AN INVESTIGATION ON STRENGTH CHARACTERISTICS OF CONCRETE CONTAINING RECYCLED AGGREGATES OF MARBLE AND GRANITE WASTE

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Abstract— The results obtained from the present investigation on strength characteristics of concrete containing natural aggregates and natural aggregates with partial replacement by marble and granite waste aggregates in different percentages have been presented. In the series of test conducted when natural aggregates were replaced by marble waste and granite waste aggregates used in equal proportions with replacement of natural aggregates by 20% (10% marble +10% granite) , 30% (15% marble +15% granite),40% (20% marble +20% granite) were cast. The compressive strength of specimens were tested for mixes containing marble and granite waste as recycled aggregates increased for replacement 20% and 30%. However for the 40% replacement of marble and granite waste aggregate with natural aggregate a marginal decrease in compressive strength is recorded. Therefore it can be concluded that the production of concrete of normal strength is feasible and viable by replacing the natural aggregates by the waste marble and granite aggregates without compromising the strength characteristics.

Index Terms—Specific-Gravity, Water Absorption, Fineness Modulus and Compressive Strength.

1. INTRODUCTION

Recycling is the act of processing the used material for use in creating new product. Stone waste i.e. Marble and Granite waste has been commonly used as building materials. Today industry's disposal of stone waste is one of the environmental problems around the world .Stones are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, the original stone mass is lost by 30%. The waste is dumped in nearby pits and vacant spaces. This leads to serious environmental pollution an occupation of vast area of land. So it poses a severe threat on the environment, eco-system and the health of the people. The Quarrying and Trimming waste also poses a serious environmental damages.

So it is necessary to use this stone waste in construction industry. Recycled aggregate of Marble and Granite waste are comprised of crushed, graded inorganic particles processed from the materials that have been considered as a waste material. In the present study an effort has been made to explore the possibility of using these materials as part replacement of natural aggregates
for making concrete.

Terzi and Karasahin (2003) investigated the use of marble dust in asphalt mixtures as a filler material for optimum filler/bitumen and filler ratio. They have concluded that marble wastes in the dust form could be used in such cases.

Abkulut and Cahit (2007) studied the use of marble quarry waste in asphalt pavements with bitumen. They reported that waste materials can potentially be used as aggregates in light to medium trafficked asphalt pavement binder layers.

Binici etal. (2008) studied durability of concrete containing granite and marble as coarse aggregates. The result indicated that marble, granite and ground blast furnace slag replacement provide a good durable concrete.

Wattanasiriwech et al. (2009) investigated the use of waste mud from ceramic tile production in paving blocks and determined compressive strengths of these blocks. They observed that the blocks containing cement 20 weight% gave satisfactory strength values.

Pereira et al. (2009) performed an experimental study using a number of coarse aggregates from different geological sources including granite, basalt, limestone and marble. They produced concretes in specific mix proportions and laboratory controlled conditions. They explored that concrete durability properties were not affected by aggregates mineralogy, but in turn were significantly affected by the aggregate size and its water content.

Padmini et al. (2009) investigated the properties of recycled aggregates from parent concrete (PC) of three strengths, each of them made with three maximum sizes of aggregates. They produced recycled aggregate concrete (RAC) using these recycled aggregates. They found that RAC required relatively lower water-cement ratio as compared to PC to achieve a particular compressive strength. They also determined that the difference in strength between PC and RAC increased with strength of concrete.

Martínez-Barrera and Brostow (2010) studied effects of gamma irradiation and the marble particle size on compressive properties and the dynamic elastic modulus of polymer concretes. One of the conclusions was that both compressive properties and the dynamic elastic modulus values depend on the combination of the marble particle sizes and the applied radiation dose. Higher numbers of dispersed particles per unit volume provide more resistance to crack propagation. Medium size marble particles provide better compression modulus.

2. EXPERIMENTAL PROGRAMME

The test programme consisted of the testing of the constituent materials i.e. cement, fine aggregate, coarse aggregate as per relevant Indian Standard Codes of Practice .The physical properties of cement, fine, coarse natural, marble and granite aggregates used in investigation are presented in Tables 2.1 to 2.9.

Table 2.1: Physical Properties of Cement

Property	Experimental value	Specified Value as per IS:8112-1989
Consistency	30%	-
Specific Gravity	3.14	3.15
InitialSettingTime	92 minutes	>30 minutes
Final SettingTime	298 minutes	< 600
Comp. Strength (N/mm^2) ➢ 3 days ➢ 7days ➢ 28 days	24.67 35.04 47.28	>23 >33 >43
Fineness (Dry Sievieng)	2.5 %	< 10 %

Table 2.2: Sieve Analysis of Fine Aggregates

IS Sieve	Wt.Retained on Sieve (gm)	Cumulative Wt.Retained (gm)	%age Passing
10mm	0.00	0.00	100.00
4.75 mm	15.10	15.1	98.49
2.36 mm	25.20	40.30	95.97
1.18 mm	250.10	290.40	70.96
600 μ	160.00	450.40	54.96
300 μ	320.10	770.50	22.95
150 μ	217.10	987.60	1.24
Pan	12.40	1000	-

Cumulative percentage wt. retained =255.43

Fineness Modulus (F.M.) = $255.43/100 = 2.55$

Table 2.3: Physical Properties of Fine Aggregates

Characteristics	Results Obtained
Grading	Grading Zone II (IS: 383-1970)
Fineness Modulus	2.55
Specific Gravity	2.62
Water Absorption (%)	0.48%
Free Moisture	Nil

Table 2.4: Physical Properties of Coarse Natural Aggregates

Characteristics	Results Obtained
Fineness Modulus	6.6
Specific Gravity	2.66
Water Absorption	0.50%
Moisture Content (%)	Nil

Table 2.5: Fineness Modulus of Coarse Aggregates

I S Sieve	Average Wt. Retained(gm)	Cumulative Wt.Retained (gm)	%age Passing
80mm	0.00	0.00	100.00
40 mm	0.00	0.00	100.00
20 mm	167.5	167.5	96.65
10 mm	2895	3062.5	38.75
4.75 mm	1857.5	4920	1.6
Pan	-	-	-

Cumulative percentage wt. retained = 163.0 + 500

Fineness Modulus (F.M.) = 663/100= 6.63

Table 2.6: Fineness Modulus of Proportioned Coarse Marble Aggregates

I S Sieve	AverageWt. Retained(gm)	Cumulative Wt.Retained (gm)	%age Passing
80mm	0.00	0.00	100.00
40 mm	0.00	0.00	100.00
20 mm	137.5	137.5	97.25
10 mm	2370	2507.5	49.85
4.75	2430	4937.5	1.25
Pan	-	-	-

Cumulative percentage wt. retained = 151.65 + 500

Fineness Modulus (F.M.) = 651.65/100= 6.51

Table 2.7: Physical Properties of Coarse Marble Aggregates

Characteristics	Results Obtained
Fineness Modulus	6.51
Specific Gravity	2.68
Water Absorption (%)	0.32
Moisture Content (%)	Nil

Table 2.8: Fineness Modulus of Proportioned Coarse Granite Aggregates

I S Sieve	Average Wt. Retained (gm)	Cumulative Wt.Retained (gm)	%age Passing
80mm	0.00	0.00	100.00
40 mm	0.00	0.00	100.00
20 mm	112.5	112.5	97.75
10 mm	3311.25	3423.75	31.53
4.75	1210.87	4634.62	7.31
Pan	-	-	-

Cumulative percentage wt. retained = 163.41 + 500

Fineness Modulus (F.M.) = 663.41/100=6.63

Table 2.9:Physical Properties of Coarse Granite Aggregates

Characteristics	Results Obtained
Fineness Modulus	6.51
Specific Gravity	2.70
Water Absorption	0.49
Moisture Content	Nil

The details of mixes with and without marble and granite
waste aggregates are given in Table 2.10.

Table 2.10 Detailed Mix Proportions for Natural and Recycled Aggregate of Marble and Granite

Cement=399Kg/m^3,Water=191.5Kg/m^3 and w/c ratio=0.48

Mix	Natural F.A (kg/m3)	Natural C.A (kg/m3)	Marble C.A (kg/m3)	Granite C.A (kg/m3)
M 1	643	1157.6	---	
M 2	643	926.0	115.76	115.76
M 3	643	810.3	173.64	173.64
M 4	643	694.5	231.52	231.52

3. RESULTS AND DISCUSSION

3.1 Compressive Strength

To study the effect of replacement of natural aggregates by marble waste and granite waste aggregates used in equal proportions, cubical specimens with replacement of natural aggregates by 20% (10% marble +10% granite) , 30% (15% marble +15% granite),40% (20% marble +20% granite) were cast and tested. The results obtained for the specimen tested for compressive strength at 7 days and 28 days are reported in Table 3.1 and 3.2 respectively.

The comparison of compressive strength at 7 days and 28 days for specimens with natural aggregates and the specimens containing marble and granite waste aggregates in different percentages is shown in Figure 3.1 and 3.2.

Table 3.1: Test Results of Compressive Strength of Specimens at 7 Days

Mix Designation	%age Replacement	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
M1	0	21.05 26.19 21.38	22.87
M2	20	26.19 25.90 25.75	25.95
M3	30	24.80 24.33 26.55	25.22
M4	40	22.92 24.65 25.60	24.39

Table 3.2: Test Results of Compressive Strength of Specimens at 28 Days

Mix Designation	%age Replacement	Compressive Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
M1	0	29.78 28.47 30.34	29.53
M2	20	34.30 27.56 34.51	32.12
M3	30	33.14 31.52 28.80	31.15
M4	40	29.23 29.38 28.99	29.20

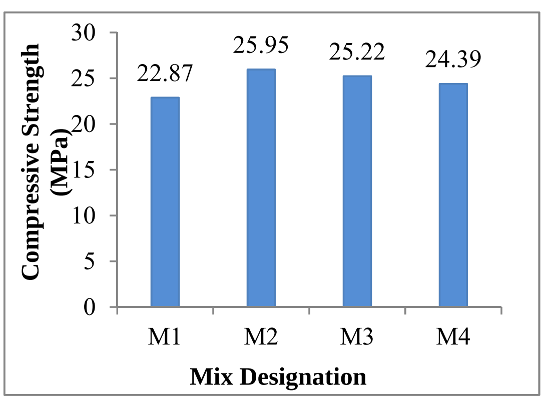

Fig. 3.1: Comparison of Compressive Strength of Specimens at 7 Days

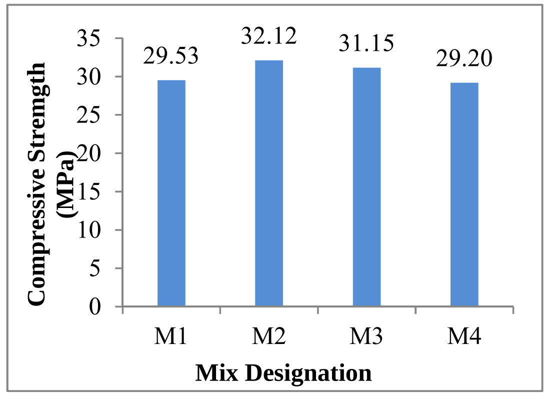

Fig. 3.2: Comparison of Compressive Strength of Specimens at 28 Days

It can be seen from Tables 3.1 and 3.2 and Figures 3.1, 3.2 that the compressive strength of mix M2 at 7 days and 28 days increased with replacement of natural aggregates by marble and granite waste aggregates by 20% when compared to the control mix M1. For M3 30% replacement of natural aggregates by marble and granite waste aggregates further increase in compressive strength was recorded as compared to control mix M1. For the mix M4 containing 40% replacement of natural aggregates by marble waste aggregates the decrease in compressive strength is recorded. The increase can be attributed to improved microstructure of concrete containing marble and granite waste aggregates which may be due to higher specific surface area of marble and granite aggregates and thus improving bond in between mortar and aggregates. The decrease in percentage improvement in compressive strength at higher replacement levels may be attributed to the grading effect. Figure 3.3 represents the typical mode of failure of cubical specimens.

Fig.3.3:Typical Mode of Failure for Cubical Specimens.

3.2 SPLIT TENSILE STRENGTH

To study the effect of replacement of natural aggregates by marble waste and granite waste aggregates used in equal proportions, cylindrical specimens with replacement of natural aggregates by 20% (10% marble+10%granite),30%(15%marble +15% granite),40% (20% marble +20% granite) were caste and tested. The results obtained for the specimen at 7 days and at 28 days are reported in Table 3.3 and 3.4.

Table 3.3: Test Results of Split Tensile Strength of Specimens at 7 Days

Mix Designation	%age Replacement	Split Tensile Strength (N/mm²)	Average strength (N/mm²)
M1	0	1.98 1.98 2.26	2.07
M2	20	2.26 2.26 2.12	2.21
M3	30	2.26 1.98 2.26	2.17
M4	40	1.98 1.98 1.98	1.98

Table 3.4: Test Results of Split Tensile Strength of Specimens at 28 Days

Mix Designation	%age Replacement	Split Tensile Strength (N/mm²)	Average strength (N/mm²)
M1	0	2.83 3.11 2.83	2.92
M2	20	3.39 3.39 3.11	3.29
M3	30	3.39 2.83 3.11	3.10
M4	40	2.83 2.83 2.55	2.73

The comparison of compressive strength at 7 days and 28 days for specimens with natural aggregates and the specimens containing marble and granite waste aggregates in different percentages is shown in Figures 3.4 and 3.5.

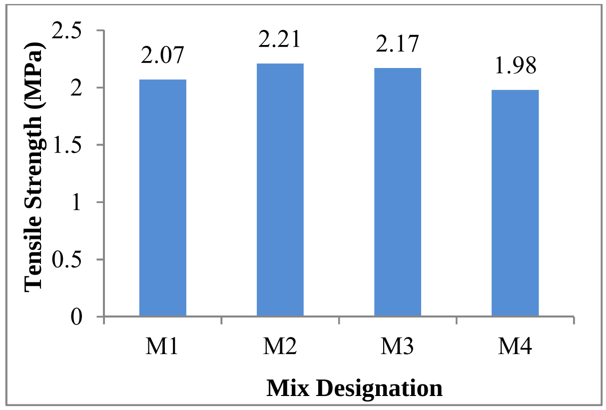

Fig. 3.4: Comparison of Split -Tensile Strength of Specimens at 7 Days

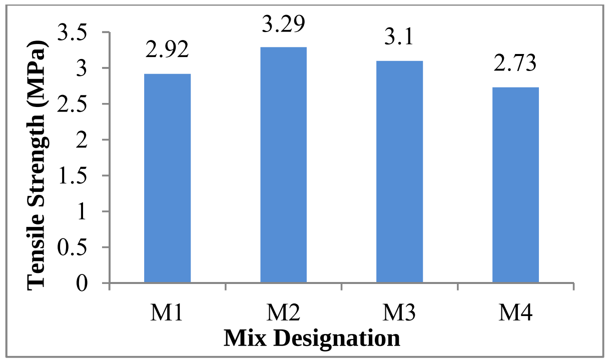

Fig. 3.5: Comparison of Split -Tensile Strength of Specimens at 28 Days

It can be seen from above Tables 3.3 and 3.4 and Figures 3.4 and 3.5 that in line with the results obtained for compressive strength , the similar trends were obtained for split tensile strength also which correlate the beneficiary effect of replacing natural aggregates by marble waste and granite waste aggregates mixed in equal proportions.

3.3 FLEXURAL STRENGTH

To study the effect of replacement of natural aggregates by marble waste and granite waste aggregates used in equal proportions, beam specimens with replacement of natural aggregates by 20% (10% marble +10% granite), 30% (15% marble +15% granite),40% (20% marble +20% granite) were cast and tested. The results obtained for the specimen are reported in Tables 3.5 and 3.6.

Table 3.5: Test Result of Flexural Strength of Specimens at 7 days

Mix Designation	%age Replacement	Flexural Strength (N/mm^2)	Average strength (N/mm^2)
M1	-	2.02 2.43 2.43	2.29
M2	20	2.83 2.63 2.83	2.76
M3	30	2.83 2.63 2.63	2.69
M4	40	2.43 2.43 2.63	2.49

Table 3.6: Test Result of Flexural Strength of Specimens at 28 days

Mix Designation	%age Replacement	Flexural Strength (N/mm^2)	Average strength (N/mm^2)
M1	-	3.64 3.84 3.64	3.70
M2	20	4.25 4.25 4.05	4.18
M3	30	3.64 4.05 4.25	3.98
M4	40	3.64 3.64 3.64	3.64

The comparison of compressive strength at 7 days and 28 days for specimens with natural aggregates and the specimens containing marble and granite waste aggregates in different percentages is shown in Figures 3.6 and 3.7.

It can be seen from above Tables 3.5 and 3.6 and Figures 3.6 and 3.7 that in line with the results obtained for compressive strength, the similar trends were obtained for flexural strength also which correlate the beneficiary effect of replacing natural aggregates by marble waste and granite waste aggregates mixed in equal proportions

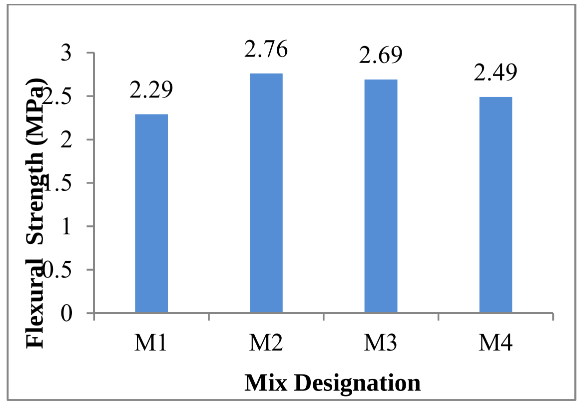

Fig.3.6:Comparison of Flexural Strength of Specimens at 7 Days

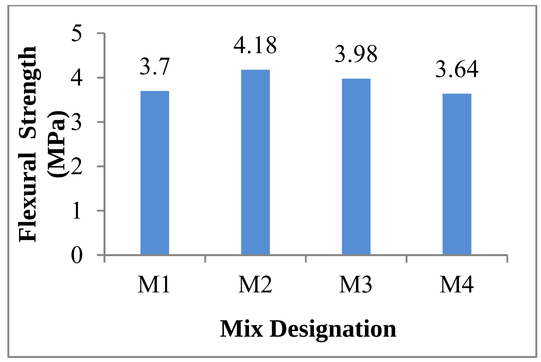

Fig. 3.7: Comparison of Flexural Strength of Specimens at 28 Days

4. CONCLUSIONS

1. The compressive strength, split-tensile strength and fl-exural strength of specimens tested in mixes containing marble and granite waste as recycled aggregates increased for replacement of 20% and 30%. However for the 40% replacement of marble and granite waste aggregates with natural aggregates marginal decrease in compressive strength is recorded. For mix containing 20% and 30% waste marble aggregates the compressive strength at 28 days was increased by 8.7 % and 5.5% when compared to the control mix.
2. The split tensile strength of specimens tested for mixes containing marble and granite waste as recycled aggregates increased for replacement of 20% and 30%. However for the 40% replacement of marble and granite waste aggregate with natural aggregate a marginal decrease in compressive strength is recorded. For mix containing 20% and 30% waste marble aggregates the split tensile strength is increased by 12.0% and 6% when compared to the control mix.

3. The flexural strength of specimens tested for mixes co-ntaining marble and granite waste as recycled aggregate increased for replacement of 20% and 30%. However for the 40% replacement of marble and granite waste aggregate with natural aggregate a marginal decrease in compressive strength is recorded. For mix containing 20% and 30% waste marble aggregates the flexural strength is increased by 12.9% and 7.5% when compared to the control mix.

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