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An experimental investigation of natural soil stabilized with sewage sludge for flexible pavement

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ABSTRACT

Soil is very important in civil engineering constructions. The poor engineering properties of the local soils may present many difficulties for construction and therefore need to improve their engineering properties. Stabilization techniques can be used to improve the properties of soil. Soil stabilization improves various engineering properties e.g. bearing capacity, compressibility, strength, and various other properties of soil. In this study the impact of Sewage Sludge to improve the strength of soil. The soil was stabilized with Sewage Sludge in stepped concentration of 5%, 10%, 15%, 20%, 25% and 30% by dry weight of the soil individually. All stabilized soil samples were also cured for 96 hours for CBR test in fully saturated condition. The test results indicate that the addition of Sewage Sludge enhances the percentage of grain size distribution, but with addition of Sewage Sludge till 20% the LL, PL,PI and decreases, while these parameters further increases in this limit beyond i.e. 20% to 30% of Sewage Sludge, but in the case of the optimal percentage of Sewage Sludge at which maximum CBR is achieved is selected, Specific gravity value of Natural Soil is 2.57, but as percentage of Sewage Sludge is increases, specific gravity value decreases gradually from 2.57 to 2.44 with increase in percentage of Sewage Sludge from 0 to 30% and value of raw soil is achieved as 1.85 gm/cc at OMC of 13.65%. It got increased to 1.93 gm/cc at OMC of 12.30 % when Sewage Sludge is increased from 0 to 20% is effective beyond also there is decreasing in MDD from 1.93 gm/cc at OMC of 12.30% to 1.89 gm/cc at OMC of 13.20% when Sewage Sludge is increased from 20 to 30%. The CBR value increases with the addition of Sewage Sludge till 20%, while it decreases beyond the limit 20% to 30% with addition of Sewage Sludge. For both soaked and unsoaked condition.

Keywords— *Sewage Sludge, OMC, MDD, Un-Soaked CBR, Soaked CBR, Natural Soil*

1. INTRODUCTION

Sub-grade soil is an essential component as it supports the sub-base/base. However, in many situations, soils in natural state may not possess adequate geotechnical properties so as to be used as foundation layers, pavement layer or as a construction material. This may be due to the fact that the existing soil at a particular location exhibits poor bearing capacity and higher compressibility. Also, soils with significant plasticity may shrink and swell substantially with changes in moisture conditions. The repeated cycles of swelling or shrinkage of soil, further cause deteriorations and distresses on the structures if these are supported in these types of soil, this necessitates the improvement/stabilization of soil at a site as an indispensable activity, due to rising cost of the land and a huge demand for infrastructure development in developing countries like India. Soil stabilization is a technique introduced with the main purpose to modify the geotechnical properties of the soils making them capable of meeting the requirements of the specific engineering projects. The most common improvements achieved through stabilization include better soil gradation reduction of plasticity index or swelling potential and increases strength and durability. Various stabilizers such as lime, cement and calcium chloride are traditionally used for the stabilization of expansive soils However, the over dependency on the utilization of such industrially manufactured soil stabilizing additives may significantly increase the cost of construction.

2. LITERATURE REVIEW

Nawabsharif Risaldar et al. (2019) Investigation on the properties of black cotton soil, it is observed that, its strength properties are very low. In order to construct any foundation one such soil, we need to stabilize the black cotton soil. Sewage Sludge is material produced by aluminum industries, which, now a days creating so many problems when we dump it on open space. To beat both the criteria red mud is used as a stabilizer. Number of mixes is proposed here and experiments are done on the same. Black cotton soil was stabilized with red mud by varying the % of mix from 15% to 30% with 1% interval Gypsum is also used in the mixes in order to give better binding between the particles. It is observed that results obtained at the mix proportions 0% to 25% is increasing. Optimum of 25% of Sewage Sludge replacement gives better results. After obtaining the test results as stated

above, another attempt has been made to understand the interrelation (linear) between the parameters; regression analysis is made. This regression analysis is made using Microsoft Excel 2010; regression summary output is also discussed in this study.

Nitin Mane, et al. (2018) in particularly, construction activities on black cotton soil brings challenging tasks to him to handle. When the civil structures are needed to construct over the soils, which are unable to provide the desired properties to civil structures for the construction in such cases stabilization is the only method to get the desired properties of soil. By studying the properties of black cotton soil, it is observed that, its strength properties such as UCS and CBR are very low. It is observed that results obtained at the mix proportions 10% to 30% is increasing. Optimum of 30% of Sewage Sludge replacement gives better results. Along with this 6% of sodium silicate replacement gives better results. The sodium silicate content increased CBR values got increased up to 8% of sodium silicate. CBR values got decreased. The maximum value of CBR being 3.9 %, which is obtained for D308 combination.

3. METHODOLOGY

3.1 Soil

Soil is a collection of earth material, obtained naturally from the decay of vegetation and rocks that may be excavated instantly with help of power equipment in field or disintegrated by gentle mechanical means in laboratory. Supporting soil underneath pavement and its unique under courses is termed as subgrade. Undisturbed soil beneath pavement is termed as natural subgrade. Compacted subgrade is soil compacted with help of controlled movement through heavy compactors. The soil used for this investigation is an expansive clay, one type of most problematic soil for subgrade constructions is used for current research work which is locally available Natural Soil collected from Raisin road near LNCT College Bhopal (Madhya Pradesh) from depth of 2.5 m from ground level. It contains deleterious substances and of various sizes. The soil was air dried and pulverized manually. This natural soil is grey and black in color.

3.2 Sewage Sludge

Sewage sludge is one of biggest waste product that had been used as the waste disposal or landfill. By using the sewage sludge in the construction field can be consider as materials which is good in term if economical and environmentally. Figure 3.2 and 3.3 shows the discharge of sewage sludge as slurry to the sewage sludge and sewage sludge ash at AIIMS, Bhopal. Figure 3.4 shows sewage sludge used in present experimental work.

4. EXPERIMENTAL PROCEDURE

(a) Particle Size Analysis: Grain size analysis on natural soil and soil-additive mixture were conducted according to I.S. 2720 (Part IV):1975.

(b) Specific Gravity: Specific gravity which is measure of heaviness of soil particles are determined by method of pychnometer method using a soil sample passing No. 10 sieve and oven dried at 105 degree centigrade. The test includes determination of specific gravity for natural soil and soil-bagasse ash mixture. Test is executed in accordance with AASHTO T100-93 testing procedure

(c) Liquid limit (LL): Liquid limit of fine-grained soil is defined as water content at which soil behaves practically like liquid but has small shear strength. It is determined in laboratory by Cassagrande apparatus.

(d) Plastic limit (PL): Plastic limit of a fine-grained soil is water content of soil below which it ceases to be plastic. It begins to crumble when rolled into threads of 3mm diameter. Or the minimum water content at which a soil will just begin to crumble when it is rolled into a thread of approximately 3 mm in diameter.

(e) Compaction test: Compaction tests to obtain moisture-density relationship of soil-additive mixtures were conducted according to I.S. 2720 (Part viii)-1965 (11). Compaction is process of soil densification with help of reduction of air voids. Degree of compaction for given soil is calculated in terms of its dry density. The dry density is maximum at optimal water content

(f) California Bearing Ratio (CBR): In 1928, California division of highways in U.S.A. developed CBR method for pavement design. The majority of curves developed later are based on original curves proposed by O. J. porter. At the start of Second World War, Corps Engineer of U.S.A. made survey of existing method of pavement design and adopted CBR method to design military airport pavements. One of the chief advantages of C.B.R method is the simplicity of the test procedure. The CBR tests were executed according to I.S. 2720 (Part xi) 1977. A standard CBR mould with a detachable collar was used.

5. RESULTS AND DISCUSSION

In the present study, Grain Size Analysis, Specific Gravity Test, Consistency Indices (Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI)), Compaction Test, and California Bearing Ratio (CBR) Un-soaked and Soaked Tests were executed on Natural Soil (B.C Soil) first by mixing with altered percentage of Sewage Sludge to stabilize Natural soil and then altered percent Sewage-Sludge at which maximum CBR is gained is chosen for further experimental work. The optimal percentage of Sewage Sludge at which maximum CBR is achieved is selected and obtain maximum strength is well-known and results are shown in graphical form and where ever possible in tabular forms.

5.1 Specific Gravity Test

Specific gravity tests were executed to determine specific gravity of raw Natural Soil and Natural Soil with altered percentage of Sewage Sludge. Results are presented in Table- 4.4 from table, it is well recognized that specific gravity value of Natural Soil is 2.57, but as percentage of Sewage Sludge is increases, specific gravity value decreases gradually. It shows that there is a decrease in specific gravity from **2.57 to 2.44** with increase in percentage of Sewage Sludge from 0 to 30% and **2.61** for 100% Sewage Sludge as Shown.

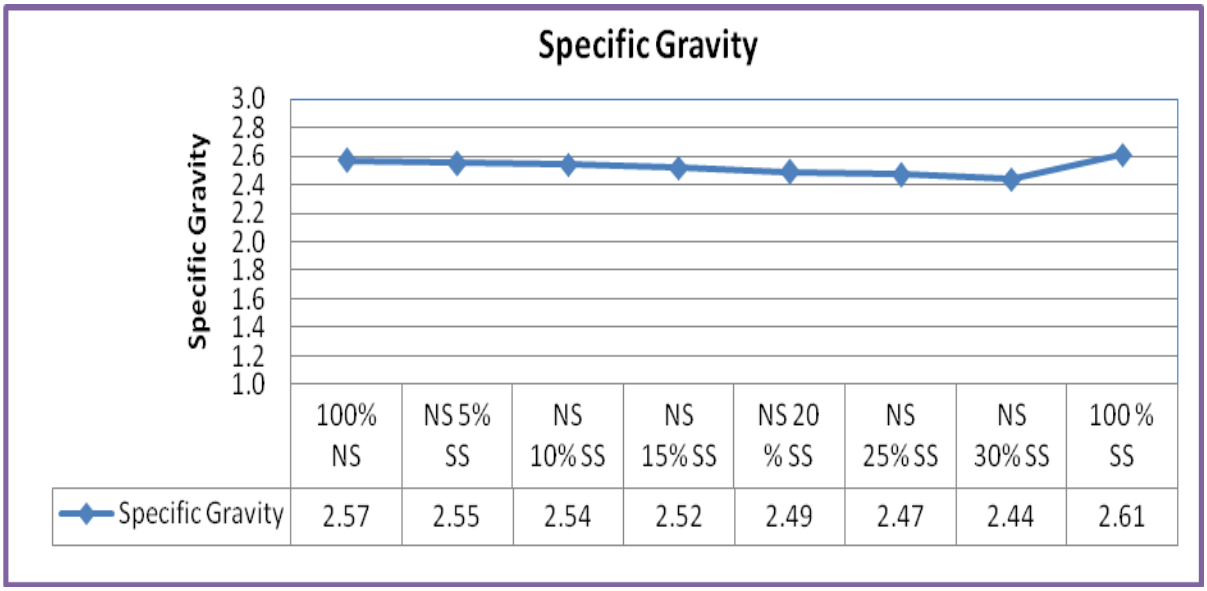

Fig. 1: Variation in Specific Gravity of Natural Soil and NS with altered percentages Sewage Sludge

5.2 Consistency Indices

Consistency tests were executed to determine Liquid Limit (LL), Plastic Limit (PL) and then Plasticity Index (PI) of raw Natural Soil and Natural Soil treated with altered percentage of Sewage sludge. The Liquid Limit, Plastic Limit and Plasticity Index are shown in. Initially the LL, PL and PI of Natural Soil are **37.00 %, 26.40 %** and **10.60** respectively. Which is very high and soil having these properties cannot be utilized for highway construction especially in sub-grade.

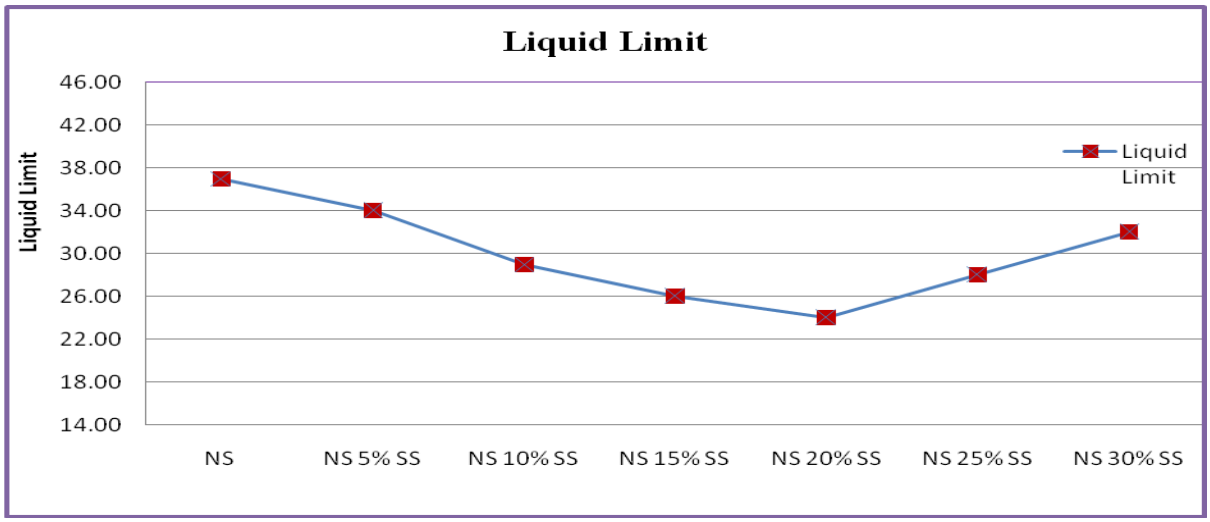

Fig. 2: Variation in Liquid Limit with Natural and NS with altered percentages Sewage sludge

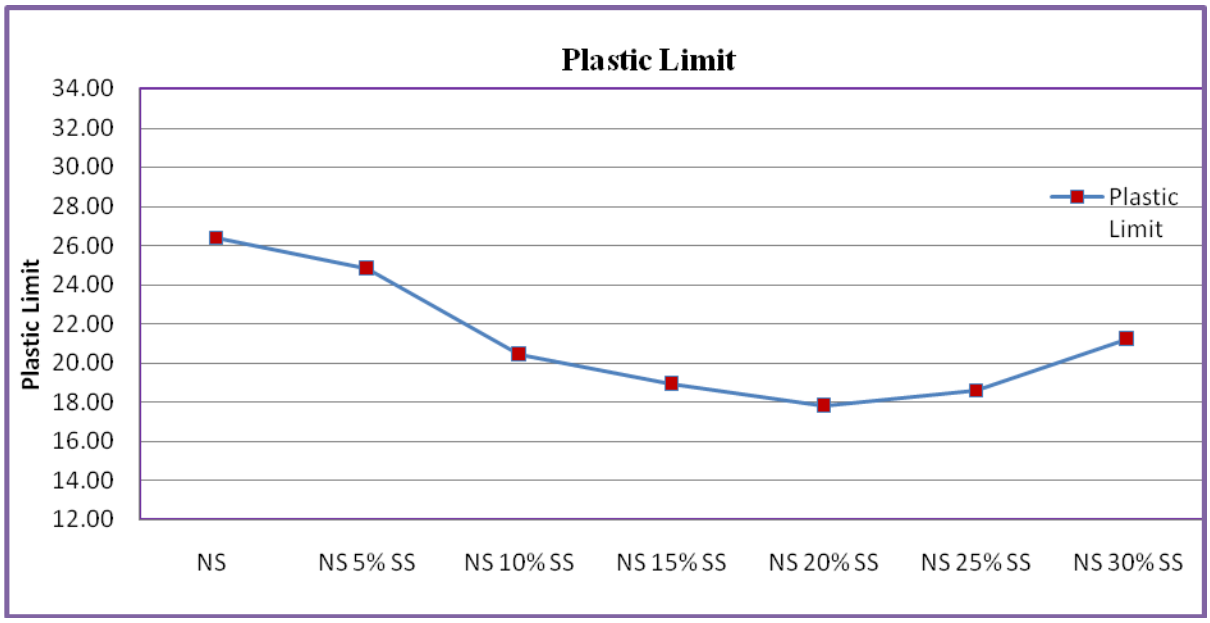

Fig. 3: Variation in Plastic Limit with Natural and NS with altered percentages Sewage sludge

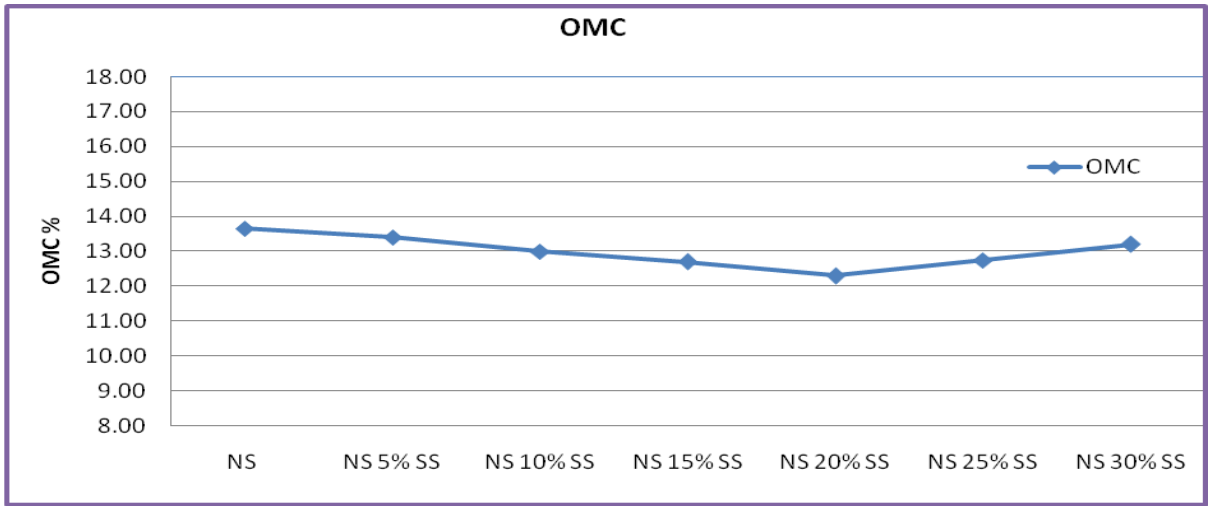

Fig. 4: Variation in OMC with Natural Soil and Natural and NS with altered percentages Sewage sludge

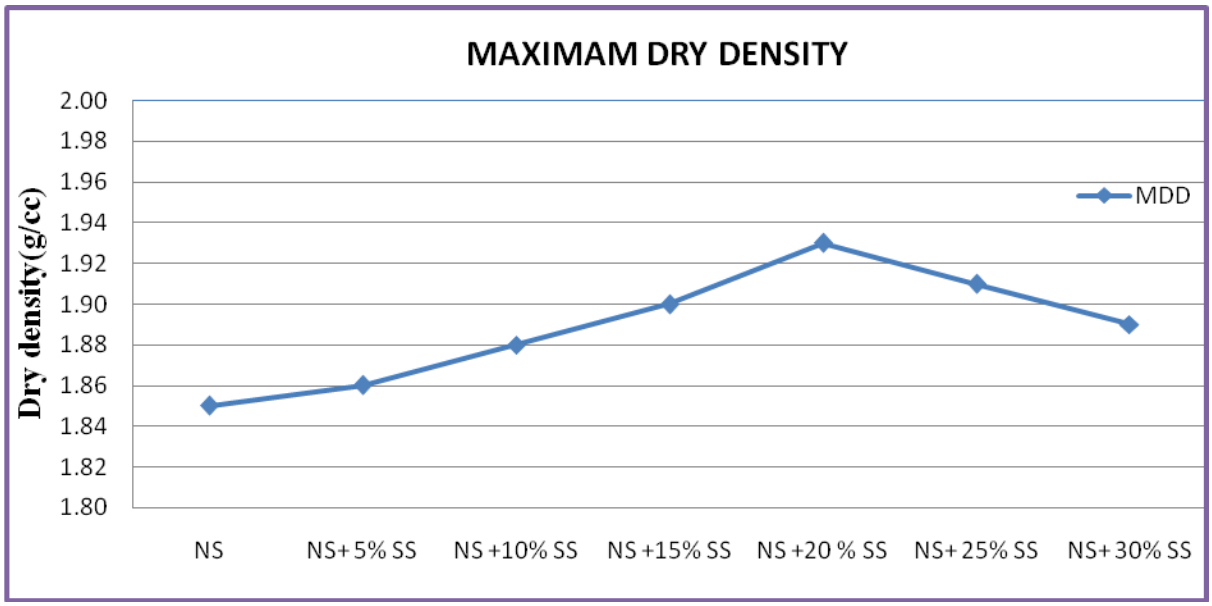

Fig. 5: Variation in MDD with Natural Soil and Natural and NS with altered percentages Sewage sludge

6. RESULTS AND DISCUSSION

6.1 California Bearing Ratio Test

California Bearing Ratio (CBR) tests were executed out to determine CBR Value for sub-grade soil and. The optimal percentage of Sewage sludge at which maximum CBR is achieved is selected and gets reinforced with varying percentage of Along required to obtain maximum strength is well-known and results are shown in graphical form and where ever possible in tabular forms.

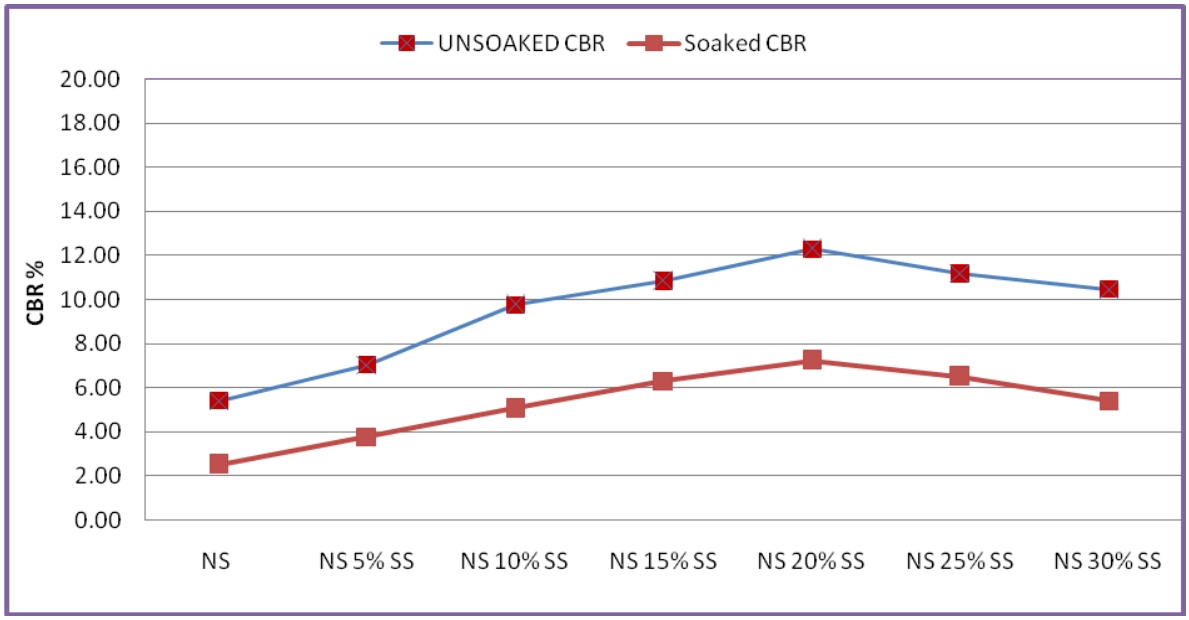

Fig. 6: Variation in CBR Value of Natural Soil and Natural soil + varying %age of Sewage Sludge

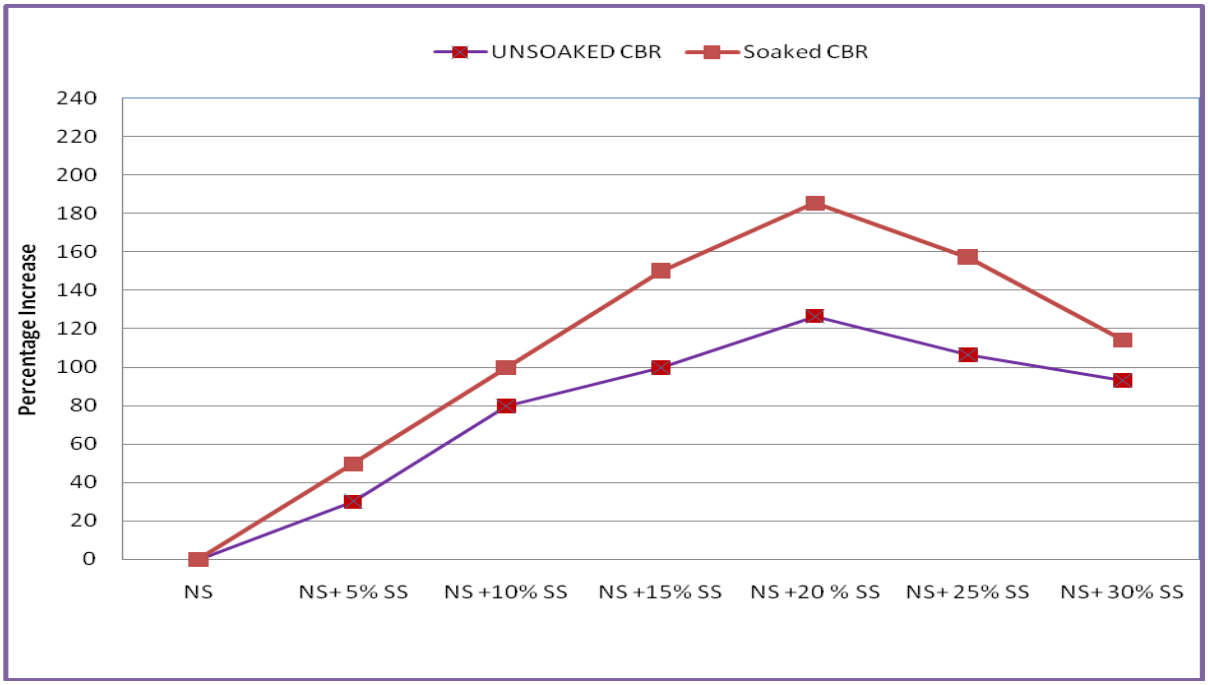

Fig. 7: Variation of Increase in CBR value of altered % age of Sewage Sludge towards Natural Soil

7. CONCLUSIONS

- Initially the LL, PL and PI values of raw soil are 37.00 %, 26.40 % and 10.60 % respectively which on mixing Sewage Sludge in ranges from 5 % to 30 % gradually decreasing in liquid limit from **37 to 24%,** Plastic Limit from **26.60% to 17.80%** and Plasticity Index from **10.60% to 6.20%** when Sewage Sludge is increased from 0 to 20% is effective beyond also there is a increase in liquid limit from **24% to 32%,** Plastic Limit from **17.80 to 21.20%** and Plasticity Index from **6.20 to 10.80%** when Sewage Sludge is increased from 20 to 30%
- Specific gravity value of Natural Soil is **2.57**, but as percentage of Sewage Sludge is increases, specific gravity value decreases gradually from **2.57 to 2.44** with increase in percentage of Sewage Sludge from 0 to 30%.
- In Compaction Test, the MDD value of raw soil is achieved as **1.85 gm/cc** at OMC of **13.65%**. It got increased to **1.93 gm/cc** at OMC of **12.30 %** when Sewage Sludge is increased from 0 to 20% is effective beyond also there is decreasing in MDD from **1.93 gm/cc** at OMC of **12.30% to 1.89 gm/cc** at OMC of **13.20%** when Sewage Sludge is increased from 20 to 30%
- The Unsoaked CBR value of the raw soil i**s 5.42 %** and after mixing of Sewage Sludge in the soil, there i s remarkabl e chang e i n CB R value fro**m 5.42 to 12.28%** . when Sewage Sludge is increased from 0 to 20% is effective beyond also there is a decrease in CBR of soil fro**m 12.28 to 10.47%** when Sewage Sludge is increased from 20% to 30%.
- The soaked CBR value of the raw soil is 2.53 % and after mixing of Sewage Sludge in the soil, there is remarkable change in CBR value. increasing from **2.53 to 7.22%** when Sewage Sludge is increased from 0 to 20% is effective beyond also there is a decrease in CBR of soil from **7.22 to 5.42%** when Sewage Sludge is increased from 20% to 30%.
- The results of percentage increment in Unsoaked CBR goes on increasing from **29.89 to 126.57%** with respect to Natural Soil when Sewage Sludge is increased from 0 to 20% and is decreases from **126.57 to 93.17%** when Sewage Sludge is increased from 20% to 30%**.** However, in Soaked CBR it increases from **49.80 to 185.38%** when Sewage Sludge is increased from 0 to 20% and is decreases from **185.38 to 114.23%** when Sewage Sludge is increased from 20% to 30%.

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