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A Study of Compressive Strength on Black Stone Marble Waste Aggregate Concrete

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ABSTRACT

The study is based on the use of Black Stone Marble Waste Aggregate Concrete (BSMWC). The high consumption usage of materials like coarse aggregate will result shortage in future and also environmental damage. Presently large amount of BSMWA is generated in marble and slab industry during processing. Therefore, this study is intended to investigate the possibility of usage of the marble waste in concrete. In this study the natural aggregate is replaced by black stone marble waste with proportions of 0, 25, 50, 75 and 100% and addition of fiber 0, 1 and 2%.

Keywords: Natural coarse aggregate concrete, Black stone marble waste aggregate concrete, cube compressive strength and steel fiber.

1. INTORDUCTION

Most often waste aggregate produced from slab industry are huge in quantity and these materials are dumped near road sides. For construction industrialization sector present and past, the urbanization growth increases with the consumption of natural aggregate material and it led to fast decline in available natural resources. Granite and marble aggregates, which are by-products come from the granite and marble stone industries. The Kadapa and Anantapuramu (Dist) of Andhra Pradesh, India are much more potential for natural black stone layers. In this connection a research work planned to utilize this waste material in fiber reinforced concrete as low cost building material. The deficiency has been attracted many researchers in the last few years and investigations are been carried out to understand the behavior of the waste aggregate concrete. Presenting the recent literature on utilization of waste aggregate in concrete. Olga et al, [1] studied the physical-mechanical properties of stone waste aggregate and concluded that the concrete density was decreased by 2.8% and strength decreased by 9%. Harika et all, [2] studied the temperature effect of concrete with waste layered aggregate collected from cuddapah stone polishing industry and concluded that the compressive strength was decreased as the percentage of waste stone aggregate increases from 25 to 100% and also as the temperature increase the ultimate strength of concrete reduces. H. Beshr et all [3] studied the coarse aggregate quality on mechanical properties of High strength concrete with various types of coarse aggregates and results shows the split tensile strength of slag aggregate concrete was higher than the waste stone aggregate. Parekh and Modhera, [4] studied on recycled aggregate concrete, explained basic properties of concrete like flexural strength, compressive strength and workability for different combinations of replacing waste stone aggregate with natural aggregate. Maselhuddin et all [5] studied comparison of properties of steel slag and crushed stone aggregate, concluded the durability characteristics of steel slag cement concrete were better than the crushed stone aggregate concrete and the compressive strength of steel slag aggregate concrete was marginally better than crushed stone aggregate. Ke-Ru et al, [6] Effect of coarse aggregate on mechanical properties of High-strength concrete, are studied and concluded that 10-20% higher compressive and splitting tensile strengths are observed with crushed quartzite when compared to marble aggregate. Ghrici et al, [7] Investigated durability of mortar and concrete, concluded lower expansion was identified in pozzolanic cement, but no change in sulphate resistance of lime stone cement. Gopinath and Senthamarai, [8] studied Mechanical properties of concrete with ceramic waste aggregate, concluded compressive strength with ceramic waste aggregate was slightly more than stone aggregate concrete.

2. EXPERIMENTAL PROGRAM

The Experimental program comprises of casting and testing of cubes of standard size of (150mmx150mmx150mm) with replacement of natural aggregate by black stone marble waste aggregate of proportions 0, 25, 50, 75 and 100 percentage and incorporation of fiber with 0, 1 and 2%.

2.1 Materials

The materials used in concrete are discussed below.

2.1.1 Cement

Ordinary Portland cement of grade 43 confirming to IS 8112-1989 was used and specific gravity of cement were observed as 3.05. The initial and final setting times were found 45 and 360 minutes respectively.

2.1.2 Coarse Aggregate

A. **Natural Coarse aggregate**

Crushed granite aggregate available from local source have been used. To obtain reasonably good grading 60% of the aggregate passing through 20mm and retained on 12.5 mm sieve was used the specific gravity of granite aggregate were observed as 2.75.

B. **Stone waste coarse aggregate**

The raw material of waste aggregate as obtained from stone polishing industry from Tadipatri town in Anantapuram dirstict. To convert the waste material as a coarse aggregate collecting from the polishing industry and crushing was made for 20mm and 12.5mm aggregate. To obtain good grading 50% of the aggregate passing through 20 mm and retained on 12.5 mm sieve and rest of the 50% aggregate passing through 12.5mm and retained on 10mm sieve. The specific gravity of stone waste aggregate was observed as 2.68.

2.1.3 Fine Aggregate

River sand used as a fine aggregate collected from local source. The specific gravity of fine aggregate were observed as 2.70.

2.1.4 Water

Portable water, which is free from acids and organic substances, was used for preparing the concrete mix.

2.1.5 Fiber

The crimple fiber with aspect ratio of 50 has been used for the experimental work. The fibers were obtained from Pune. The physical properties of rounded crimple fibers are shown in the below table 1 and the same fibers can be viewed in figure 1.

Table 1: Properties of rounded crimped steel fiber

S.No	Property	Values
1	Equivalent Diameter, mm	1.00
2	Specific Gravity, (kg/m3)	7840
3	Tensile Strength, (Mpa)	345
4	Young's Modulus. (Gpa)	200
5	Ultimate Elongation, %	10
6	Aspect Ratio	50

Figure 1: Crimped fiber

2.2 Casting

The Cubes are casted in steel moulds of inner dimensions of 150 x 150 x 150mm. All the materials are weighed as per the mix design. The cement, coarse aggregate, fine aggregate, crimped fibers and black stone marble waste aggregate were mixed thoroughly till it reach uniformly in to the concrete mix. While mixing utmost care has to be taken to avoid balling effect.

All the test specimens with moulds were kept on the table vibrator and place the concrete in to the moulds in layers and compaction was done by mechanical vibrator. After 24 hours the moulds were removed and the specimens were exposed to water bath for 7, 28 and 90 days in curing pond. The specimens are taken out from curing pond and kept under shade to allow drying before testing.

2.3 Test program

The detailed test procedure discussed below

2.3.1 Compressive Strength

The test set up for conducting cube compressive strength test is depicted in figure 2. Compression test on cubes was conducted with 2000kN capacity compression testing machine. The machine has a least count of 1kN. The cube was placed in the compression testing machine and the load on the cube is applied at a constant rate till to failure of the specimen and the corresponding load is noted as ultimate load. Then the cube compressive strength of the specimen is computed by using standard formula and the results are presented below.

Figure 2: Compression Testing Machine (CTM)

2.4 Analysis of Test Results

The experimental results of cube compressive strengths are presented in the table 2, 3 and table 4 and figure 3, 4 and figure 5. The values presented here are the average compressive strength obtained from the three specimens. Based on the results from the experimentation, the following section presents an analysis and gives insights in to the behavior of BSMWAC concrete cubes.

The cube compressive strength with 0% fiber and replacement of BSMW aggregate concrete by 25, 50, 75 and 100 % and natural aggregate concrete are discussed below.

The results of cube compressive strength made with natural aggregate concrete and black stone marble waste aggregate concrete for 7, 28 and 90 days are presented in table 2 and the graph were drawn cube compressive strength Vs percentage replacement of

BSMWAC and are shown in figure 3. From table 2 and figure 3 the results shows that as the replacement of BSMW aggregate percentage increases the ultimate compressive strength decreases continuously.

For NAC-0-0 the ultimate strength reported for 7 days as 27.15 MPa and BSMWAC-25-0, BSMWAC-50-0, BSMWAC-75-0 and BSMWAC-100-0 the ultimate strengths are 23.07, 18.13, 16.53 and 12.13 MPa respectively.

Percentage decrease of compressive strength for 7 days with respect to NAC-0-0 are 15.03, 33.22, 39.12 and 55.32 for BSMWAC-25-0, BSMWAC -50-0, BSMWAC -75-0, BSMWAC -100-0 respectively.

For NAC-0-0 the ultimate strength reported for 28 days as 33.11 MPa and BSMWAC-25-0, BSMWAC-50-0, BSMWAC-75-0 and BSMWAC-100-0 the ultimate strengths are 29.33, 24.04, 21.95 and 17.20 MPa respectively.

Percentage decrease of compressive strength for 28 days with respect to NAC-0-0 are 11.42, 27.38, 33.71 and 48.05 for BSMWAC-25-0, BSMWAC -50-0, BSMWAC -75-0, BSMWAC -100-0 respectively. From the above we can recommend up to 50% replacement of BSMWA concrete for general purpose and may be used where the strength and durability is not of much importance.

For NAC-0-0 the ultimate strength reported for 90 days as 37.60 MPa and BSMWAC-25-0, BSMWAC-50-0, BSMWAC-75-0 and BSMWAC-100-0 the ultimate strengths are 33.42, 27.42, 24.97 and 20.17 MPa respectively.

Percentage decrease of compressive strength for 90 days with respect to NAC-0-0 are 11.22, 27.07, 33.59 and 46.36 for BSMWAC-25-0, BSMWAC -50-0, BSMWAC -75-0, BSMWAC -100-0 respectively.

For NAC-0-1 the ultimate strength reported for 7 days as 29.12 MPa and BSMWAC-25-1, BSMWAC-50-1, BSMWAC-75-1 and BSMWAC-100-1 the ultimate strengths are 25.23, 20.13, 18.15 and 13.37 MPa respectively and the values are shown in table 3 and figure 4.

Percentage decrease of compressive strength for 7 days with respect to NAC-0-1 are 13.36, 30.87, 37.67 and 54.09 for BSMWAC-25-1, BSMWAC -50-1, BSMWAC -75-1, BSMWAC -100-1 respectively

For NAC-0-1 the ultimate strength reported for 28 days as 34.25 MPa and BSMWAC-25-1, BSMWAC-50-1, BSMWAC-75-1 and BSMWAC-100-1 the ultimate strengths are 30.42, 25.36, 23.25 and 18.15 MPa respectively.

Percentage decrease of compressive strength for 28 days with respect to NAC-0-1 are 11.18, 25.96, 32.12 and 45.96 for BSMWAC-25-1, BSMWAC -50-1, BSMWAC -75-1, BSMWAC -100-1 respectively. From the above we can recommend up to 50% replacement of BSMWA concrete for general purpose and may be used where the strength and durability is not of much importance.

For NAC-0-1 the ultimate strength reported for 90 days as 38.44 MPa and BSMWAC-25-1, BSMWAC-50-1, BSMWAC-75-1 and BSMWAC-100-1 the ultimate strengths are 34.43, 28.66, 26.46 and 21.55 MPa respectively.

Percentage decrease of compressive strength for 90 days with respect to NAC-0-1 are 10.43, 25.44, 31.17 and 43.94 for BSMWAC-25-1, BSMWAC -50-1, BSMWAC -75-1, BSMWAC -100-1 respectively.

For NAC-0-2 the ultimate compressive strength for 7 days were 31.05 MPa and BSMWAC-25-2, BSMWAC-50-2, BSMWAC-75-2 and BSMWAC-100-2 the ultimate strengths are 27.13, 22.18, 20.27 and 14.59 MPa respectively and the values are shown in table 4 and figure 5.

Percentage decrease of compressive strength for 7 days with respect to NAC-0-2 are 12.62, 28.57, 34.72 and 53.01 for BSMWAC-25-2, BSMWAC -50-2, BSMWAC -75-2, BSMWAC -100-2 respectively.

For NAC-0-2 the ultimate strength reported for 28 days as 35.39 MPa and BSMWAC-25-2, BSMWAC-50-2, BSMWAC-75-2 and BSMWAC-100-2 the ultimate strengths are 31.45, 26.40, 24.32 and 19.23 MPa respectively.

Percentage decrease of compressive strength for 28 days with respect to NAC-0-2 are 11.13, 25.40, 31.28 and 45.66 for BSMWAC-25-2, BSMWAC -50-2, BSMWAC -75-2, BSMWAC -100-2 respectively.

For NAC-0-2 the ultimate strength reported for 90 days as 40.51 MPa and BSMWAC-25-2, BSMWAC-50-2, BSMWAC-75-2 and BSMWAC-100-2 the ultimate strengths are 36.49, 30.38, 28.41 and 23.13 MPa respectively.

Percentage decrease of compressive strength for 90 days with respect to NAC-0-2 are 9.92, 25.01, 29.87 and 42.90 for BSMWAC-25-2, BSMWAC-50-2, BSMWAC -75-2, BSMWAC -100-2 respectively.

From the above we can recommend up to 75% replacement of BSMWAC-75-2 for all structural members.

Table 2: Compressive strength for black stone marble waste aggregate concrete with 0% fiber for 7, 28 and 90 days.

S.No	Nomenclature	Average stress ((N/mm^2)			% stress decreased with respect to		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
1	NAC-0-0	27.15	33.11	37.60	-	-	-
2	BSMWC-25-0	23.07	29.33	33.42	15.03	11.42	11.12
3	BSMWC-50-0	18.13	24.04	27.42	33.22	27.38	27.07
4	BSMWC-75-0	16.53	21.95	24.97	39.12	33.71	33.59
5	BSMWC-100-0	12.13	17.20	20.17	55.32	48.05	46.36

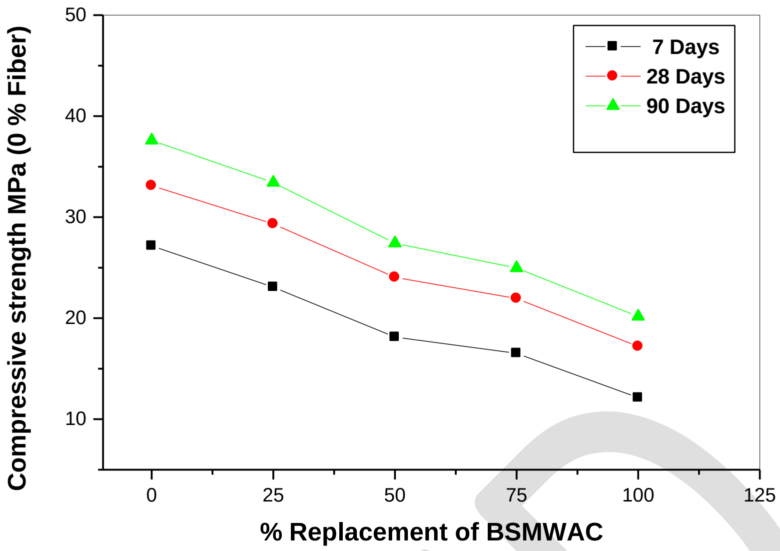

Fig. 3: compressive strength of concrete Vs % replacement of BSMWAC

Table 3: Compressive strength of black stone marble waste aggregate concrete with 1% fiber for 7, 28 and 90 days

S.No	Nomenclature	Average stress ((N/mm^2)			% stress decreased with respect to		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
1	NAC-0-1	29.12	34.25	38.44	-	-	-
2	BSMWC-25-1	25.23	30.42	34.43	13.36	11.18	10.43
3	BSMWC-50-1	20.13	25.36	28.66	30.87	25.96	25.44
4	BSMWC-75-1	18.15	23.25	26.46	37.67	32.12	31.17
5	BSMWC-100-1	13.37	18.51	21.55	54.09	45.96	43.94

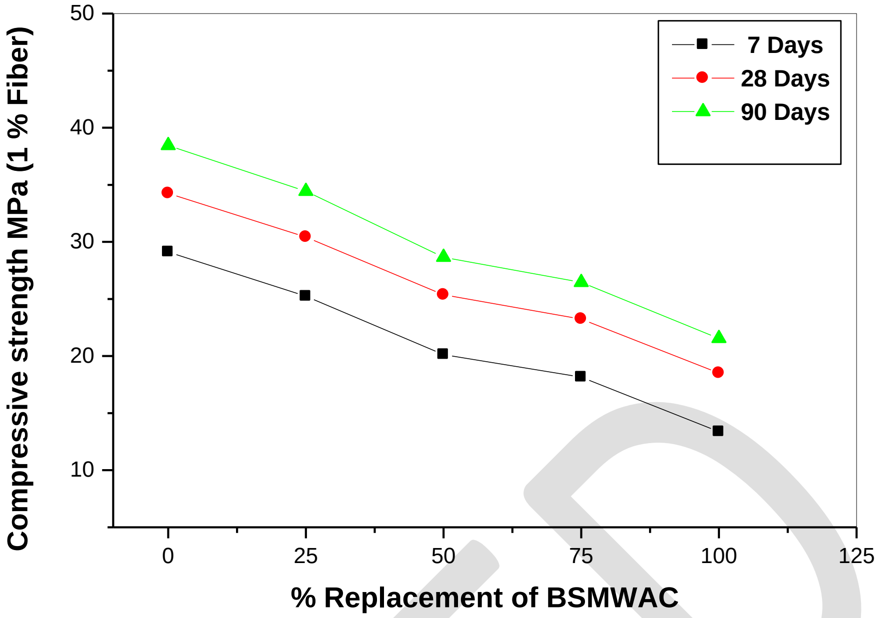

Fig. 4: compressive strength of concrete Vs % replacement of BSMWAC

Table 4: Compressive strength of black stone marble waste aggregate concrete with 2% fiber for 7, 28 and 90 days

S.No	Nomenclature	Average stress ((N/mm^2)			% stress decreased with respect to		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
1	NAC-0-2	31.05	35.39	40.51	-	-	-
2	BSMWC-25-2	27.13	31.45	36.49	12.62	11.13	9.92
3	BSMWC-50-2	22.18	26.40	30.38	28.57	25.40	25.01
4	BSMWC-75-2	20.27	24.32	28.41	34.72	31.28	29.87
5	BSMWC-100-2	14.59	19.23	23.13	53.01	45.66	42.90

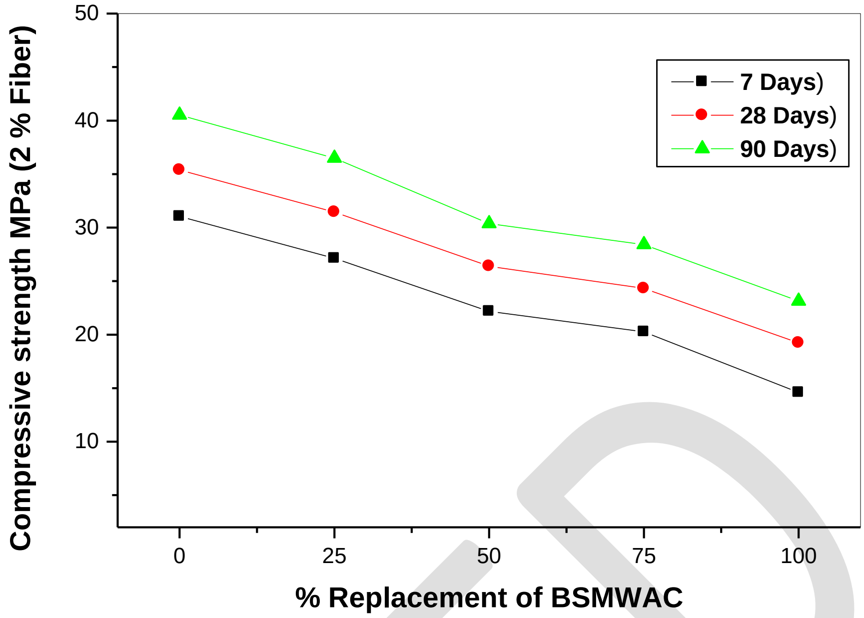

Fig. 5: compressive strength of concrete Vs % replacement of BSMWAC

CONCLUSIONS

1. The workability of black stone marble waste aggregate concrete is increased when compared with natural coarse aggregate.
2. The compressive strength of natural aggregate concrete is higher than those of BSMWAC-25 to BSMWAC-100.
3. The incorporation of black stone marble waste is beneficial for concrete works up to 75% replacement of black stone marble waste and with 2% fiber.

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