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GEO-IMPROVEMENT OF CLAYEY SOIL WITH RBI GRADE 81, WOOD ASH AND SILICA GEL

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ABSTRACT

The soil exists in natural state have some technical weakness in it. It tends to swell when it comes in contact with water and also get shrunk after drying. This is quite dangerous for the structures built upon such soil, as the structures get collapsed due to differential settlement. The differential settlement occurs due to variation of CBR value of the beneath soil, low UCS value and high compressibility. To evaluate the quality of soil various test have been performed such as consistency limits test, particle size distribution and compaction test (Standard Proctor Test) which exposed the condition of soil before and after stabilization. To avoid risk of life and failures in the structures it is better to enhance the properties of weak soil by stabilizing and reinforcement techniques. Stabilization and reinforcement techniques help to enhance the quality of soil by mixing cementitous, siliceous and reinforcing material respectively in the optimum quantity. Soil is treated to make it stabilize by using various admixtures like RBI grade 81 and industrial wastes as Wood ash and Silica gel. RBI grade 81 has some cementitious properties with some fibrous content, whereas wood ash and silica gel have siliceous content with different particle size. The pozzolanic reaction fill the gap between particles and bind it together to take the strength to higher level which tends to reduce the compressibility of soil. The maximum dry density and Optimum moisture content significantly increase after mixing of RBI grade 81, Silica Gel and Wood ash upto some proportion after that it start decreasing. The optimum values obtained of the mixes after evaluating by various geotechnical tests are Wood ash 10%, RBI Grade 81 is 6% and Silica gel is 5%. The results show that with the addition of RBI grade 81, wood ash and Silica gel enhances the properties of clayey soil at an extent level when it is mixed at the optimum limit.

Keywords: Clayey Soil, RBI Grade 81, Wood Ash, Silica Gel, Stabilization, Fibers.

I. INTRODUCTION

From the previous case studies, it has been found that many damages occurred due to existing weak soil beneath the structures which leads to the risk of many human being's life and also affect the environment at much intent which also indirectly affect the human life and enhancing the risk of health of living being. Some industrial wastes that are dumped into the earth, rivers, seas and oceans are also quite risky to the life of living being as it adulterated in our body through several indirect means which also responsible for ill health of living beings under the water and on the land too. Solid biomass for heat and electricity production increases the quantity of wood ashes which are further dumped into the earth but it can be managed as it can be used for stabilization of weak soil. (Bayshaki Deb Nath et al 2018). The addition of waste Wood ash shows improved Liquid, Plastic and Shrinkage Limits respectively but decreased in the Plasticity Index. MDD and UCS of the lateritic soil are increased with the addition of waste wood ash. In addition of 6% waste Wood Ash by weight of dry soil material (Oluremi, Johnson Rotimi et al 2019). Sustainable reuse increased the cost of waste disposal and Environmental concerns. Feasibility of utilizing Silica gel as a stabilizer in expansion soil where swelling characteristics are higher which severely damages the structure and road pavement. Silica gel (5%, 15% and 20%) mixed using mechanical kneader (V. NIVETHA et al 2019). When silica gel added to cement sand particles, it improves the strength of sand seeped by colloidal Silica. The results show greater macroscopic shear strength due to mixing carbon nanotubes and colloidal silica to seep a sand ground improvement based on the stress. (Weifeng Jin et al 2021) (Mark Risse et al 2010). The instance use of bricks in civilization firstly cited in Rome and first ever bricks are sundried mud bricks which has proved for wide range structural clayey products or strength RBI Grade 81 chemical used in varied percentages (Surabhi S 2020). Consumption and pollution of natural products can be compensated by conservation, saving and restoration to create a balance in ecosystem between man and nature. Silica sol is a pure mineral product that has binding properties and neutralizing properties against some pollutants. It is also suitable soil reinforcement material and soils neutralization from pollutants such as Heavy Metals ions (Antonina Sakharova et al 2019). Plastic clay treated with cement kiln dust and (RBI 81) are used after evaluation of geotechnical properties including consistency limits, compaction characteristics, unconfined compression strength, California-bearing ratio and consolidation properties before and after treating the soil. The result shows various mix of cement kiln dust and RBI grade 81 with clayey soil is low plastic in nature. The pavements having high compressible subgrade in rural areas, these materials helps in improvement of CBR values and also make it durable and less maintenance of pavements are required. Clayey soil treated mix are used for rural and low-cost construction road infrastructures (Sudheer Kumar Jala et al 2019). Clay of plastic nature swells when it contacts with water. Such type of soil is expansive soil and different technique used to improve its strength, durability and reduces its compressibility. Engineering properties of soil after the addition of Brick kiln dust and RBI grade 81 improves the consistency limits and shear strength of soil. The maximum dry density is decreasing and optimum moisture content is increasing with increase in percentage of Brick kiln dust and RBI grade 81 (Jasbir Singh et al 2018).

II. METHODOLOGY

The numbers of laboratory tests were performed on clayey soil mixed with various percentages of RBI Grade 81, Wood Ash and Silica Gel. Atterberg's limits, Compaction characteristics were investigated. All tests were performed as for IS: 2720 (Part-III), IS: 2720 (Part-V), IS: 2720 (Part-VII), IS: 2720 (Part-X), IS: 2720 (Part-VI) standards.

III. MATERIALS AND TESTING METHODS

Clayey Soil

Clayey soil was collected from Samkehar, Distt. Kangra Near Pong Dam, (HP), India. Clayey soil creates numerous problems due to its low strength, high compressibility and high level of volumetric changes. Index properties are given as Table 1.

Table 1: Index properties of clayey soil

Index property	Index value
Natural water content%	31
Liquid limit%	37
Plastic limit%	27
Shrinkage limit%	20
Plasticity index%	10
Activity	0.60
Specific gravity	2.69

RBI Grade 81

RBI means Road Building International; RBI 81 is natural stabilizer which is cost effective and environment friendly which is made up of natural occurring compounds. The application of RBI Grade 81 chemical stabilizer causes the liquid limit to decrease and the plastic limit to increase, thereby decreasing the plasticity index of clayey soil under investigation.

Wood Ash

Wood Ash is provided in homemaker and it is burnt in the open environment. Wood Ash is powdery residue remaining after the combustion of wood, such as burning the largest component of wood ash (about 25%) is calcium carbonate, a common liming material that increases soil alkalinity. Physical and chemical properties of wood ash table 2 and 3.

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Table 2: Physical properties of Wood Ash

Properties	Sources of Wood Ash				
	W1	W2	W3	W4	W5
Retained on no. 325 sieve (%)	23	60	90	40	12
Water requirement percentage of control	115	155	115	126	130
Autoclave expansion percentage	0.2	0.5	-0.6	-0.22	0.12
Unit weight Kg/m	545	412	1376	509	162
Specific gravity	2.26	2.41	2.60	2.26	2.33

Table 3: Chemical properties of Wood Ash

Compound	Composition (%)
Silicon dioxide (Sio2)	33
Aluminium oxide (Al2O3)	25
Iron oxide (Fe2O3)	1.98
Calcium oxide (Cao)	12.8
Magnesium oxide (MgO)	8.7
Potassium oxide (K2O)	9.5
Sodium oxide (Na2O)	7.8

Silica Gel

Silica Gel is an amorphous and porous form of silicon dioxide (Silica). It is an irregular tri-dimensional frame work of alternating silicon and oxygen atoms with nanometer- scale voids and pores. The voids may contain water or some other liquid filled by gas or vacuum. Physical and chemical properties of Silica gel table 4 and 5.

Table 4: Physical properties of Silica Gel

Property	Value	Comments
Thermal conductivity	0.01W/m. K	Determined by Vacuum Insulation conductivity tester
Bulk density	0.45 g/ml	Determined by using Helium picometre
Porosity	80%	Determined by (burner, Emmett and teller).
Specific surface area	142-357m/g	Determined by nitrogen adsorption/desorption
Mean pore diameter	13nm	Determined by nitrogen adsorption/desorption
Primary particle diameter	5-50nm	Determined by electron microscopy
Refractive index	1.46	Very low for a solid material
Dielectric constant	1-2	Very low for a solid material

Table 5: Chemical properties of Silica Gel

Oxides	**Weight (%)**
Silicon dioxide **(**SiO2)	92.72
Aluminum oxide (Al2O3)	3.42
Ferric oxide **(**Fe2O3)	0.71
Calcium oxide (Cao)	0.20

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Sodium oxide (Na2O)	0.05
Magnesium oxide (MgO)	0.14
Potassium oxide (K2O)	0.69
Titanium dioxide (TiO2)	0.09
Phosphorus pentoxide (P2O5)	0.09
Loss on ignition (LOI)	1.30

IV. RESULTS AND DISCUSSIONS

Effect of RBI Grade 81, Wood Ash and Silica Gel on Maximum Dry Density and Optimum Moisture Content

From the compaction test, the maximum dry density attained for a given soil with a standard amount of compaction effort when various soil samples are compacted at different water content. The standard proctor compaction test is a laboratory method which helps in determining the optimum moisture content which a given soil type will become its maximum dry density.

Table 6: Optimum moisture content (OMC) values

6% RBI grade 81+ wood Ash	Silica Gel (%)			
	0	2.5	5	7.5
0	28	29	18	15
5	31	27	16	17
7.5	35	25	14	18
10	33	23	11	19
12.5	30	20	12	20

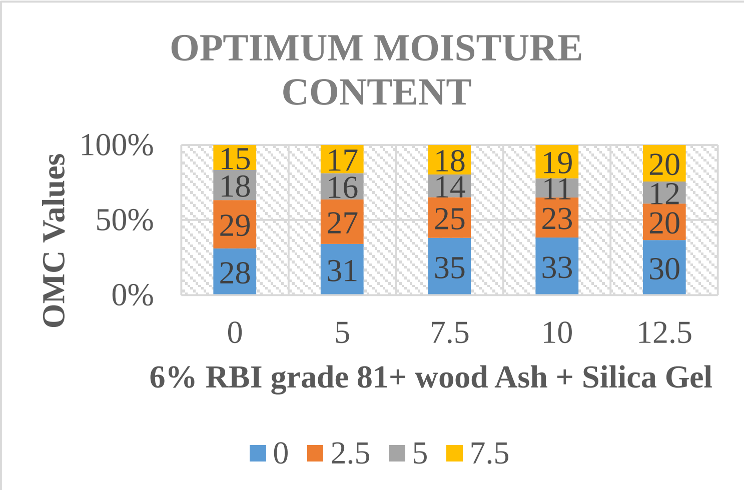

Fig 1: Optimum moisture content mixing with RBI Grade 81, Wood ash and Silica gel

Table 7: Maximum dry density (MDD) values

6% RBI grade 81+ Wood Ash	Silica Gel (%)			
	0	2.5	5	7.5
0	1.32	1.35	1.63	1.58
5	1.3	1.47	1.65	1.62
7.5	1.28	1.61	1.7	1.64
10	1.26	1.58	1.75	1.69
12.5	1.25	1.56	1.72	1.7

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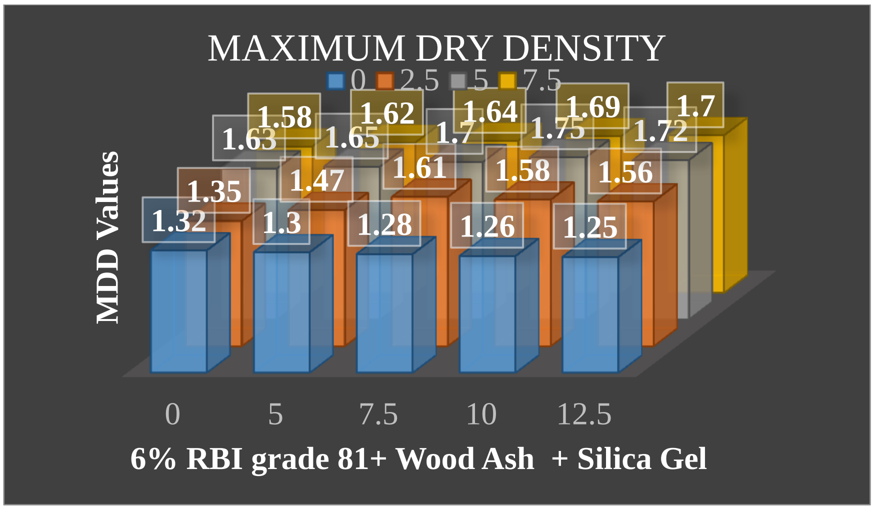

Fig 2: Maximum dry density of clayey soil mixing with RBI Grade 81, Wood ash and Silica gel

Effect of RBI Grade 81, Wood Ash and Silica Gel on (Consistency limit)

The Atterberg's limits test shows compressibility range which is evaluated through observance of water content at which fine-grained clayey and silty soils transition between the different phases. The limit where the water content in percent observed when the inter-distance between the grooving cut of soil sample contain in the Casagrande close to a distance of 0.5 inches along the bottom of a groove after 25 blows in a liquid limit and in case of plastic limit the water content of soil sample in the thread form having diameter of 3.2 mm (about 1/8 inch).

Liquid Limit Test

Table 8: Liquid limit behaviour of clayey modified with RBI Grade 81, Wood ash and Silica gel

6% RBI grade 81+ wood Ash	Silica Gel (%)			
	0	2.5	5	7.5
0	52.3	50.8	48.4	49.6
5	50.7	47.5	46.3	45.1
7.5	49.2	46.6	43.9	45.4
10	48.4	45.4	40.2	46.2
12.5	49.6	46	43.8	45.9

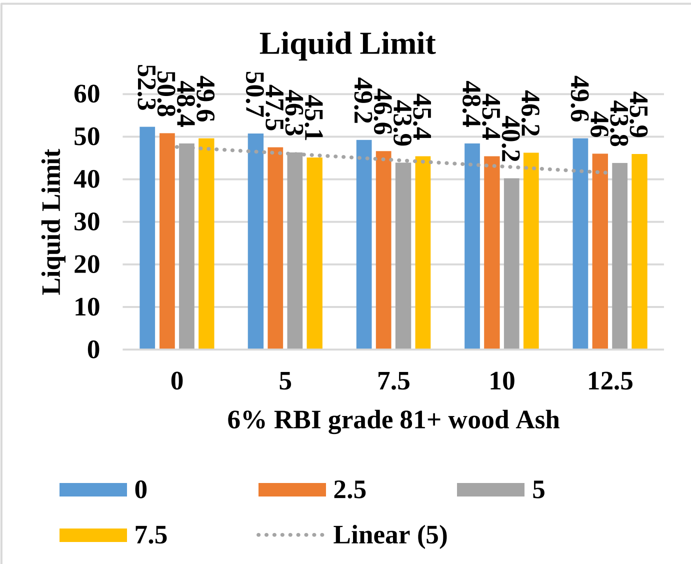

Fig 3: Liquid Limit behaviour of clay with RBI Grade 81, Wood ash and Silica gel

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Plastic Limit Test

Table 9: Plastic limit test result

6% RBI grade 81+ wood Ash	Silica Gel (%)			
	0	2.5	5	7.5
0	25	26.5	29.3	28.7
5	27.7	27.9	30.6	27
7.5	28.6	28.7	32.1	26.7
10	31.2	31.9	33.7	26.2
12.5	30.4	30.6	32.6	27.5

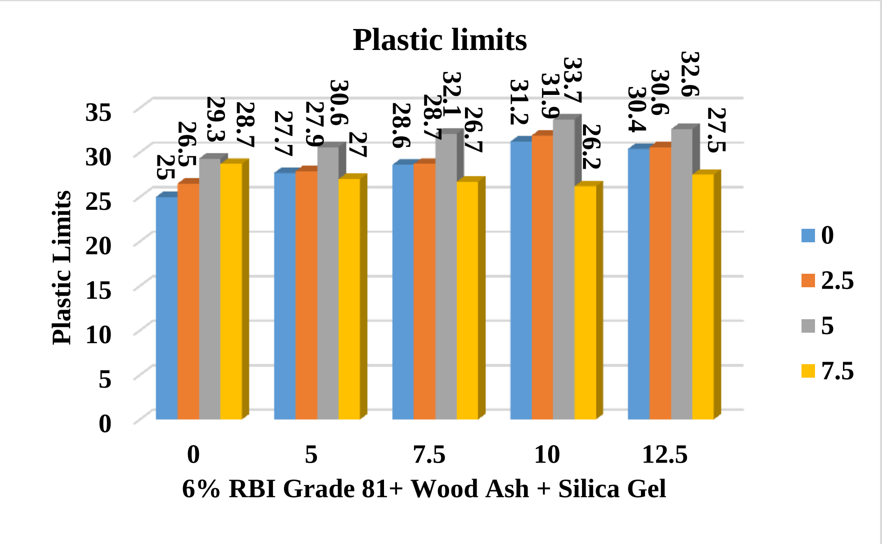

Fig 4: Determination of limit from plastic limit

Plasticity Index

Table 10: Plasticity Index

6% RBI grade 81+ wood Ash	Silica Gel (%)			
	0	2.5	5	7.5
0	27.3	24.3	1.91	20.9
5	23	19.6	15.7	18.1
7.5	20.6	17.9	11.8	18.7
10	17.2	13.5	6.5	20
12.5	19.2	15.4	11.2	18.4

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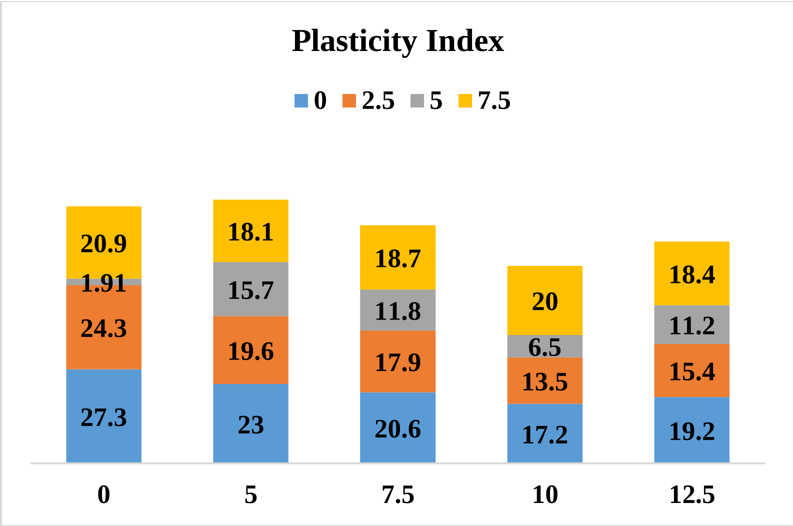

Fig 5: Influence of RBI Grade 81, Silica Gel and Wood Ash on Plasticity Index

V. CONCLUSION

The collected soil samples were treated with Wood Ash, Silica Gel and RBI Grade 81 in various proportions. The various tests are also conducted to determine the different engineering properties such as Atterberg's limit test, Compaction tests, Unconfined Compressive Strength test (UCS), California Bearing Ratio test (CBR) are carried in soil.

The following conclusions were made from this research work-

1. The optimum moisture content and maximum dry density of various mixtures are determined through standard proctor test and found that the value of optimum moisture content decreases and value of maximum dry density decreases up to the optimum limit.
2. While analysing the compressibility of soil with and without admixtures through consistency limit it has been found that the value of liquid limit and plasticity index keep decreasing and value of plastic limit increasing after mixing wood ash, silica gel and RBI grade 81 into the clayey soil.
3. The optimum limit of the mix for the best results is of RBI Grade 81 at 6%, Wood Ash at 10% and Silica Gel at 5% mixed in the clayey soil.

Wood Ash and Silica Gel help soil stabilizer i.e., RBI Grade 81 to improve the engineering properties of clayey soil. These products are used to improve the strength properties of soil and also reduce the compressibility of soil.

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