Study of Mechanical properties of Sand extracted from Overburden of WCL Mines – the Effective Sustainable Sand Solution

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Abstract: Ecological environment concerns are being raised against exploitation of natural resources. The lack of consensus are mostly related to preserve soil beds from erosion and the fact of having natural sand as a filter media for ground water. For a period of time, coal industry in India is facing shortage of river sand due to new mining laws and its increasing demand in infrastructure expansion. The present study concentrates on study of extraction of sand from the overburdens of opencast mines of Coal fields and its feasibility as a fine aggregate in concrete. The surcharge soil spread over in mines needs to be removed for separation of coal to an external dump till ample space is produced for back filling by obtaining of land nearby coal carrying area. Moreover surcharge waste needs to be managed at the time of closure of mine for land acquisition. In present project study of physical properties of extracted sand from overburden and natural sand from river bed is compared and effort is made to utilize the waste generated in tones into sustainable sand solution.

Keywords: Natural sand. Extracted sand, overburden, sustainability.

1. Introduction

Major constituent of coastline categorized as a "fine aggregate", resulting from the erosion of siliceous and other rocks forms a major building material. At a large scale there is scarcity of this building material and this is the situation in many progressing nations. According to statistics, the need of sand as fine aggregate for infra structure development in the country is about in million tonnes and it is growing at the significant rate per year. The resources for generation of natural sand are limited. As a matter of fact, the generation is not uniform in quantity and in quality. The state of uncertainty and unsatisfactoriness in supply, the rate of the material changes promptly leading to wrong practices. Uncontrolled exploitation of sand reserves leads to disturbing ecological balance. Complications of illegitimate excavation, environmental concerns, and variations in costs and quality of sand connected with each other are predomination across many nations. Open cast mining is a surface mining expertise of excavating hard strata or inorganic element from the earth by their separation from an open pit or earth's surface. Bhanegaon open cast mine, bears a sand patch at a depth of 8m to 10m. After that from overburden, sand is extracted by using sand segregation plant. In overburden 40%- 50% sand obtained and other are mud and gravel.

2.Brief review of the past work

ZhengfuBian, 2007[1], studied that the preliminary thing to treat extracted waste as lining for construction practices , and use it as building material, stuffing underground empty spaces , filling subsided basin to rejuvenate lands for forestation purpose and agricultural production and landscaping .A.Y.U.Stolboushki, 2016 [2] in his study utilized waste generated in the process of coal mining for production of bricks and fuel for their burning, carried out research of waste coal from processing plant abashevskaya and carbonaceous argillites from the lignite open-cut in korkino and found the possibility for compound use of waste coal as a raw material for preparing ceramic bricks, and as fossil energy for kilns. Parthasarathi, 2016 [3] studied the effect on workability of concrete due to partial replacement of fine aggregate with gold mine remains. The residues of gold mine are extremely fine particles with a fineness modulus of 0.28 and contain around 69% of around medium and fine sand. Due to substitution of natural sand with fine tailings there was variation in the quantity of medium and fine sand. The percentage variation of medium and fine sand in the sand resulting for 10%, 20% and 30% substitution levels were found to be 82%, 75% and 69% respectively. The workability acquired for concrete for 30% replacement was found to be very 1ow. However, the modified concrete was found to be applicable for binding, shallow sections and pavement using pavers K. Ram Chandar,(2016)[4], studied gradation results marked on a semi-log plot with respect to percentage passing on (Y-axis) and sieve size on logarithmic axis (x-axis) interpreted S-curve conforming to well-graded aggregate for sandstone. The fineness modulus of the sandstone obtained as 2.25 and found it to be substitution of fine aggregate. Flow properties of concrete increased percentage variation of replacement of sand. Increased content of fly-ash with constant sandstone percentage workability was found to be increased. Merbouh,(2017)[5] in his study of experimental investigation on study of mines waste as sand on properties of concrete, found that the flow property of all the concrete mix decreases with increased percentage of substitution of sand by coal waste aggregate. Compressive strength of concrete

increased till 4% coal waste used as sand in concrete.[7],[8] The skewed substitution of the sand by coal waste improved early compressive strength .Ibrahim, 2019[6] in his study of Recycling of Ash from coal as a substitute of cement found that the workability parameter decreased with the increasing percentage of coal ash as a cement replacement and further concluded that high fineness of ground CBA particles results in increased abortion of water. C.R. Santos(2015) results showed that it was possible to process the coal waste from the carboniferous region of Santa Catarina and obtain a recycled fine aggregate that can be used in civil construction.[9]

3.General Information of Bhanegaon Open Cast Mine

WCL is scrutinizing to deal with its production by separating sand while digging out coal. It has begun segregating sand from soil dug out for mining coal. A like project for manufacturing bricks has also been initiated. Surcharge, overburden as it is called in mining terms, is the earth dug out while mining activity. The same is used for backfilling of cavities created. Apart from this, surcharge soil has no other utility. Currently it has started segregating sand by mechanical means from the surcharge soil. Its splits sand particles from the earth. Along with this, rocks are also crushed into sand. The company has started supplying 500 m^3 per day to Nagpur Improvement Trust to be used for a low cost housing scheme of government. WCL has got enquiry from agencies like National Highway Authority of India. WCL is looking forward to improve its overall revenues. It may lie between 5% to 105% of the public sector units' turnover regarding sand a source. It sum to about 200 million tons of overburden in per annum. Although it is used to backfill mines, but a lot amount of soil is left out in process. Due to the swelling of soil there is increase in the volume by 20% which can be used for making sand and remaining can be used for backfilling.

Fig. 1. Bhanegoan Open Cast Mine

Fig.2 Sand patch at open cast mine

1. Name of the subsidiary : western coalfields limited
2. Name of area : Nagpur area
3. Name of mine : Bhanegaon open cast mine

4. Date of opening : 17-03-2015

5. Location :Latitude N21^{0}16’37”- N21^{0}15’36”Longitude E79^{0}10’12”-E79^{0}08’41”

6. Total land required : 610.12 Ha

7. Excavation area : 146 Ha

8. External overburden dump area:: 245

9. Area of quarry : 1.5km*1.0km

Minimum depth of quarry : 65 m

Maximum depth of quarry : 215m

Life of the mine : 26 years

3.1 Sand from overburden of coal mines:

3.1.1.Characteristics

The surcharge soil spread over in open areas of coal mines need to be relocated for coal extraction to far away dumping yards in order to create l adequate space for back filling by acquiring of land near coal bearing area. Further, this surcharge soil needs to handle properly at the time of shutting of mine reclamation of land. As per mine closure rule, 80% of the extracted surcharge utilized for backfilling of the cavity created remaining percentage to be utilized for extraction of sand.

3.1.2.Demerits of Overburden

1. External overburden dump is w aste by products as is of no use to the company.

2. Huge quantity of land has to be acquired for overburden dump incurring huge cost to the company.

3. The external dumps always possess treat to nearby habitants that necessitates rehabilitation of villagers to a safe place which adds to additional capital investment.

4. Overburden dumps pollutes the environment, flora fauna of species nereby area adjacent to the mine

3.2.Sand Segregation Plant

The main function of this plant is the sepration of sand from overburden waste. Plant consist of various unit like resand bunkarhaving capacity 25cu.m, turn screening unit, sand processing unit, , rotating bucket , conveyor belt having width 800mm. which is used for passing the material from one unit to another unit, wing wheel 2m length. Overall length of plant is 40m.

4.Working Of Sand Segregation Plant

Introduction: sand segregation plant is used to separated sand from overburden waste. The main function of segregation plant is toremove mud and bigger sizes stone.The first stage involves separation of bigger size stone available in overburden waste. The overburden contains both sand as well as mud.

1. 2. After removal of bigger size stone the remaining overburden is passed to next unit called as screen.

2. 3. In this unit 2 type of mesh is provided that is one for course and other for fine Particles. In this process course and fine particle are properly shake. 4. In next stage the overburden waste is passage to sand processing unit. This unit is provided over the RRC platform. In this unit water is applied to the overburden waste by force, due to this action mud is dissolve with water and is collected in tank which is provided under the mesh. Then by the use of pipe which is connected to the tank mud and water is kept outside of plant. After this remaining material called as (segregated sand) is collected in bucket. Then clean wet sand is passed to drying platform by the use of conveyor belt which is 800mm in width and sand is collected from delivery end.

4.1.Merits Of Segregation Of Sand From Overburden

1. Depletion in natural river sand can be stopped.

2. Sand is a national asset and recovery of sand from waste overburden is best out of waste product.

3. Land occupied by overburden can be freed for mine exploration, afforestation, cultivation or any other economic activity that adds revenue to the company.

4. The land degradation can be minimised.
5. Indirect employment can be generated by installing a processing plant.
6. Uninterrupted supply of sand can be ensured throughout year without any seasonal affects.
7. Supply of sand can be regulated as per requirement.
8. The recovered sand will be supplied to government agencies as cheaper price than the prevailing market price.

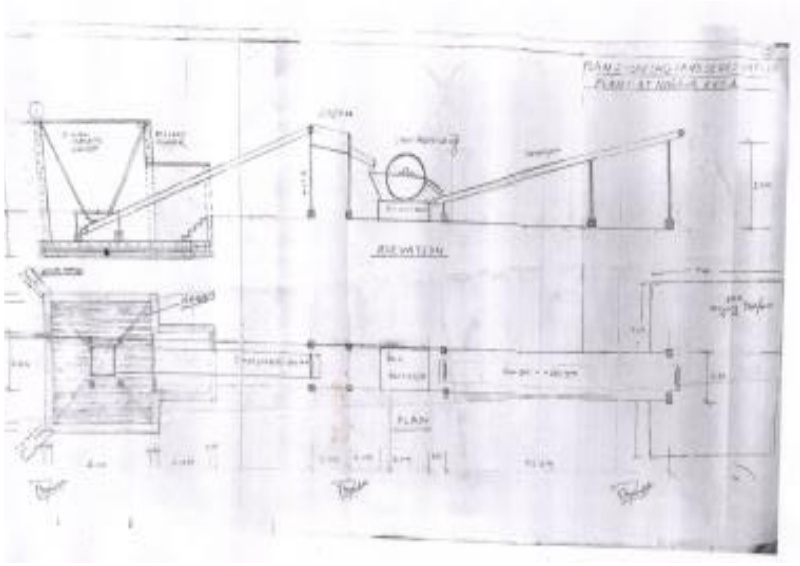

Fig.3 Layout of Sand Segregation Plant



Fig.4 Components of Segregation Plant

5.Materials

5.1 Natural Sand

Natural sand has an ideal shape for use as fine aggregate in concrete. The natural sand particles are well rounded and are usually nearly spherical. spherical particles decreases the percentage of voids within the concrete mixtures so no additional paste is required to fill these voids. Well-shaped natural sands are ideal for workability of mixtures. Natural sand does not require more water to enhance the workability of the mixture so that amount of bleed water in the concrete will not be increased.

5.2. Extracted Sand

In Bhanegaon open cast mine, while extracting coal they got a sand patch at a depth of 8m to 10m. After that from overburden, sand is extracted by using sand segregation plant this is called as the extracted sand.

5.2.1..Experimental program:

Fine Aggregate in a concrete is structural filler, it is a granular material used to produce concrete and when the particles of the granular material are so fine and they pass through a 4.75mm sieve. In the project locally available natural sand and the extracted sand had been used for experimental purpose and physical properties of fine aggregate had been determined as per IS 383-1970[10].

5.2.2.Tests performed on natural sand and extracted sand:

1) Particle Size Distribution
2) Bulking Of Sand
3) Silt Content
4) Specific Gravity and water absorption of fine aggregate.

Table 1.Fineness Modulus of Natural Sand

Is sieve	Weight of fine aggregate (gm)	Percentage of weight retained (%)	Cumulative percentage of passing (%)	Percentage passed (100-cpr)	Remark
10 mm	0	0	0	100	100
4.75mm	5	0.5	0.5	99.5	90-100
2.36mm	16	1.6	2.1	97.9	75-100
1.18mm	103	10.3	12.4	87.6	55-90
600micron	399	39.9	52.3	47.7	35-54
300micron	393	39.3	91.6	8.4	8-30
150micron	80	8	99.6	0.4	0-10
75micron	2	0.2	99.8	0.2	-
Pan	2	0.2	100	0	-

Table 2. Fineness Modulus of Extracted Sand

Is sieve	Weight of fine aggregate (gm)	Percentage of weight retained (%)	Cumulative percentage of passing (%)	Percentage passed (100-cpr)	Remark
10 mm	0	0	0	100	100
4.75mm	40	4	4	96	90-100
2.36mm	40	4	8	92	75-100
1.18mm	170	17	25	75	55-100
600micron	280	28	53	47	35-54
300micron	410	41	94	6	08-30
150micron	50	5	99	1	0-10
75micron	0	0	0	0	-
Pan	0	0	0	0	-

Table 3. Bulking phenomena of given sample of natural sand

Sr. No	Water content (%)	Initial volume of sample (v1)	Final volume of sample (v2)	V2-v1	Bulking (%) = ((v2-v1)/v1) *100	Bulking factor = v2/v1
1	2	150	200	50	33.33	1.33
2	4	150	240	90	60	1.6
3	6	150	250	100	66.67	1.67
4	8	150	240	90	60	1.6
5	10	150	230	80	53.33	1.53
6	12	150	210	60	40	1.4

Table 4. Bulking Phenomena of Extracted Sand.

Sr. No	Water content (%)	Initial volume of sample (v1)	Final volume of sample (v2)	V3 =	Bulking (%)= (v3/v1)*100	Bulking factor = v2/v1
1	2	150	200	50	33.33	1.33
2	4	150	210	60	40	1.4
3	6	150	240	90	60	1.6
4	8	150	250	100	66.67	1.67
5	10	150	230	80	53.33	1.533
6	12	150	210	60	40	1.4

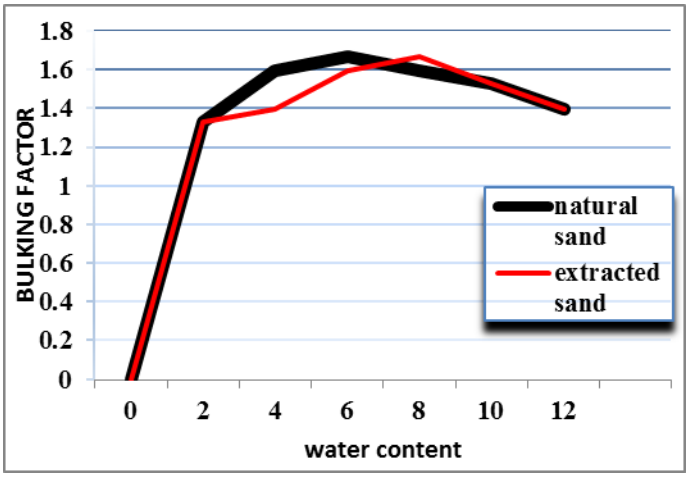

Fig.7 Bulking of natural sand versus Extracted sand

Table 5. Silt Content of Natural sand and extracted sand

Sr.no	Description	natural sand sample 1	natural sandsample 2	Extracted sand sample 1	extracted sand sample 2
1	Volume of sample sand V2	76	82	76	82
2	Volume of silt layer V1	3	3	2	2
3	Percentage of silt	3.95	3.6	2.63	2.4
	Average	3.77 %		2.515 %	

Table 6. Physical properties of natural sand & Extracted Sand from overburden

Sr no	Properties	Natural	Extracted	As per Indian standard code
1	Sieve analysis	zone 1	zone 2	Zone 1 to zone 4
2	Silt content	3.77%	2.52%	< 8%
3	specific gravity	2.63	2.59	2.5 to3.0
4	water absorption	0.8	1.41	0.3 to 2.5%
5	Bulk density	1500kg/m3	1603 kg/m3	1520 to1680

Fig.8. Approximate cost of Sand segregation at Bhanegaon open cast mines

6.Conclusion:

1) The results show that both natural and extracted sand comes under the zone II.

2) The silt content is in permissible limits, as the extracted sand contains less silt content as compared to the natural sand i.e .2.52%

3) Specific gravity of extracted sand is 2.59 which is within permissible limits and proves to be a good replacement of natural sand.

4) The bulk density and the water absorption is also in the permissible limits of properties of sand and hence can be concluded that the extracted sand from the overburden of open cast mines of Coal fields seems to be a sustainable substitute of natural sand.

5) The cost analysis of extraction at segregation plant goes to about 250/- per cumec which is much more less than the current rate of natural sand supplied for various construction activities. Thus making extracted sand most economical, sustainable substitute of natural sand.

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