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Effect of Crusher Dust on Geotechnical Properties and Strength Parameters of Highly Plastic Clay

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Abstract
A flexible pavement is consisted of four layers such as surface course, base course, sub-base course, and most importantly sub-grade layer. In rigid pavement the bottom layer that is sub-grade is common. Sub-grade acts as a foundation to the pavement. The sub-grade soil can be clay, sand, morrum etc. If the sub-grade soil is soft or weak there is a great chance of deformation in the pavement and also weak sub-grade soil require larger depth for laying pavement on it. It is not cost effective to replace all the sub-grade soil at the time of construction. Nowadays soil stabilization with admixture is followed everywhere as it is cheaper as compared to other ground improvement techniques. Here stabilization using a non-cementitious admixture is on the focus. In this study crusher dust is used as a stabilizer for clayey soil. Using crusher dust as a stabilizer serves two purposes that is soil stabilization and waste minimization from the quarry industry. In this study certain percentages of crusher dust were added to the soil sample such as 5 %, 10 %, 15 %, 20 % to evaluate the amount of crusher dust that can give the best possible solution to the weak soil. Different kinds of test are performed on the soil and crusher dust mixture to assess the stability and permanency of strength of the sub-grade soil. Reducing the swelling and plasticity of the clay soil is one of the prime targets of this research. The performed tests are Atterberg limits, CBR test, triaxial test, Standard compaction test and Swelling index test. The results in the end support the statement that crusher dust can be good stabilizer for clay soil.
Keywords: *CBR, Crusher Dust, Plastic Clay,), Maximum Dry Density (MDD), Optimum Moisture Content (OMC), Plastic Index, Swelling Index, Triaxial Test etc.*

I. INTRODUCTION

in the era of rapid urban and industrial development we are witnessing the increasing demand for the construction of good road ways and many other civil engineering structures. In order to make the road construction cost effective we have to use the challenging soil, water logged lands for the construction activities. Challenging soils such as soft clays/highly plastic clays, black cotton soils, waterlogged lands need to be treated or replaced with respect to the economic design of the pavement. In stabilization of these kinds of soils, generally bearing capacity, shear strength, settlement behavior is analyzed and optimized in the laboratory.

A clay soil is termed as highly plastic clay when it allows great amount of continuous deformation. It has the tendency of exhibiting large amount of strain with increase of small quantity of load. Soft clay has the property to contract and expand with change in water content. Due to this alternate change in volume of the soil mass, it has an adverse effect on the overlying structures. During monsoon season due to large no of voids present in the clay soil, it holds large quantity of moisture and swells. Subsequently the soil becomes soft and impermeable. Where as in the dry season or summer season the soil loses its moisture in the process of evaporation and becomes hard. After hardening of the soil, cracks are visible which is unfavorable for laying a pavement on it. The soil which contains montmorillonite and Illite in its configuration shows such kind of behavior.

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Generally all types of clay have more or less shrink-swell property. But this property magnifies itself in areas where extreme climatic condition seen i.e. the area which is exposed to heavy rainfall in rainy season as well as intensive heat during the summer season. In that area highly plastic clay is regarded as potentially natural hazard. Generally this type of soil is composed of Illite mineral and montmorillonite mineral. If these kinds of soil remains untreated it can cause much damage to any civil engineering structures as well as to human being. U Arun Kumar andKiran B. Biradar (2014)[5] observed that on addition of quarry dust to the soil clay content of the soil get reduced, also percentage of coarser particle increases. Again, they identified that addition of (40%) Quarry dust results high CBR value compare to virgin Soil. R Rakhil Krishna and Devi Krishnan (2016)[4] reviewed the results of the experimental programmes which is already carried out by stabilizing the problematic soil like expansive soil using ceramic dust made from locally available waste ceramic tiles also found that economic feasibility of utilizing the ceramic dust for improves the properties of expansive soil used for construction. GuruprasadJadhav et al. (2016)[3] studied the unconfined compressive strength of stabilized clayey soil at different densities at particular water content, for different curing period and various percentage of copper slag and cement content found that copper slag and cement is effective in stabilizing the soil, where he found a significant improvement in unconfined compressive strength. AmulyaGudla et al (2017)[2] reported that the potential use of crusher dust as stabilizing additive to clayey soil, which involves the determination of the Atterberg limits, California bearing ratio (CBR) test, Standard Proctor Test on clayey soil in its natural state, also when mixed with varying proportion of crusher dust found a significant effect on original soil property. PiyushKolhe&RushikeshLangote (2018)[1] conducted the various test on black cotton soil using different percentage of crumb rubber shread which results found that CBR value increases with increase in the percentage of rubber tyreshread and also its effect on shear strength parameters was also checked by performing various laboratory tests.

The above study insisted me to check the feasibility of Crusher dust which is easily available locally for treatment of such soils in Bhabanipatna, Kalahandi district because, if these kinds of soil remains untreated it can cause much damage to any civil engineering structures as well as to human being.

II. MATERIAL AND METHODOLOGY

A. Material Used

In order to conduct an experiment the soil sample was collected from the site Bhawanipatna, Kalahandi, Odisha. Firstly the soil was oven dried at temperature between 100 °C to 105 °C and then sieved through 4.75 mm sieve in order to perform index and engineering properties of the soil sample. Due to the extreme weather condition over Kalahandi district, the clay soil expected to show significant swelling and shrinkage property.Crusher dust was choosen as a stabilizing agent as it is a non plastic material which will reduce the plasticity of clay soil when it will be replaced with it in certain percentage. It is basically the coarse grained waste produced by the quarring activity. For investigating the effect of crusher dust on soil, the crusher dust of 1mm size was collected from Narayanpur quarry of Ganjam district, Odisha. Required amount of crusher dust was oven dried at temperature between 100℃ to 105℃ after coming to the laboratory to remove any moisture content before it was mixed with the soil. The physical properties of virgin sample obtained noted in Table-I.

Table-I: Physical properties of clayey soil and Crusher dust

Physical Parameter	Clayey Soil	Crusher Dust
Colour	Light grey	Grey
Shape	Rounded/ sub rounded	Rounded/ sub rounded

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Uniformity coefficient (C_u)	70	15.8
Coefficient of curvature (C_c)	0.21	2.89
Specific gravity (G)	2.73	2.71
Optimum moisture content (OMC)	20.50%	10%
Maximum Dry Density (MDD)	1.7 g/cc	2.00 g/cc
Free Swell Index (FSI)	50%	0
Liquid Limit (%)	51.45%	NA
Plastic Limit (%)	21.70%	NA
Shrinkage Limit (%)	2.92%	NA
Plasticity index	29.75	Non Plastic

B. Test Programme and Methodology

The soil sample and the crusher dust samples were thoroughly mixed separately in order to achieve homogeneity and they were oven dried at temperature between 100℃ to 105℃ the index properties like specific gravity, liquid limit, plastic limit, shrinkage limit, swelling index of the samples were determined according to Indian Standard Code IS 2720 part (3), IS 2720 part (5), IS 2720 part (6), IS 2720 part (40) respectively.

After evaluating properties of individual samples the swelling, plasticity index, OMC, MDD, CBR and Triaxial test was perform with different percentage of crusher dust using standard procedure as per IS codes i.e. IS 2720 part (5), IS 2720 part (40), IS: 2720 (part 7)-1980, IS 2720 part (16) and IS 2720 part (11)respectively.

III. RESULT AND DISCUSSION

The index properties like specific gravity, liquid limit, plastic limit, swelling index of the samples were determined according to Indian Standard Code IS 2720 part (3), IS 2720 part (5), IS. 2720 part (40) respectively. The tests we found that with addition of crusher dust the plasticity and swelling index continuously decreasing with increase in percentage of crusher dust as shown in Fig.1. Test result obtained also show below in Table- II. This is a good sign with respect to pavement construction. Less is the swelling index lesser will be the swelling characteristics.

Table-II:Observation of Swelling Index and Plasticity Index

Combination	Liquid Limit	Plastic Limit	Plasticity Index	Swelling Index
Clay soil	51.45%	21.70%	29.75	50%
Clay soil + 5 % crusher dust	47.61%	20.16%	27.45	47%
Clay soil+ 10 % crusher dust	44.10%	18.43	25.68	44%

Clay soil+ 15 % crusher dust	41.25%	17.66%	23.59	42%
Clay soil+ 20 % crusher dust	38.27%	16.46	21.81	38%

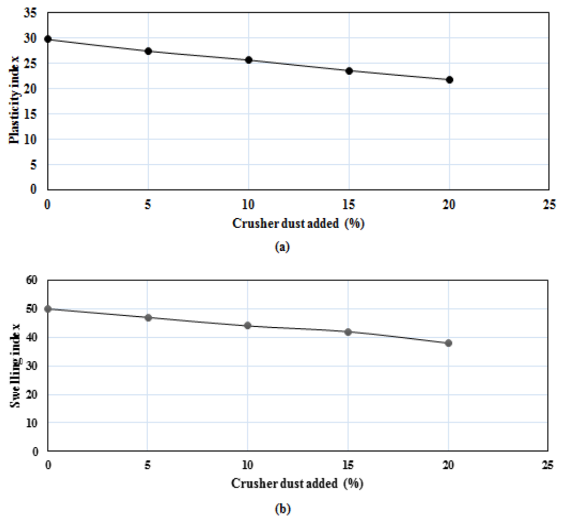

Fig. 1 (a) Plasticity Index with increase in Percentage of Crusher dust (b) Swelling Index with increase in Percentage of Crusher dust

Fig. 2 shows with increasing percentage of Crusher dust the MDD increases but after certain limit it decreases and vice versa happens for OMC of soil samples. When the crusher dust was replaced the clay soil it reduced its water absorbing capacity of entire mixture. So up to a certain percentage it enhances the strength of soil but after too much replacement of soil, the overall density decreased. That is why after 20 % addition of crusher dust the dry weight decreased and the OMC increased.

Table –III: OMC, MDD, CBR, ϕ & c for all sample combinations

Sample combination	Standard Procter test		CBR Value		Triaxial Test	
	OMC (%)	MDD (g/cc)	Unsoaked	Soaked	ϕ	c
Clay soil	20.5	1.7	3.18	0.87	3.99	0.54
Crusher dust	10	2	22.35	9.86	25	0
Clay soil + 5 % crusher dust	16.98	1.79	6.36	1.13	12.99	0.4
Clay soil+ 10 % crusher dust	16.2	1.82	7.42	1.87	16.34	0.36
Clay soil+ 15 % crusher dust	15.32	1.84	8.05	2.49	17.96	0.22
Clay soil+ 20 % crusher dust	15.75	1.82	7.52	2.17	18.08	0.2

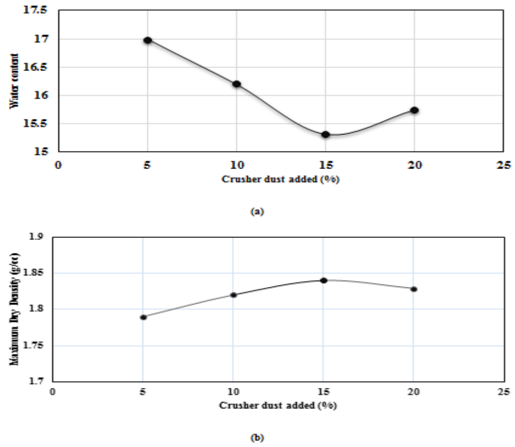

Fig. 2 (a) Optimum Moisture Content (OMC) with increase in Percentage of Crusher dust (b) Maximum Dry Density (MDD) with increase in Percentage of Crusher dust

The CBR value of the soil sample also followed the similar pattern like OMC and MDD. The CBR value increased to a particular value of crusher dust added and then decreased as the dry density decreased so the bearing capacity also decreased. This phenomenon was obtained for both unsoaked and soaked sample as show in Fig. 3.

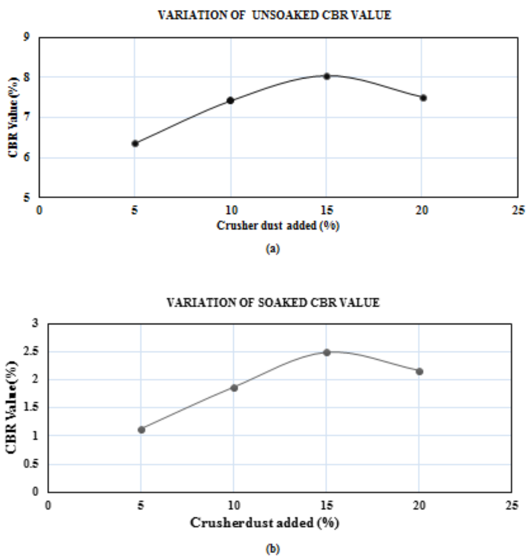

Fig. 3(a) CBR Value for Unsoaked with increase in Percentage of Crusher dust (b) CBR Value for Soaked with increase in Percentage of Crusher dust

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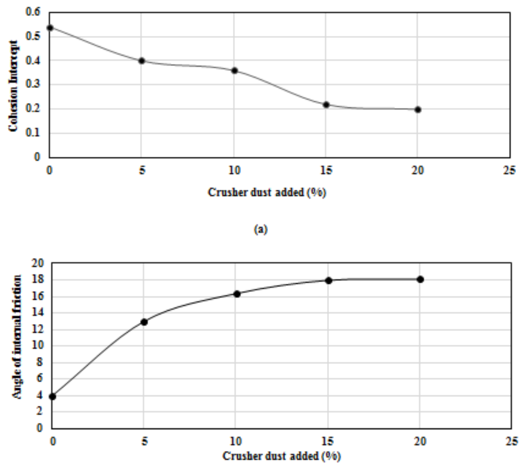
As expected, due to cohesion less property of crusher dust sample, a significant effect observed on the shear parameters of soil i.e. cohesion intercept and angle of internal friction. With increasing the percentage of crusher dust in soil it was continuously decreasing the cohesion intercept and continuously increasing the angle of internal friction asin Fig. 4



(a)

(b)

Fig. 4(a) Cohesion Intercept (c) with increase in Percentage of Crusher dust (b) Angle of internal friction (ϕ) with increase in Percentage of Crusher dust

IV. CONCLUSIONS

Based on the results, it has been found that as the percentage of crusher dust increases, plasticity index and swelling index decreases from 29.74 to 21.81 and 50 to 38 respectively since crusher dust added decreases the plasticity property of the soil as well as moisture content of soil decreases also observed in OMC study. The dry density of the soil sample started increasing with increase in percentage of crusher dust from the beginning and after 15 % crusher dust added it starts decreasing may be due to absorption of moisture of clayey soil by fine crusher dust. The optimum compaction result was at 15 % crusher dust mixed with soil. The maximum dry density increased from 1.7 g/cc to 1.82 g/cc which was 7 % greater than virgin soil. On contrary the optimum water content started decreasing from the beginning and increased after addition of 15 % crusher dust. So the OMC decreased from 20.5 % to 15.75% which was 23% lesser than virgin soil.As the dry density of sample containing 15 % was found to be maximum, the unsoaked CBR value also followed the similar trend that is at 15% crusher it gave maximum value i.e. 8.04 %. The unsoaked CBR value increased by 53% i.e. from 3.18 % to 8.05 %. Like the unsoaked CBR the soaked CBR also gave the maximum result at 15 % crusher dust. The soaked CBR value increased from 0.87 % to 2.49 %. The soaked CBR value increased by 86 %.From the study of triaxial test result it can be concluded that with increase of percentage of crusher dust the cohesion intercept (c) decreased continuously and the angle of internal friction (ϕ) increased with increase in percentage of crusher dust.

Hence crusher dust can be used as a good additive for decreasing the swelling as well as the plasticity property of clayey soil for highly plastic clay whenever required.

REFERENCES

[1] PiyushKolhe&RushikeshLangote “Black Cotton soil Stabilized With Rubber TyreShread” in Journal of Geotechnical Studies 2018, Volume 2 Issue.
[2] AmulyaGudla, BharathiNukaraju, BalivadaSaiLaxman“Addition of Crusher Dust in Clayey Soil as Subgrade material” , in IJRSI Volume IV, Issue V, May 2017 | ISSN 2321–2705
[3] Prof. GuruprasadJadhav, Mr.Gavhane Dinesh & Mr. BehereBabaso “Experimental Study on Stabilization of Expansive Soil Using Admixtures” in IJSTM Volume V, Issue 12, December 2016
[4] Rakhil Krishna R & Devi Krishnan “Effect of Waste Ceramic Dust on the Geotechnical Properties Expansive Soils in IRJET Volume III, Issue 12, December 2016
[5] Arun Kumar U, Kiran B Biradar, “Stabilization with Quarry Dust-An Industrial Waste,” in IJRET, (2014), ISSN:2319-1163, Issue 8, Vol.3, PP 409-412.

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