

# Experimental Investigations on the Use of Coal Mine Overburden as Partial Replacement for Fine Aggregate

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**ABSTRACT:** Waste produced during extraction and processing of various minerals constitute one of the largest waste streams in the world. It involves materials that must be removed to gain access to the mineral deposit such as topsoil, overburden waste rock, as well as tailings remaining after minerals have been extracted from the ore. The ore can be extracted using either opencast mining or underground mining. The waste generated is more during opencast mining. During opencast mining for coal, the overlying soil is removed and the fragmented waste rock is heaped in the form of overburden dumps. These occupy large amount of land, which loses its original use and generally gets soil qualities degraded. As the dump materials are generally loose, fine particles from it become highly prone to blowing by wind. These get spread over the surrounding fertile land, flora, disturbing their natural quality and abstains the growth of fresh leaves. A positive utilization of such waste rock can not only saves considerable land and also reduces environmental problems. One of the uses can be partial replacement of fine aggregates in concrete.

**KEYWORDS:** Coal mine overburden, Replacements for fine aggregate, concrete, Sandstone

## I. INTRODUCTION

Concrete is one of the basic requirements for creation of any infrastructure, buildings, roads, etc. Concrete required natural aggregates, which are obtained from a variety of resources. As sand and gravel can be extracted from rivers easily, such deposits do not require much processing other than size grading. Presently there are various materials such as recycled fine aggregate, china clay waste, stone dust, robo sand etc. But most of the times mine wastes are neglected as alternatives even though they are huge in quantity.

In India there are two types of mining that are operated as opencast and underground mining. Opencast mining is a developmental activity, which is bound to damage the natural ecosystem by several mining activities. During opencast mining, the overlying soil is removed and the fragmented rock is heaped in the form of overburden dumps (Ghosh, 2002). Dumpfertile land, flora, disturbing their natural quality, and abstains the growth of fresh leaves. It has been materials are left over the land in the form of overburden dumps. These occupy large amount of land, which loses its original use and generally gets soil qualities degraded (Barpanda et al., 2001). As the dump materials are generally loose, fine particles from it become highly prone to blowing by wind. These get spread over the surrounding found that overburden dump top materials are usually deficient in majornutrients. Hence, most of the overburdendumps donot support plantation. A positive utilization of such waste rock can not only saves considerable land and also reduces environmental problems. One of the uses can be partial replacement of fine aggregates in concrete

## II. RELATED WORK

In general, coal mine overburden compromises of run-of-mine waste, coarse grained washery discard, fine grained discard and slurry, rejects and tailings. Petro graphically coal mine overburden consists of argillaceous and arenaceous rocks represents mainly by mudstone, siltstone and sandstone with admixture of coal and coal shale (Twardowska et al.,

# International Journal of Innovative Research in Science, Engineering and Technology

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2004). Surface coal mining involves material that must be removed to gain access to the coal resource including topsoil, overburden and waste rock (Zhengfu et al., 2010). Figure 2-1 represents the Coal bed of the Pocahontas Formation. The unit amount of overburden that must be removed to gain access to a similar unit amount of coal or mineral material is known as stripping ratio. Coal mining companies in India removed about 1058.874 million cubic meters (Mcu.m) of overburden (OB) to produce 504.195 million tons of coal in 2012-13 at an average stripping ratio of 2.12 of overburden against per ton of coal produced (coal statistics 2012-13). Table 2.1 and Table 2.2 represents the stripping ratios and overburden statistics.

Stripping ratio (Coal statistics, 2012-2013)

Sector	Strip Ratio		
	2010-11	2011-12	2012-13
Public	2.22	2.18	2.05
Private	2.88	2.73	2.97

• **Replacement as a fine aggregate**

A study on replacement of fine aggregate with crushed sandstone as 0%, 20%, 40% and 60 % compressive strength on HPC using crushed sandstone sand has been observed under water curing. It was concluded that there is high potential for utilization of crushed sandstone sand in HPC production (Kumar et al., 2005). Crushed sandstone was used as fine aggregate in the concrete and the results showed that it is a good replacement for fine aggregate (Fontanini et al., 2013). The replacement of fine aggregate with coal mine overburden in concrete paving block showed the maximum strength at 50% and beyond that it reduces the strength of the paving block (Santos et al., 2013). under service loads but it was within acceptable limit (Kumar et al., 2007). Five different aggregate types (gabbro, basalt, quartzite, limestone and sandstone) were used to produce high strength concrete containing silica fume and among them the lowest strength was obtained by sandstone .

The beams made with coarse aggregate as sandstone, due to lower stiffness of sandstone aggregates, resulted in excessive deflection types such as, gabbro, basalt, quartzite, limestone and sandstone were to produce high strength concrete. It was concluded that gabbro concrete showed the highest compressive and, while sandstone showed the lowest compressive strength (MuctebaUysal, 2012).

### III. EXPERIMENTAL RESULTS

The experiments to find out the physical properties of sandstone and its elemental composition, strength properties of concrete incorporated with sandstone and strength properties of concrete incorporated with sandstone and fly ash together were tested as mentioned in the above sections conforming to particular Indian standard codes. The results are tabulated below in this section.

Grain size distribution was done by sieve analysis, with sieves ranges from 75µm to 4750µm. Wet sieve analysis was conducted totally for 5 samples to find the accurate results. For wet sieve analysis the sample was washed and passed through the sieves and dried for 24 hours. Then the weights were measured for materials retained on each sieve. Based on the values obtained cumulative passed and cumulative retained were calculated for each sieve.

**Table 36. Sieve analysis for sample**

IS sieve size (micron)	Retained Weight (grams)	Percentage retained	Cumulative percentage retained
4750	31.20	1.56	1.56
2360	43.80	2.19	3.75
1180	236.50	11.83	15.58
600	517.22	25.86	41.44
300	607.08	30.35	71.79
150	354.33	17.72	89.51
75	86.47	4.32	93.83

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**Figure 34 Grain size distribution for sample**

*Compressive strength (25% replacement)*

**25% replacement with sandstone (3-Days)**

S.No	Weight of cube (Kg)	Load resisted (KN)	Compressive strength (N/mm <sup>2</sup> )
1	8.07	310	13.78
2	7.99	310	13.78
3	8.04	320	14.22
4	7.88	310	13.78
		Average	13.89

• **3-days strength**

The 3-days strength at 0% replacement found to be 13.78N/mm<sup>2</sup> which is quite good for M20 grade concrete. The variation of strength with replacement of sandstone is shown in fig 4.3. With the 25% replacement, compressive strength was increased just by 0.8% with an average of 13.89. From 25% to 50% strength was increased by 8.07%, which is a noticeable variation. From 50% to 75% strength got increased by 4.44% and for 100% replacement it showed same strength as 75% replacement. Overall the 3-days compressive strength was increased by 14.51% for 100% replacement with sandstone

**25% replacement with sandstone (7-Days)**

S.No	Weight of cube (Kg)	Load resisted (KN)	Compressive strength (N/mm <sup>2</sup> )
1	7.97	400	17.78
2	8.01	370	16.44
3	7.95	410	18.22
4	7.92	370	16.44
		Average	17.22

7- Days strength of concrete with 0% replacement found to be 17.22 N/mm<sup>2</sup>. The variation of strength showed in fig 4.5. For the replacement of 25% with sandstone (CMO) there is no increment in strength. From 25% to 50% strength was increased by 5.16%. From 50% replacement to 75% replacement strength was increased by 1.21%. From 75% to 100% strength was increased by 1.25%. Overall for 100% replacement the strength was increased by 13.4% compare with control mix.

**25% replacement with sandstone (28-Days)**

S.No	Weight of cube (Kg)	Load resisted (KN)	Compressive strength (N/mm <sup>2</sup> )
1	7.95	530	23.56
2	7.98	520.00	23.11
3	7.86	530	23.56
4	7.98	520	23.11
		Average	23.33

variation of compressive strength with percentage of replacement Even though the 3 and 7 days compressive strength was calculated the most required strength for the concrete is for after 28-days curing. The strength of concrete can be usually talked in terms 28-days compressive strength. 28- Days strength of concrete with 0% replacement found to be

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22.56 N/mm<sup>2</sup>. For the replacement of 25% with sandstone (CMO) there is 3.33% increase in strength. From 25% to 50% strength was increased by 4.28%. From 50% replacement to 75% replacement strength was increased by 0.36%.

## IV. RESULTS AND DISCUSSION

Fineness modulus of samples is varying from 2.23 to 2.30, with an average value of 2.25. It indicates that the material will come under fine sand which is perfectly suitable as replacement. The 3-days strength at 0% replacement found to be 13.78N/mm<sup>2</sup> which is quite good for M20 grade concrete. The variation of strength with replacement of sandstone is shown in fig 4.3. With the 25% replacement, compressive strength was increased just by 0.8% with an average of 13.89. From 25% to 50% strength was increased by 8.07%, which is a noticeable variation. From 50% to 75% strength got increased by 4.44% and for 100% replacement it showed same strength as 75% replacement. Overall the 3-days compressive strength was increased by 14.51% for 100% replacement with sandstone

Percentage of variation in strength with respect to base mix

Mix	Percentage of variation in strength with reference to base mix				
	Compressive strength			Split tensile strength	Flexural strength
	3 Days	7 Days	28 Days	28 Days	28 Days
25% sandstone replacement	0.79	0.00	3.43	2.28	10.00
50% sandstone replacement	9.65	5.17	7.60	6.73	13.33
75% sandstone replacement	14.51	6.47	7.52	8.95	16.67
100% sandstone replacement	14.51	7.76	9.09	8.95	20.00
100% sandstone replacement + 10% FA	8.85	5.81	10.30	11.17	20.00
100% sandstone replacement + 20% FA	3.99	3.89	10.16	12.29	23.33
100% sandstone replacement + 30% FA	3.19	-3.83	11.93	17.85	26.67

Tabulated readings as shown in Table 4-3 represent the variation of strength with reference to base mix. From the results we can observe that only the 7-days strength of 30% fly ash replaced along with sandstone acquired lower strength compared with base mix. Apart from that lone mix all other showed an increasing trend. Flexural strength and split tensile strength exhibited higher variation when compared with compressive strength.

## V. CONCLUSION

Based on the experimental investigations, the following conclusions were drawn.

- Sieve analysis results when plotted on a semi-log plot w.r.t. percentage passing on (Y-axis) and sieve size on logarithmic axis (X-axis) depicted an S-curve conforming as well-graded aggregate for sandstone
- The fineness modulus of the sandstone obtained as 2.25 and its clearly indicating it is a good replacement for fine aggregate.
- Workability of the concrete increased with increasing in percentage replacement of fine aggregate. With increasing in fly ash content keeping sandstone percentage constant workability was increased. For all the cases true slump was observed.
- 25% replacement with sandstone didn't encounter much variation in strength when compared to base mix. But replacement of 50% and 75% rendered a very high early strength to base mix. Even the 100% replacement was slightly greater than 75% in terms of early strength.

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(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 12, December 2016

## REFERENCES

1. Gautam, S.P., Vikas Srivastava, and V.C. Agarwal. . "Use of glass wastes as fine aggregate in Concrete." *J. Acad. Indus. Res.* Vol. 1(6), 320-322,2012.
2. Gupta, Anup Kumar, and Biswajit Paul. . "A Review on Utilisation of Coal Mine Overburden Dump Waste as Underground Mine Filling Material: A Sustainable Approach of Mining." *Int. J. Mining and Mineral Engineering*, Vol. 6, No. 2, 172-186,2015.
3. Kumar, P S, M A Mannan, V J Kurian, and H Achyutha. . "Effect of Crushed Sandstone Sand on the Properties of High Performance Concrete." *Journal of Civil Engineering Research and Practice* Vol. 2(2), 1-11,2005.
4. Kumar, P.S., M.A. Mannan, V.J. Kurian, and H. Achuytha. . "Investigation on the flexural behaviour of high-performance reinforced concrete beams using sandstone aggregates." *Building and Environment*, Vol. 42, 2622–2629,2007.
5. P.S.P, Fontanini, Pimentel L.L, A.E Jacintho, and Migliato C. L.. "Brazilian Geological Sandtone Characterization and its Utilization as Aggregate in Structural Concrete." *Applied Mechanics and Materials* Vols. 271-272, 141-146,2013.