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Improving the Soil Properties of Natural Soil using the Copper Slag and Cement as Additives

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Abstract

Copper slag impacting coarseness is made of the granulated slag of copper processing plants, and utilized for impact cleaning of metal surface. In various enterprises it is called various names rough powder, coarseness, copper slag coarseness, mineral coarseness, crushing grains, and so on. In any case, its primary use is still for surface impact cleaning. Copper slag rough is reasonable for shoot cleaning of steel and stone/solid surfaces, expulsion of factory scale, rust, old paint, earth and so forth. The Various objectives of the study are: To determine the optimum content of cement and copper slag in soil, to determine the unconfined compressive strength of soil by using cement and copper slag, to investigate the use of copper slag in geotechnical and transportation applications, and to classify these materials according to relevant factors such as availability, application, environmental impact, and cost, to determine the California bearing ratio of various soil sample by using cement and copper slag.

Introduction

The money related advancement of any country is relied up upon the infrastructural improvement. In each multiyear plan, the lion offer of adventure occurs for the structures unequivocally roads and express ways. India has an expansive road arrangement of 3.3 million Kms which is the second greatest on earth. The eleventh multiyear plan furthermore contributed more than 3.5 lakh cores in the road division. Subsequently experts are requiring difficult effort to design the quality road pavements likewise; it depended upon the nature of the sub-level. Normally versatile black-top will be the adroit choice for the advancement of road. The trademark soil will be the sub-grade material reliably, yet the rundown properties and nature of the earth isn't adequate. By then the consistency of the sub-assessment will be practiced by modification. The admixture, for instance, fly soot, rice husk blazing flotsam and jetsam, lake ash, copper slag and some other mechanical wastes are endeavored as a stabilizer to achieve quality and incompressibility. Soil improvement is the system in improving the structure properties of soils and thusly making it dynamically consistent. It is fundamental when the soil accessible for improvement isn't proper for the predicted reason. In its broadest sense, alteration included compaction, reconsolidation, squander and various other such method. However, the term change is generally restricted to the methodology which changes the earth material itself for advancement of its properties a cementing material or an engineered is incorporated o a trademark soil with the ultimate objective of modification is to improve the standard soils for the advancement of foundations, expressways and runways. Soil modification is used to decrease the vulnerability what's more, compressibility of the earth mass n earth structures and to construct its shear quality. Soil change is of twisted required to construct the bearing furthest reaches of foundation soils. Regardless, the major usage of the guidelines of soils change are used for controlling the assessing of soils and aggregates in the advancement of bases and sub-bases of the foundations, freeways and runways. A part of the progressing tries made by couple of researchers has explored the sensibility of granulated copper slag, made as waste from cooking of copper, being viably used as interstate advancement material. It has found its fittingness in various layers of the black-top, both versatile and resolute, in blend in with the local soils or some other waste materials. In any case, mass utilization of fine copper slag for road improvement and land filling practices yet need suitable assessment through passing on various lab and field tests. Squander is clearly associated with human headway, both imaginative and social. The game plans of different wastes have contrasted after some time and zone, with mechanical headway and advancement being honestly associated with waste materials.

Results

This dissertation work is performed to obtain geotechnical properties of Cement and Copper slag for its application in the stabilization of soft soil. The geotechnical properties of cement and copper slag will be evaluated by various laboratory tests to investigate the feasibility of using cement and copper slag in soil stabilization.

4.2 Liquid Limit Test Results

Liquid Limit Test was conducted on virgin soil as well as on soil samples mixed with varying percentages of Cement and copper slag. The liquid limit of virgin soil as well as of soil samples mixed with varying percentages of Cement and copper slag is Tabulated in Table 4.1 and shown in Figures 4.1 to 4.5.

Table 4.1 Liquid Limit Results

S. No	Mix No	Mix	Liquid Limit (%)
1	M1	Soil	46.85
2	M2	Soil sample + 7 % Cement	51.25
3	M3	Soil sample + 14 % Cement	60.45
4	M4	Soil sample + 21 % Cement	54.32
5	M5	Soil sample + 13 % Copper Slag	53.55
6	M6	Soil sample + 26 % Copper Slag	61.43
7	M7	Soil sample + 39 % Copper Slag	67.35
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	59.45
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	67.34
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	64.32
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	60.76
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	68.43
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	65.35
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	55.32
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	61.45
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	67.32

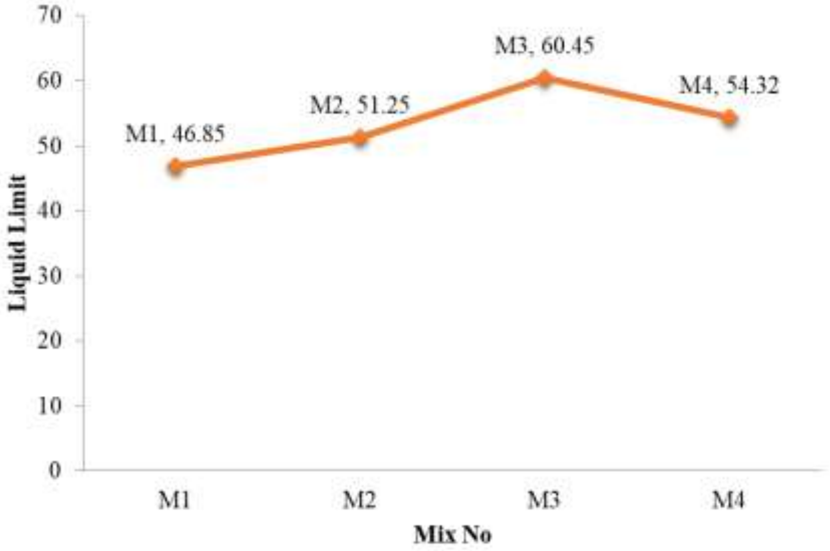

Figure 4.1: Liquid limit of soil with Different percentages of Cement

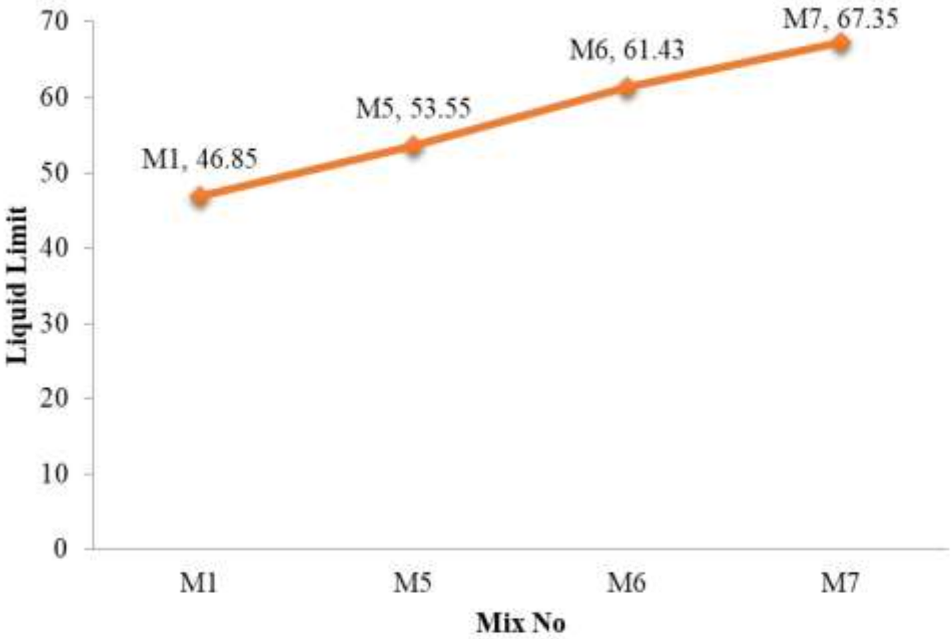

Figure 4.2: Liquid limit of soil with Different percentages of Copper slag

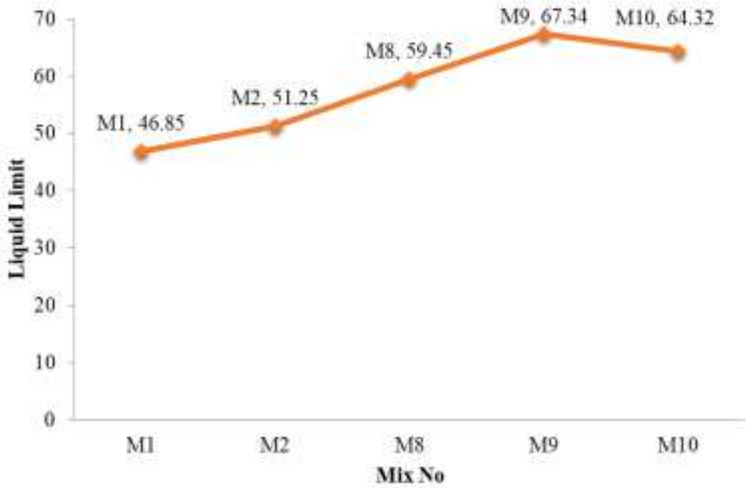

Figure 4.3: Liquid limit of soil using Different percentages of Copper slag with 7% Cement

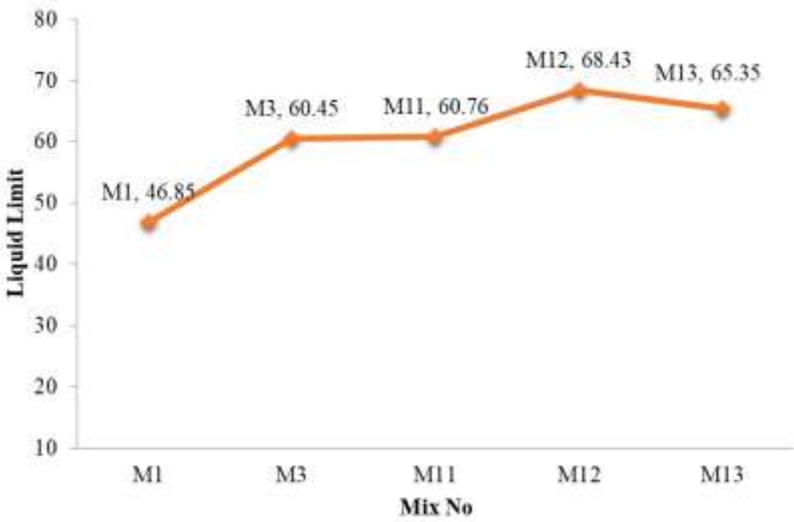

Figure 4.4: Liquid limit of soil using Different percentages of Copper slag with 14% Cement

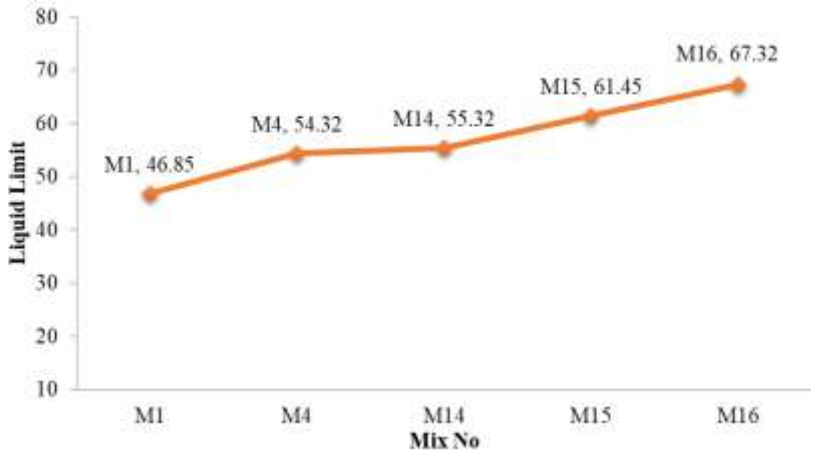

Figure 4.5: Liquid limit of soil using Different percentages of Copper slag with 21% Cement

4.3 Plastic Limit Test Results

Plastic Limit Test was conducted on virgin soil as well as on soil samples mixed with varying percentages of Cement and copper slag. The plastic limit of virgin soil as well as of soil samples mixed with varying percentages of Cement and copper slag is Tabulated in Table 4.2 and shown in Figure 4.6 to 4.10

Table 4.2 Plastic Limit Results

S. No	Mix No	Mix	Plastic Limit (%)
1	M1	Soil	33.53
2	M2	Soil sample + 7 % Cement	34.98
3	M3	Soil sample + 14 % Cement	48.43
4	M4	Soil sample + 21 % Cement	49.51
5	M5	Soil sample + 13 % Copper Slag	37.45
6	M6	Soil sample + 26 % Copper Slag	49.55
7	M7	Soil sample + 39 % Copper Slag	53.45
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	44.56
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	47.63
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	49.65
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	51.32
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	54.32
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	56.43
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	46.54
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	55.65
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	57.32

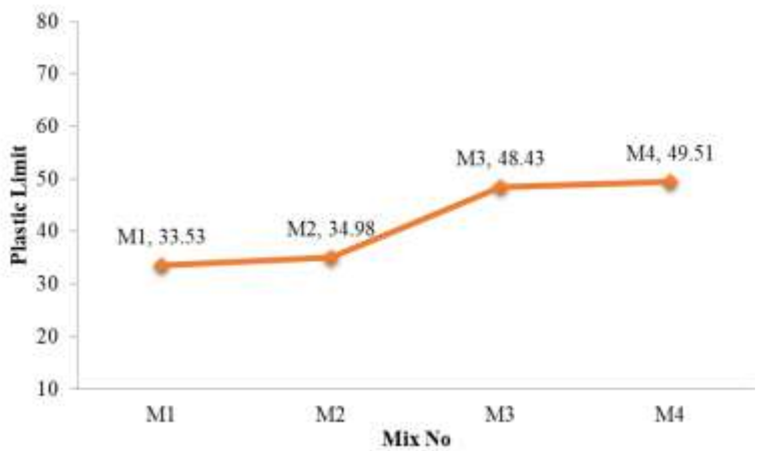

Figure 4.6: Plastic limit of soil with Different percentages of Cement

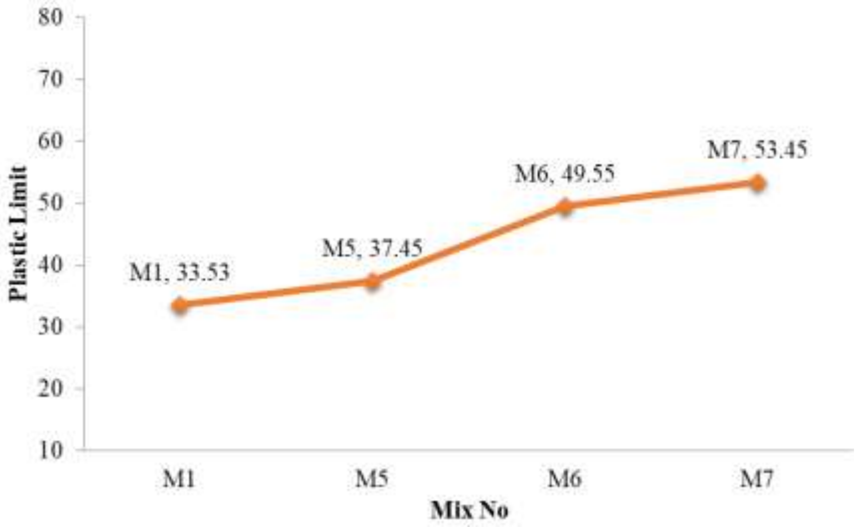

Figure 4.7: Plastic limit of soil with Different percentages of Copper Slag

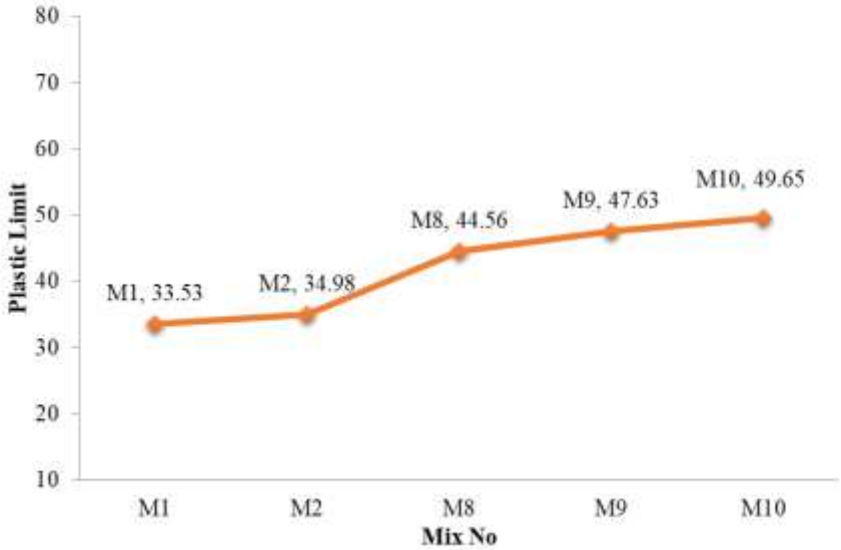

Figure 4.8: Plastic limit of soil using Different percentages of Copper slag with 7% Cement

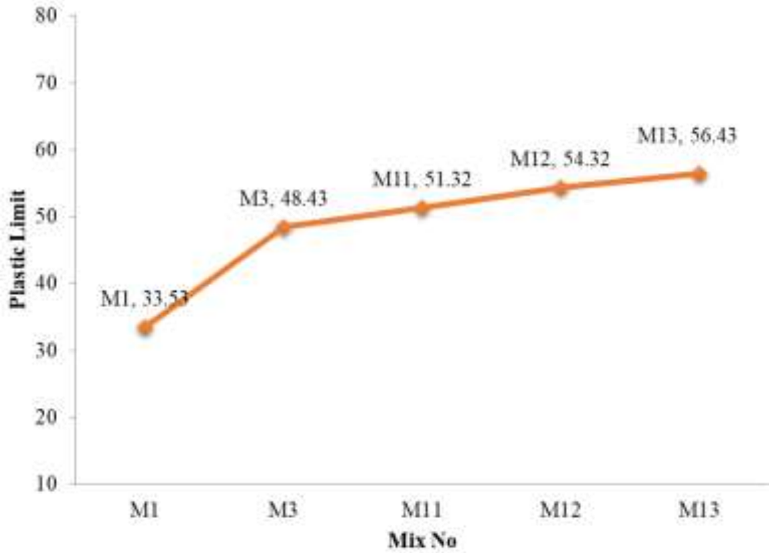

Figure 4.9: Plastic limit of soil using Different percentages of Copper slag with 14% Cement

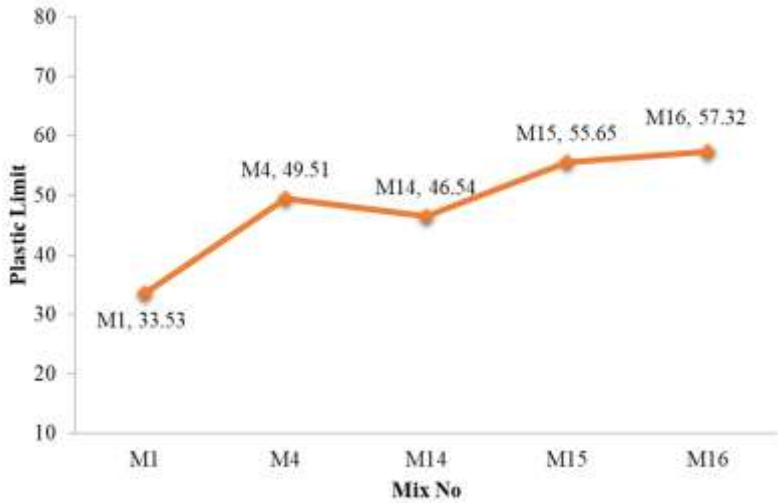

Figure 4.10: Plastic limit of soil using Different percentages of Copper slag with 21% Cement

4.4 Plasticity Index Results

The plasticity Index of virgin soil as well as of soil samples mixed with varying percentages of Cement and copper slag is Tabulated in Table 4.3 and shown in Figure 4.11 to 4.15

Table 4.3 Plasticity Index Results

S. No	Mix No	Mix	Plasticity Index (%)
1	M1	Soil	13.32
2	M2	Soil sample + 7 % Cement	16.27
3	M3	Soil sample + 14 % Cement	12.02
4	M4	Soil sample + 21 % Cement	4.81
5	M5	Soil sample + 13 % Copper Slag	16.1
6	M6	Soil sample + 26 % Copper Slag	11.88
7	M7	Soil sample + 39 % Copper Slag	13.9
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	14.89
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	19.71
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	14.67
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	9.44
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	14.11
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	8.92
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	8.78
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	5.8
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	10

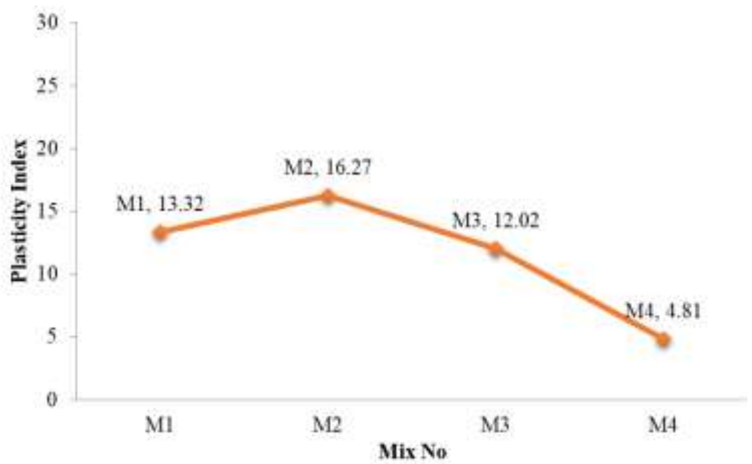

Figure 4.11: Plasticity Index of soil with Different percentages of Cement

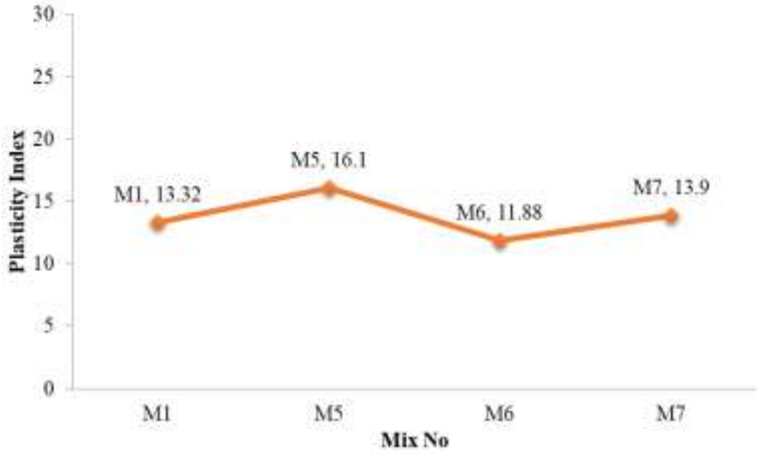

Figure 4.12: Plasticity Index of soil with Different percentages of Copper Slag

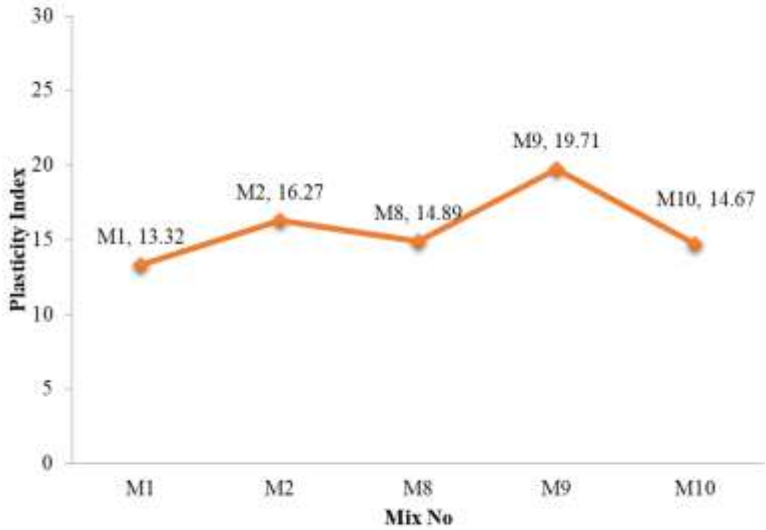

Figure 4.13: Plasticity Index of soil using Different percentages of Copper slag with 7 % Cement

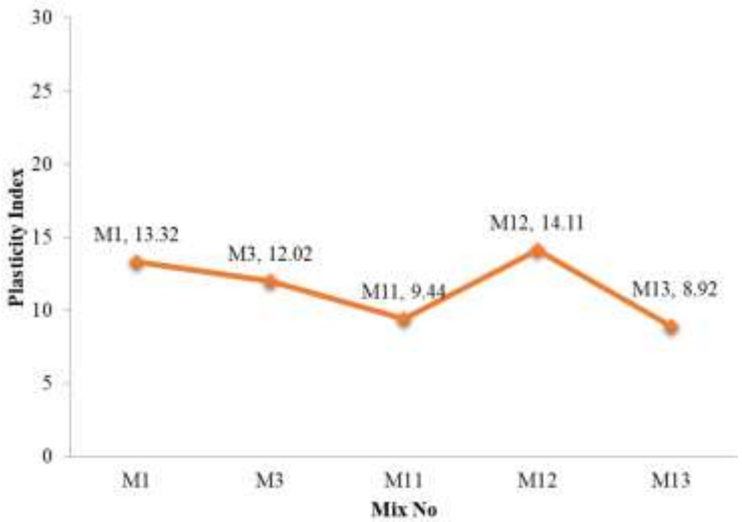

Figure 4.14: Plasticity Index of soil using Different percentages of Copper slag with 14% Cement

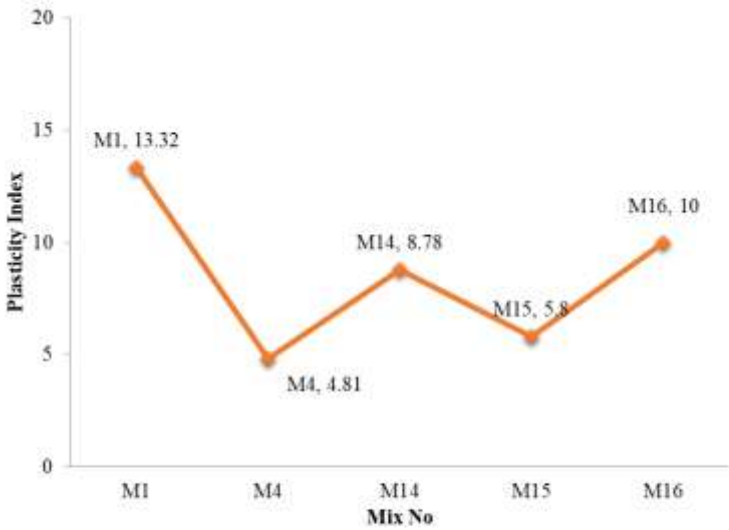

Figure 4.15: Plasticity Index of soil using Different percentages of Copper slag with 21% Cement

4.5 Grain Size Distribution

Results obtained From Grain Size Distribution Test are tabulated below in Table 4.4

Table 4.4 Grain Size Distribution Results

Sieve	Percentage
4.75	96.12
2.36	76.93
1.18	69.34
0.6	57.7
0.425	55.92
0.3	47.18
0.15	42.37
0.075	27.89

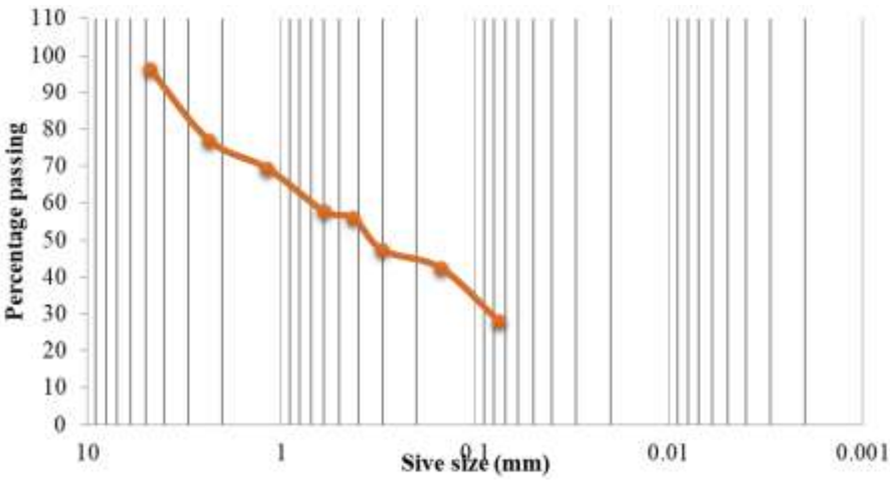

Figure 4.16: Particle Size Distribution Curve

4.6 Specific Gravity Test Results

Specific Gravity Test was conducted on virgin soil as well as on soil samples mixed with varying percentages of Cement and Copper slag. The Specific Gravity Test result of virgin soil as well as of soil samples mixed with varying percentages of Cement and copper slag is Tabulated in Table 4.5 and shown in Figure 4.17 to 4.21.

Table 4.5 Specific Gravity Test Results

S. No	Mix No	Mix	Specific Gravity
1	M1	Soil	2.54
2	M2	Soil sample + 7 % Cement	2.62
3	M3	Soil sample + 14 % Cement	2.65
4	M4	Soil sample + 21 % Cement	2.77
5	M5	Soil sample + 13 % Copper Slag	2.63
6	M6	Soil sample + 26 % Copper Slag	2.67
7	M7	Soil sample + 39 % Copper Slag	2.78
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	2.64
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	2.66
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	2.68
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	2.66
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	2.69
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	2.74
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	2.74
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	2.76
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	2.79

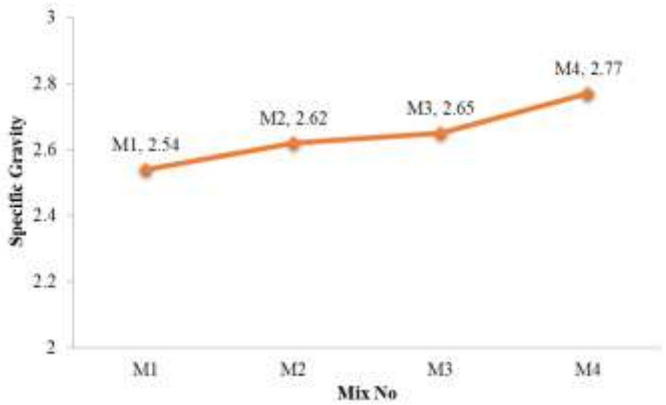

Figure 4.17: Specific Gravity of soil with Different percentages of Cement

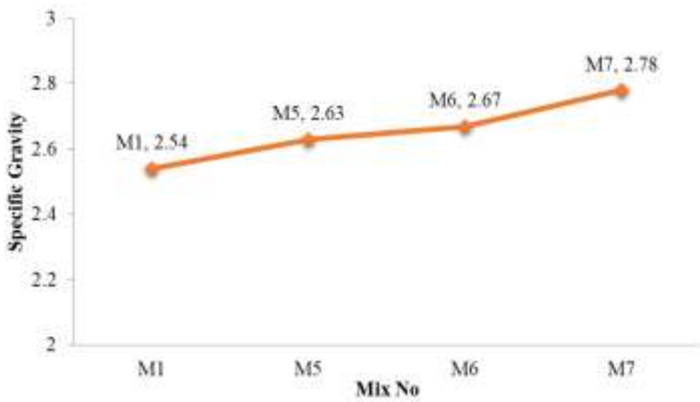

Figure 4.18: Specific Gravity of soil with Different percentages of Copper Slag

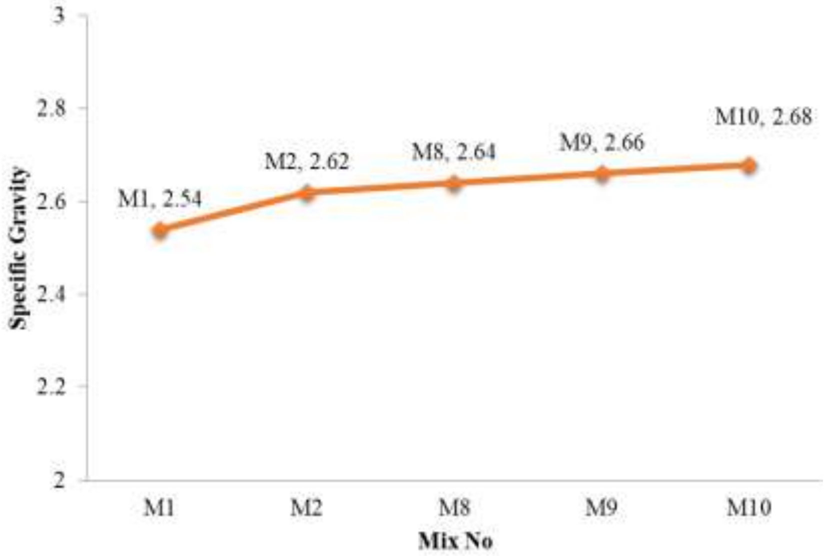

Figure 4.19: Specific Gravity of soil using Different percentages of Copper slag with 7% Cement

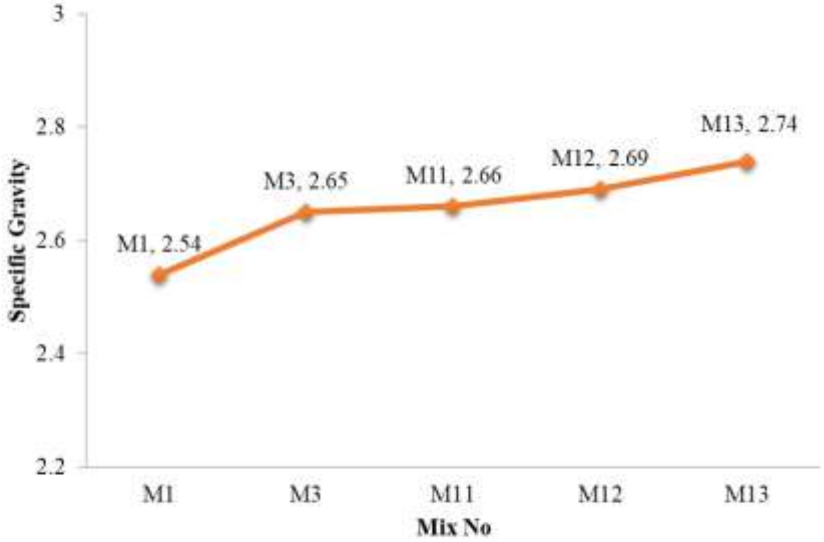

Figure 4.20: Specific Gravity of soil using Different percentages of Copper slag with 14% Cement

Figure 4.21: Specific Gravity of soil using Different percentages of Copper slag with 21% Cement

4.7 Maximum Dry Density and Optimum Moisture Content Test Results

The maximum dry density and optimum moisture content of virgin soil as well as of soil samples mixed with varying percentages of Cement and Copper slag is tabulated in Table 4.6 and shown in Figure 4.22 and Figure 4.31.

Table 4.6 Maximum Dry Density and Optimum Moisture Content

S. No	Mix No	Mix	MDD	OMC
1	M1	Soil	1.86	32.11
2	M2	Soil sample + 7 % Cement	1.92	36.32
3	M3	Soil sample + 14 % Cement	1.89	34.54
4	M4	Soil sample + 21 % Cement	1.85	39.67
5	M5	Soil sample + 13 % Copper Slag	1.75	28.81
6	M6	Soil sample + 26 % Copper Slag	1.78	29.45
7	M7	Soil sample + 39 % Copper Slag	1.80	36.32
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	1.92	36.12
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	1.96	39.95
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	1.65	43.08
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	1.86	34.21
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	1.95	35.42
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	1.51	33.35
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	1.84	30.95
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	1.87	37.54
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	1.55	39.25

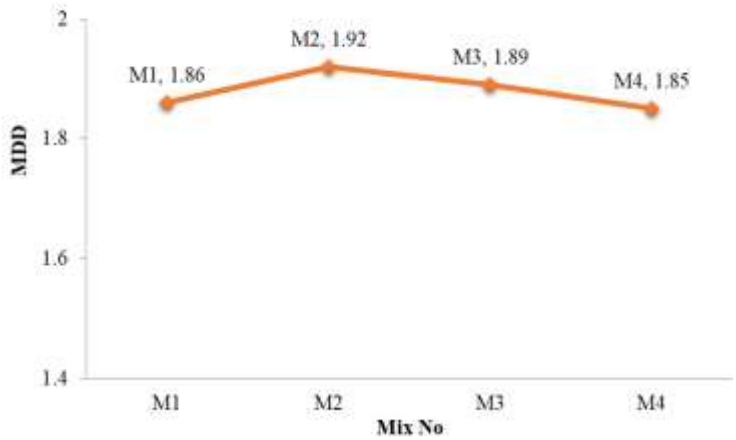

Figure 4.22: MDD of soil with Different percentages of Cement

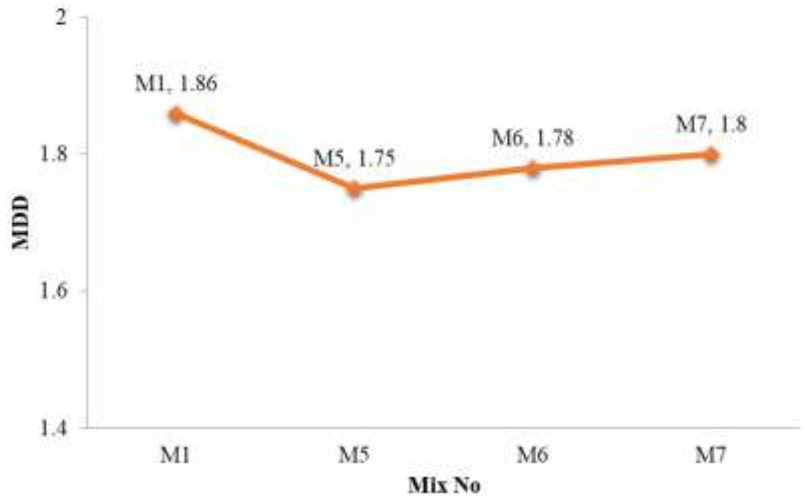

Figure 4.23: MDD of soil with Different percentages of Copper Slag

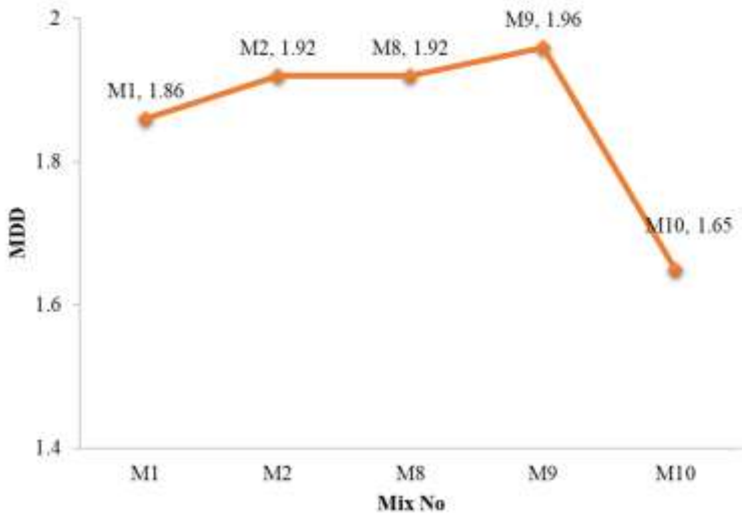

Figure 4.24: MDD of soil using Different percentages of Copper slag with 07% Cement

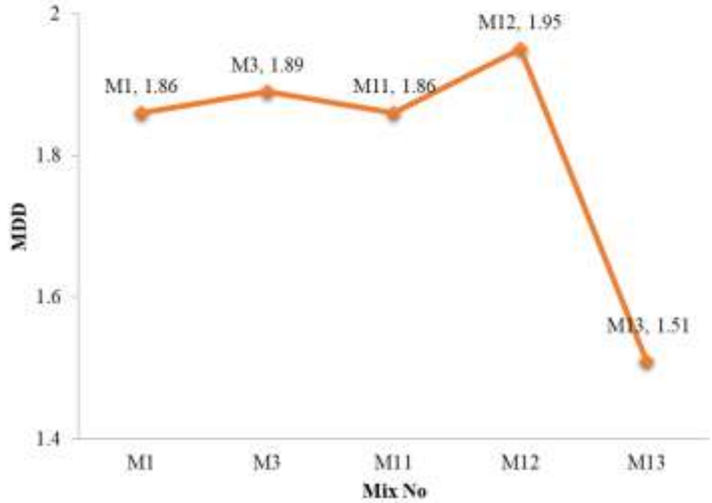

Figure 4.25: MDD of soil using Different percentages of Copper slag with 14% Cement

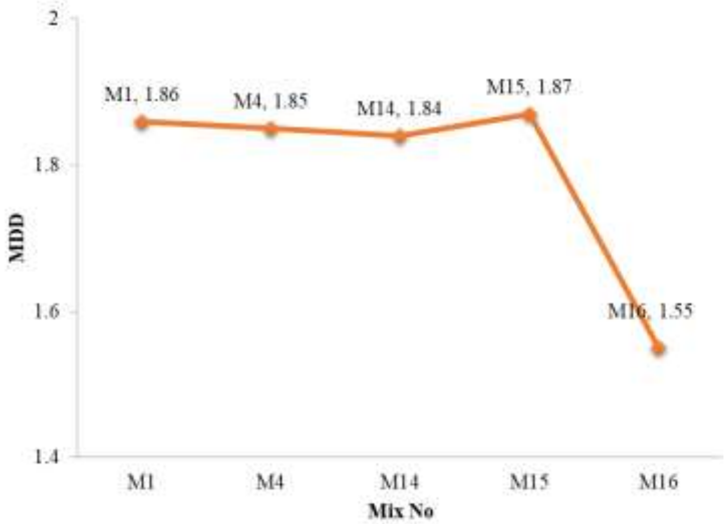

Figure 4.26: MDD of soil using Different percentages of Copper slag with 21% Cement

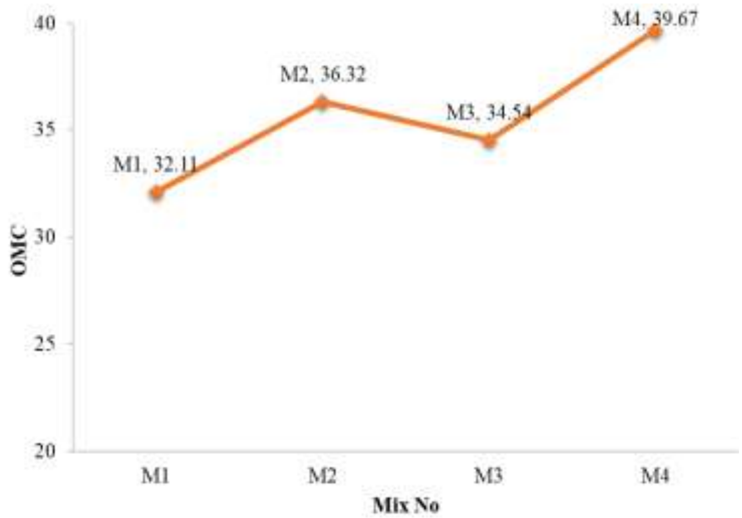

Figure 4.27: OMC of soil with Different percentages of Cement

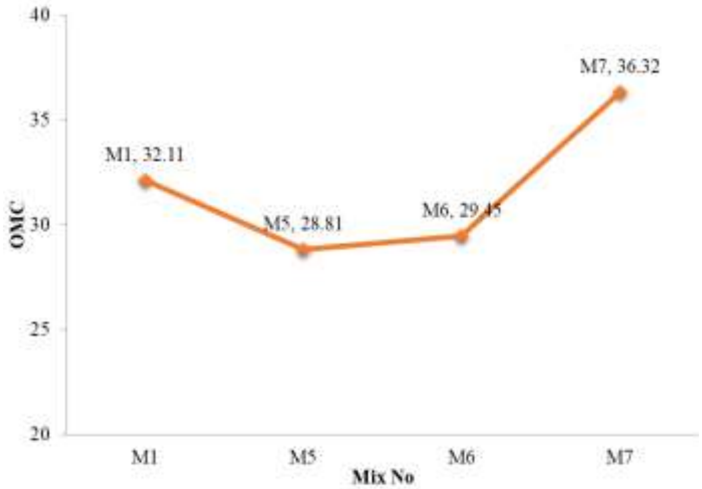

Figure 4.28: OMC of soil with Different percentages of Copper Slag

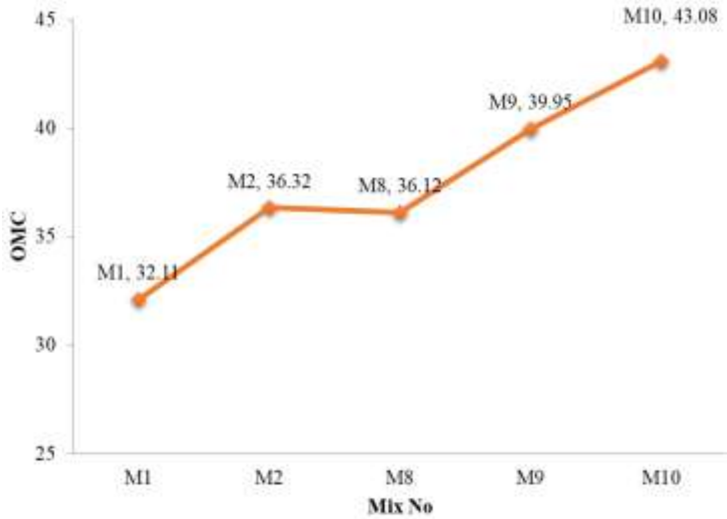

Figure 4.29: OMC of soil using Different percentages of Copper slag with 7% Cement

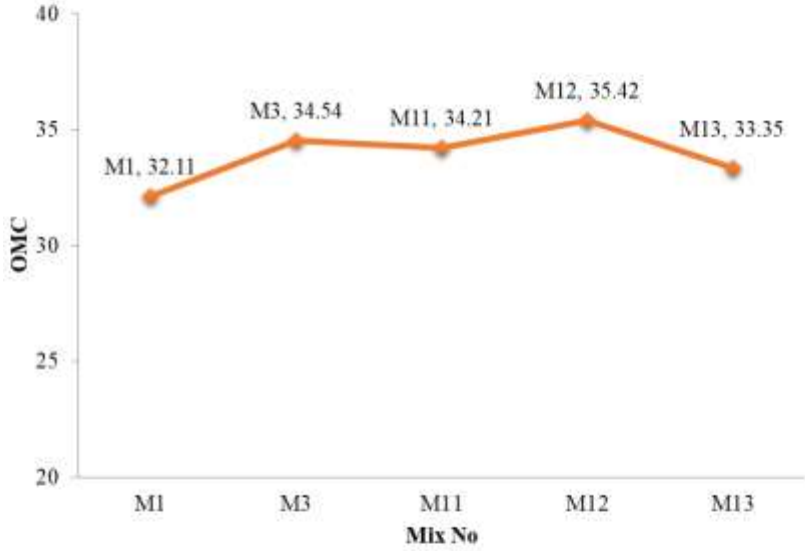

Figure 4.30: OMC of soil using Different percentages of Copper slag with 14% Cement

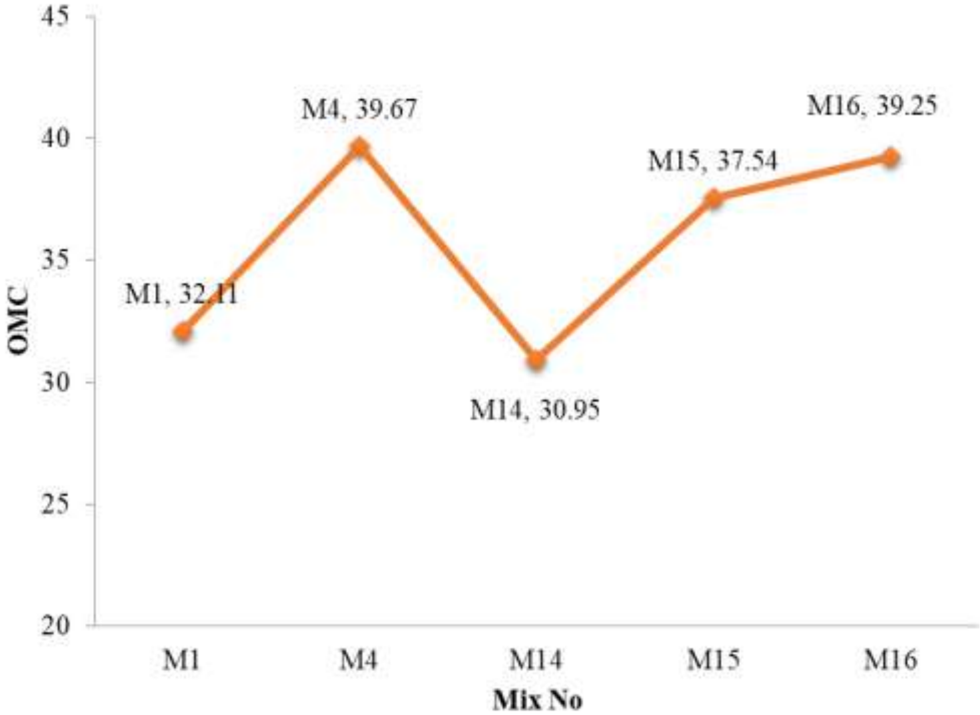

Figure 4.31: OMC of soil using Different percentages of Copper slag with 21% Cement

4.8 Unconfined Compressive Strength Test Results

The Unconfined Compressive Strength Test results of virgin soil as well as of soil samples mixed with varying percentages of Cement and Copper Slag is Tabulated in Table 4.6 and shown in Figure 4.32 to Fig 4.36.

Table 4.7 Unconfined Compressive Strength Test Results

S. No	Mix No	Mix	UCS	
			7 Days	28 Days
1	M1	Soil	142.84	200.98
2	M2	Soil sample + 7 % Cement	158.25	232.43
3	M3	Soil sample + 14 % Cement	169.45	247.34
4	M4	Soil sample + 21 % Cement	182.34	251.43
5	M5	Soil sample + 13 % Copper Slag	161.23	243.95

6	M6	Soil sample + 26 % Copper Slag	179.32	259.16
7	M7	Soil sample + 39 % Copper Slag	192.32	277.56
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	194.31	266.57
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	202.34	291.54
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	196.32	269.73
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	191.23	280.32
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	204.45	290.98
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	200.20	277.65
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	187.22	279.86
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	199.25	288.65
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	204.60	261.11

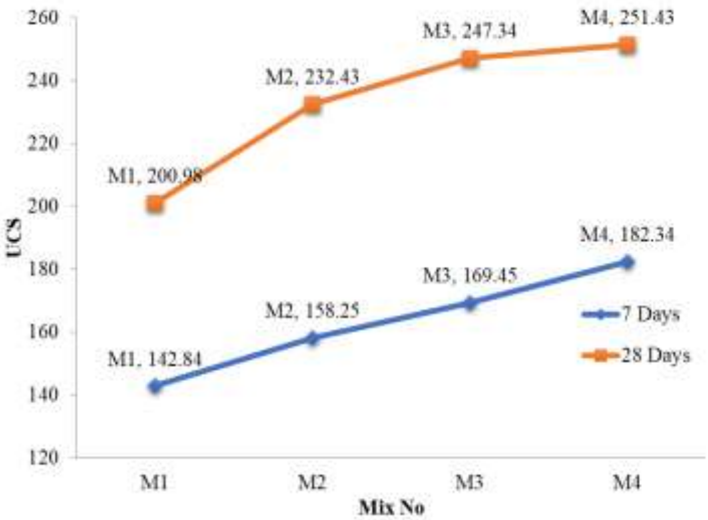

Figure 4.32: UCS of soil with Different percentages of Cement

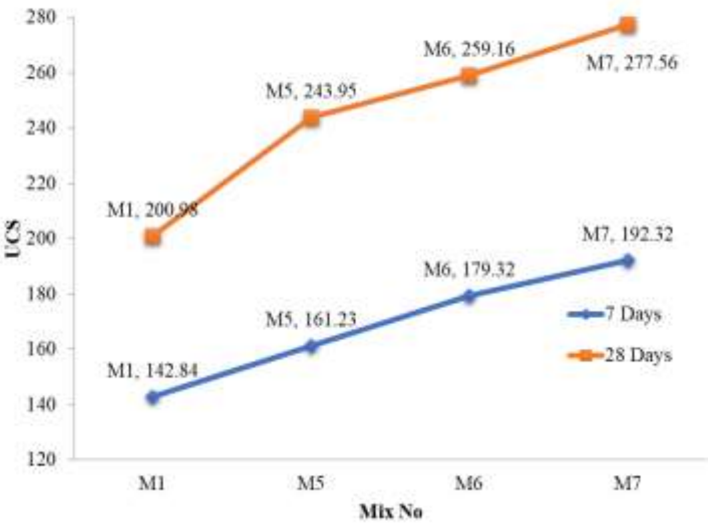

Figure 4.33: UCS of soil with Different percentages of Copper Slag

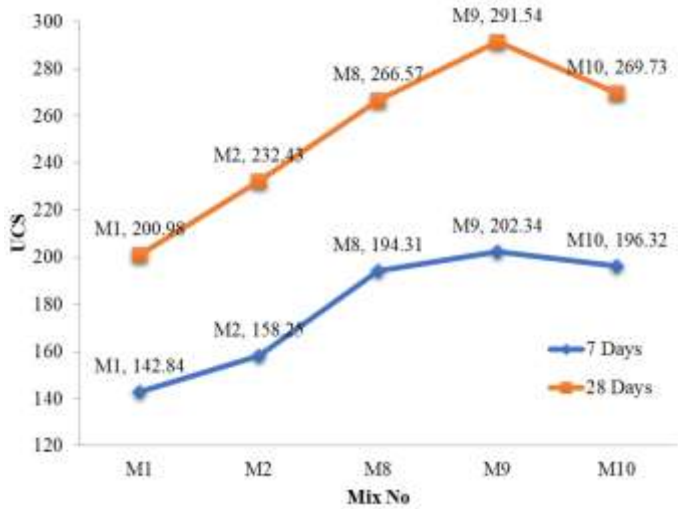

Figure 4.34: UCS of soil using Different percentages of Copper slag with 7% Cement

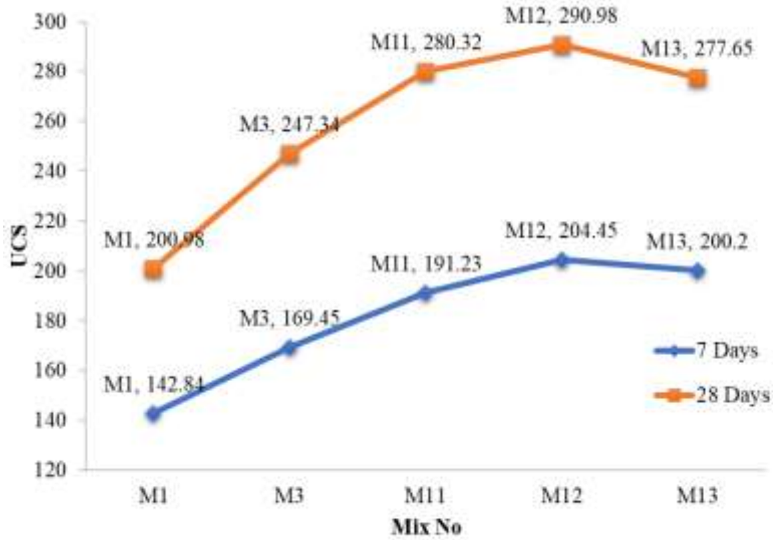

Figure 4.35: UCS of soil using Different percentages of Copper slag with 14% Cement

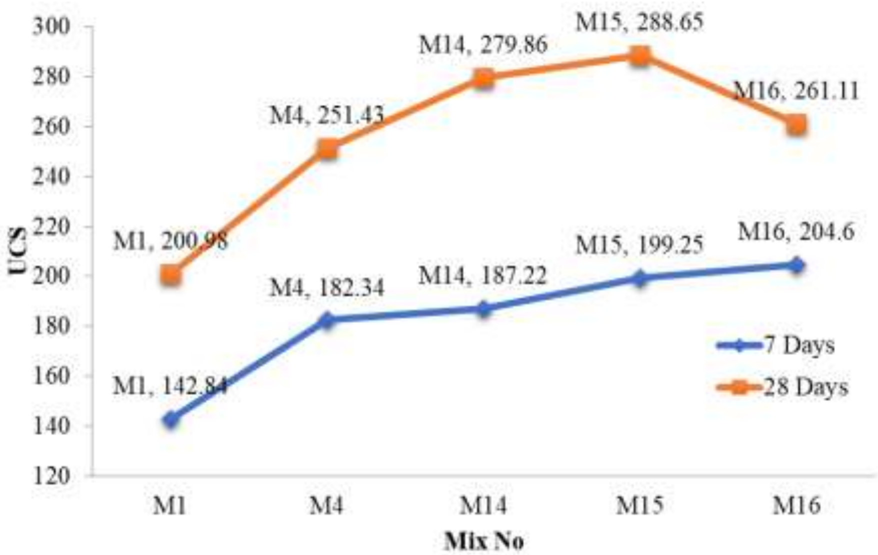

Figure 4.36: UCS of soil using Different percentages of Copper slag with 21% Cement

4.9 California Bearing Ratio Test Results

The California Bearing Ratio Test results of virgin soil as well as of soil samples mixed with varying percentages of Cement and Copper Slag is Tabulated in Table 4.7 and shown in Figure 4.37 to Fig 4.41.

Table 4.8 CBR Test Results

S. No	Mix No	Mix	CBR	
			Unsoaked	Soaked
1	M1	Soil	3.33	7.12
2	M2	Soil sample + 7 % Cement	5.68	10.23
3	M3	Soil sample + 14 % Cement	5.97	10.65
4	M4	Soil sample + 21 % Cement	6.54	15.64
5	M5	Soil sample + 13 % Copper Slag	6.41	15.98
6	M6	Soil sample + 26 % Copper Slag	6.70	16.65
7	M7	Soil sample + 39 % Copper Slag	6.88	17.16
8	M8	Soil sample + 7 % Cement + 13 % Copper Slag	7.33	18.16
9	M9	Soil sample + 7 % Cement + 26 % Copper Slag	7.70	19.92
10	M10	Soil sample + 7 % Cement + 39 % Copper Slag	8.78	13.20
11	M11	Soil sample + 14 % Cement + 13 % Copper Slag	9.35	15.65
12	M12	Soil sample + 14 % Cement + 26 % Copper Slag	11.10	18.77
13	M13	Soil sample + 14 % Cement + 39 % Copper Slag	11.33	23.94
14	M14	Soil sample + 21 % Cement + 13 % Copper Slag	9.95	21.65
15	M15	Soil sample + 21 % Cement + 26 % Copper Slag	10.87	24.35
16	M16	Soil sample + 21 % Cement + 39 % Copper Slag	11.34	24.98

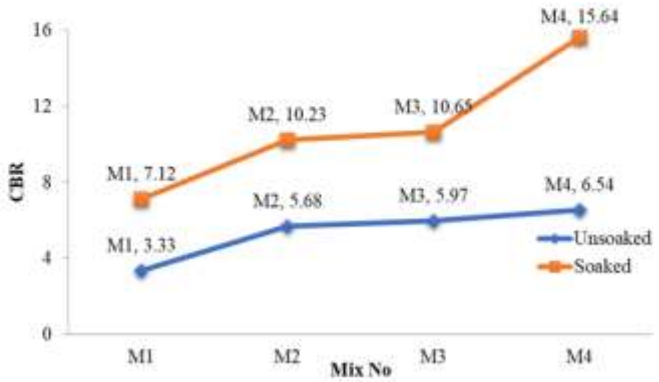

Figure 4.37: CBR of soil with Different percentages of Cement

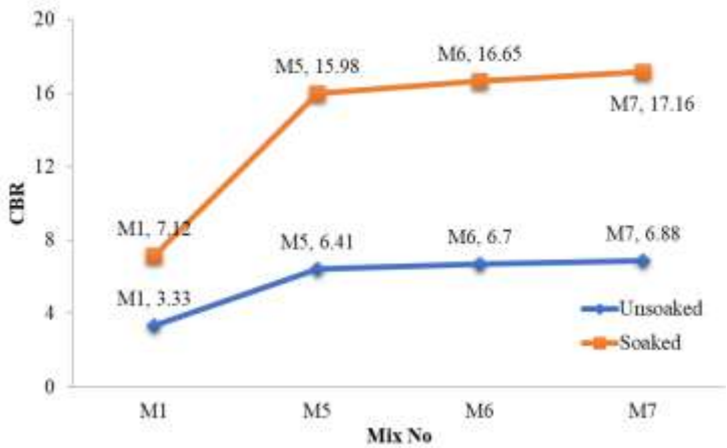

Figure 4.38: CBR of soil with Different percentages of Copper Slag

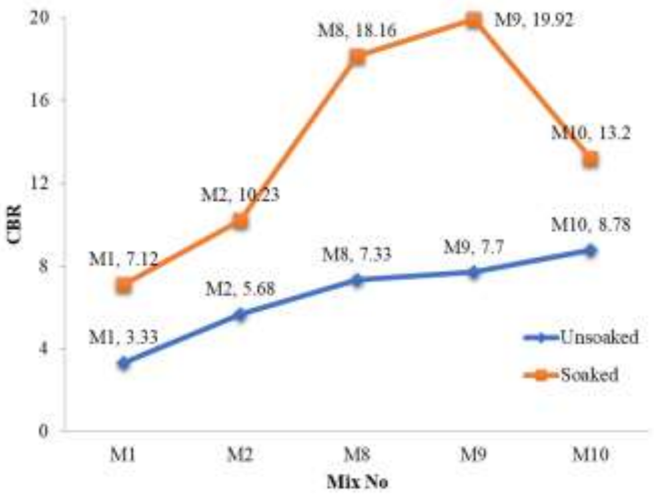

Figure 4.39: CBR of soil using Different percentages of Copper slag with 7% Cement

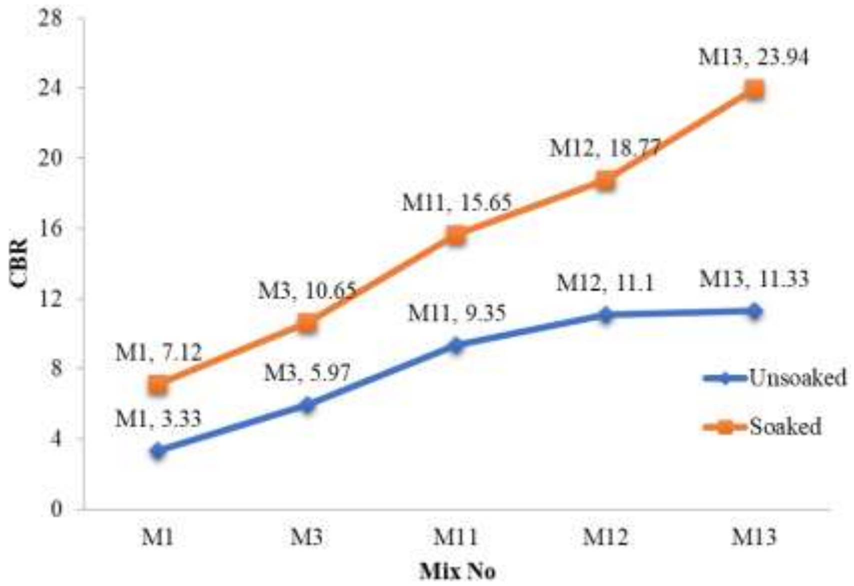

Figure 4.40: CBR of soil using Different percentages of Copper slag with 14% Cement

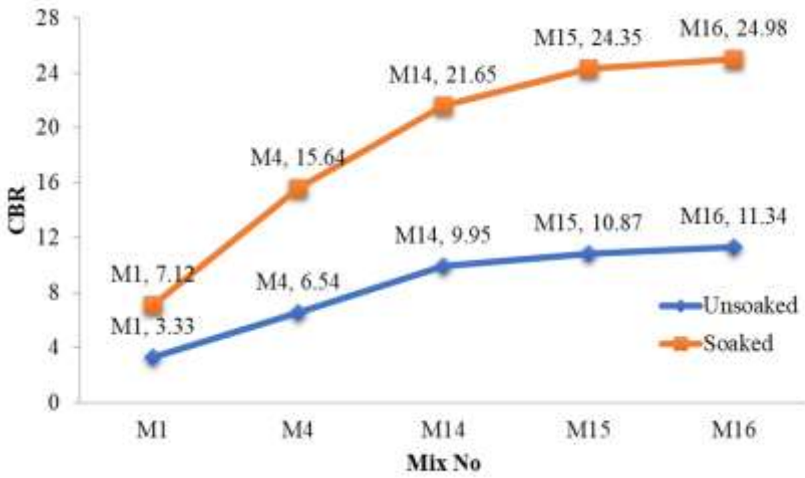

Figure 4.41: CBR of soil using Different percentages of Copper slag with 21% Cement

Conclusion

On the basis of test results following conclusions are drawn;-

1. Dry density of soil increased to a maximum of 1.96 g/cc at 7% Cement and 26% Copper slag.
2. In Mix M-16 maximum CBR value is obtained.
3. In Mix M-16 maximum unconfined compressive strength value is obtained.
4. With the use of Cement and Copper slag Optimum Moisture content of soil Increases.
5. With the use of Cement and Copper slag Liquid Limit of soil Increases.
6. With the use of Cement and Copper slag Plastic Limit of soil Increases.
7. The use of copper slag as stabilizing agents can be economically attractive in regions near to the areas where these waste by-products are obtained.
8. Utilization of copper slag in this manner also has the advantage of reusing industrial waste by-product without adversely affecting the environment or potential land use.
9. Copper slag has the potential to use as admixture to improve the properties of problematic soils.
10. By utilizing and reusing the industrial waste product, namely, copper slag, wastage of good cultivable land can be avoided when large quantities of the accumulated slag is dumped and left on costly land.
11. By using waste in geotechnical field, we have not only protected the environment but also to achieve the sustainable development of country.

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