Effects of Steel Slag on the Strength Properties of Clay, Lateritic and Black Cotton Clay Soil

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Abstract

Excessive use of materials, leads to industrialization, which has an adverse impact on the environment. From industries, large amount of chemicals or other suspended particles as a waste are produced, which are mostly dumped that acquires large space leading to deterioration of soil properties. So, we should use these waste for some constructive or useful purposes. As steel industry releases waste with some good engineering properties so, we can use this type of waste with soil which has low strength and does not have good engineering properties. Various techniques are available like soil stabilization, providing reinforcement etc. to improve load bearing capacity of soil. Soil stabilization is one of the modification techniques used to improve the geotechnical properties of soil and has become the major practice in construction engineering which enables the effective utilization of industrial wastes as a stabilizer. This technique becomes more popular because of its easy availability and adaptability. In this study, the steel slag (an industrial waste) is mixed with Clay(CI), Lateritic(A-7-6(5)) , Black cotton clay soil to enhance its strength properties and make them more suitable for use. In this way industrial waste can be reduced economically.

1. INTRODUCTION

Many items discarded by people, organizations and companies have the potential to be reused for their original purposes or for new ones. Reuse allows people to get the most out of the products they buy and saves them money as well. Additionally, reusing products conserves natural resources and saves valuable landfill space. Use of environment-friendly materials in any industry is of paramount importance. limited waste landfill space, increasing cost of waste disposal in combustion facilities and landfills, depletion of the natural resources, and the need for sustainable development have all amplified the need to reuse the materials that were once regarded as wastes as substitutes for natural resources.

Million tons of waste materials are produced annually in India and their disposal has become a major environmental concern. Addition of these wastes in stabilization technique makes proper utilization of these wastes and solves the problem of disposal. Steel slag is a by-product produced during the conversion of iron ore or scrap iron to steel. In this study, the steel slag (an industrial waste) is mixed with Clay(CI), Lateritic(A-7-6(5)), Black cotton clay soil to enhance its strength properties. For every type of stabilized soil several properties like OMC, MDD, k, swelling potential, Unconfined Compressive Strength, CBR(Soaked & Unsoaked) are determined, Thus, we can determine the optimum % of steel sag for stabilization for different type of soils.

2. MATERIALS USED

2.1 Location

The Clay Soil (CI) of required quantity is taken from village Ahirauli ,Sultanpur district ,Uttar Pradesh. The Lateritic soil of required quantity is taken from Chhindwara district, Madhya Pradesh. The Black Cotton soil is taken from Jabalpur district, Madhya Pradesh. Steel slag is taken from Malvika Steel Ltd. Jagadishpur, sultanpur, U.P.

Table-1 : Properties of Unmodified Soil

Properties Of Soil	Clay Soil (CI)	Lateritic Soil [A-7-6(5)]	Black Cotton Clay Soil
Specific Gravity	2.6	2.5	2.4
Liquid Limit(%)	47.7	41	66
Plastic Limit(%)	25.65	26.5	24.5
Plasticity Index(%)	22.05	14.3	41.5
Optimum Moisture Content(%)	15.8	17.45	20
Maximum Dry Density(kN/m^3)	18.04	18.22	16
CBR Soaked(%)	1.82	49	24
CBR Unsoaked(%)	3.46	51	30
Unconfined Compressive Strength(kN/m^2)	107	102	31
Swelling Potential (%)	0.205	0.21	0.4

Table-2: Properties of Steel Slag

Properties	Value
Specific Gravity	2.74
MDD(kN/m3)	19.77
OMC(%)	7.81
Sand size particles(%)	95
Gravel size particles(%)	1
Fines size particles(%)	4

3. EXPERIMENTAL RESULT

The liquid limit and plastic limit tests were conducted as per IS: 2720 (Part 5) - 1995. Standard compaction test was carried out according to IS: 2720(Part 7)1997.

Table-3 : Influence of Steel Slag on Optimum Moisture Content of Soils

Steel Slag Content(%)	Clay soil	Lateritic Soil	Black Cotton Clay Soil
0	15.8	17.45	20
5	15	16.12	15
8	14.5	14.74	14.8
10	14.2	14.69	14.5
15	13.5		13.5
20	12.9		13
25	12.2		12.5
30	11.4		11
40	10.05		
50	9.6		

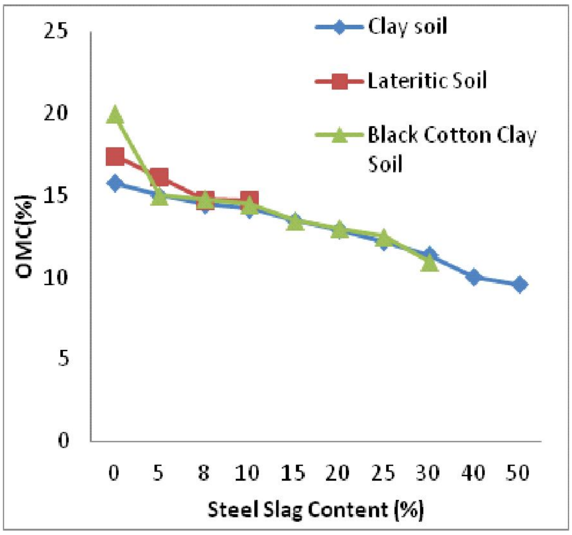

Fig.1: Influence of Steel Slag on Optimum Moisture Content of Soils

Table-4 : Influence of Steel Slag on Maximum Dry Density(kN/m3) of Soils

Steel Slag Content(%)	Clay soil	Lateritic Soil	Black Cotton Clay Soil
0	18.04	18.22	16
5	18.21	18.26	18
8	18.31	18.31	17.8
10	18.38	18.36	17.5
15	18.6		20
20	18.68		20.1
25	18.9		21.6
30	19.1		23
40	19.7		
50	19.75		

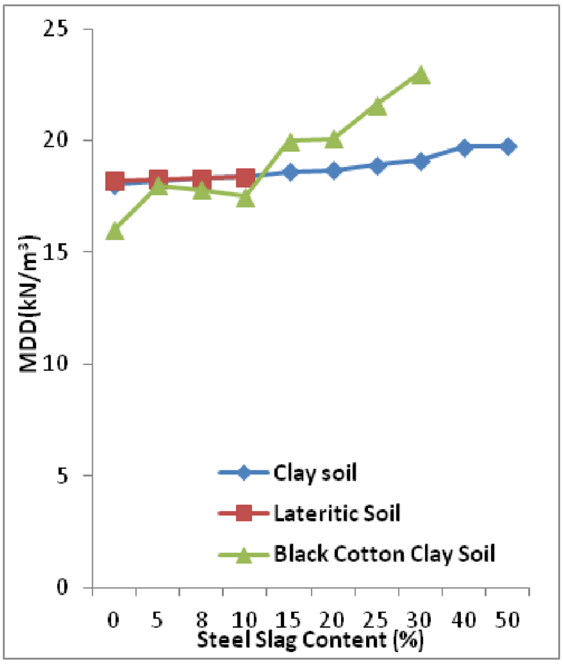

Fig.2: Influence of Steel Slag on Maximum Dry

The California Bearing Ratio (CBR) tests were conducted at OMC and MDD as per IS: 2720 (Part 16) – 1997.

Table -5 : Influence of Steel Slag on Soaked CBR(%) of Soils

Sted Slag Content(%)	Clay soil	Lateritic Soil	Black Cotton Clay Soil
0	1.82	49	24
5	2.37	25	5
8	2.69	28	4.5
10	2.91	30	4
15	3.5		3
20	4.02		2
25	4.4		1.5
30	4.83		1
40	5.1		
50	5.2		

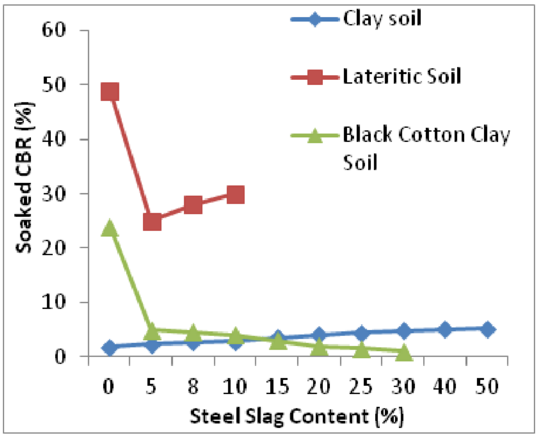

Fig.3: Influence of Steel Slag on Soaked CBR(%) of Soils

Table-6: Influence of Steel Slag on Unsoaked CBR(%) of Soils

Sted Slag Content(%)	Clay soil	Lateritic Soil	Black Cotton Clay Soil
0	3.46	51	30
5	4	60	40
8	4.31	91	40.5
10	4.52	79	41
15	5.1		56
20	5.78		58
25	6.25		60
30	6.74		61
40	7.55		
50	7.7		

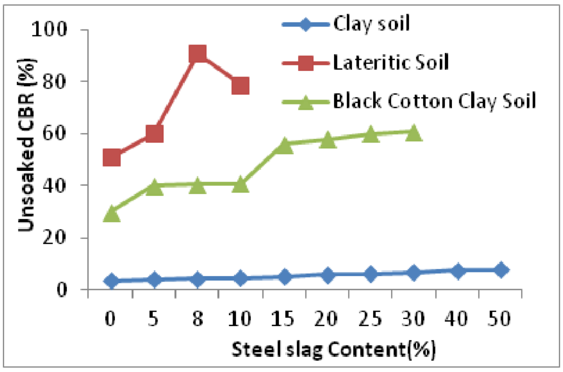

Fig.4: Influence of Steel Slag on Unsoaked CBR(%) of Soils

Table-7: Influence of Steel Slag on Unconfined Compressive Strength(kN/m²) of Soils

Sted Slag Content(%)	Clay soil	Lateritic Soil	Black Cotton Clay Soil
0	107	102	31
5	118	113	49
8	175	165	45
10	138	140	42
15			38
20			32
25			31
30			30

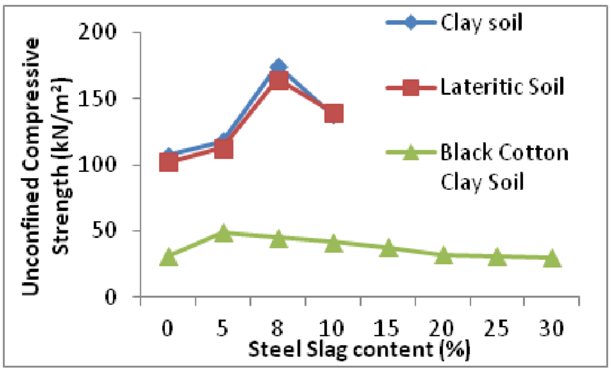

Fig-5: Influence of Steel Slag on Unconfined Compressive Strength(kN/m2) of Soils

Table-8: Influence of Steel Slag on Swelling Potential(%) of Soils

Steel Slag Content(%)	Clay soil	Lateritic Soil	Black Cotton Clay Soil
0	0.205	0.21	0.4
5	0.175	0.17	0.35
8	0.16	0.15	0.33
10	0.15	0.13	0.3
15			0.25
20			0.2
25			0.19
30			0.18

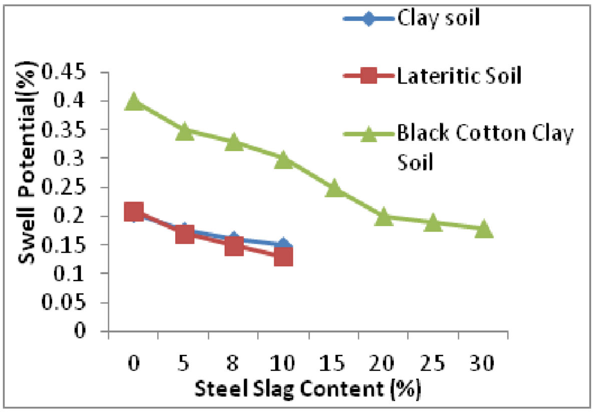

Fig.6: Influence of Steel Slag on Swelling Potential(%) of Soils

Table-9: Influence of Steel Slag on Permeability k(cm/s) of Soils

Steel Slag Content(%)	Clay soil	Lateritic Soil
0	0.00017	0.000165
5	0.00018	0.000175
8	0.000215	0.00023
10	0.00025	0.00027

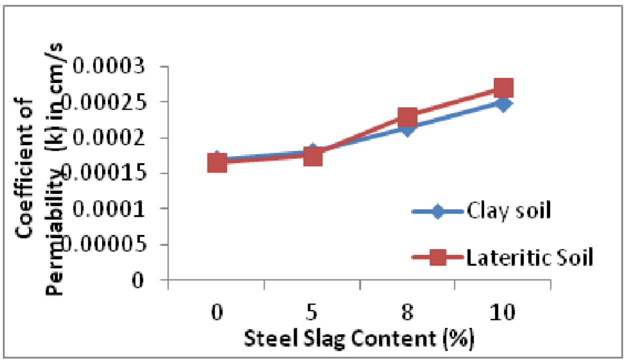

Fig-7: Influence of Steel Slag on Permeability k(cm/s) of Soils

4. CONCLUSION

Maximum dry density of the modified soil is increased by 9.20% for (40%) Steel slag. Optimum moisture content of the modified soil is reduced by 39.24% for Steel Slag. CBR (Soaked) for the modified Soil is increased by 180% for (40%) Steel slag. CBR (Unsoaked) for the modified Soil is increased by 122% for (40%) Steel Slag. So 40% steel slag is optimum value for stabilization of CI soil.

Test results generally indicate that the addition of ground Steel Slag reduced the plasticity of lateritic soil and thereby improved its workability and reduced its moisture-holding capacity and swell potential. The maximum dry unit weight of the soil increased with increasing steel slag contents while optimum moisture content decreased as the amount of steel slag in the mixture increased from 0 to 8 %. The uncured strength of the soil increased with increasing steel slag content until after 8 % steel slag. Consequently, the optimum steel slag content was determined to be 8 %, based on strength criterion. The permeability of the soil was generally increased with increasing steel slag contents. Therefore, 8 % optimal stabilization of the A-7-6 soil with effectively reduced the plasticity of the natural soil to meet the requirement for use as either subgrade, sub base and base course materials but reduced the soaked CBR value of the natural soil (which satisfied the sub-base requirement) to meet requirement for use as only subgrade material.

Steel Mill Scale (SMS) increased the MDD of black cotton soils by about 19%. The increase is within the range of 1720 to 1920kg/m3 which is considered satisfactory to excellent. Steel Mill Scale reduced the OMC of black cotton soils by about 28%. The strength characteristics of the soil-

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steel mill scale mixtures improved as the swelling potential was reduced by about 60%. Steel mill scale also increased the Un-soaked CBR of black cotton soils by about 16%. The increase in strength shows a potential for future usage. The addition of steel mill scale reduced the Soaked CBR of black cotton soils by about 75%. Steel Mill Scale increased the unconfined compressive strength of black cotton soils by about 53% at 5% Steel Mill Scale content.

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