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An Experimental Study of Split Tensile Strength on Black Stone Marble Waste Aggregate Concrete

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ABSTRACT

The study is to understand the behavior of concrete made with Black Stone Marble Waste Aggregate (BSMWA). The consumption of materials like coarse aggregate, fine aggregate, it will result the shortage the same in the future and also to environmental damage. Presently large quantum of Black Stone Marble Waste Aggregate is generated in marble and slab industry during the processing. Therefore, this study is to investigate the possibility of utalisation of the marble waste in concrete. The natural aggregate is replaced by the black stone marble waste with a proportion of 0, 25, 50, 75 and 100% and with addition of fiber 0, 1 and 2 percentages.

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

1. INTORDUCTION

Generally the waste aggregate produced from the slab industry are huge in quantity and they are dumped on road sides. For the construction industry sector past and present, the urbanization growth increases with the consumption of natural aggregate material and it led to decline in available natural resources. Marble and granite aggregates, which are by-products from the marble and granite stone industries. India is much more potential for natural black stone layers. In this context a research work has planned to utilize this waste material in fiber reinforced concrete. The deficiency has been attracted researchers in the last few years and the investigation has been carried out to understand the behavior of waste aggregate concrete. Presenting the recent literature on utilization of waste aggregate in concrete. Murali et al, [1] studied the concrete properties with different stone waste aggregate concrete like granite stone aggregate concrete, recycled aggregate concrete, shabath stone aggregate concrete and natural aggregate concrete and concluded that the split tensile strength of concrete of granite stone aggregate concrete was 5.39% lesser than the natural aggregate concrete. Rajendra and Gokulram [2] studied the strength properties of concrete aggregate with waste cuddapah stones with replacement of 20, 40 and 60%. At 60% waste stone with 20% fly ash the split tensile strengths are more than the conventional concrete. Ikponmwosa and Ehikhuenmen [3] investigated on the partial replacement of ceramic as a coarse aggregate with replacement levels of 25, 50 and 75%. They concluded that the split tensile strengths are 8.39 Mpa to 6.13 Mpa for the control specimen and 75% replacement respectively. Giridhar et al [4] studied the influence of ceramic waste aggregate on strength properties of concrete with replacement of 0, 20, 40, 60, 80 and 100%. And reported that the replacement levels are increased, and the split tensile strengths are decreased. Arunakanthi and nirmala [5] studied the workability and strength characteristics of concrete with waste marble aggregate replacement 0, 5, 10, 15, 20 and 25%. The results are shown that up to 10% replacement of coarse aggregate by waste marble aggregate, the split tensile strengths are increased and beyond 10% replacement the strengths are decreased. Roshan Lal and Kuldeep Kumar [6] investigated the strength characteristics of recycled aggregate concrete of marble waste and the results shows that up to 30% replacement the split tensile strengths are increased beyond that the split tensile strengths are decreased.

2. EXPERIMENTAL PROGRAM

The Experimental program comprises of casting and testing of cylinders of standard size of (150mmx300mm) 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 and the specific gravity of granite aggregate was 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. The waste material is collecting from polishing industry and converting as a coarse aggregate. 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 was observed as 2.70.

2.1.4 Water

Potable 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 Figure 1.

Table 1: Properties of rounded crimped steel fiber

S.No	Property	Values
1	Equivalent Diameter, mm	1.0
2	Aspect Ratio	50
3	Ultimate Elongation, %	10
4	Tensile Strength, (Mpa)	345
5	Young's Modulus. (Gpa)	200
6	Density (kg/m3)	7840

Figure 1: Crimped fiber

2.2 Casting

The cylinders were cast in moulds of inner dimensions of 150 mm diameter and 300mm height. 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 is 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 Split tensile Strength

The test set up for conducting cylinder split tensile strength test is depicted in figure 2. Split tensile test was conducted with a uniform load is applied until cylinder fails. The same load is considered as ultimate load. Split tensile strength is calculated from this load for each specimen by using standard formula. Results are presented below

Figure 2: Split tensile strength Testing Machine (CTM)

2.4 Analysis of Test Results

The experimental results of split tensile 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 split tensile 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 cylindres.

The cylinder tensile 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 split tensile 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 split tensile 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 split tensile strength reported for 7 days are 2.77 MPa and BSMWAC-25-0, BSMWAC-50-0, BSMWAC-75-0 and BSMWAC-100-0, the ultimate strengths are 2.35, 1.86, 1.70 and 1.27MPa respectively.

Percentage decrease of split tensile strength for 7 days with respect to NAC-0-0 are 15.03, 32.79, 38.67 and 54.26 for BSMWAC-25-0, BSMWAC -50-0, BSMWAC -75-0, BSMWAC -100-0 respectively.

For NAC-0-0 the split tensile strength reported for 28 days as 3.38 MPa and BSMWAC-25-0, BSMWAC-50-0, BSMWAC-75-0 and BSMWAC-100-0, the ultimate strengths are 3.0, 2.48, 2.24 and 1.78 MPa respectively.

Percentage decrease of split tensile strength for 28 days with respect to NAC-0-0 are 11.30, 26.57, 33.82 and 47.28 for BSMWAC-25-0, BSMWAC -50-0, BSMWAC -75-0, BSMWAC -100-0 respectively. From the above it can be 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 split strength reported for 90 days as 3.84 MPa and BSMWAC-25-0, BSMWAC-50-0, BSMWAC-75-0 and BSMWAC-100-0 the ultimate strengths are 3.43, 2.80, 2.56 and 2.06 MPa respectively.

Percentage decrease of split tensile strength for 90 days with respect to NAC-0-0 are 10.69, 27.07, 33.20 and 46.36 for BSMWAC-25-0, BSMWAC -50-0, BSMWAC -75-0, BSMWAC -100-0 respectively.

For NAC-0-1 the split strength reported for 7 days as 2.97 MPa and BSMWAC-25-1, BSMWAC-50-1, BSMWAC-75-1 and BSMWAC-100-1 the ultimate strengths are 2.59, 2.05, 1.87 and 1.38 MPa respectively and the values are shown in table 3 and figure 4.

Percentage decrease of split tensile strength for 7 days with respect to NAC-0-1 are 12.79, 30.87, 37.10 and 53.54 for BSMWAC-25-1, BSMWAC -50-1, BSMWAC -75-1, BSMWAC -100-1 respectively

For NAC-0-1 the split strength reported for 28 days as 3.51 MPa and BSMWAC-25-1, BSMWAC-50-1, BSMWAC-75-1 and BSMWAC-100-1 the ultimate strengths are 3.10, 2.60, 2.37 and 1.90 MPa respectively.

Percentage decrease of split tensile strength for 28 days with respect to NAC-0-1 are 11.61, 26.01, 32.44 and 45.97 for BSMWAC-25-1, BSMWAC -50-1, BSMWAC -75-1, BSMWAC -100-1 respectively. From the above it can be 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 split strength reported for 90 days as 3.92 MPa and BSMWAC-25-1, BSMWAC-50-1, BSMWAC-75-1 and BSMWAC-100-1 the ultimate strengths are 3.52, 2.92, 2.71 and 2.20 MPa respectively.

Percentage decrease of split tensile strength for 90 days with respect to NAC-0-1 are 10.29, 25.44, 30.87 and 43.94 for BSMWAC-25-1, BSMWAC -50-1, BSMWAC -75-1, BSMWAC -100-1 respectively.

For NAC-0-2 the split tensile strength for 7 days were 3.18 MPa and BSMWAC-25-2, BSMWAC-50-2, BSMWAC-75-2 and BSMWAC-100-2 the ultimate strengths are 2.77, 2.27, 2.07 and 1.49 MPa respectively and the values are shown in table 4 and figure 5.

Percentage decrease of split tensile strength for 7 days with respect to NAC-0-2 are 12.91, 28.51, 34.74 and 53.17 for BSMWAC-25-2, BSMWAC -50-2, BSMWAC -75-2, BSMWAC -100-2 respectively.

For NAC-0-2 the split strength reported for 28 days as 3.62 MPa and BSMWAC-25-2, BSMWAC-50-2, BSMWAC-75-2 and BSMWAC-100-2 the ultimate strengths are 3.21, 2.69, 2.50 and 1.97MPa respectively.

Percentage decrease of split tensile strength for 28 days with respect to NAC-0-2 are 11.47, 25.69, 31.05 and 45.51 for BSMWAC-25-2, BSMWAC -50-2, BSMWAC -75-2, BSMWAC -100-2 respectively.

For NAC-0-2 the split strength reported for 90 days as 4.13 MPa and BSMWAC-25-2, BSMWAC-50-2, BSMWAC-75-2 and BSMWAC-100-2 the ultimate strengths are 3.73, 3.10, 2.91 and 2.37 MPa respectively.

Percentage decrease of split tensile strength for 90 days with respect to NAC-0-2 are 9.74, 25.01, 29.61 and 42.62 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: Split tensile strength for black stone marble waste aggregate concrete with 0% fiber for 7, 28 and 90 days.

S.No	Nomenclature	Average strength (N/mm^2)			% strength decreased with respect to NAC-0-0		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
1	NAC-0-0	2.77	3.38	3.84	-	-	-
2	BSMWC-25-0	2.35	3.00	3.43	15.03	11.30	10.69
3	BSMWC-50-0	1.86	2.48	2.80	32.79	26.57	27.07
4	BSMWC-75-0	1.70	2.24	2.56	38.67	33.82	33.20
5	BSMWC-100-0	1.27	1.78	2.06	54.26	47.28	46.36

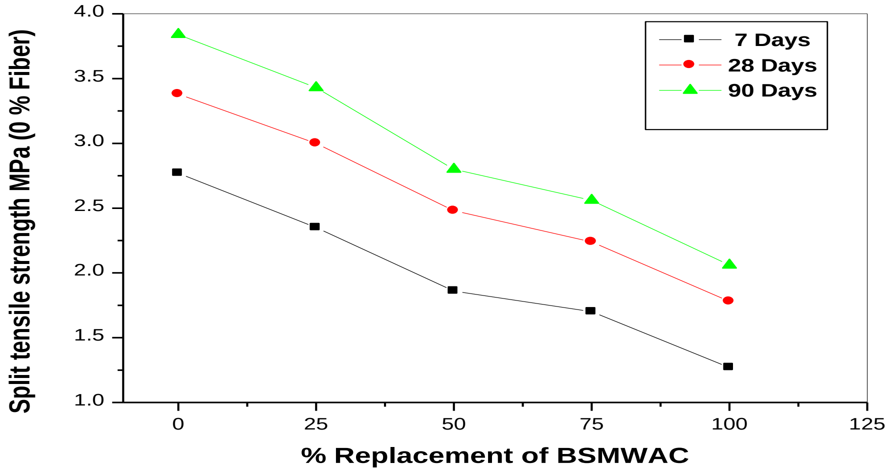

Fig. 3: split tensile strength of concrete Vs % replacement of BSMWAC

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

S.No	Nomenclature	Average strength (N/mm^2)			% strength decreased with respect to NAC-0-01		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
1	NAC-0-1	2.97	3.51	3.92	-	-	-
2	BSMWC-25-1	2.59	3.10	3.52	12.79	11.61	10.29
3	BSMWC-50-1	2.05	2.60	2.92	30.87	26.01	25.44
4	BSMWC-75-1	1.87	2.37	2.71	37.10	32.44	30.87
5	BSMWC-100-1	1.38	1.90	2.20	53.54	45.97	43.94

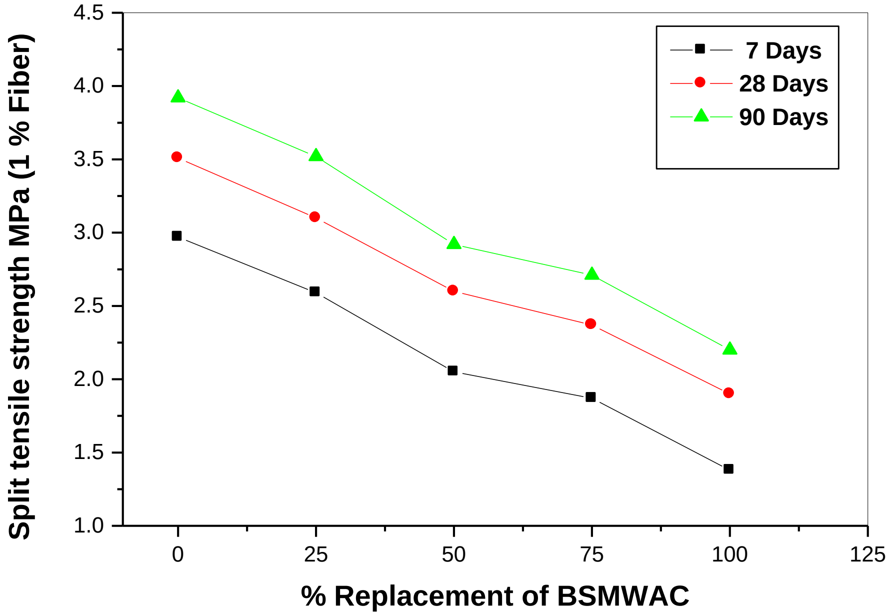

Fig. 4: split tensile strength of concrete Vs % replacement of BSMWAC

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

S.No	Nomenclature	Average strength (N/mm^2)			% strength decreased with respect to NAC-0-2		
		7 Days	28 Days	90 Days	7 Days	28 Days	90 Days
1	NAC-0-2	3.18	3.62	4.13	-	-	-
2	BSMWC-25-2	2.77	3.21	3.73	12.91	11.47	9.74
3	BSMWC-50-2	2.27	2.69	3.10	28.51	25.69	25.01
4	BSMWC-75-2	2.07	2.50	2.91	34.74	31.05	29.61
5	BSMWC-100-2	1.49	1.97	2.37	53.17	45.51	42.62

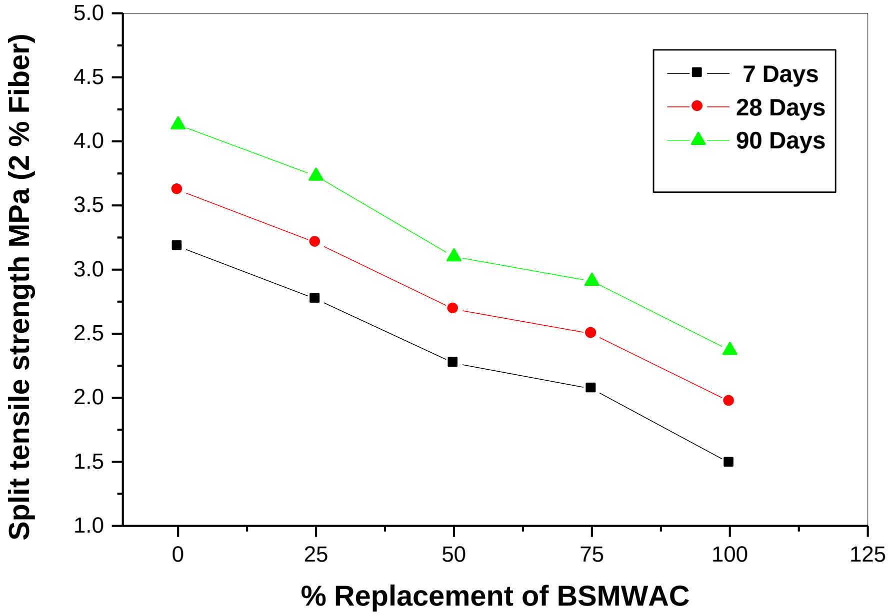

Fig. 5: split tensile strength of concrete Vs % replacement of BSMWAC

CONCLUSIONS

1. The workability of black stone marble waste aggregate concrete is increased when compared with natural coarse aggregate.
2. The split tensile 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.
4. The usage of this aggregate is recommended after considering compression, flexural strength.

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