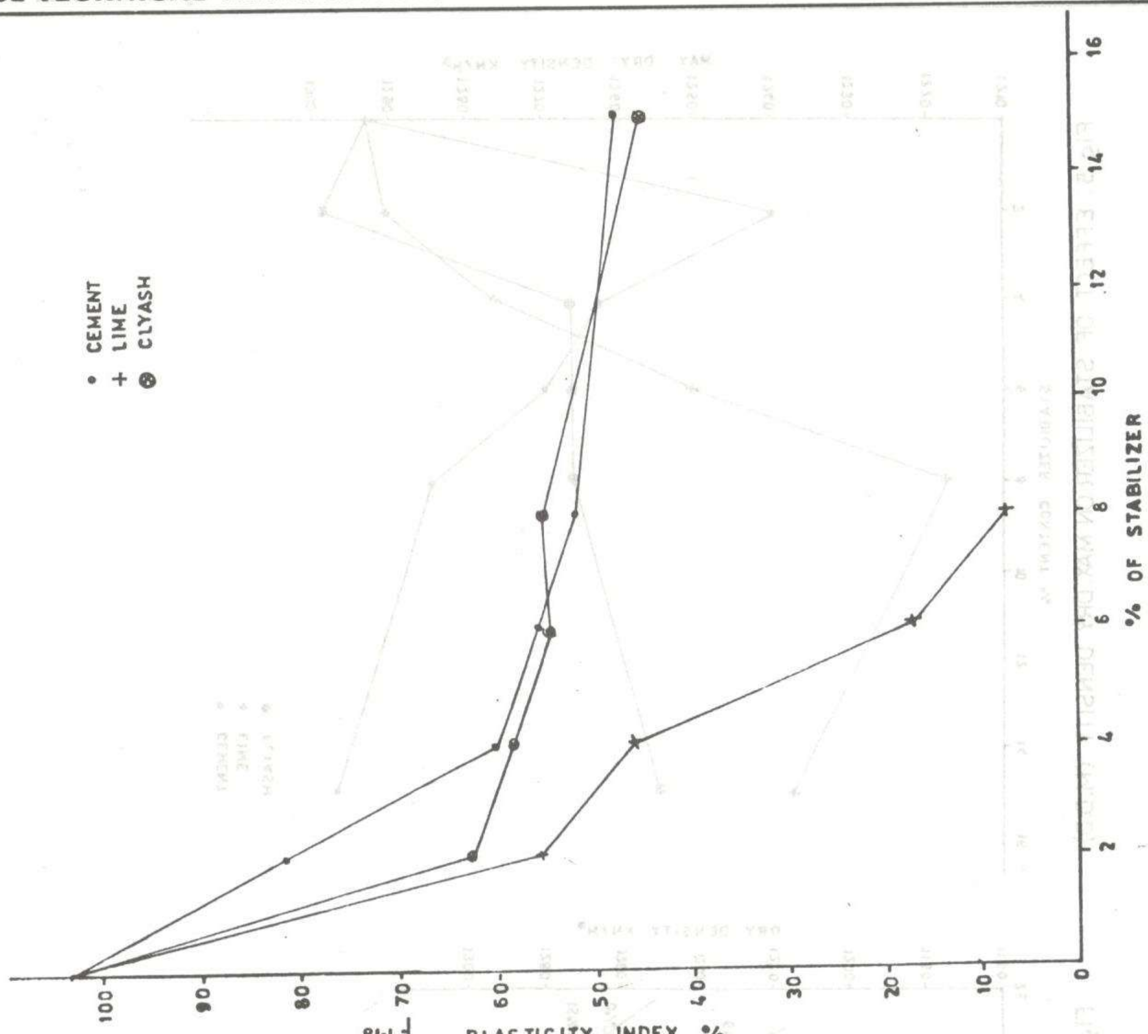

Fig. 4 : EFFECT OF STABILIZER ON PLASTICITY INDEX OF IMOCLAY SHALE

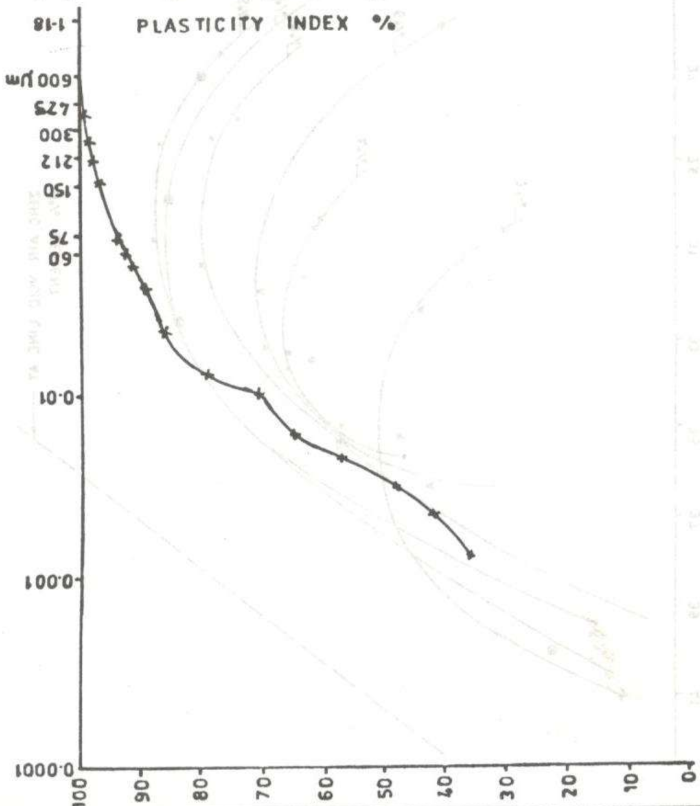

Fig.3 : PARTICLE SIZE mm

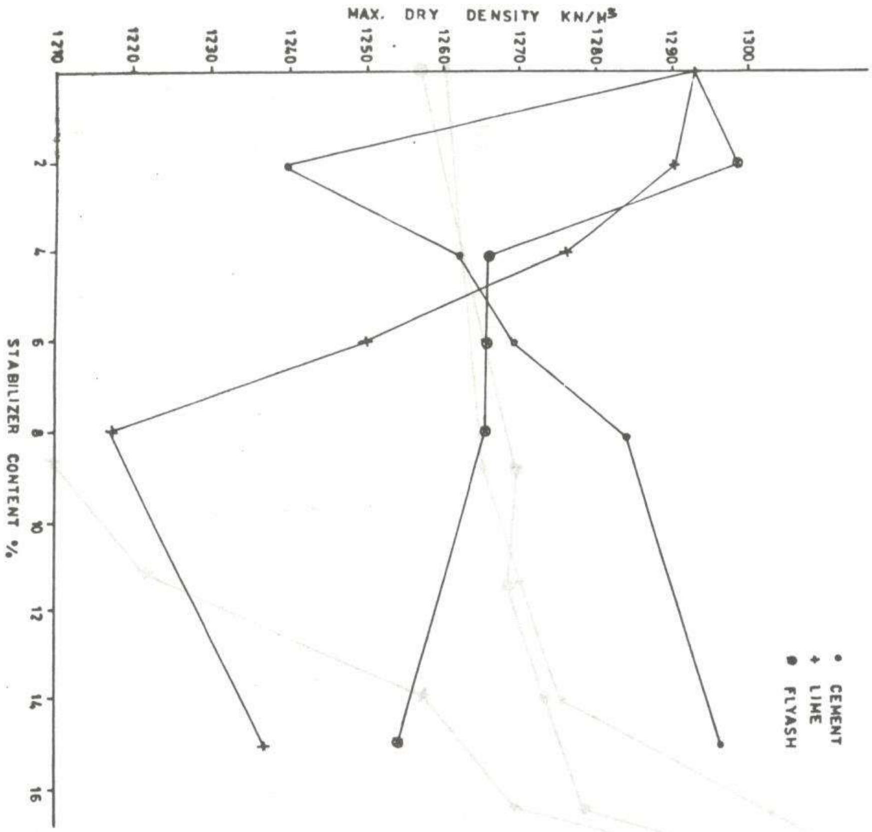

Fig.5: EFFECT OF STABILIZER ON MAX. DRY DENSITY (M.D.D)

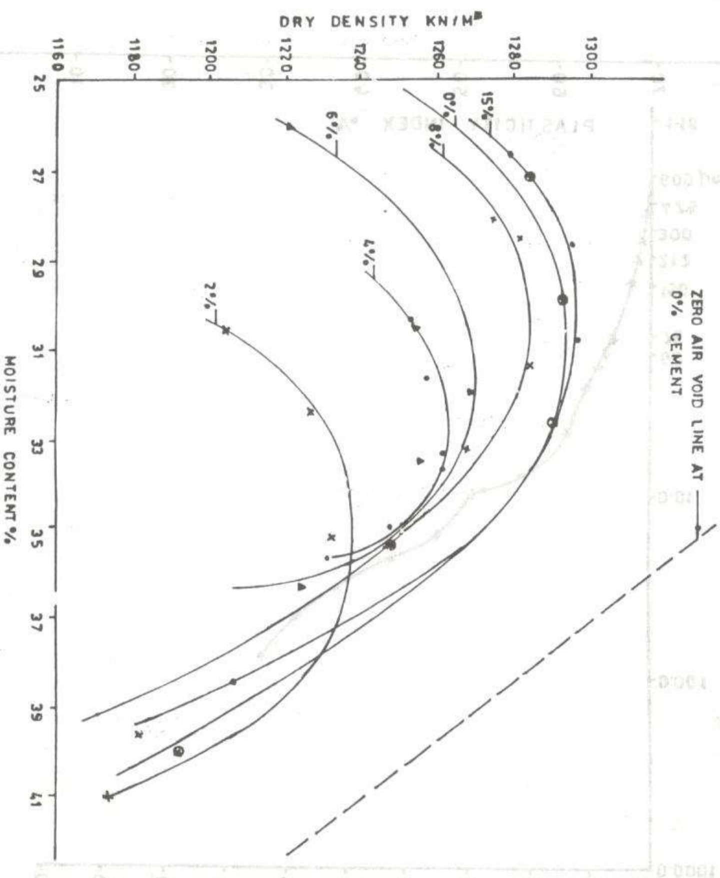

Fig. 6: COMPACTION CURVES FOR IMOCLAYSHALE STABILIZED WITH CEMENT AT VARIOUS PERCENTAGES

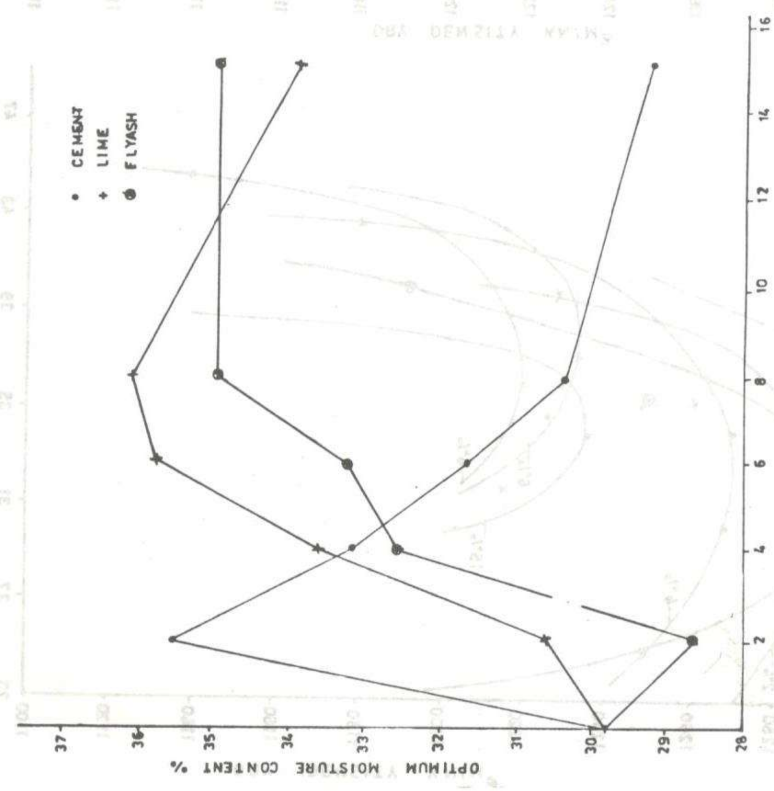

Fig. 9: EFFECT OF STABILIZERS ON OPTIUM MOISTURE CONTENT (O.M)

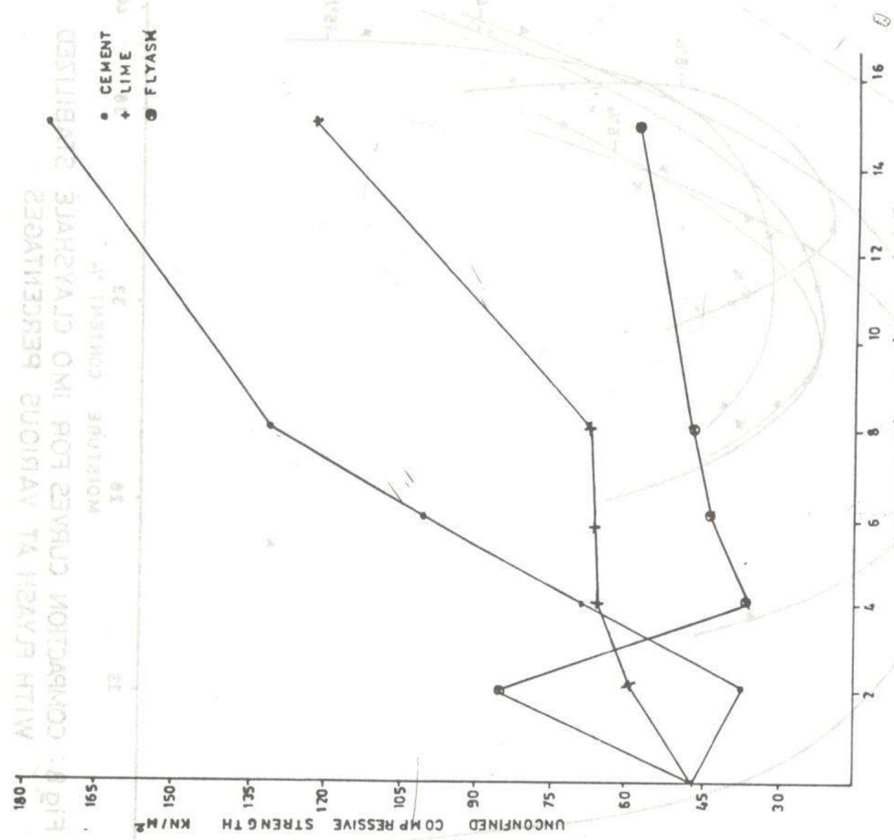

Fig.10: EFFECT OF STABILIZER ON UNCONFINED COMPRESSIVE STRENGTH (U.C.S)

C. B. R. — C. P. R. TESTS

STABILISER TYPE CEMENT 15%
DAYS SOAKED 0 DAYS

REMARKS Bearing Values at 0·1" 0·2"

Bottom :— $\frac{120}{3000} \times 100 = 4 \cdot 0\%$ $\frac{180}{4500} \times 100 = 4 \cdot 0\%$

Top :— $\frac{110}{3000} \times 100 = 3 \cdot 67\%$ $\frac{155}{4500} \times 100 = 3 \cdot 44\%$

AV : 4.00%

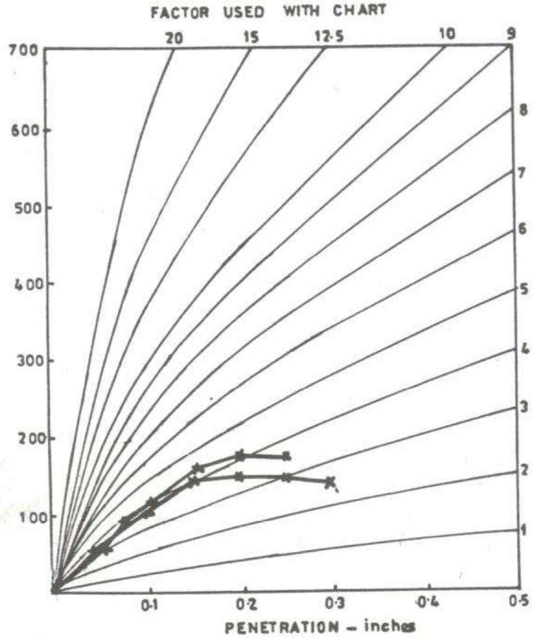

Fig. 11: FROM THE GRAPH C.B.R. IS < 4%

C.B.R – C.P.R. TESTS

SAMPLE NO 15% CEMENT
LOCATION USUGBE

STABILISER TYPE CEMENT 15%
DAY SOAKED 7 DAYS

REMARKS C. B. R. at 0·1" 0·2"

Bottom :— $\frac{280}{3000} \times 100 = 9 \cdot 33\%$ $\frac{420}{3000} \times 100 = 9 \cdot 33\%$

Top :— $\frac{520}{3000} \times 100 = 17 \cdot 33\%$ $\frac{500}{3000} \times 100 = 11 \cdot 11\%$

AV. = 14·22%

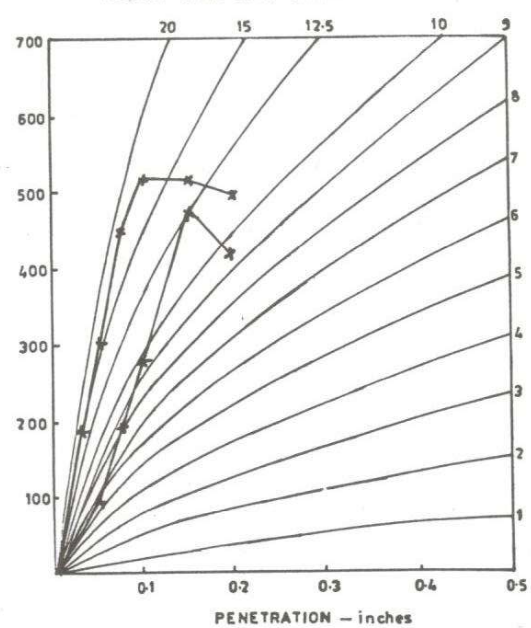

Fig. 12: FROM THE GRAPH C.B.R. IS < 15%