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Potential Utilisation of Mine Overburden

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ABSTRACT
To fulfill the growing demand of coal for power generation, large open cast mining is operational in Dhanbad. The process includes underground mining and open cast mining. In Open Cast mining a bulk volume of over-burden (OB) materials are generated and are often dumped as an external dump or in-pit dump. The behavior and characteristics of the OB disposal vary greatly with different geological and weathering conditions. Generally the Overburden is keep in the nearby land in trapezoidal formation for proper stability. This on one hand creates stability issues also on the other hand causes problems of land degradation, air pollution during dry weather and water pollution during the rainy season.

This paper studies the application of coal mine overburden (OB) dump material to be used as Vegetation cover to meet environmental problems, to replace river sand in construction material and to be used as backfilling in underground mine voids created due to coal mining in deeper seams/horizons. Backfilling in the open cast mines requires huge amount of river sand which depletes the natural resources. River sand is used for both as backfilling in underground mine voids and as a construction material. So through this investigation we can reduces the dependency on river sand. The coal mine overburden which are left behind as residue could be a good replacement for sand and provide a sustainable mining practice.

Geotechnical and physicochemical characterization is required to evaluate the suitability of OB dump material to be used as an alternative of river sand. Also the overburden dump has become a huge problem for the environment and of land degradation. When the coal was taken out from the mines the upper land has loose its strength and it's very high risky as such land can settle down with passage of time. So it's very necessary to backfill those mines with the proper filling material and compact it. As the demand of coal is increasing every year the overburden dump is also increasing with it. It's been observed in the recent years that with increasing in the industries the coal demand increases so as to overburden dump. Through this project we try to utilize this dump as a vegetation cover to reduce the air pollution in the mining zones.

I. INTRODUCTION

The key major source of energy in India is Coal. Almost 70% of the energy produced is obtained from coal energy. This increases the coal demand and so the mining activities. Many countries like China Australia have dependency on coal for its power production. As India is densely populated country it requires huge amount of energy on the daily basis which is found from the coal. Coal is found under the surface of the earth in layers. To extract the coal to the surface mining activities are done whether it is underground mining or open cast mining. Now a days open cast mining is preferred over underground mining as it is less risky and more economical for mass excavation of coal. Coal seams which are present in upper crust is extracted by open cast mining process and the deep coals are extracted by underground mines operation. The OB production in the open cast mines is very high. Dhanbad is often named as India's coal capital. As of July 2021, 112 coal mines in Dhanbad were operational, with a complete yearly production of 27.5 MT. In developing countries like India, coal is that the primary supply of energy, and because the population grows, thus will the demand for coal. Coal is that the chief supply of energy globally with a complete share of twenty ninth as per 2015 (Bhatt et al. 2019, Anand and Sarkar 2021). In the previous couple of decades, the demand for coal for power generation has increased exponentially. With the increase demand of power, coal mining firms are beneath tremendous pressure to provide immense quantity of coal to fulfill the growing need of power. Consequently, a huge number of open pit mines are being excavated to fill the gap between demand and provide of the coal for power generation. To ensure most and economical recovery of coals, a huge number of open pit mines are operational within the district of Dhanbad. However, open pit mining operation additionally results in generation of a bulk volume of material that must be deposited in an exceedingly safe and in accordance with the environmentally friendly manner. The first stage of a coal winning operation is to get rid of overburden so as to reveal the underlying coal for excavation. As the overburden material is waste and non-marketable product, it's fastidiously removed and disposed of. The key goal of the overburden dump construction is to supply a stable operative surface for the dump deposit. As discussed earlier that the open cast mines producing large amount of OB and a well planned structure should be available for its proper disposal. This paper widely dedicates for its utilization for different purposes. Most of this waste is disposed of at the surface, which inevitably requires extensive planning and control to minimize the environmental impact of the mining. A judicious dumping of the same ensures saving in ground and chances of any slide back or dangerous incidents in future. While very low height and flat dumps could be ideal from the point of stability, these would not only occupy lot of ground space but also prove very expensive. In this paper we have also mixed fly ash content with the OB material to know the changes in its geotechnical properties. Different coal mines operational in dhanbad and production of OB from the mines is summed in Table1.

Table 1: The OB production in Jharia coal fields (Source: BCCL regional office)

Area	OB-production in m3 from 2016-2019
Kusunda	58634339
Katras	43230604
Bastacolla	27552772
Lodna	18325336
Sijua	37035002
PB Area	17459842
EJ Area	20453619
Barora	22623427
Govindpur	10620235

II. STUDY AREA AND SAMPLE COLLECTION

Samples from three different sites selected for the project which are:

Bastacola colliery: The site area is under BCCL having geographical location at 23.7687 N, 86.4112 E under Dhanbad district in Jharkhand State.

Kusunda colliery: The site area is under BCCL having geographical location at 23.7831 N, 86.3908 E under Dhanbad district in Jharkhand State.

Chasnala colliery: The site area is under BCCL having geographical location at 23.6635 N, 86.4516 E under Dhanbad district in Jharkhand State.

The overburden soil sample is collected from the area and taken to laboratory for further examine. The other required additives like fly ash is taken from the nearby supplies.

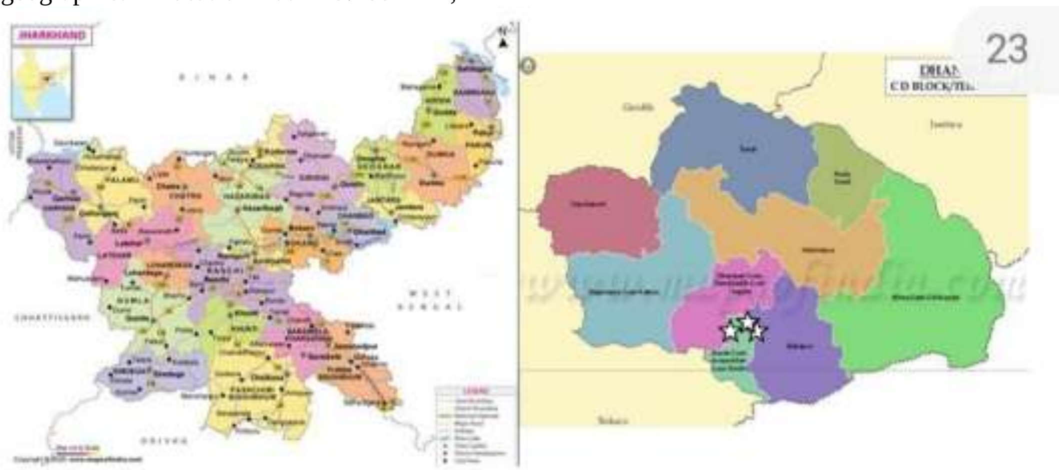

Fig 2.1: Study Area of project

III. EXPERIMENTATION AND RESULT:

Samples are collected from the above mentioned sites and sre crushed to break the clumps of the OB. After this different procedures have been adopted to carry out the different experiments. Sedimentation of the OB material is carried out to take out the fines particles of the OB which later is filled in bucket in which water is filled upto 2/3rd for 30 mins to know the water absorption capacity of the sample. To know the presence of the organic matter in the sample, it is taken in the bucket and mixed vigorously and left to settle down, the organic matter present is separated out. The finer particles which is formed from the Overburden is we call as OB sand (OBS). This sand is can be successfully tested for its strength with cement concrete.

The organic matter present in the sample is also useful for the OB. Different researchers have studied the presence of organism or organic matter in the OB for its useful utilization. Groudev and Groudeva (1993) have find algae and fourteen yeast sorts were identified from mine waste soil. Also Natrajan (1998) discussed about the conservation and utilization of microbial range in mine soil.

Fly ash content mixing

Further The OB sample is mixed up with different proportion of the Fly ash content to know its changes in its geotechnical properties such as shear strength characteristics, compaction characteristics, OMC and MDD of the sample, Unconfined compressive strength of the sample.

3.1 Grain size distribution

Samples of the OB are then further taken for sieve analysis to know its particle size distribution. There is a significant importance of grain size over geotechnical assessment of filling material. Backfilling material, which contains well-graded particles, should offer more resistance to displacement and settlement than one with uniformly graded particles. From the experimental analysis, the results indicates that about 54.8%, 60% and 60.5% of the sample passes the 4.75mm sieve. i.e more than 50% of the sample passing the 4.75mm sieve which indicates that the OB sample contains fine aggregates also very few percentage is passing 0.075mm sieve which clearly indicates that the sample contains sand and silt with few percentage of clay particles.

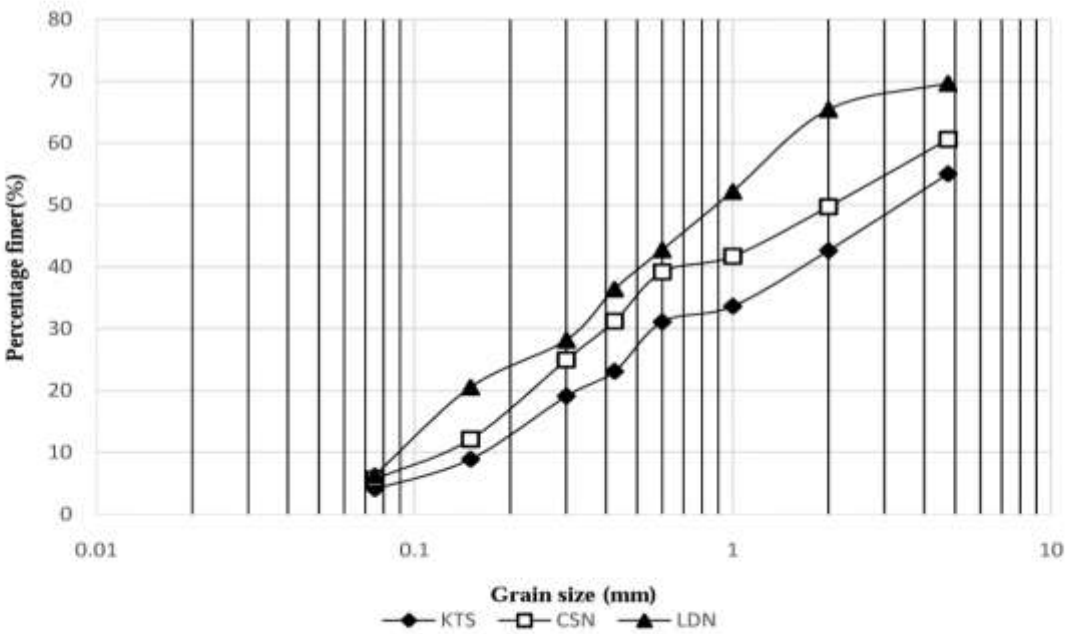

Fig 3.1.1: Grain size distribution curve

3.2 Specific gravity

The specific gravity of solids is frequently required for computation of several quantities such as void ratio, degree of saturation, unit weight, etc. For determining the specific gravity three sample of oven dried OB soil is taken and calculations were done according to the procedure. The void ratio and degree of saturation gives important finding about its utilization as the backfilling material in the underground mines as a replacement of sand. We know the specific gravity of the river sand is found to be around 2.56 so our material has to be near of it for its use as replacement of sand. On conducting the experiment with the pycnometer the three OB sample exhibits sp. gravity of 2.29, 2.30, 2.33 respectively. On addition of the fly ash Content to 15% by volume the sp. Gravity changes to 2.20 and on further addition of 20% it becomes 2.10 but on further increasing the ash content, sp gravity change is minimal.

Sample	Specific Gravity
S1 (Bastacola)	2.29
S2 (Kusunda)	2.30
S3 (Chasnala)	2.33

Table 1: specific gravity of different samples

3.3 Compaction characteristics

Standard Proctor test is used to determine the compaction characteristics and degree of compaction. In these tests, a specified amount of compactive effort is applied to a constant volume of soil mass. For this test, a mould of volume 944 cc is used and the OB sample is filled with three layers. Each layer is compacted by 25 blows with a standard hammer of weight 2.495kg falling from a height of 304mm. The OMC and MDD of the OB sample.

Moisture content determination is important as at low water contents, the soil is stiff and the soil grains offer more resistance to compaction. As the water content increases, the particles develop larger and larger water films around them, which tend to lubricate the particles and make them easier to be worked around, to move closer into denser configuration, resulting in a higher dry unit weight and lower air voids. For the optimum moisture content the sample acquires the maximum dry density. From the experiment the OMC & MDD of the samples are tabulated below. Also the OMC & MDD after mixing the samples with 20% fly ash content by volume is determined.

Table 3.3.1: OMC and MDD of OB

Sample location	OMC%	MDD(g/cc)	With fly ash OMC%	With Fly ash MDD (g/cc)
Bastacola	13	1.90	24	1.26
Kusunda	13.6	2.08	24.5	1.27
Chasnala	14.1	2.18	23.5	1.26

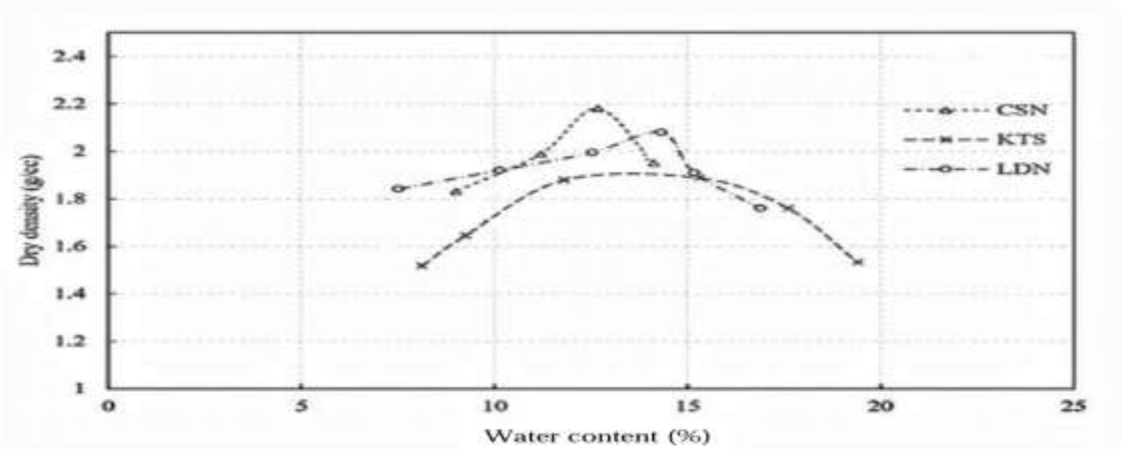

Fig 3.3.1: MDD vs OMC graph

3.4 Shear strength characteristics

Shear behavior of any sample is known from its characteristics of cohesion and angle of internal friction which gives the strength of the the sample. This test is conducted on OB soil sample to know the shearing strength of the sample. Sample is taken in the shear box and load is applied gradually and the reading of dial gauge and proving ring is recorded. The content of the fly ash is mixed with the sample and again the reading were observed to determine the changes in the strength through c’ & ϕ' .

A total of ten samples were gathered from each location and analyzed for shear using a traditional direct shear test apparatus, as recommended by IS 2720. (Part 39). The mean and variation of the shear strength characteristics of the dump waste material were determined by a large number of tests. Table shows the effective cohesion and effective angle of internal friction values obtained for each sample at all three sites.

Location	c' (kPa)	ϕ'
Bastacola	1.88	38.8
	1.45	29.8
	0.77	31.9
	1.88	43.2
	4.34	33.8
	1.54	35.5
	1.07	36.9
	1.96	33.4
	1.72	35.8
	0.00	31.6
Kusunda	4.18	33.3
	3.87	31.9
	5.16	34.8
	2.82	33.9
	3.79	31.6
	4.82	27.5
	1.45	29.5
	1.77	33.8
	1.54	31.7
	1.93	32.9
Chasnala	2.01	30.9
	5.09	33.3
	1.82	37.5
	4.14	31.3
	3.70	39.0
	5.16	35.1
	2.18	37.3
	4.13	39.8

Table 3.4.1: Shear strength parameter obtained for OB dump.

By mixing the samples with the fly ash content the shear strength parameters get improved by almost 10- 15 % as the fly ash increases the cohesion between the particles also the friction angle gets reduced which enhances the stability of the slope.

3.5 Unconfined compressive strength value (ucs)

It is a parameter to describe the strength gained in the sample after stabilization.

The unconfined compressive strength (UCS) is the maximum axial compressive stress that a cylindrical sample of material can withstand under unconfined condition as the confining. The UCS test is performed on the OB material mix with 20% fly ash content and the strength increases to about 9.03%. under different proportion of mix and different curing conditions the range of variation of strength lies from 8.9 to 9.14 %.

IV. CONCLUSION AND DISCUSSION

From the above experiments and results analysis we can conclude the following observation:

- From sieve analysis it is clear that the soil is sandy soil and very few percentage pass through 0.075mm sieve. Because of the presence of higher amount of sand particles in

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the OB samples, there will be fast removal of water passing through the dump material that is one of the characteristic features of stowing material. The amount of water flow through coal mine refuse can be empirically related to its gradation and void ratio. Permeability decreases with a decrease in the effective size of the material. An indication of the gradation of the refuse can be computed from a grain-size distribution curve for grain sizes larger than the 0.075 mm.

- From average specific gravity determination the specific gravity of the sample is found to be 2.3which is near to close to river sand. Hence the OBS is usefully can be utilized in specific proportion for the preparation of cement mix mortar, also can be utilized as the backfilling material in the underground mines.
- The avg moisture content of the sample is comes to be 13.56 and after addition of the fly ash content the OMC content changes to 24 which clearly signifies that the cohesion behavior of the sample increases as the water binding with the OBS and fly ash which further increases the maximum dry density of the Overburden material.
- The shear strength characteristics of the and the UCS test signifies the strength increase of the sample and its stability to be used as a backfilling material in the mines. With the fly ash content increases up to 30% it can be successfully utilized as sub grade material. Fly ash increases the cohesion and decreases angle of internal friction.
- As the OB contains boulder size rocks with disintegrated parts of the rocks and sand portion the weathering action on these let it disintegrate in finer particles and the OB also contains some microorganism like algae with the help of which plantation can be carried out on OB to reduce the environmental pollution in the mining areas. Mining companies like BCCL, CCL etc are using this technique and carry out plantation work during rainy season to make the OB greenery.
- The introduction of the fly ash content in the OB material will help in giving nutrients, increases its water holding capacity, reduces the metal toxicity.
- The bulk unit weight of the sample is found to be 2.124 and the dry unit weight of the sample is found to be 1.88 also the OB sample is found to be non plastic in nature.

Fig 4.1 : Eco-restoration of Ob dump

Thus the outcome of this paper recommends the utilization of mine OB as a replacement of the river sand in mine backfilling along with its use a material in cement concrete. With the help of nutrients and microorganisms and different techniques we can make the OB dump greenery and reduce environmental pollution. Also mixing of the fly ash increases the strength parameters of the OB sample. However evaluation of heavy metal contents of the OB material is required before its utilization in backfilling to reduce leaching impacts in ground water.

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