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An Experimental Study of Natural Soil Subgrade Stabilized with Wheat Husk Ash and Polypropylene

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Abstract: ***Quality of a pavement depends on the strength of its sub-grade soil. The strength of sub-grade is the major parameter for determining the thickness of pavement. In case of pavement the sub-grade must be uniform in terms of geotechnical properties like shear strength, compressibility etc. Pavement construction may be on natural soil which may be Expansive soil, Black cotton soil, clayey soil, organic soil etc. Natural soils, suffer volume change due to moisture content, which causes heaving, cracking and the break-up of the road pavement. Due to this reason Stabilization of these types of soil is necessary, to suppress swelling and increase the strength of the soil.***

The growing cost of traditional stabilizing agents and the need for the economical utilization of industrial and agricultural wastes for beneficial engineering purposes has prompted an investigation into the stabilizing potential of Wheat Husk Ash (WH) and Polypropylene (PP) in subgrde soil. The objective of this work is to utilize the effectiveness of Wheat Husk Ash and Polypropylene material to enhance the properties of natural soil used for subgrade material in pavement. The soil was stabilized different percentages of (5, 10, 15, 20, 25 & 30) of WH and after getting optimum percentage of WH, PP with percentage of 0.25%, 0.50%, 0.75%, 1.00%, is added along with WH individually, for the construction of sub grade soil and test like Liquid Limit, Plastic Limit, Plasticity Index, Specific Gravity, Optimum Moisture Content, Maximum Dry Density, Swelling Pressure and CBR is performed.

Keywords: Wheat Husk Ash (WH), Polypropylene (PP), Swelling, OMC, MDD, CBR

I. INTRODUCTION

Soil is basic and important element in civil engineering field. Stability of every structure depends on the type and characteristics of foundation which in turn depends on the type of soil. Many problems irrupt if expansive soil, Natural soil is to be used in foundation, because of its shrinkage and swelling properties. There are many methods to make natural soil stable for various constructions. Natural soil is comfortable for road work, compared to other types of soil. There are two ways to enhance the quality of subgrade soil -"Replacement of soil" or "Soil stabilization". Soil stabilization can be done chemically or mechanically. Chemical stabilization is carried out by adding different chemicals in suitable proportion, while mechanical stabilization is achieved by addition of admixtures which helps to improve the properties of soil. The present entire practice of major road construction over deep layer of natural soil subgrade appears to be conservative lacking technical and financial optimization. It is therefore, realized that for the major road construction in natural soil subgrade areas, an alternative approach needs to be made to evolve a pavement subgrade system, that will ensure its effectiveness with respect to both no traffic load condition and maximum traffic load condition along with its simple, easy, economic and durable construction. Wheat is the most common and important human food grain and ranks second in total production as a cereal crop. Wheat grain is a staple food used to make flour for leavened, flat and steamed breads etc., Wheat Husk Ash fiber is waste of crop of wheat, which is escaped out while getting grain from crop. Wheat straw ash is a agricultural waste which obtained from burning wheat straw. When crops of wheat is cut then straw is remain in the ground it self, this straw is a complete waste. But now a days by burning these straw its ash can replace by cement. Much literature is not available on wheat straw ash but it completely shows that it posses pozzolanic properties. Polypropylene (PP) also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packing, etc. Polypropylen**e** (PP) is a lightweight fiber, it has density of 0.91 gm/cm³.It does not absorb water. It presents that it has good resistance towards water absorb. Polypropylene has excellent chemical resistance. PP fibres are very resistant to most acids and alkalis. The thermal conductivity of this fiber is lower than that of other fibers. PP also has low melting temperature and has high creeping rate. The use of Polypropylene and Wheat Husk Ash as stabilizing material for natural soil can be checked under various tests such as grain size distribution, liquid limit, plastic limit, Plasticity index, Specific gravity, OMC, MDD, Swelling pressure and California bearing ratio (CBR) for soaked and unsoaked

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conditions. In present study use of Polypropylene and Wheat Husk Ash are used as admixtures for mechanical stabilization of soil subgrade. Polypropylene(PP) and Wheat Husk Ash (WH) help to improve important properties like plasticity, swelling and CBR by addition of these admixtures upto 30%. admixtures used in powder form, mixed with soil in various ratios to modify the properties and to study the change in soil properties. Today, world faces a serious problem of disposal of large quantities of agricultural and industrial waste like Rice husk ash, Wheat Husk Ash etc. The disposal of these wastes without proper attention creates hazardous impact on environmental health. So Polypropylene and Wheat Husk Ash used in this project because these waste materials are also low cost.

II. OBJECTIVE OF THE STUDY

A. The work is undertaken with the following sub objectives are

1) To determine the Geotechnical properties of Natural Soil, PP, WH individually, for the construction of sub grade soil.
2) To study the suitability of stabilized soil for sub grade soil.
3) To use Agriculture waste and Industrial waste (Polypropylene and Wheat Husk Ash) as a stabilized material.
4) To determine the Geotechnical properties of Natural soil (Black Cotton Soil), Stabilized with different percentages of (5, 10, 15, 20, 25 & 30) of WH and after getting optimum percentage of WH, PP with percentage of 0.25%, 0.50%, 0.75%, 1.00%, is added along with WH individually, for the construction of sub grade soil.
5) To find the optimum value of Polypropylene and Wheat Husk Ash for use as a stabilized material.
6) To study the variation of Grain size distribution, Liquid Limit, Plastic Limit, Plasticity Index, Specific Gravity, Optimum Moisture Content, Maximum Dry Density, Swelling Pressure and CBR for both conditions of natural soil with and without PP and WH with above percentage.
7) To study and compare the increases percentages of CBR value of natural soil, PP and WH with stabilized soil.

III. METHODOLOGY

A. Material Used in Research Work

1) *Natural Soil:* The Natural soil sample is used in this project were taken from local area 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.
2) *Wheat Husk Ash (WH):*Wheat husk is collected locally, these husk is burnt and collected ash is used un this project.
3) *Polypropylene (PP):* Polypropylene is collected locally, length of the fiber used in this project is 40mm and thickness is 2mm.
4) *Water:* Throughout the investigation tap water is used in this project, which is supplied by municipal co-operation.

B. Experimental Program

There are various test performed in laboratory as per IS code standards like test Grain size distribution, liquid limit, plastic limit, plasticity index, specific gravity, compaction, optimum moisture content (OMC), maximam dry density (MDD), swelling and California bearing ratio (CBR) test were conducted.

IV. RESULT & DISCUSSION

A. Natural Soil

Table 1**:** Summary for Index Properties of N sample

S.N.	Parameters	Value
1	Grain Size Distribution	
	Gravel (%)	18.40
	Coarse Sand (%)	7.20
	Medium Sand (%)	52.60
	Fine Sand (%)	20.30
	Silt and Clay (%)	1.50
2	IS Soil Classification	CL
3	AASHTO Classification	A-6

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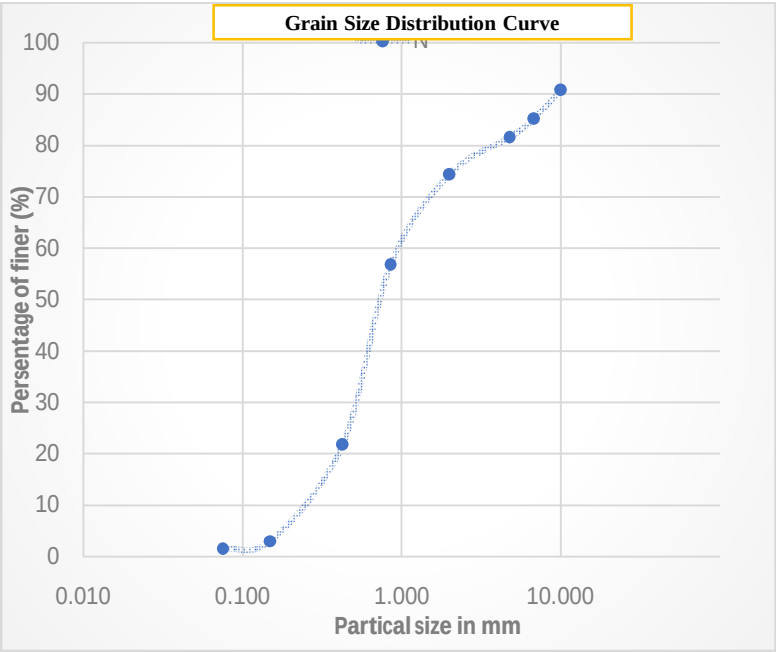
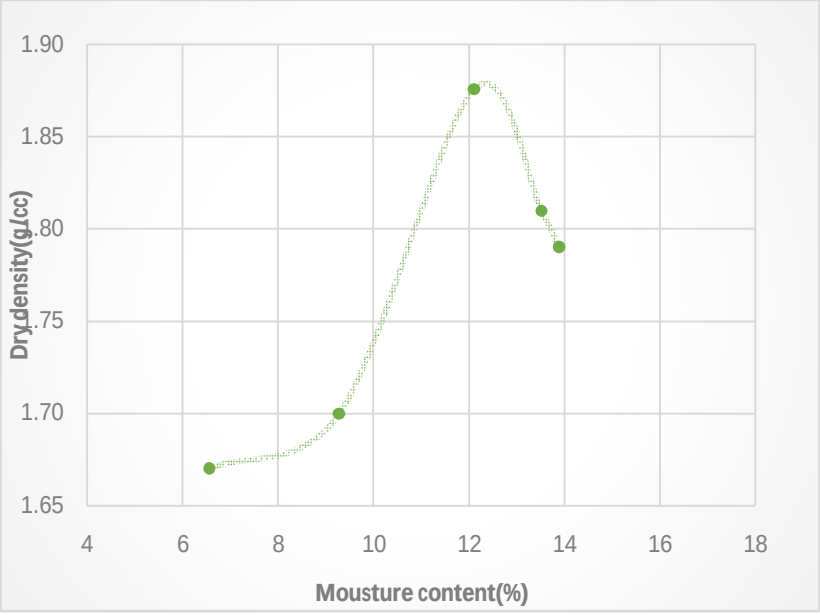
4	Liquid Limit (%)	26.00
5	Plastic Limit (%)	17.40
6	Plasticity Index (%)	8.60
7	Specific Gravity	2.63



Graph 1: Grain Size Distribution of Natural Soil

Compaction factor parameters are MDD=1.88 KN/m^3 and OMC =12.18%.



Graph 2: OMC/MDD of Natural Soil (N) Sample

Graph 4**:** Soaked CBR of N Sample

Soaked CBR Value for Natural soil Sample is 3.79 % and Unsoaked CBR Value for Natural soil Sample is 7.04 %

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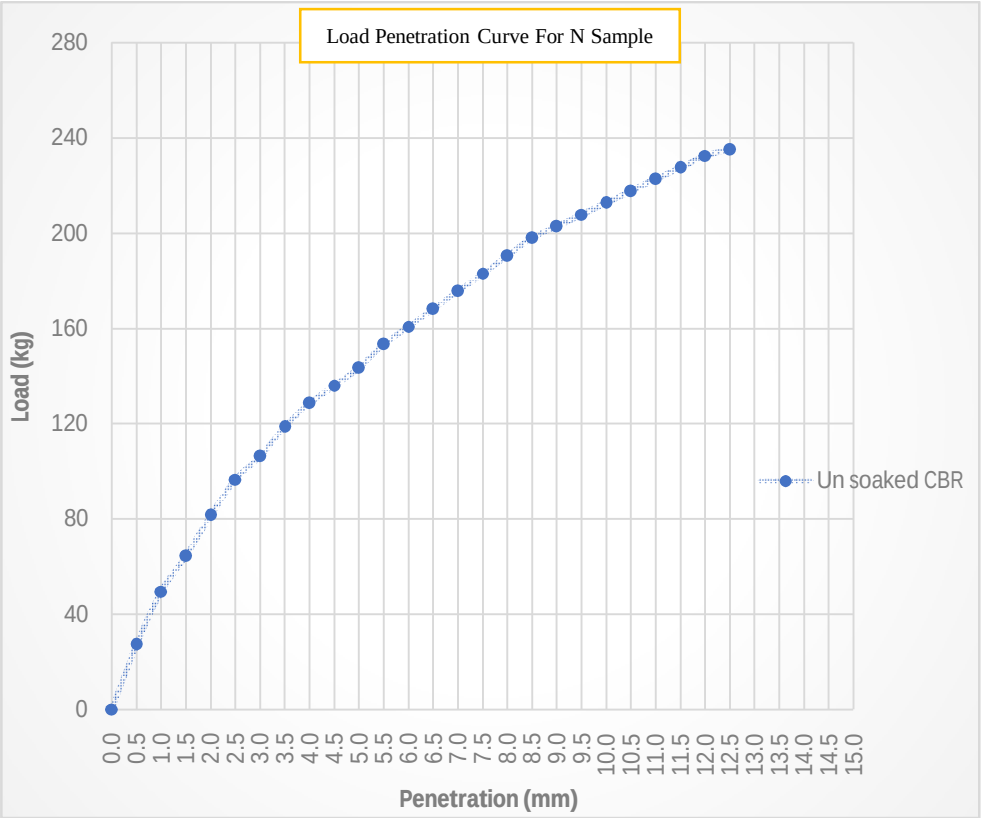
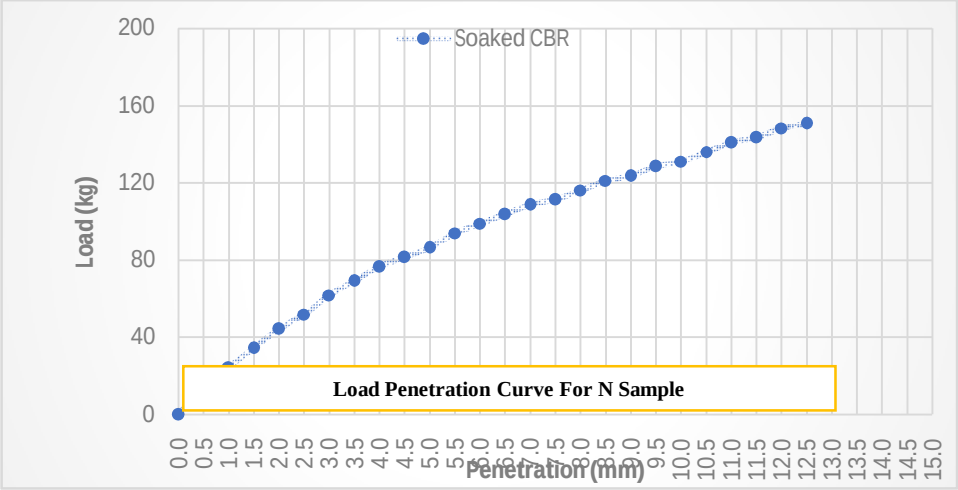


Graph 3: Unsoakesd CBR of N Sample



B. Tests Results of Natural & Wheat Husk Ash Samples (NW)

1) *Index Properties of NW Sample:* The tests are conducted on Artificial Mix Samples (NW) type samples i.e. when wheat husk ash is added in the soil upto 30%. and Grain Size Distribution, Liquid Limit, Plastic Limit, Plasticity Index, Specific Gravity have performed.

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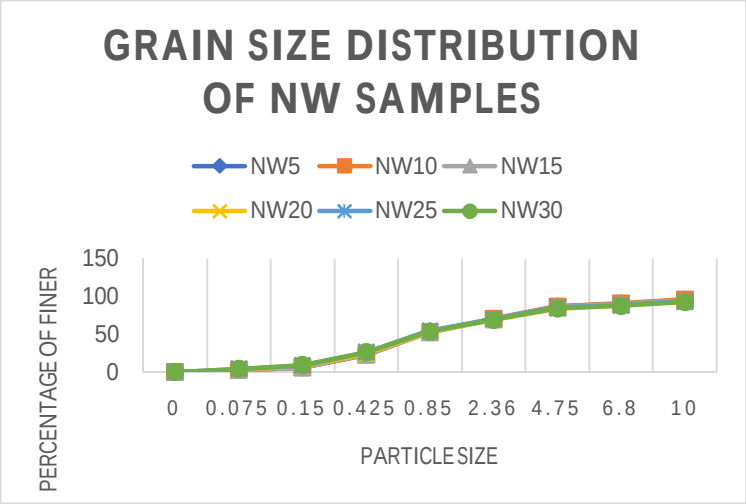
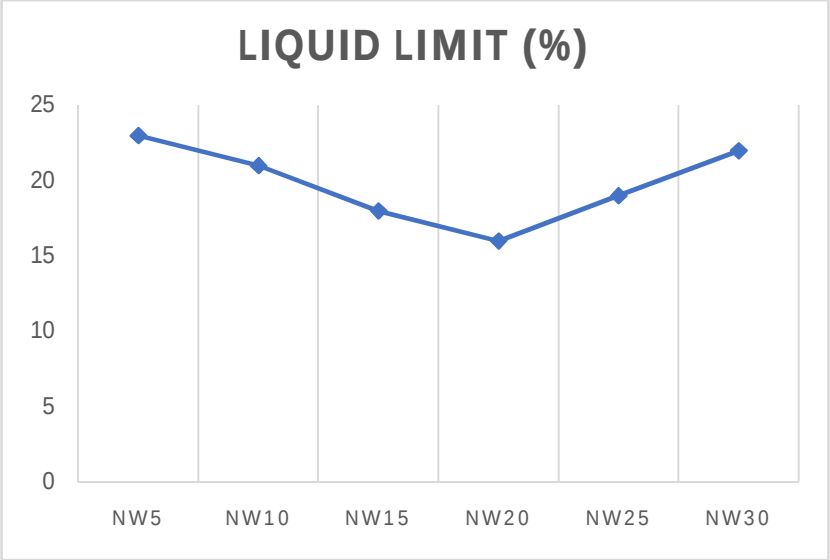


Graph IV.1: Grain Size Distribution Curve of NW Sample

Table IV.1: Summary of Test Results for Index Properties of NS Samples

S.N.	Index Properties of NS Sample	Name of Artificial Mix NW Samples					
		NW5	NW10	NW15	NW20	NW25	NW30
1	Grain Size Distribution						
	Gravel (%)	13.04	13.53	13.40	16.00	15.00	15.70
	Coarse Sand (%)	16.30	15.80	16.60	45.00	14.80	15.20
	Medium Sand (%)	47.70	47.50	46.70	45.00	43.90	42.80
	Fine Sand (%)	20.80	20.70	20.40	21.10	22.40	21.90
	Silt And Clay (%)	2.16	2.47	2.90	3.40	3.90	4.40
2	IS Soil Classification	CL	CL	CL	CL	CL	CL
3	AASHTO Classification	A-6	A-6	A-6	A-6	A-6	A-6
4	Liquid Limit (%)	23.00	21.00	18.00	16.00	19.00	22.00
5	Plastic Limit (%)	14.80	13.40	11.50	10.70	12.20	14.30
6	Plasticity Index (%)	8.20	7.60	6.50	5.30	6.80	7.70
7	Specific Gravity	2.61	2.57	2.54	2.49	2.45	2.39



Graph IV.2: Variation in Liquid limit of NW samples

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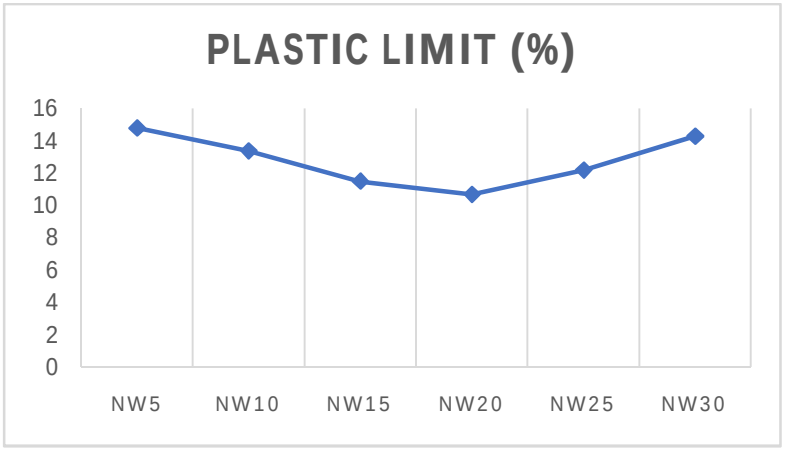
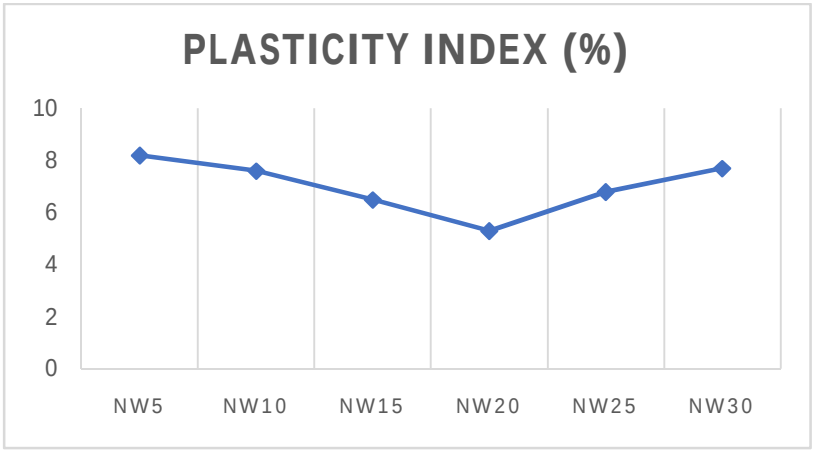
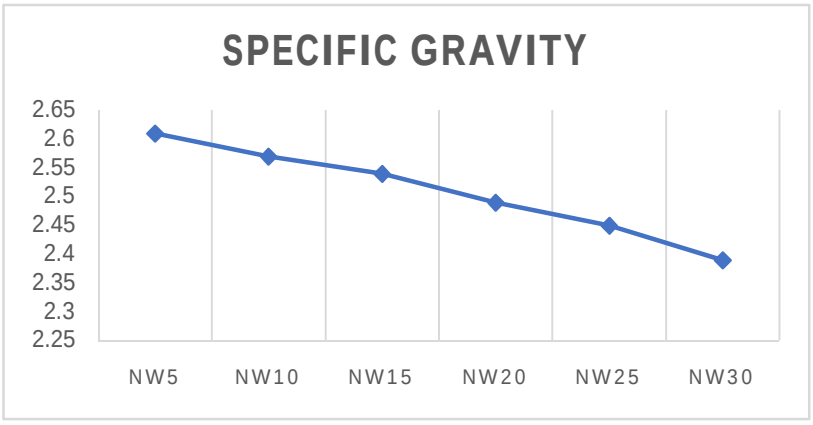


Graph IV.3: Variation in Plastic limit of NW samples



Graph IV.4: Variation in Plastic lndex of NW samples



Graph IV.5: Variation in Specific Gravity of NW samples

The results of Liquid Limit tests Clay with Low Compressibility (CL) treated with different percentage of Wheat Straw Ash (WHA)can be seen that with increase in percentage of ash the Liquid Limit of CL soil goes on decreasing from 26 to 16%, when WHA waste is increased from 0 to 20% is effective beyond also there is a increase in liquid limit from 16% to 22% when WHA waste is increased from 20 to 30% and further the value for 100% WHA, the sample shows non plastic behavior.

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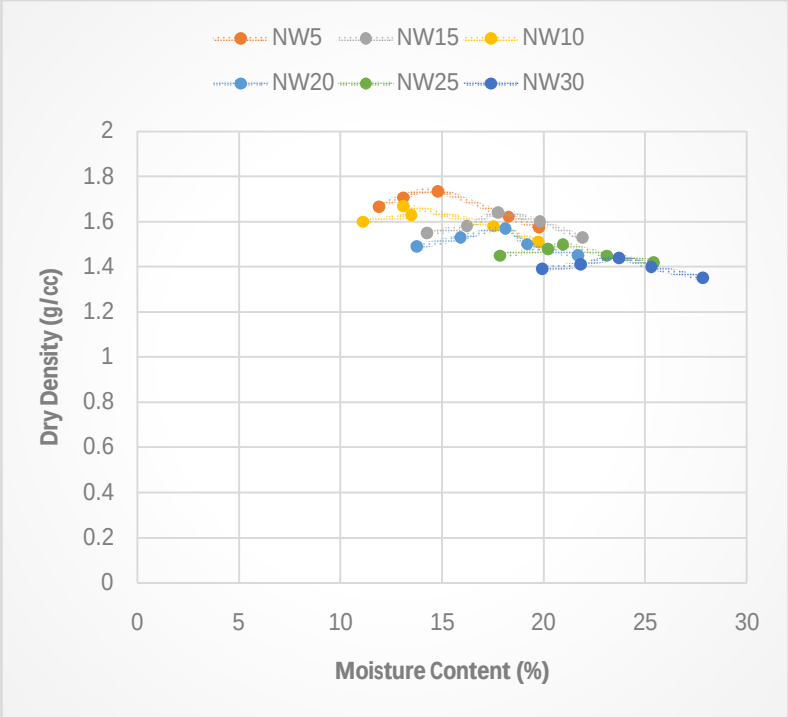
The results of Plastic Limit tests CL soil treated with different percentage of WHA can be seen that with increase in percentage of ash the Plastic Limit of CL soil goes on decreasing from 17.40% to 10.70%, when WHA waste is increased from 0 to 20% is effective beyond also there is a increase in Plastic Limit from 10.70 to 14.30% when WHA waste is increased from 20% to 30%.
The results of Plasticity Index tests CL soil treated with different percentage of WHA can be seen that with increase in percentage of ash the Plasticity Index of CL soil goes on decreasing from 8.60% to 5.30%, when WHA waste is increased from 0 to 20 % is effective beyond also there is a increase in Plasticity Index from 5.30 to 7.70% when WHA waste is increased from 20% to 30%.
The results of Specific Gravity tests on CL soil treated with different percentage of WHA i.e. NS Sample shows that there is a decrease in specific gravity from 2.63 to 2.39 with increase in percentage of ash from 0 to 30% and 1.87 for 100% WHA.

2) *Proctor Compaction Test:* The tests on these Artificial Mix Samples were conducted as on N samples and curve for OMC and MDD were plotted for NW Samples. This curve showing variation of Compaction Curve (OMD and OMC) of Sample NW-5 to NW-30 and the desired NW Samples.



Graph IV.6: Compaction Curve of NW Sample

Table IV.2: Summary of Test Results for Compaction Properties of Artificial NW Samples

S.N.	Compaction Properties of NS Sample	Name of Artificial NS Samples					
		NW5	NW10	NW15	NW20	NW25	NW30
1	Optimum Moisture Content (%)	14.42	15.80	17.85	18.05	21.00	23.80
2	Maximum Dry Density (gm/cm3)	1.74	1.67	1.64	1.58	1.50	1.44

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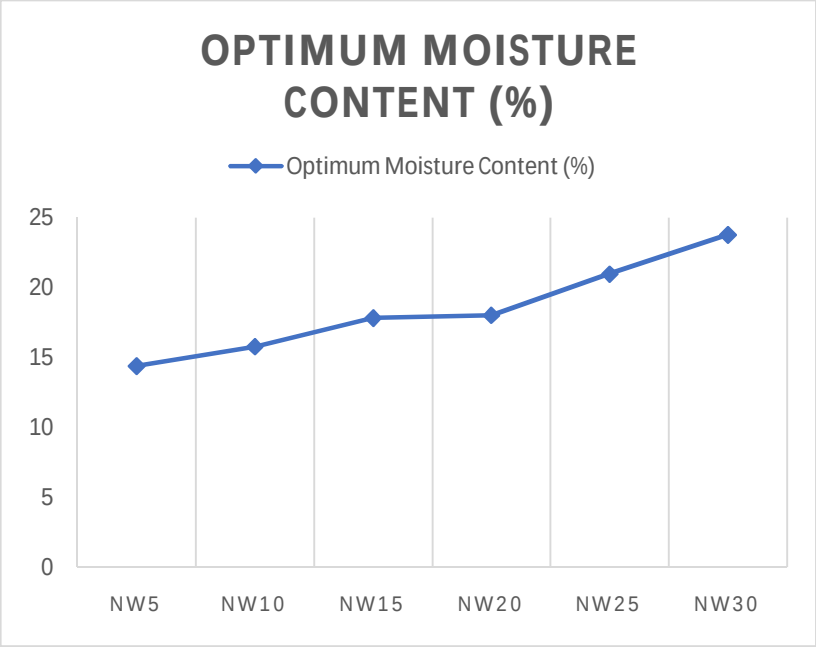
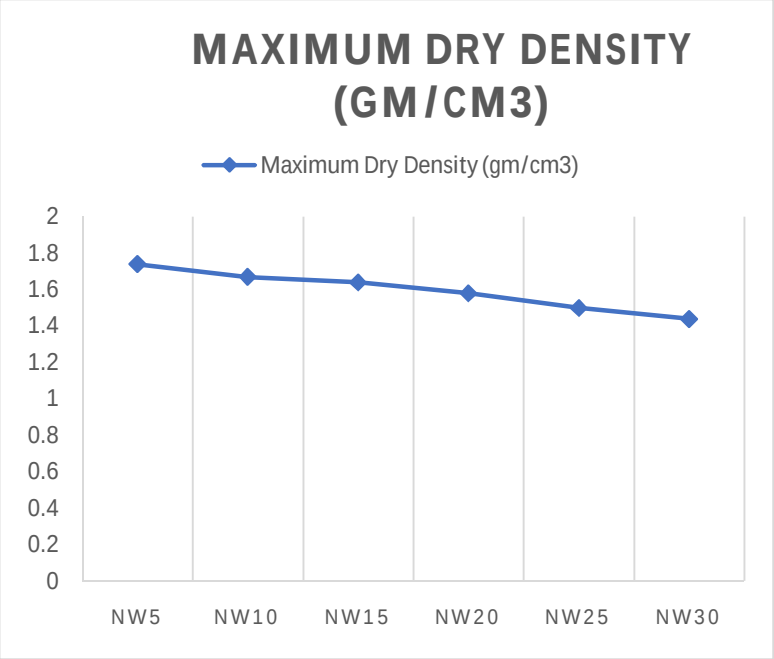


Graph IV.7: Variation in Optimum Moisture Content of NW samples



Graph IV.8: Variation in Maximum Dry Density of NW samples

Natural Soil is mixed with varying percentages of Wheat Straw Ash (WHA) waste material by weight. From the test results Moisture Content continuously increases 12.18 to 23.80% and for 100% WHA value of water content is 47.22%. However The Maximum Dry Density decreases from 1.88 g/cc to 1.44 g/cc from 0 to 30% of WHA and the value are 0.98 g/cc for 100% WHA.

3) *California Bearing Ratio:* The tests on these Artificial Mix Samples were conducted as on NW Samples. CBR test were conduct on Samples containing wheat straw ash and evaluate these values and load presentation curve was plotted. NW Samples are showing Compaction Curve shown in graph below and also for Unsoaked and Soaked CBR Curve.

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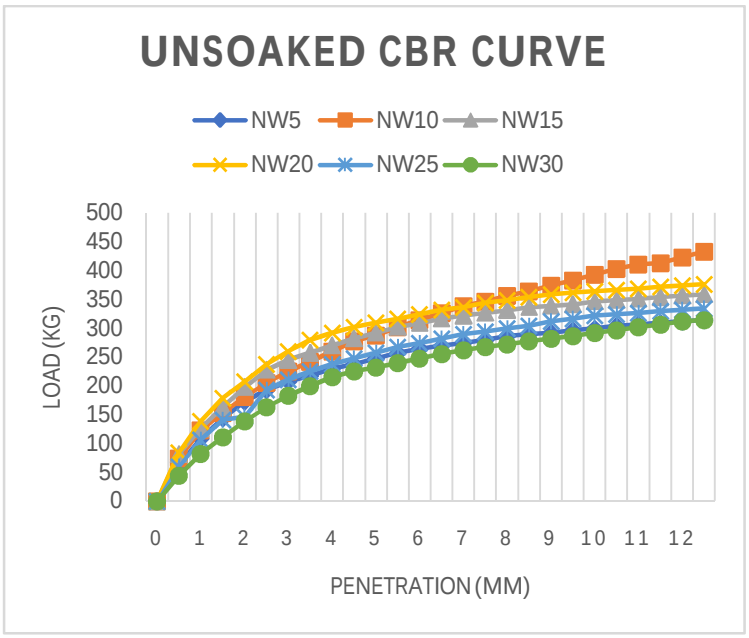
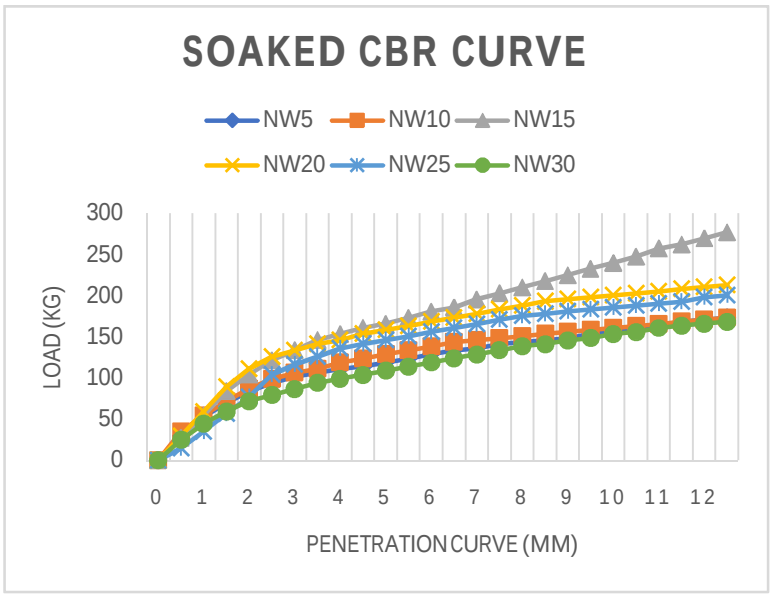


Graph IV.9: Unsoakesd CBR of NW Sample



Graph IV.10: Soaked CBR of NW Sample

Table IV.3: Summary of Test Results for Strength Properties of Artificial NW Samples

S.N.	Strength Properties of NW Sample		Name of Artificial NS Samples					
			NW5	NW10	NW15	NW20	NW25	NW30
1	CBR (%)	Unsoaked	14.08	14.98	16.24	17.33	14.08	11.91
		Soaked	6.86	7.22	8.84	9.21	7.58	5.78

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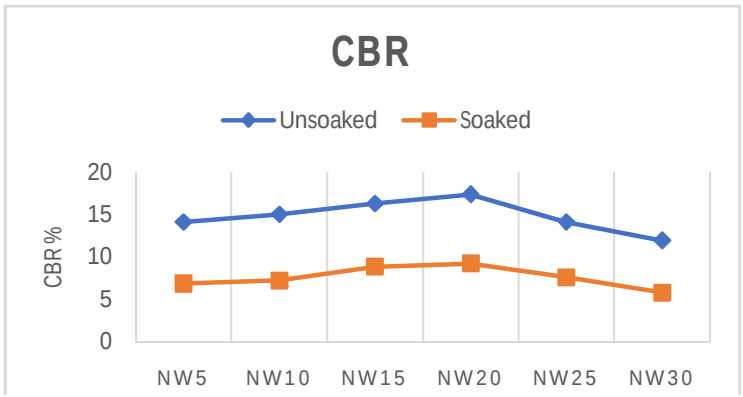


Graph IV.11: Variation in CBR of NW samples

The results of Unsoaked CBR tests on CL Soil treated with different percentage of WHA and from the results it can be seen that with increase in percentage of ash waste, the Unsoaked CBR of soil goes on increasing from 7.04 to 17.33% when WHA is increased from 0 to 20% is effective beyond also there is a decrease in CBR of soil from 17.33 to 11.91% when WHA waste is increased from 20% to 30% and further the value for 100% WHA is 7.95%.

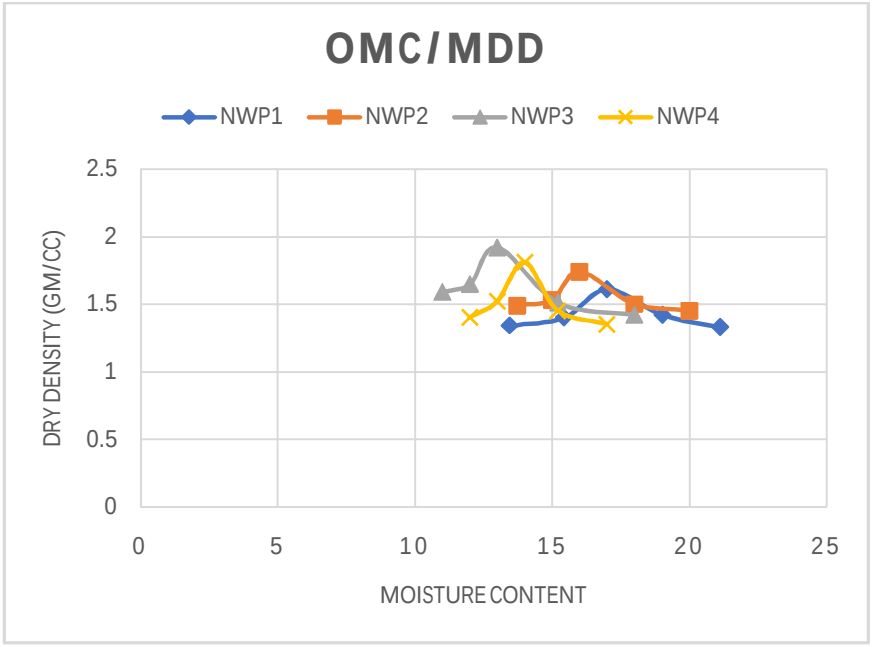
The results of Soaked CBR tests on CL Soil treated with different percentage of WHA and from the results it can be seen that with increase in percentage of ash waste, the soaked CBR of soil goes on increasing from 4.21 to 9.21% when WHA is increased from 0 to 20% is effective beyond also there is a decrease in CBR of soil from 9.21 to 5.78% when WHA waste is increased from 20% to 30% and further the value for 100% WHA is 5.41%.

The results of Swelling Pressure tests on CL Soil treated with different percentage of WHA and from the results it can be seen that with increase in percentage of ash waste, the Swelling Pressure of soil goes on decreasing from 2.15 to 0.67 when WHA is increased from 0 to 20% is effective beyond also there is a increase in Swelling Pressure of soil from 0.67 to 1.42 when WHA waste is increased from 20% to 30% and further the value for 100% WHA is 1.95.

C. Test Result of Natural Soil with Polypropylene & Wheat Husk Ash

Natural soil with 20% of Wheat Straw Ash i.e. WH20 mix give optimum value of CBR in both soaked and unsoaked condition, now polypropylene is added upto 1% with an interval of 0.25%.

1) Proctor Compaction test



Graph IV.12: OMC/MDD of NWP samples

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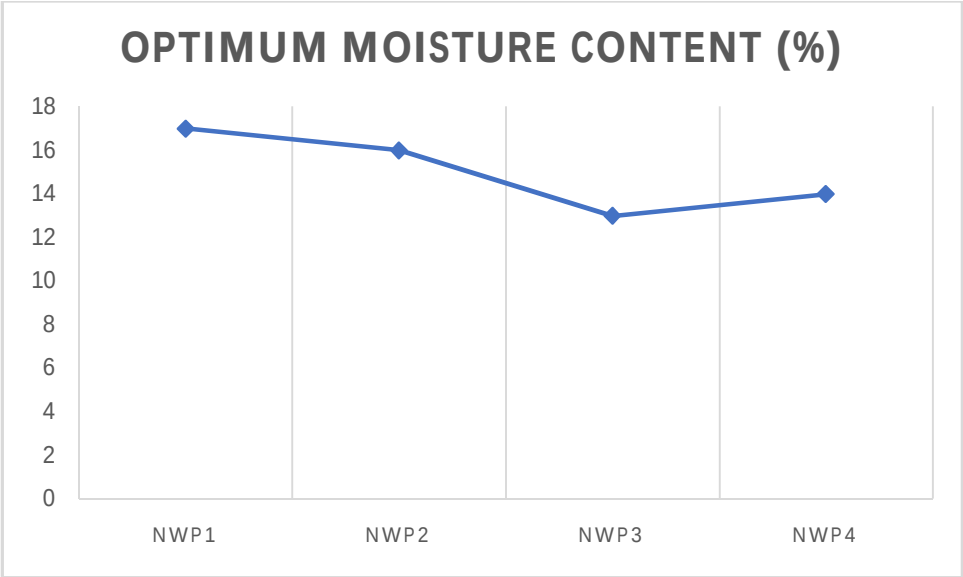
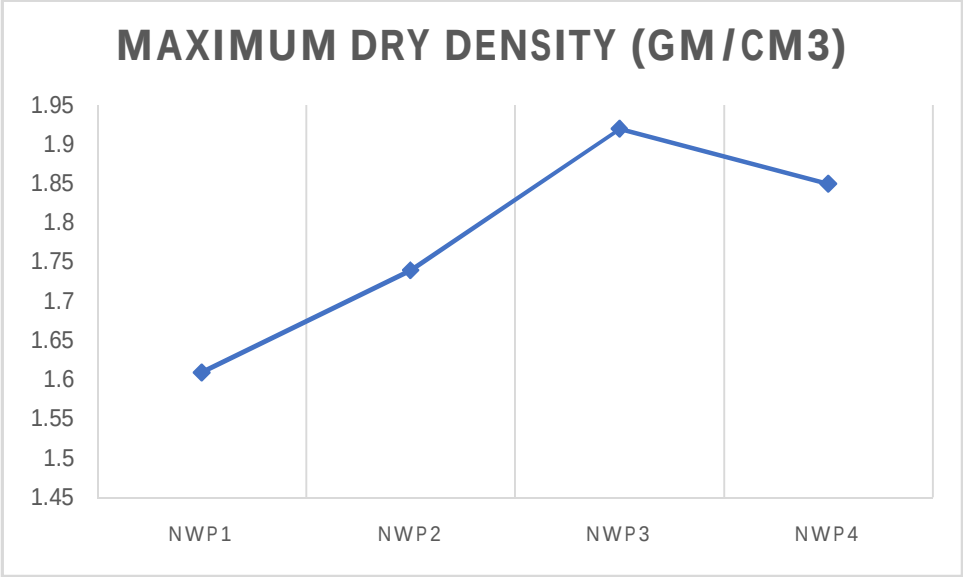
Table IV.4: Compaction Properties of NWP samples

S.N.	Compaction Properties of NWP Sample	Name of Artificial NWP Samples			
		NWP1	NWP2	NWP3	NWP4
1	Optimum Moisture Content (%)	17	16	13	14
2	Maximum Dry Density (gm/cm^3)	1.61	1.74	1.92	1.81



Graph IV.13: : Optimum Moisture Content of NWP samples



Graph IV.14: Maximum Dry Density of NWP samples

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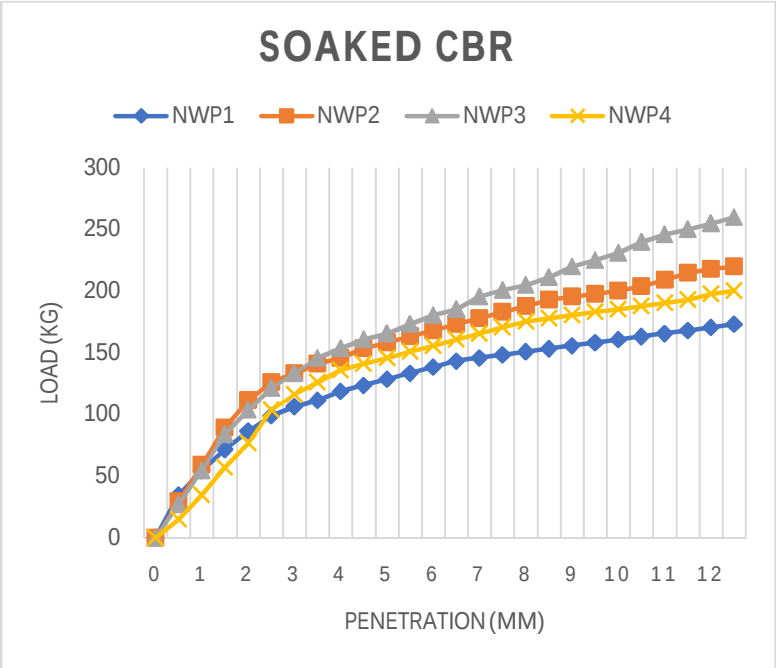
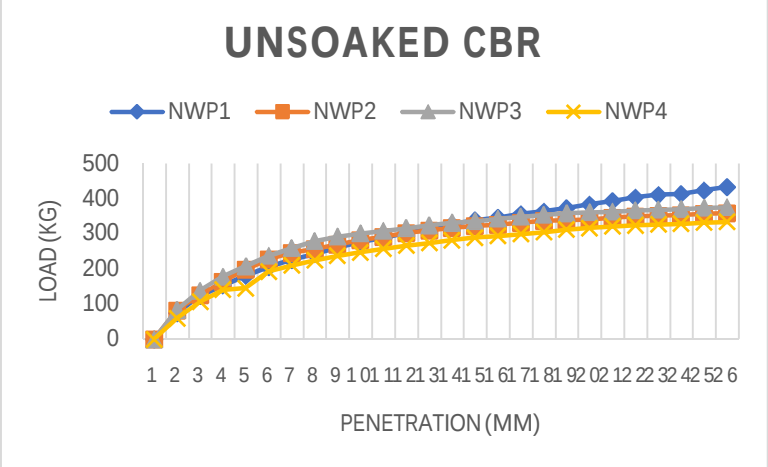
2) California Bearing Ratio



Graph IV.15: Soaked CBR of NWP samples



Graph IV.16: UnSoaked CBR of NWP samples

Table IV.5: Strength Properties of NWP Samples

S.N.	Strength Properties of NWP Sample		Name of Artificial NWP Samples			
			NWP1	NWP2	NWP3	NWP4
1	CBR (%)	Unsoaked	18.25	18.85	20.56	19.41
		Soaked	9.90	10.18	12.27	11.67

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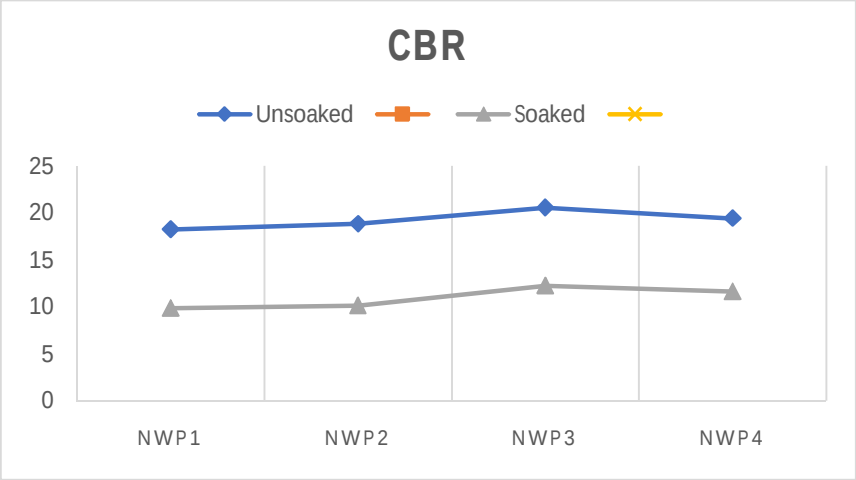

Table IV.6: Variation in CBR of NWP samples.

Above result shows that the, 0.75% of polypropylene fiber with 20% wheat husk is give maximum value of CBR in both soaked and unsoaked condition, when natural soil of low compressibility is stabilized by wheat husk ash after obtaining the optimum percentage of wheat husk ash i.e. 20% then polypropylene fiber is added in the in the mix and it has been foun that 0.75% of polypropylene gives best result with 20% wheat husk ash, by the help of CBR test result.

V. CONCLUSION

When soil stabilized with wheat husk ash and with polypropylene for soil subgrade conclusion drawn is, Unsoaked California Bearing Ratio tests result on natural soil treated with different percentage of wheat husk ash and from the results it can be seen that with increase in percentage of ash waste, the unsoaked California Bearing Ratio of soil goes on increasing from 7.04 to 17.33% when wheat husk ash is increased from 0 to 20% is effective beyond also there is a decrease in California Bearing Ratio of soil from 17.33 to 11.91% when wheat husk ash waste is increased from 20% to 30% and further the value for 100% wheat husk ash is 7.95%.The results of soaked California Bearing Ratio tests on cl soil treated with different percentage of wheat husk ash and from the results it can be seen that with increase in percentage of ash waste, the soaked California Bearing Ratio of soil goes on increasing from 4.21 to 9.21% when wheat husk ash is increased from 0 to 20% is effective beyond also there is a decrease in California Bearing Ratio of soil from 9.21 to 5.78% when wheat husk ash waste is increased from 20% to 30% and further the value for 100% wheat husk ash is 5.41%.0.75% of polypropylene fiber with 20% wheat husk is give maximum value of california Bearing ratio in both soaked and unsoaked condition, when natural soil of low compressibility is stabilized by wheat husk ash after obtaining the optimum percentage of wheat husk ash i.e. 20% then polypropylene fiber is added in the in the mix and it has been foun that 0.75% of polypropylene gives best result with 20% wheat husk ash, by the help of california Bearing ratio test result. With wheat husk ash soil attain strength, based on California bearing ratio test which is extremally good and give optimum percentage of wheat husk ash i.e. 20% and when polypropylene is mixed in soil, with 20% Wheat husk ash on basis of California bearing ratio, soil which contains polypropylene 0.75% with 20% wheat husk ash attain maximum strength.

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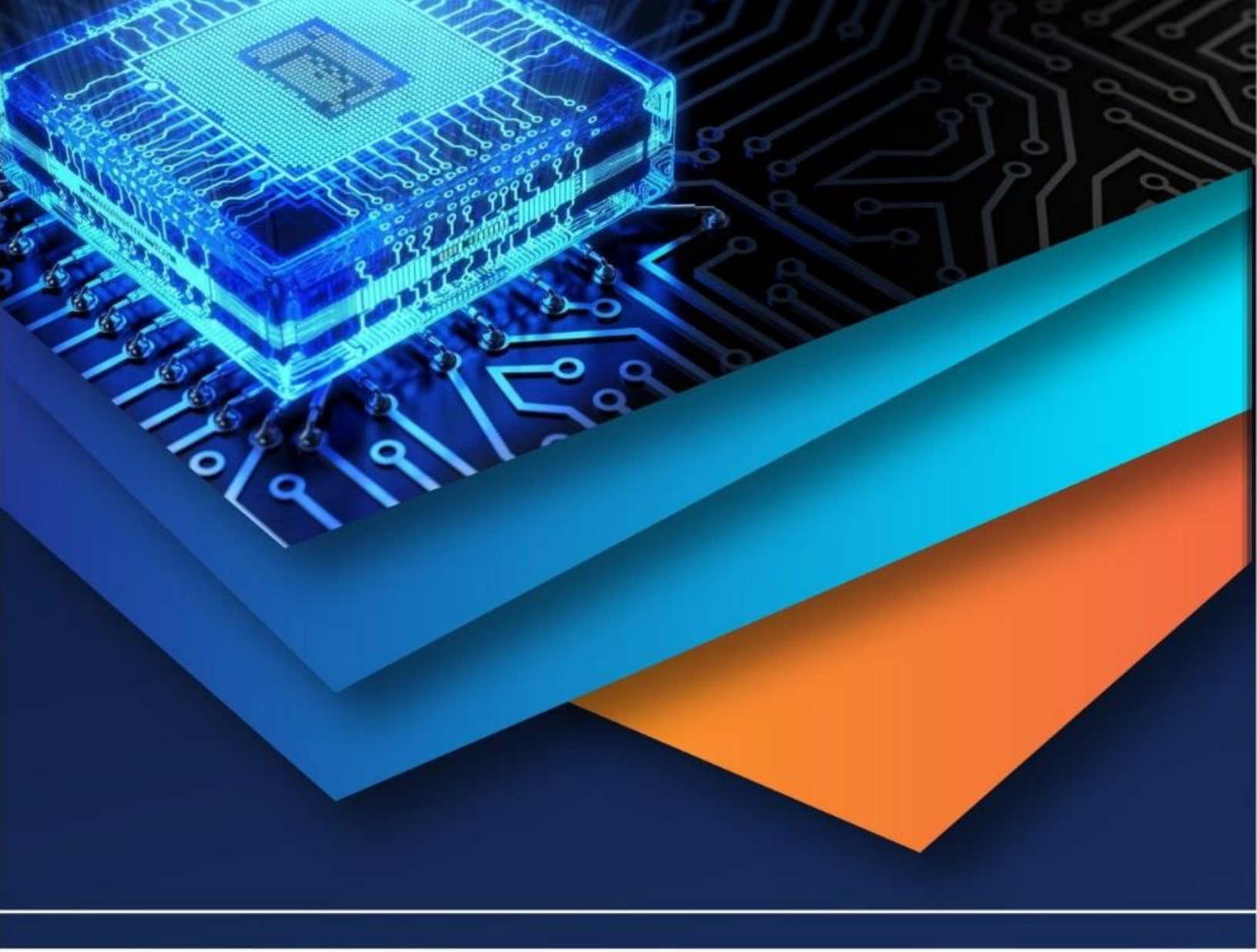

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