A Comparative Study on The Efficacy of Different Industrial Wastes in Stabilization of Soil

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Abstract – *While industrialization has increased the standard of living dramatically, it has also caused pollution and generated expansive amounts of solid waste. An alternative to waste disposal is essential, reusing waste is the best option. Using industrial waste management since recycling has been advocated for some time now. Civil Engineers have frequently encountered weak soils as one of the most prominent problems of their field. Many techniques are available in order to stabilize such poor soils, such as lime and cement. Although solid Wastes have potential and promise, their use in soil stabilization provides a double benefit of improving soil while managing waste. The purpose of this study is to evaluate the various industrial wastes that have been accepted for soil stabilization as standalone stabilizers, in order to provide insight into the prospects of increasing their use for soil stabilization.*

***Key Words*: Stabilization, Waste Gypsum, Waste Iron Nail Granules, Waste Insulated Wires, MDD, OMC, SPT, CBR, UCS, DST.**

1.INTRODUCTION

With the advent of the industrial revolution, society's standards of living increased rapidly due to mass-produced goods, job opportunities and greater wages. Unfortunately, one of the downsides of the industrialization has been the production of by-product wastes, which have quickly grown to enormous proportions, causing environmental pollution, disposal problems and management problems. Many efforts have been made to enhance waste management practices. The most effective way to manage industrial wastes is to find suitable uses for them in various sectors of engineering. A geotechnical Engineer has always encountered weak soils as one of the prime obstacles of the field. Due to their poor strength and low bearing capacity, these soils are very difficult to work with during construction. Before construction can be executed on these soils n a safe and stable manner, these soils must be improved. The purpose of soil stabilization is to improve the physical properties of weak soil and enable it to achieve the required engineering properties. In the literature, chemical soil stabilization techniques like lime and cement have been we documented. With a rapid rise in soil waste generation, a sustainable approach to waste management us the use of solid wastes for soil stabilization.

2. AIM OF THE REASEARCH

1. To achieve optimum stabilization of soil from an area that is frequently flooded. (Gogjibagh, Srinagar) with maximum cost effectiveness.
2. Disposal and management of Industrial Waste in a safe and beneficial way.
3. To explore the use of the stabilized soil with different additives and make a careful comparison in their efficacy of successfully stabilizing and improving the behavior of the weak soil.

3. EXPERIMENTAL INVESTIGATIONS AND TESTING METHODOLOGY FOR RAW SOIL

The soil samples were procured from Gogjibagh, Srinagar, which is a flood prone area. The soil samples taken were both disturbed (remolded) and Undisturbed in abundant quantity.

The index and Engineering properties of soil without additives was first determined to understand the inherent characteristics of the soil and to make better comparisons.

Table 1. Index and Engineering Properties

1	**Moisture Content, w (%)**	24.43%
2	**Dry Density, γ_d (g/cc)**	1.416
3	**Liquid Limit, wL (%)**	35.76
4	**Plastic Limit, wP (%)**	24.78
5	**Specific Gravity, G**	2.64
6	**OMC (%), MDD (g/cc)**	17.5,1.75
7	**Unconfined Compressive Strength From UCS, (C), (kg/cm²)**	0.448
8	**Shear Strength from Direct Shear Test, (S), (kg/cm²)**	0.281
9	**CBR (%)**	At 2.5mm=1.24%, At 5mm=1.53%

The results were indicative of the following conclusions:

1. From the wet sieve analysis carried out, the soil could be classified as a **Gap graded- fine grained soil.**
2. The liquid Limit and Plastic Limit obtained indicate that the soil is **Silty Sand of Medium Plasticity.**

4. USE OF INDUSTRIAL WASTES/ADDTIVES

Three additives were used namely, Waste Gypsum,

Waste Iron Nail Granules and Waste Insulated Wires.

Each Additive was added in three trial percentages, viz.**: 3%, 7% and 9%** of the soil sample by weight.

4.1 Standard Proctor Test

The standard proctor test was performed conforming to IS 2720 (part VII) 1980. The Compaction was performed with the conventional apparatus of mould capacity of 1000ml and with a rammer weighing 2.6 kg for each trial percentage. Respective OMC's and MDD's were determined.

Fig 3: Waste Gypsum

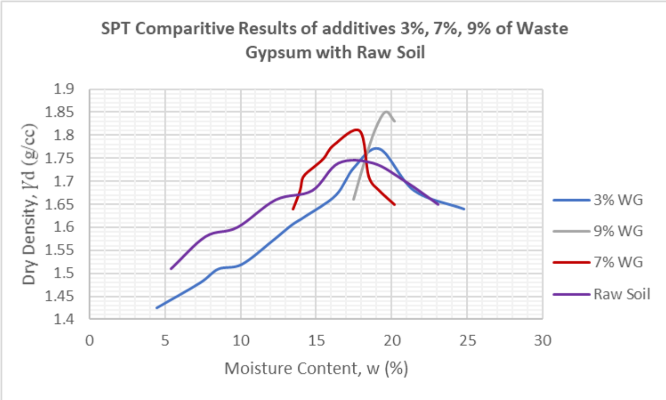
4.1.1 Waste Gypsum

Waste Material was acquired from an industrial estate in Khonmoh. It was pulverised, cleaned then that passed through **1.18mm** IS Sieve

Table 2. Results of SPT with 3 trail percentages of Waste gypsum

S.no	% Of Waste Gypsum	MDD (g/cc)	OMC (%)
1	3%	**1.77**	**17.9**
2	7%	**1.81**	**19.52**
3	9%	**1.86**	**19.53**

Graph 1: Comparative representation of SPT results with Waste Gypsum



4.1.2 Waste Iron Nail Granules

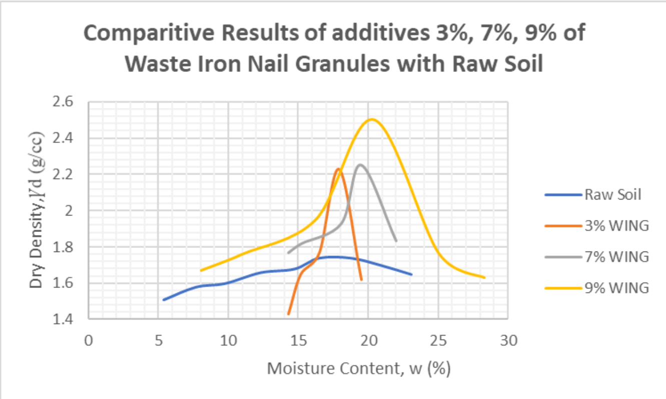
Waste Iron Nail Granules were acquired from the Industrial Estate in Rangreth, Srinagar, Jammu and Kashmir. Granules used were of sizes between **0.3-0.5mm** and were acquired from an Industry producing Iron Nails from Mild Steel.

Fig 4: Waste Iron Granules

Table 3. Results of SPT with 3 trail percentages of Waste Iron Nail Granules

S.no	% Of Waste Granules	MDD (g/cc)	OMC (%)
1	3%	1.81	**19.9**
2	7%	2.21	**19.52**
3	9%	2.5	**20.375**

Graph 2: Comparative representation of SPT results with Waste Iron Nail Granules



4.1.3 Waste Insulated Wires

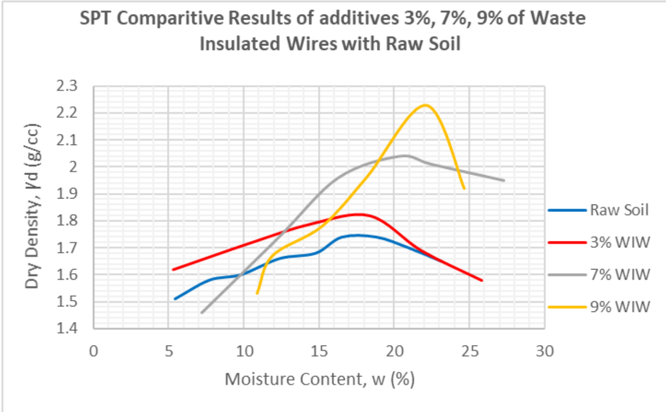
Waste Insulated Wires were acquired from the **Industrial Estate in Rangreth**, the Wires were **0.1 mm thick in Diameter** and in order to incorporate them in the soil efficiently, they were cut into lengths **of 1cm to 3cm**, depending upon the type of test to be performed, in other words the amount of sample to be taken.

Fig 5: Waste Insulted Wires

Table 4. Results of SPT with 3 trail percentages of Waste Insulated Wires

S.no	% Of Waste Wires	MDD (g/cc)	OMC (%)
1	3%	1.81	**19.9**
2	7%	2.21	**19.52**
3	9%	2.5	**20.375**

Graph 3: Comparative representation of SPT results with Waste Insulated Wires



4.2 Direct Shear Test

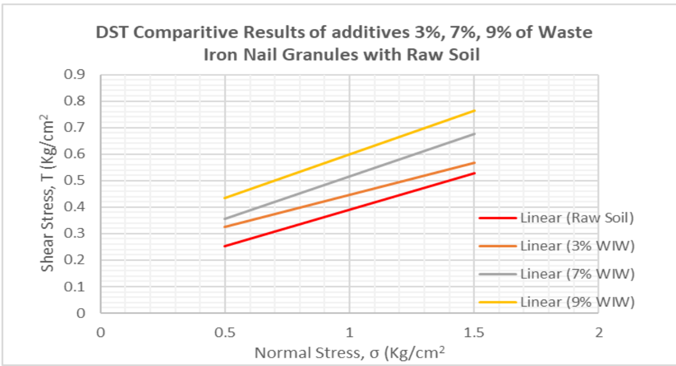
The Test was performed conforming to IS 2720 (part 15) 1986. Three different samples were used for each trial percentage. The soil samples along with respective percentage of waste gypsum were compacted and remolded in shear box of size 6×6. The shear force readings were given by the proving ring corresponding to the Horizontal dial gauge (used for horizontal displacement) at normal stresses of 0,5, 1.0, 1.5 kg/cm^2.

4.2.1 Waste Gypsum

Table 5. Results of DST with 3 trail percentages of Waste gypsum

S.no	% Of Waste Gypsum	Shear Strength (kg/cm^2)
1	3%	0.306
2	7%	0.400
3	9%	0.450

Graph 4: Comparative representation of DST with Waste Gypsum

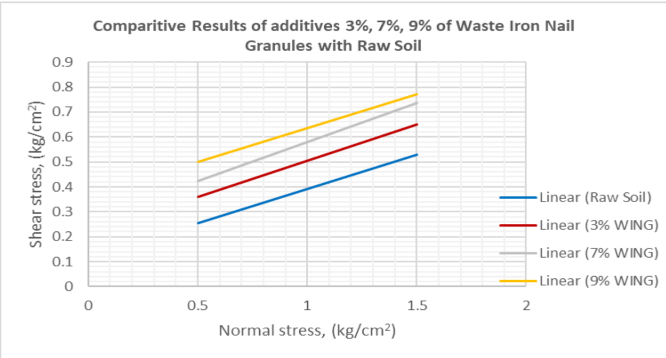


4.2.2 Waste Iron Nail Granules

Table 6. Results of DST with 3 trail percentages of the Waste Iron Nail Granules

S.no	% Of Waste Granules	Shear Strength (kg/cm²)
1	3%	0.330
2	7%	0.445
3	9%	0.5

Graph 5: Comparative representation of DST with Waste Iron Nail Granules

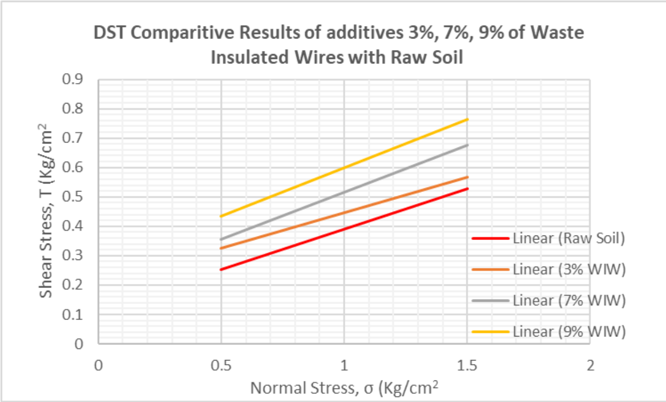


4.2.3 Waste Insulated Wires

Table 7. Results of DST with 3 trail percentages of Waste Insulated Wires

S.no	% Of Waste Wires	Shear Strength (kg/cm²)
1	3%	0.315
2	7%	0.372
3	9%	0.459

Graph 6: Comparative representation of DST with Waste Insulated wires



4.3 Unconfined Compressive Strength Test

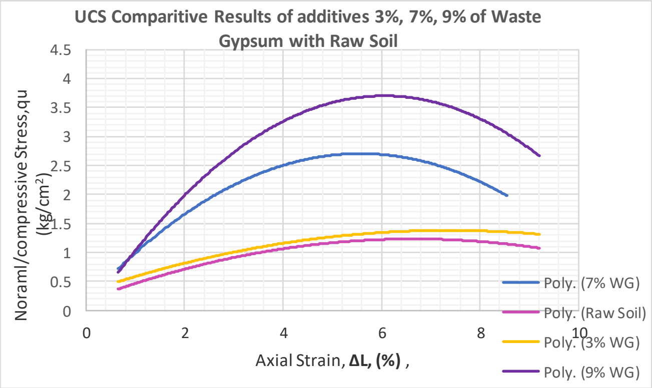
The Test was performed conforming to IS 2720 (part 10) 1991. Three representative samples were taken, having been remolded along with different trails of Waste Gypsum them and extracted them with a tube sampler. The average dimensions of the samples were kept as 7.6cm of Height and 3.8 cm of diameter. The unconfined Compressive Strength was determined on a machine with a proving ring for compressive stress and vertical dial gauge for determining the displacement of sample.

4.3.1 Waste Gypsum

Table 8. Results of UCS with 3 trail percentages of Waste Gypsum

S.no	% Of Waste Gypsum	Unconfined Compressive Strength (kg/cm²)
1	3%	1.7
2	7%	2.55
3	9%	3.17

Graph 7: Comparative representation of UCS with Waste Gypsum

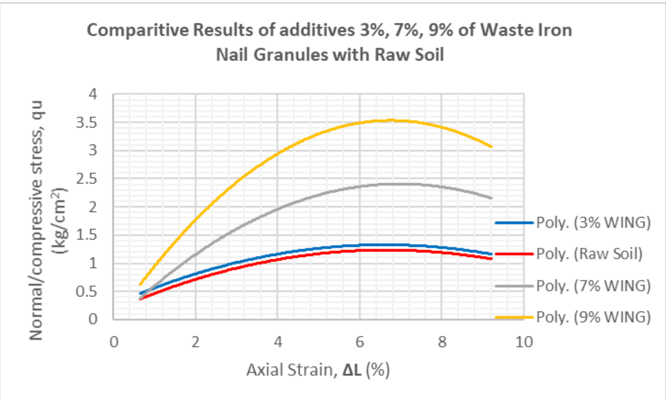


4.3.2 Waste Iron Nail Granules

S.no	% Of Waste Wires	Unconfined Compressive Strength (kg/cm²)
1	3%	1.31
2	7%	1.5
3	9%	1.56

Table 9: Results of UCS with 3 trail percentages of Waste Iron Nail Granules

Graph 8: Comparative representation of UCS with Waste Iron Nail Granules

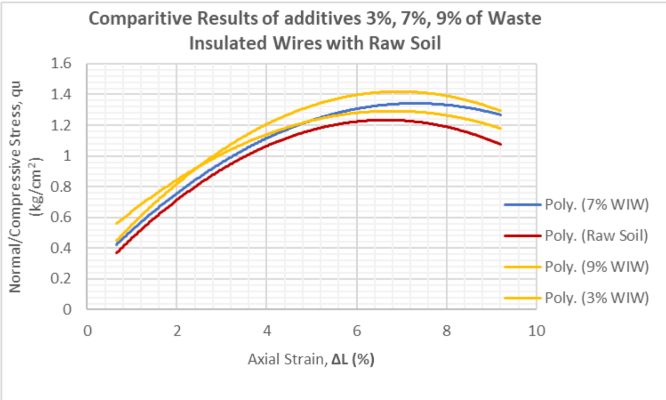


4.3.3 Waste Insulated Wires

Table 10: Results of UCS with 3 trail percentages of Waste Insulated Wires

S.no	% Of Waste Granules	Unconfined Compressive Strength (kg/cm²)
1	3%	0.915
2	7%	1.2
3	9%	1.41

Graph 9: Comparative representation of UCS with Waste Insulated Wires



4.4 California Bearing Ratio Test

The Test was performed conforming to IS 2720 (part 16) 1987. The California Bearing Ratio Test was conducted to evaluate the suitability of the stabilized soil to be used as a soil subgrade and sub-base in a pavement.

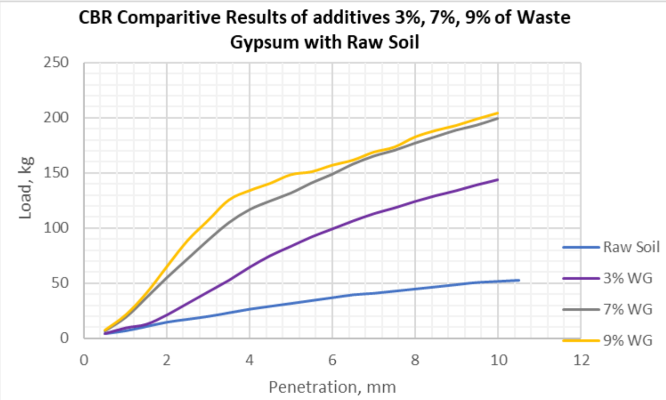
The plunger in the CBR penetrates the specimen in the mould at the rate of 1.25mm/minute. The loads required for a penetration of 2.5mm and 5mm are determined. The penetration load is expressed as percentage of the standard loads at the respective penetration level of 2.5mm or 5mm.

4.4.1 Waste Gypsum

Table 11. Results of CBR with 3 trail percentages of Waste Gypsum

S.No	% Of Waste Gypsum	CBR Value (%)
1	3%	At 2.5mm = 1.53 At 5.0mm = 3.96
2	7%	At 2.5mm = 5.54 At 5.0mm = 6.40
3	9%	At 2.5mm = 6.5 At 5.0mm = 7.23

Graph 10: Comparative representation of CBR with Waste Gypsum

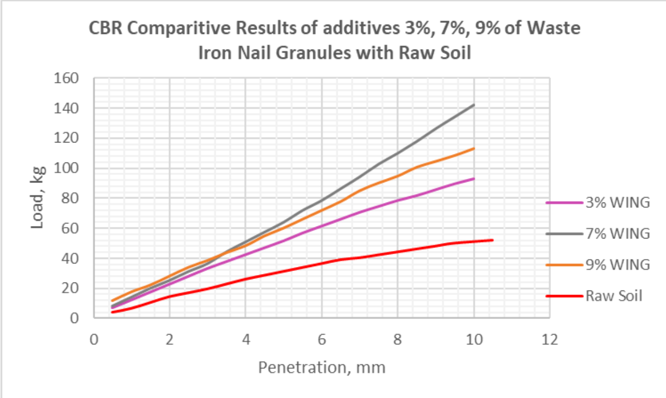


4.4.2 Waste Iron Nail Granules

Table 12. Results of CBR with 3 trail percentages of Waste Iron Nail Granules.

S.No	% Of Waste Granules	CBR Value (%)
1	3%	At 2.5mm = 2.05 At 5.0mm = 2.5
2	7%	At 2.5mm = 2.29 At 5.0mm = 3.12
3	9%	At 2.5mm = 2.5 At 5.0mm = 3.33

Graph 11: Comparative representation of CBR with Waste Iron Nail Granules

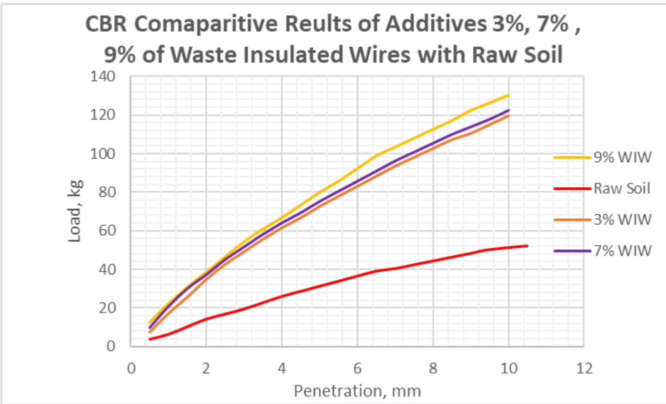


4.4.3 Waste Insulated Wires

Table 13. Results of CBR with 3 trail percentages of Waste Insulated Wires

S.No	% Of Waste Wires	CBR Value (%)
1	3%	At 2.5mm = 3.1 At 5.0mm = 3.53
2	7%	At 2.5mm = 3.29 At 5.0mm = 3.56
3	9%	At 2.5mm = 3.39 At 5.0mm = 3.88

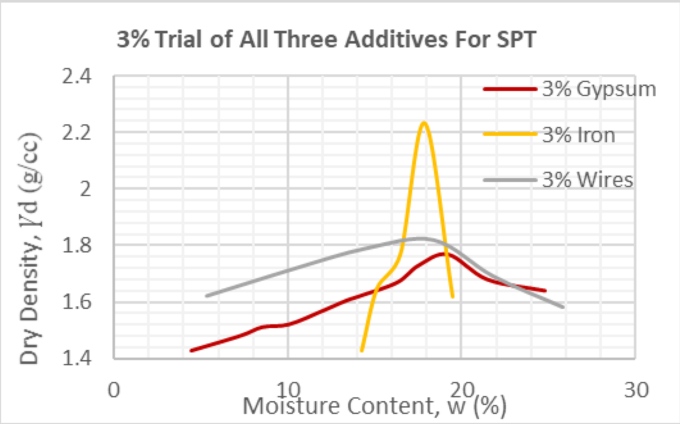
Graph 12: Comparative representation of CBR with Waste Insulated Wires



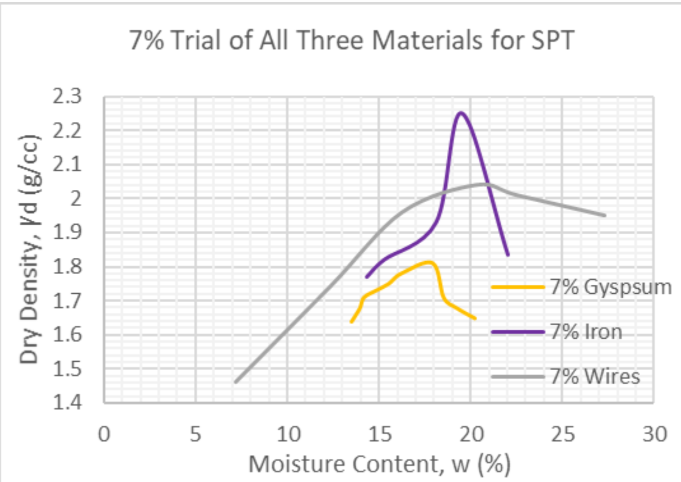
5. GRAPHICAL COMPARISON OF DIFFERENT ADDITIVES WITH SIMILAR TRAIL PERCENTAGES USED IN EFFICACY OF STABILZATION OF RAW SOIL

5.1 Standard Proctor test

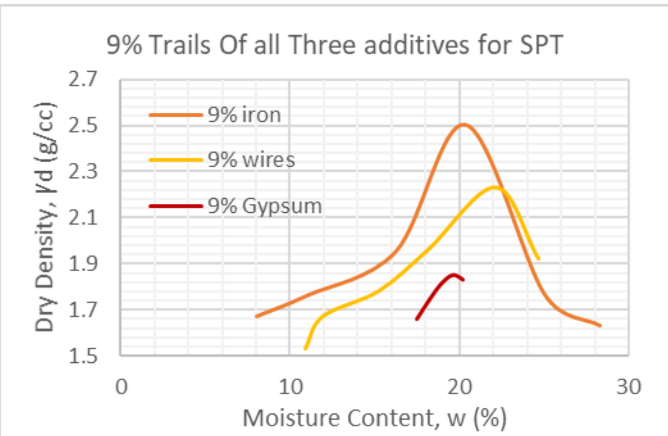
3% Additive



7% Additive

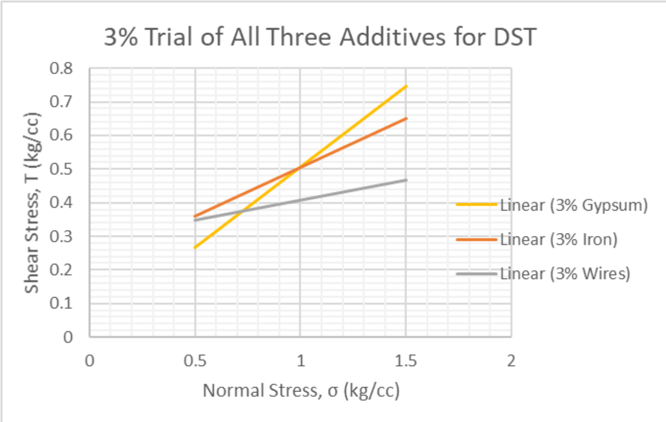


9% Additive

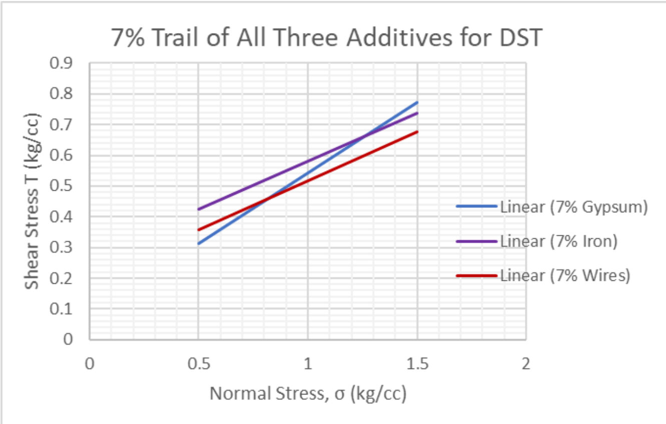


5.2 Direct Shear Test

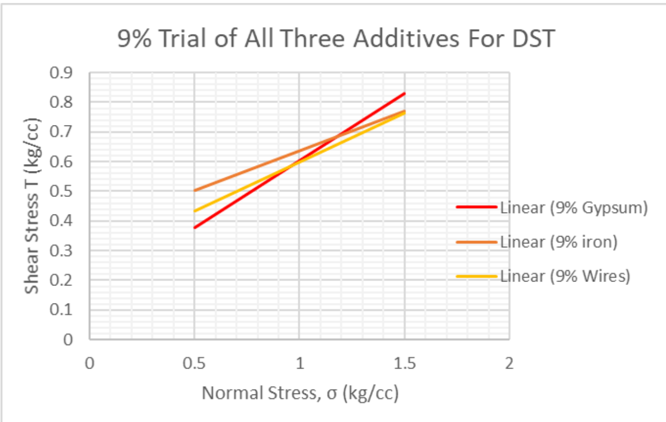
3% Additive



7% Additive

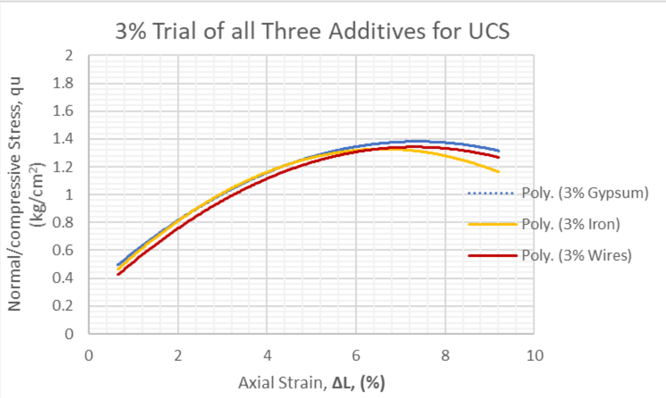


9% Additive

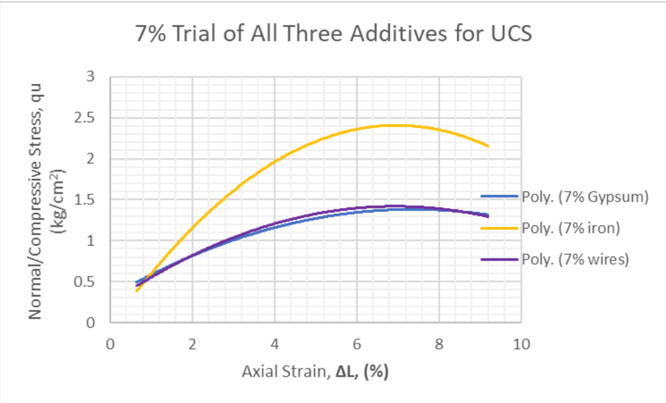


5.3 Unconfined Compressive Strength Test

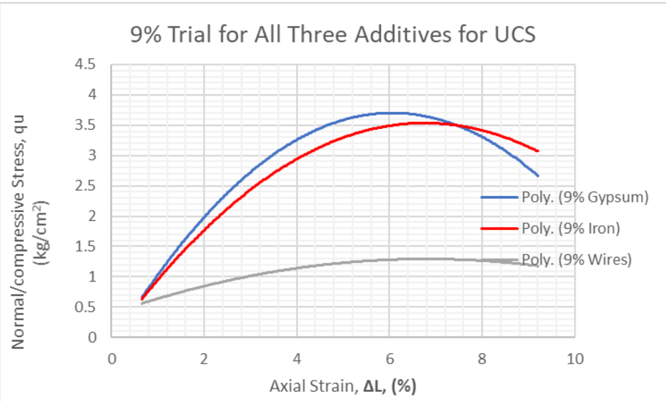
3% Additive



7% Additive

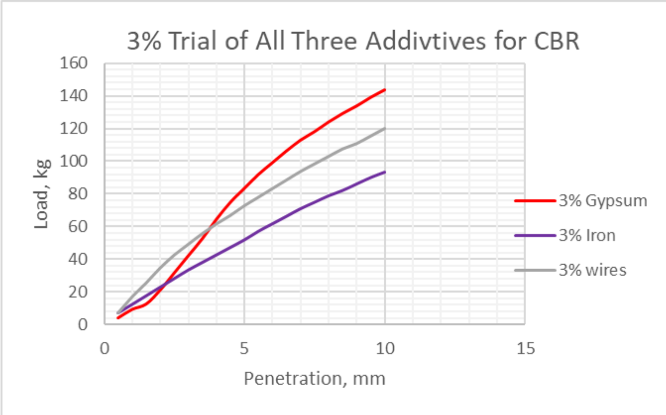


9% Additive

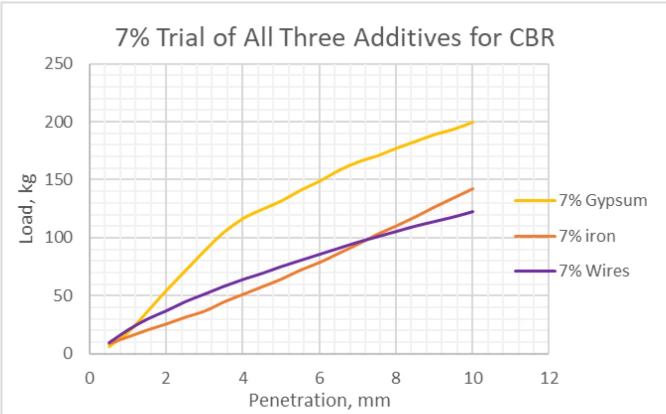


5.4 California Bearing Ratio Test

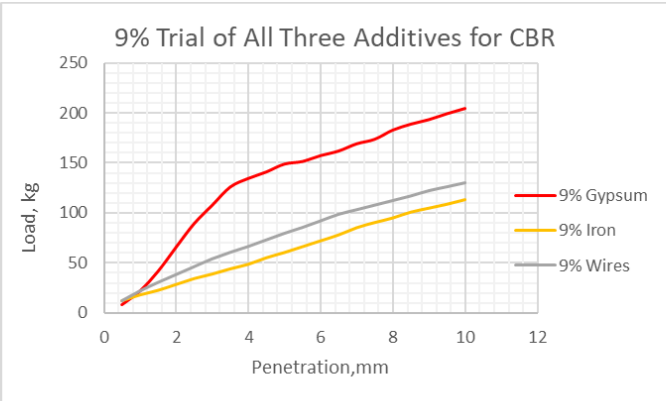
3% Additive



7% Additive



9% Additive



6. CONCLUSIONS

From the above shown results and graphical representations following conclusions can be drawn

1. When it comes to comparison between the efficacy of three Industrial Wastes, viz.: Waste Gypsum, Waste Iron Nail Granules and Waste Insulated Wires. It is quite Evident that Waste Gypsum has proved to be the most effective in improving majority of the Strength parameters of the weak soil.

2. Preceding Waste Gypsum, Waste Iron Nail Granules have shown intermediate results in improving the overall behavior of the soil and Waste Insulated Wires have been the least effective of all and hence have the lowest efficacy in stabilizing soil.

3. It can also be concluded that, each material has improved the conglomerate condition of the soil to some extent when compared to the test results conducted on raw soil. In other words, any one of the three materials can be used as a stabilizing additive, however the order of their efficacy can be written as:

WASTE GYPSUM > WASTE IRON NAIL GRANULES > WASTE INSULATED WIRES

4. Lastly, it can be concluded that the soil stabilized with the three additives can be used as:

   a) As a sub-grade material.

   b) In construction of sub-base.

   c) As a foundation material.

   d) Construction of earthen dams and highway pavements.

   e) For filling of low-lying construction sites.

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