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Gondegaon Coal Mine Overburden Dump Stabilization by Using Industrial by-Product

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ABSTRACT: Open cast mining is done dominantly all over the world. During these mining operations huge amount of overburden (OB) is generated. The higgledy-piggledy management of this Overburden can result in substantial issues which may adversely affect safety and production of the mine. Failure of this overburden dumps consequences in loss of life, production and impact on the neighboring amenities. This research aims to utilize the overburden dump in the construction industry by adding optimal dose of industrial by-product. Hence study is done on this aspect at Gondegaon opencast Mines under the administrative control of Western Coalfields Ltd. This study investigates the critical parameters of OB dump and Industrial by-product with different doses for examining the suitability in construction activities for sustainable development.

Keywords: Overburden Dump, Industrial by product, sustainable development.

Introduction

Mining plays a prominent role in the economy worldwide since human efforts have been more concentrated in extraction than recycling of natural resources. Waste generated due to mining activity poses a serious predicament due to the substantial amounts generated and is often associated with the risk posed by its storage and environmental management. The mining industry triggers intense environmental impacts.

The propitious management of the overburden dump generated during mining activities is one of the formidable issues faced by the industry [14]. It has been observed that the residual friction angle of this mining OB material is one of the major aspects during mining activities [15]. After detailed investigation this OB material generated during mining can be utilized for filling the voids generated after mining operation [01]. In India humungous quantity of mining waste is generated hence this material should be utilized in construction activities or in manufacturing of construction materials [02].

The effective utilization of this large amount of waste generated during mining activities is the main objective of this study. This aspect will help in minimizing the Geo environmental issues in the vicinity.

2. Site Details

2.1 Location

The Gondegaon Extension Opencast (OC) Coal Mine Expansion project also known as Amalgamated Gondegaon-Ghatrohan OC mine of 3.5 MTPA. Fig.01 represents the OB location in village Gondegaon, Tehsil Parseoni, District Nagpur in the State of Maharashtra, India. Gondegaon opencast mines is located approximately 25 km away from Nagpur is selected for the study. It is situated in Parseoni district. The mine was started in 2009 under the sponsorship of western coalfields limited.

The coal obtained from this mine is used in Khaparkheda thermal power plant, Koradi thermal power plant and other nearby small scale industries.Fig:01 shows the sample location of Gondegaon mines.

Fig. 01. Sample Location Gondegaon mine

2.2 Geology of the area

At this location, cohesive soil is perceived in the upper layer, which is followed by thick layer of sand stone and clay. Occurrence of coal is observed in different seams up to a large depth.

2.3 Description of material

Based on field observations, cohesive as well as cohesion-less OB dump samples are collected from different overburden dumps for research work. Cohesive material is obtained from the upper layer deposits excavation whereas the cohesion less material is formed by the disintegration of coarse grained sandstone during mining operations. This formation is highly weathering in nature resulting in disintegration while performing mining activities.

3.0 Methodology

The experimental program for the OB dump and fly ash is carried out in following progression.

a. Index and engineering properties of the cohesive and cohesion-less OB sample has been determined during laboratory investigation.
b. Fly ash has been mixed with cohesive and cohesion-less OB samples in varying doses of 10 %, 20 %, 30 % and 40 % and following tests has been performed on the mix with abovementioned doses.
    i) Atterberg's Limits
    ii) Proctor Test

iii) Direct Shear test

iv) UCS Test

v) CBR Test

c. Proctor compaction test has been performed on cohesive and cohesion-less OB samples in the laboratory. The determined OMC and MDD value is used for UCS & CBR test.

3.1 Testing on OB Sample

The collected Cohesive and cohesion less overburden dump samples are tested in laboratory for various parameters as per available Indian standards. Fig. No.02 and 03 shows samples in laboratory after performing the specified tests with addition of fly ash.

Fig. 02. UCS test on OB Sample

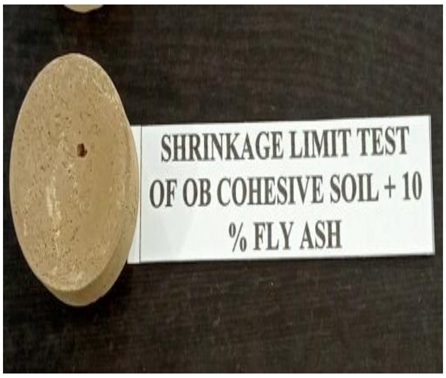

Fig. 03. Shrinkage Limit test on OB Sample

3.1.1 Sieve analysis:

Particle size distribution of the accumulated OB samples has been carried out as per IS: 2720 part 4-1985 [7]. The graphical demonstration (Graph 01 & 02) shows the test results that the gravel content is nil in both types of sample. Silt and clay percentage is more in cohesive sample whereas in cohesion less sample the sand content is high.

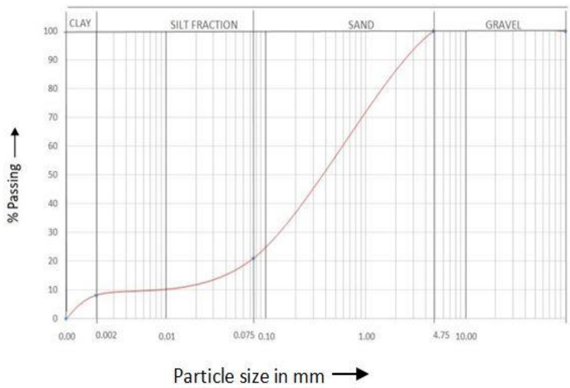

Fig. 04. Particle size distribution of cohesive OB sample

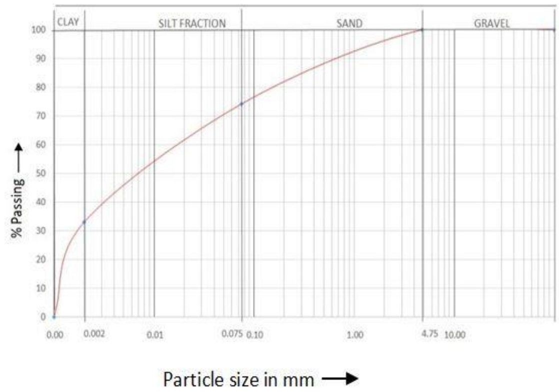

Fig. 05. Particle size distribution of cohesive OB sample

3.1.2 Specific Gravity

Specific gravity test is performed according to IS 2720 part 3, 1980 [6]. In recent analysis the average specific gravity of the cohesive and cohesion less OB material is obtained as 2.635 and 2.648 respectively.

3.1.3 Atterberg's limit

This test has been done as per the IS 2720 part 5, 1985 [8]. As per the test result indicated in Graph 03, the liquid limit of the cohesive and cohesion less OB material is obtained as 35.8 % and 16.51 % respectively. It has been observed that the plasticity properties are decreasing with increase in dose of fly ash.

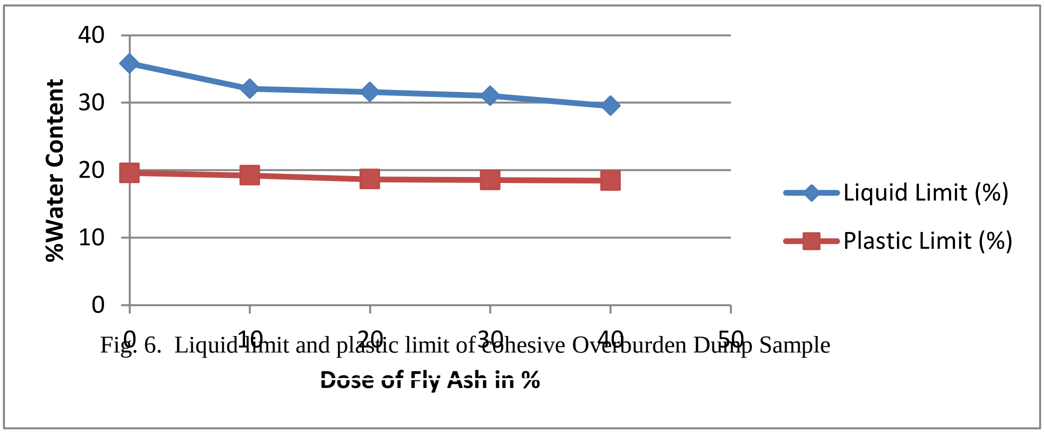

Fig. 6. Liquid limit and plastic limit of cohesive Overburden Dump Sample

3.1.4 Proctor test:

Proctor test is performed as per the IS 2720 part 8, 1983 [9]. The proctor test results displayed in Graphs 04, 05, 06 & 07 point out that optimum moisture content (OMC) and maximum dry density (MDD) of cohesive as well as cohesion less OB samples are decreasing with increase in dose of fly ash.

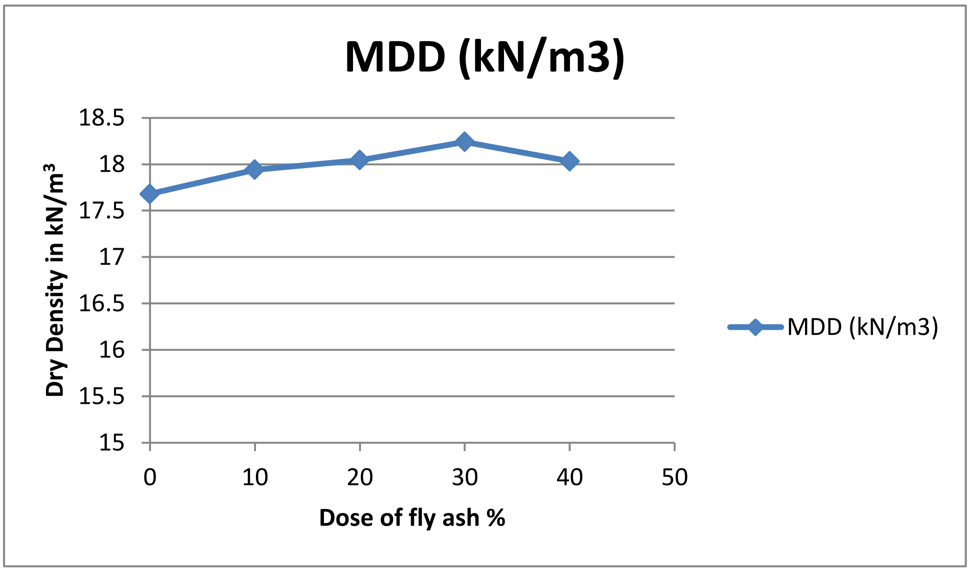

Fig.7. MDD of cohesive OB sample

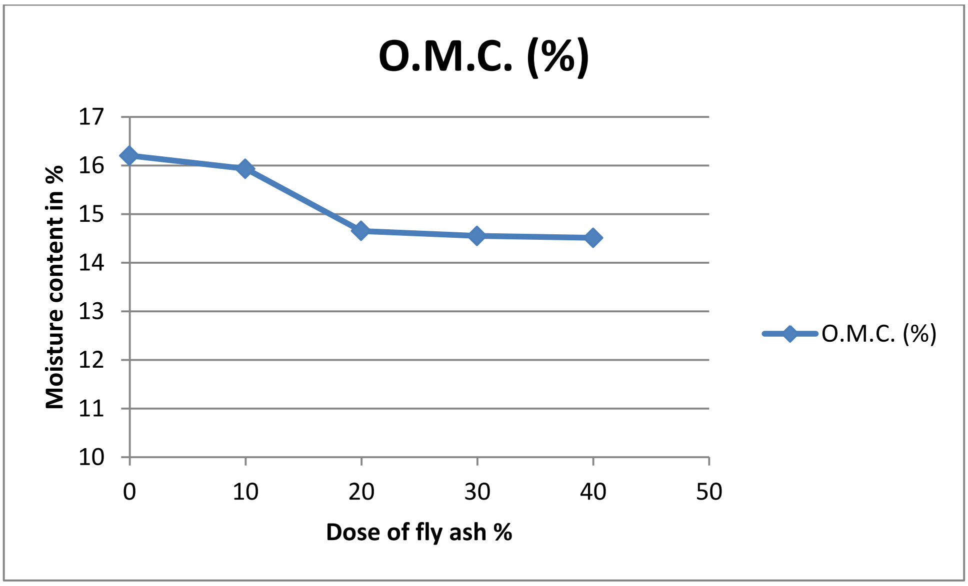

Fig. 8. OMC of cohesive OB sample

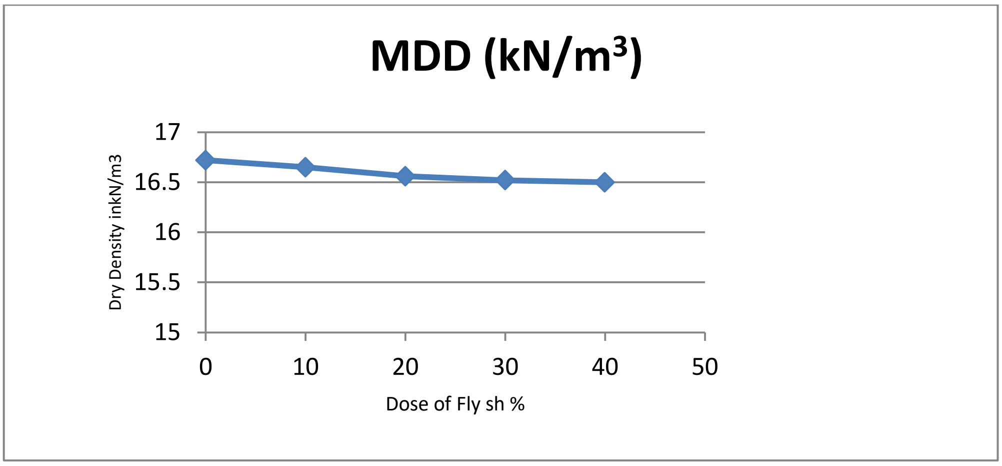

Fig. 9. MDD of cohesion-less OB

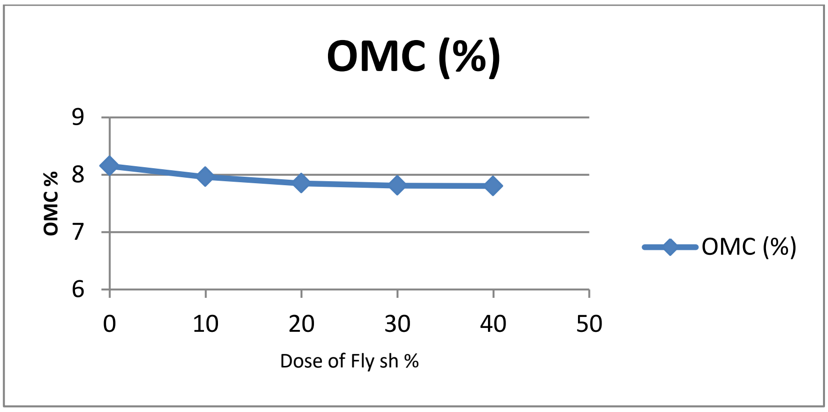

Fig. 10. MDD of cohesion-less OB

3.1.5 UCS test

Unconfined compressive strength (UCS) test has been performed on the cohesive OB material as per IS 2720 part 10, 1991 [12]. The soil samples were placed in desiccator at 100 % humidity and were removed from the desiccator after specific curing time period. The soil samples mixed with fly ash were cured to analyze the pozzolonic reaction and improvement in UCS of the soil samples. Graph 08 indicates that the value of UCS after seven days is increasing with increase in fly ash dose.

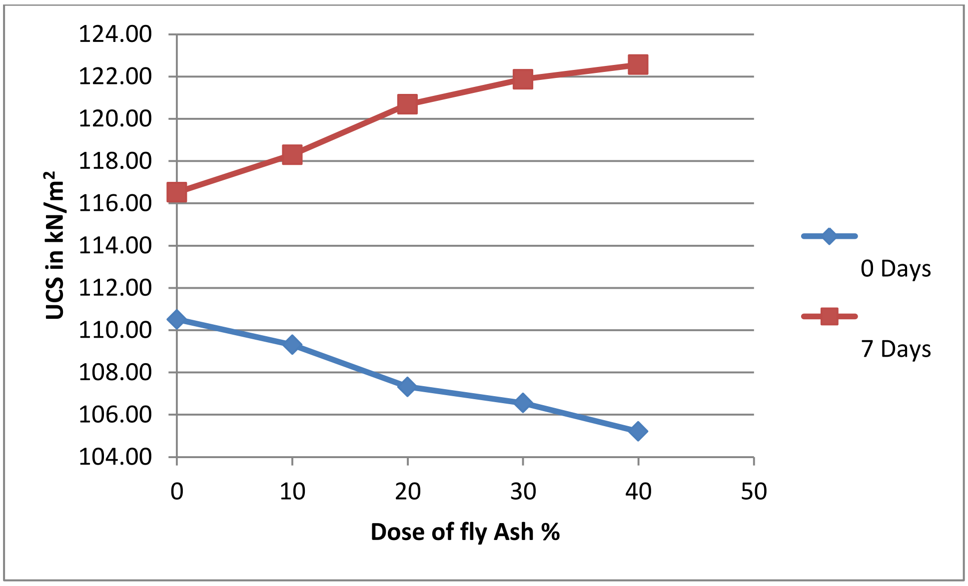

Fig.11. UCS of cohesive OB sample

3.1.6 Direct shear test

Direct shear test has been done on the collected cohesion-less OB dump sample as per IS 2720 part 13 1986 [10]. The test results obtained from Graph 09 and 10 indicate that the value of cohesion is increasing with increase in dose of fly ash whereas the angle of shearing resistance is decreasing.

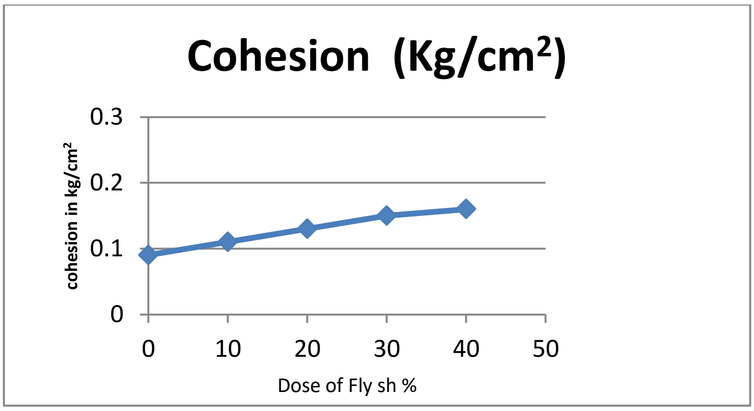

Fig. 12. 'c' value of cohesion-less OB sample

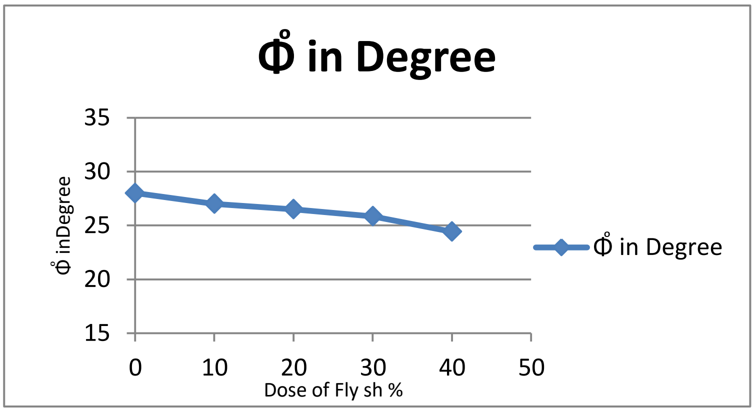

Fig. 13. Φ value of cohesion-less OB sample

3.1.7 California bearing ratio test:

California bearing ratio (CBR) test has been performed on the collected OB sample as per IS 2720 part 16, 1987 [11]. Fig 04 and 05 represents the proctor test and CBR test performance on the OB sample.The test result indicates that the CBR value of cohesive as well as cohesion-less sample is increasing significantly with increase in dose of fly ash successively.

Fig. 14. Proctor test on OB Sample

Fig. 15. CBR test on OB Sample

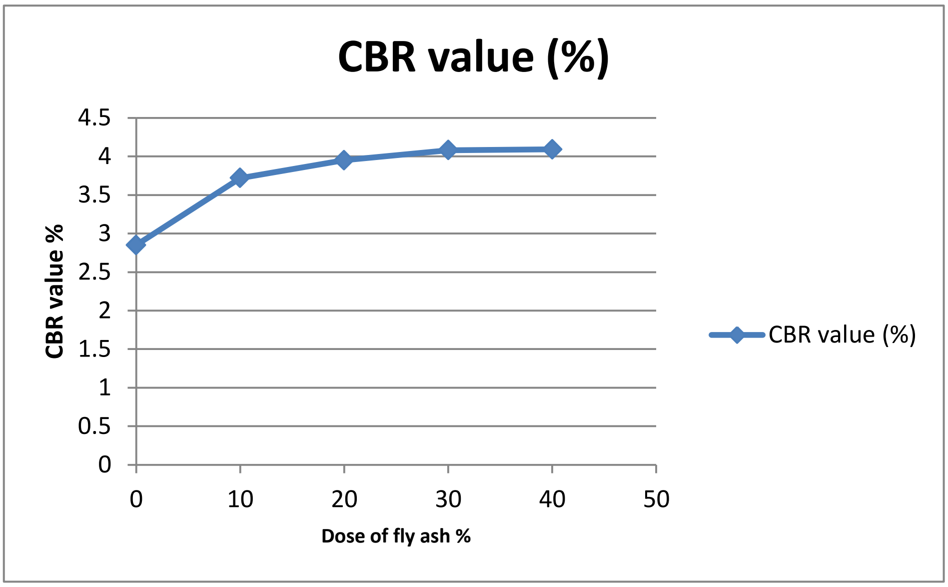

Fig. 16 CBR value of cohesive OB sample

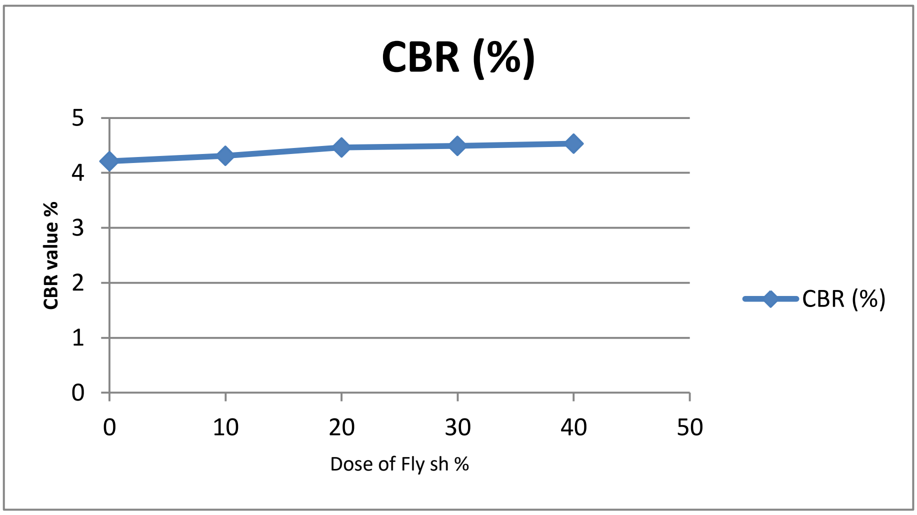

Fig. 17 CBR value of cohesion-less OB sample

3.1.8 Free Swell Index:

This test has been performed on the collected OB sample as per IS 2720 Part XL, 1997 [13]. In recent analysis the free swell index value of the cohesive OB material is obtained as 21.74 %.

Table 01: Properties of OB Sample

Parameter	***Test Method***	***Cohesive OB Sample***	***Cohesion-less OB Sample***
Grain Size Analysis	2720 (Part-IV)		
Gravel		NIL	NIL
Sand		25.77 %	78.91
Silt		41.21	12.97
Clay		33.02	8.12
Specific Gravity	2720(P-III)	2.635	2.648
Free Swelling Index (Fsi)	IS 2720 (Part-XL)	21.74 %	-
Liquid Limit (%)	IS-2720 – (Part V)	35.8	16.51
Plastic Limit (%)		19.57	NP
Plasticity Index		16.23	Nil
Shrinkage Limit (%)	IS – 2720 Part VI	13.95	-
OMC (%)	IS – 2720 (Part VIII)	16.2	8.15
MDD (kN/m^3)		17.68	16.72
C (kg/cm^2)	IS – 2720 (Part XIII)	0.27	0.09
Φ In Degree		9	28
UCS (soil) kN/m^2 0 Days	IS – 2720 (Part X)	110.51	-
UCS (soil) kN/m^2 7 Days		116.52	-
CBR Soak (%)	IS – 2720 (Part XVI)	2.85	4.21

Table 02: Cohesive OB Sample Test Results

Sr. no.	Sample ID	Doses of Fly Ash (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Shrinkage Limit (%)	Heavy Compaction		C (kg/cm^2)	Φ In Degree	UCS (soil) kN/m^2 0 Days	UCS (soil) kN/m^2 7 Days	CBR Soak (%)
							OMC (%)	MDD (kN/m^3)					
1	S0 + 10	10	32.04	19.21	12.83	13.72	15.93	17.940	-	-	109.31	118.30	3.72
2	S0 + 20	20	31.56	18.64	12.92	13.56	14.65	18.044	-	-	107.32	120.68	3.95
3	S0 + 30	30	30.99	18.53	12.46	13.31	14.55	18.240	-	-	1.6.55	121.87	4.08
4	S0 + 40	40	29.51	18.44	11.07	12.80	14.51	18.032	-	-	105.21	122.56	4..09

Table 03: Cohesion-less OB Sample Test Results

Sr. no.	Sample I.D.	Doses of Fly Ash (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Shrinkage Limit (%)	Heavy Compaction		C	Φ In Deg.	CBR Soak (%)
							OMC (%)	MDD (kN/m^3)			
1	S0 + 10	10	-	NP	Nil	-	7.96	16.65	0.11	27	4.31
2	S0 + 20	20	-	NP	Nil	-	7.85	16.56	0.13	26.5	4.46
3	S0 + 30	30	-	NP	Nil	-	7.81	16.52	0.15	25.84	4.49
4	S0 + 40	40	-	NP	Nil	-	7.80	16.50	0.16	24.42	4.53

4. Results and Discussion

Based on the overburden dump material characteristics collected from Gondegaon mines, it has been accentuated that cohesion-less OB material supplemented with different doses of fly ash is showing considerable enhancement in CBR values and compaction parameters. In case of cohesive overburden sample the notable amelioration in unconfined compressive strength value has been observed. Hence, it has been recommended that these Overburden dump materials, which is an impediment for the mining industry can be efficiently brought into play by the construction industry , in addition of nearby industrial by product i.e. Fly ash collected from Khaparkheda thermal power plant. This effort will lead to the sustainable development of the region.

5. Conclusions:

Following conclusion can be drawn, from the test results:

- After detailed investigation, with hindsight, this overburden material can be used in combination with nearby industrial by product, like fly ash, in variable percentage in myriad construction activities i.e. Pavement Construction, Embankments etc.

- Slope stabilization of the OB dump can be looked into and improvised after adding different doses of fly ash. This will fructify the effective land utilization as well as industrial by product, with appropriate safety analysis, which is indispensible desideratum. Furthermore, environmental hindrances with their feasible solutions can be proposed to the authorities in charge keeping in mind further research work of overburden dump.

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