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Preparation of concrete using Goldmines Waste

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Abstract: *In the present work, experimental investigations were performed such as compressive strength test and flexural strength test on the concrete containing (0% and 100% replacement of goldmines waste in place of coarse aggregate. The tests were conducted for the above replacements of goldmines waste for M20 and M40 Grade concrete at different curing periods of (7, 14 and 28 days). The results of compressive strength of M20 and M40 grade concrete were in the range of 31.218N/mm^2 to 34.008N/mm^{2}and 51.293N/mm^2 to 52.174N/mm^2 respectively. The Flexural Strength results of M20 and M40 grade concrete were in the range of 6.28 N/mm^2 to 6.90N/mm^2 and 8.306N/mm^2 to 9.060N/mm ^{2} respectively.*
Keywords: *Compressive strength, Flexural Strength and Durability*

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I. Introduction

Gold mines Crushed Black stones are one of the primary waste products of mining operations of Hutti Goldmines Limited. They comprise of Stone chips and dust of the parent rock from which the ore is extracted. The characteristics of Gold mines Crushed Blackstone depend upon the composition of parent rock. The disposal of this material is a major environmental problem for the mining industry. Among the 960 million tons of solid waste generated annually in India, nearly 290 million tons are inorganic wastes of industrial and mining sectors. The gold mining industry at Hutti village in Raichur district of Karnataka is producing abundant quantity of tailings and Crushed Blackstone which is un-utilized for several years, for extraction of 1 gram of gold, 1 ton of waste material is generated; Annually Hutti goldmines limited is generating nearly 2000 tons of waste daily containing tailing and crushed Blackstone. There is no vegetation on dumps, which leads to release of fine particles into the atmosphere due to wind erosion. This causes air pollution in the area. The tailings and Crushed Blackstone have affected the landscape and topography of the area as well. Hence, it is essential to find some way to use the Gold mine wastes. Fine and coarse aggregates are becoming scarce and meeting the demand of aggregates in the construction industry is becoming a challenging task. In this investigation an attempt is made to utilize Gold mines Crushed Blackstone as a substitute for coarse aggregates in producing concrete. Further Gold mines Crushed Blackstone referred as GMW coarse aggregate and concrete made of it is referred as GMW concrete. The acceptability of utilizing goldmine tailings as a substitute to sand in concrete production was found to be satisfactory on the basis of compressive strength and durability. This study is initiated to assess the suitability of Gold mines Crushed Blackstone as substitute for coarse aggregate in concrete. The evaluation was based on parameters such as physical properties of materials, workability, compressive strength, flexural strength and durability. A Hutti goldmine is in the nearby locality of Kalaburagi, black stone is available in large quantity. About 70% of gold mine tailings are coarser than 75 micron size and 63% of this material belongs to fine sand category. Chemical composition of gold mine tailings shows that the major constituent is silica [1] and due to presence of silica content, the goldmine waste in different industrial application ensures environmental sustainability and economic benefits [3].The presence of cyanide contain in goldmine waste is very less. Thus, goldmine tailing is safe as construction material [2].The workability of concrete in terms of both slump and compaction factor for concrete containing gold mine tailings alone is very low, which can be attributed by the presence very fine particles. Concrete containing goldmine waste was observed good workability with a specific amount of Super plasticizer [4].The acceptability of utilizing goldmine tailings as a substitute to sand in concrete production was found to be satisfactory on the basis compressive strength and durability [5]The control mix can attain a compressive strength more than the target strength at 28 days and replacement of goldmine waste does not affect the rate of gaining strength [1].The flexural strength of concrete is increasing marginally with percentage of replacement of sand up to 20% however at 30% replacement, the flexural strength decreases marginally. Good correlation was observed between flexure strength and compressive strength [1].

II. Materials used

Ordinary Portland cement confirming to IS: 1489-1991[6] was used. Ultratech cement OPC 53 grade procured from single source was used .The cement used in the project has Specific gravity of 3.157, Normal consistency of 32% and has a initial and final setting time of 120 minutes and 210 minutes respectively. Good quality zone-II locally available fine aggregate was used in the project with specific gravity of 2.652, Fineness modulus of fine aggregate was 3.02, Bulk density in the loose and compacted condition was 1.605 and 1.678g/cc, and water absorption of 1.14%. The fine aggregate conforming to IS: 383-1970[7] was used. Locally available Basalt aggregate of two fractions i.e. 20mm and 12.5 mm and Goldmines waste coarse aggregate of 20mm down size were used in the project. The different tests for physical properties of local Coarse aggregate and Goldmines waste coarse aggregate were carried out in the laboratory and the same is presented in Table 1.

Local coarse aggregates (20mm and 12.5mm down size)

GMW coarse aggregates (20mm down size)

Table 1: Comparison of local and GMW coarse aggregates

Sl. No	Properties	Local coarse aggregate	GMW coarse aggregate
1.	Specific gravity	2.856	2.885
2.	Fineness modulus	8.340	7.310
3.	Water absorption	1.0	1.520%
4.	Free surface	Nil	Nil
5.	Bulk density a)Loose b)Compacted	 1.436 g/cc 1.582 g/cc	 1.582 g/cc 1.740 g/cc
6.	Crushing test	17.29 %	12.71 %
7.	Impact Value	13.33 %	12.22 %

Table 2: Sieve analysis results of local and GMW coarse aggregates

Sieve size	Cumulative % finer for local Coarse aggregate (20mm down size)	Cumulative % passing finer for GMW coarse aggregate (20mm down size)	Values as per IS standards for Coarse aggregate (20mm down	
40mm	100	100	100	The both aggregates are nearly graded
20mm	84.61	82.50	95-100	
16mm	74.66	74.0	---	
12.5mm	63.76	40.11	---	
10mm	54.56	33.94	25-55	
4.75mm	3.74	12.47	0-10	

Table 1 represents physical properties of local coarse aggregate and GMW coarse aggregate. From table 1 it is observed that, specific gravity for both the aggregates are nearly same. However there is a variation in the results of fineness modulus and bulk density between GMW coarse aggregate and locally available coarse aggregate, this variation in results may be due to manual crushing of GMW coarse aggregate. From the results of crushing test, the GMW coarse aggregate are stronger as compare to locally available coarse aggregate. Impact value for both the aggregates is nearly same. Water absorption of GMW coarse aggregate is higher than locally available coarse aggregate. Table 2 represents sieve analyses of local coarse aggregate and GMW coarse aggregate. From table 2 it is observed that, both the aggregates are nearly graded.

III. Mix Design

Grades of concrete mix M20 and M40 were designed as per IS 10262-2009[8]. The Trial casting of both grades M20 and M40 for different W/c ratio and curing period of 7 days were caste and the W/c ratio which resulted in the maximum strength satisfying the requirement of M20 and M40 grade concrete was used for the final castings, the mix proportions are given in Table 3 and 4.

Table 3: Mix Proportion for the combination of fine aggregate and local coarse aggregate For M20 and M40 grade Concrete

Sl o.	Grade of Concrete	Cement	Fine Aggregate	Coarse Aggregate 12.5mm	Coarse Aggregate 20mm down	W/c	% of Super Plasticizer	Compressive Strength in N/mm2 [Normal Curing] [7 days]
1.	M20	1	1.86	2.233	0.960	0.53	--	22.846
2	M40	1	1.23	1.641	0.700	0.40	1.5	37.322

Table 4: Mix Proportion for the combination of fine aggregate and GMW coarse aggregate For M20 and M40 grade Concrete

Sl No.	Grade of Concrete	Cement	Fine Aggregate	GMW coarse aggregate 20mm down size	W/c	% of Super Plasticizer	Compressive Strength in N/mm2 [Normal Curing] [7 days]
1.	M20	1	1.86	3.226	0.53	---	26.598
2	M40	1	1.23	2.367	0.40	1.5	38.513

IV. Results & Discussions

General

Various properties of concrete using GMW coarse aggregate as 0% and 100% replacement with the local coarse aggregate were studied; results were compared for compressive strength, flexural strength, permeability and chloride attack of GMW mix with Control mix.

4.1 Hardened State Concrete Properties

4.1.1 Compressive strength: The compression test was carried out using the guidelines from IS: 516-1959[9] code.

4.1.1.1 M20 GRADE

Table 5: Results for different combination of M20 grade concrete at different Curing periods.

Grade of concrete	w/c ratio	Mix combination of fine aggregate and	Average 7 days compressive strength in N/mm^2	Average 14 days compressive strength in N/mm^2	Average 28 days compressive strength in N/mm^2
M20	0.53	local coarse aggregate	22.846	24.502	31.218
		(100%)GMW coarse aggregate	26.598	28.195	34.008

From the Table No 5 it is observed that concrete using 100% replacement of local coarse aggregate with GMW coarse aggregate has resulted in higher compressive strength at all the three ages that is 7, 14 and 28 days compare to control mix concrete. The percentage increase in compressive strength of 7, 14 and 28 days are 16.5%, 15.1% and 9 % respectively. This increase in strength is due to GMW coarse aggregate are stronger as compare to locally available coarse aggregate, as it is observed by crushing strength test result presented in Table No 1.

4.1.1.2 M40 GRADE

Table 6: Results for different combination of M40 grade concrete at different Curing periods.

Grade of concrete	w/c ratio	Mix combination of fine aggregate and	Average 7 days compressive strength in N/mm^2	Average 14 days compressive strength in N/mm^2	Average 28 days compressive strength in N/mm^2
M40	0.40	local coarse aggregate	37.322	42.989	51.293
		(100%)GMW coarse aggregate	38.513	44.030	52.174

From the table 6 it is observed that concrete using 100% replacement of local coarse aggregate with GMW coarse aggregate has resulted in higher compressive strength at all the three ages that is 7, 14 and 28 days compare to control mix concrete. The percentage increase in compressive strength is marginal. This increase in strength is due to GMW coarse aggregate are stronger as compare to locally available coarse aggregate, as it is observed by crushing strength test result presented in Table No 1.

4.1.2 Flexural strength: The flexural test was carried out using the guidelines from IS: 516-1959[9] code.

At the ends of the curing periods i.e. 14 and 28 days the prism were taken out of curing tank and they are exposed to laboratory temperature, till the surface becomes dry. Prisms are tested under the flexural strength testing machine .the loading arrangement with symmetric loads (P) at 1/3 points procedures a pure bending zone with constant bending moment and zero shears on the middle third of the span. The Flexural test was carried out using the guidelines of IS 516-1959[9] code.

4.1.2.1 M20 GRADE

Table 7: Flexural Strength Results for different mixes for 14 and 28 days curing age

Grade of concrete	w/c ratio	Mix combination of fine aggregate and	Average 14 days flexural strength in N/mm^2	Average 28 days flexural strength in N/mm^2	Theoretical value as per IS 456-2000
M20	0.53	local coarse aggregate	4.58	6.28	3.13
		(100%)GMW coarse aggregate	4.80	6.90	

From table No 7, it is observed that flexural strength increased with increase in curing age, the percentage increase in flexural strength from 14 to 28 days for control and GMW mix concrete is 37% and 44% respectively. The flexural strength of M20 grade concrete using both local and GMW coarse aggregates at the end of 28 days curing is exceeded theoretical value given in IS: 516-1959[9].The flexural strength at the end of 28 days curing is 1/5 of compressive strength at 28 days.

4.1.2.2 M40 GRADE

Table 8: Flexural strength results for different mixes for 14 and 28 days curing age.

Grade of concrete	w/c ratio	Mix combination of fine aggregate and	Average 14 days flexural strength in N/mm^2	Average 28 days flexural strength in N/mm^2	Theoretical value as per IS 456-2000
M40	0.40	local coarse aggregate	6.280	8.306	4.43
		(100%)GMW coarse aggregate	7.062	9.060	

From table No 8, it is observed that flexural strength increased with increase in curing age, the percentage increase in flexural strength from 14 to 28 days for control and GMW mix concrete is 29% and 33% respectively. The flexural strength of M20 grade concrete using both local and GMW coarse aggregates at the end of 28 days curing is exceeded theoretical value given in IS: 516-1959[9].The flexural strength at the end of 28 days curing is 1/6 of compressive strength at 28 days.

Testing of Beams for Flexural strength test

4.1.3 Permeability test on concrete

Permeability test is conducted as per DIN 1048[10].

Permeability Assembly

Table 9: Permeability test results for the M20 and M40 grade Concrete

Grade of concrete	w/c ratio	Mix combination of fine aggregate and	Avg. depth of penetration in cm
M20	0.53	local coarse aggregate	0.80
		(100%)GMW coarse aggregate	1.14
M40	040	local coarse aggregate	0.73
		(100%)GMW coarse aggregate	1.05

From table No 9, For M20 and M40 grade Concrete, it is observed that the depth of penetration in case of GMW concrete is higher as compare control mix concrete, this may be due to higher water absorption of GMW coarse aggregates.

4.1.4 Reaction to Chloride Attack of Concrete

Table 10: Results of Chloride attack test for the M20 and M40 grade Concrete

Grade of concrete	w/c ratio	Mix combination of fine aggregate and	Average loss of weight in %	Average loss of compressive strength in %
M20	0.53	local coarse aggregate	0.183	1.78
		(100%)GMW coarse aggregate	0.324	2.51
M40	040	local coarse aggregate	0.170	1.81
		(100%)GMW coarse aggregate	0.300	2.45

From table No 10, For M20 and M40 grade Concrete, it is observed that the loss of weight and loss of compressive strength of both concrete is very less.

V. Conclusion

Following conclusions are drawn from this investigation.

1. The specific gravity for both locally available and GMW Coarse Aggregate are same but Variation in Fineness modulus and bulk density due to manual crushing of GMW coarse aggregate. The water absorption of GMW coarse aggregate is higher than local aggregate.
2. GMW coarse aggregate are stronger as compare to local coarse aggregate, this evident from the results of crushing value of both the aggregate.
3. The workability of local and GMW coarse aggregate is nearly same in terms of slump.
4. For M20 and M40 grade concrete, the compressive strength of both control and GMW concrete has exceeded the target mean strength. The compressive strength of GMW concrete is higher than the control concrete. The relation between 7 and 28 days compressive strength is agreement with the various researchers.
5. For M20 and M40 grade concrete, the flexural strength of both control and GMW concrete has exceeded the theoretical value of flexural strength. The flexural strength of GMW concrete is higher than the control concrete.
6. From permeability tests results for M20 and M40 grade concrete, the depth of penetration of GMW concrete is higher as compare to control concrete; this may be due to high water absorption of GMW coarse aggregate.
7. Concrete using Goldmines waste coarse aggregate is resistant to chloride attack after immersion for a period of 28 days.

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