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AN INVESTIGATION ON STRENGTH CHARACTERISTIC OF CONCRETE CONTAINING RECYCLED AGGREGATES OF MARBLE 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 waste aggregates in different percentages have been presented. Various specimens were cast and tested .The cubes were used to determine compressive strength, cylinder for determining split tensile strength and beams were cast to determine flexural strength. In the series of test conducted when natural aggregates were replaced by marble waste aggregates in percentages varyinf from 10% to 40% and the effect of replacement on the compressive strength, split tensile strength and flexural strength were observed. The compressive strength, split tensile strength and flexural strength of specimens were tested for mixes containing marble waste recycled aggregates increased for replacement upto 30%. However for the 40% replacement of marble waste aggregate with natural aggregate a marginal decrease in compressive, split and flexural 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 marble waste aggregates without compromising the strength characteristics.

Keywords: Compressive Strength, Split Tensile Strength And Flexural Strength

INTRODUCTION

Recycling is the act of processing the used material for use in creating new product. Stone waste i.e. Marble 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 and occupation of vast area of land. The marble slurry generated during the processing of marble causes the environmental damage.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.. 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 etal.(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. As expected, several processing parameters affecting

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development of strength in the blocks.

Pereira etal.(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 significantly affected by the aggregate size and its water content.

Padmini etal.(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.

EXPERIMENTAL PROGRAMME

Test Programme

The test programme consisted of the following activities:

(i) Testing of the constituent materials i.e. cement, fine aggregate, coarse aggregate as per relevant Indian Standard Codes of Practice, wherever applicable.Table 2.1 to Table 2.7 represents the properties of cement, fine and coarse aggregate used in the investigation along with the grading curve is shown in Figures 2.1, 2.2 and 2.3

(ii) Design of the concrete mix and casting of the test specimens with Natural aggregates and with recycled aggregates of marble.Table 2.8 represents the mix proportions of various mixes.

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 minutes
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

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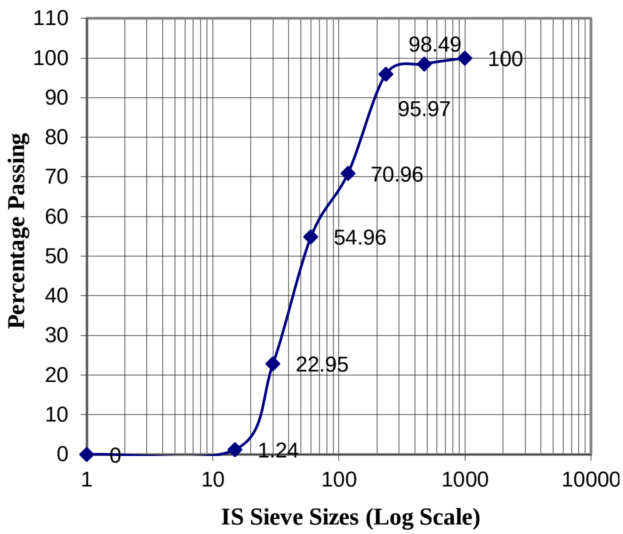

Figure 2.1: Grading Curve for Fine Aggregates

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 2.5: 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 2.4: 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	1857.5	4920	1.6
Pan	-	-	-

Cumulative percentage wt. retained = 163.0 + 500
Fineness Modulus (F.M.) = 663/100= 6.63

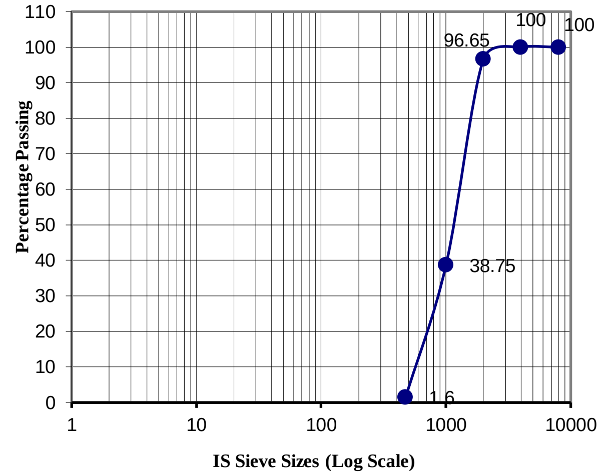

Figure 2.2: Grading Curve for Coarse NaturalAggregates

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

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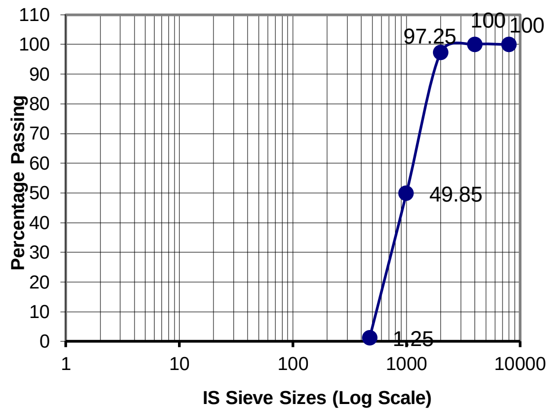

Figure 2.3: Grading Curve for Coarse Marble Aggregates

Table 2.8 Detailed Mix Proportions for Natural and Recycled Aggregate of Marbl e

Cement=399Kg/m³,Water=191.5Kg/m³ and w/c ratio=0.48

Mix	Natural F.A. (kg/m³)	Natural C.A. (kg/m³)	Marble C.A. (kg/m³)
M1	643	1157.60	---
M2	643	1041.84	115.76
M3	643	926.08	231.52
M4	643	810.32	347.28
M5	643	694.56	463.04

DISCUSSION OF RESULTS

Compressive Strength

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

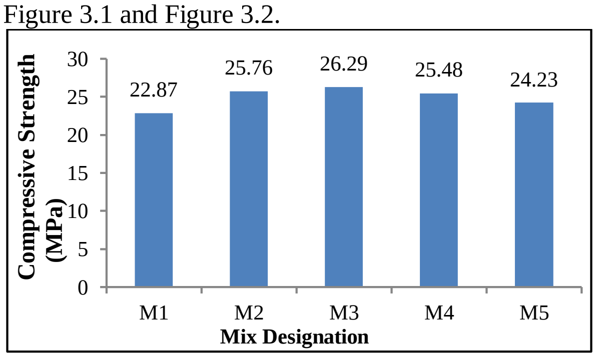

Figure 3.1 Comparison of Compressive Strength of Specimens at 7 Days

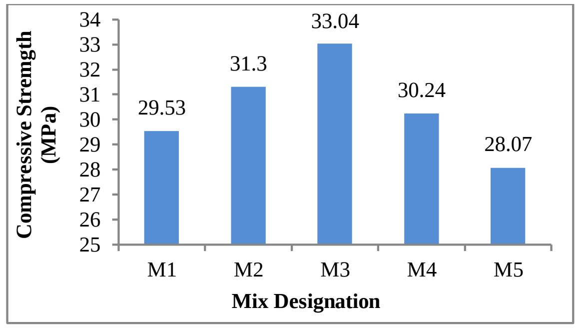

Figure 3.2 Comparison of Compressive Strength of Specimens at 28 Days

It can be seen from Figure. 3.1 and Figure 3.2 that the compressive strength at 7 days and 28 days increased with replacement of natural aggregates by marble waste aggregates by 10%. For 20% and 30% replacement of natural aggregates by marble waste aggregates further increased in compressive strength was recorded. However, the maximum increase in compressive strength was obtained for 20% replacement of natural aggregates by marble waste aggregates. For the replacement of 30% of natural aggregates by marble waste aggregates the compressive strength of mix decreased as compared to mix M2 and M3 containing 10% and 20% replacement with marble waste aggregates. When compared to the control mix M1, the compressive strength recorded were comparable. For mix M4, 40% replacement of natural aggregates by marble waste aggregates, the compressive strength recorded was marginally reduced as compared to control mix M1.Therefore for the comparable strength 30% replacement appeared to be optimum.

Split Tensile Strength

The comparison of split tensile strength at 7 days and 28 days for specimens with natural aggregates and the specimen containing marble waste aggregates in different percentages is shown in Figures 3.3 and 3.4.

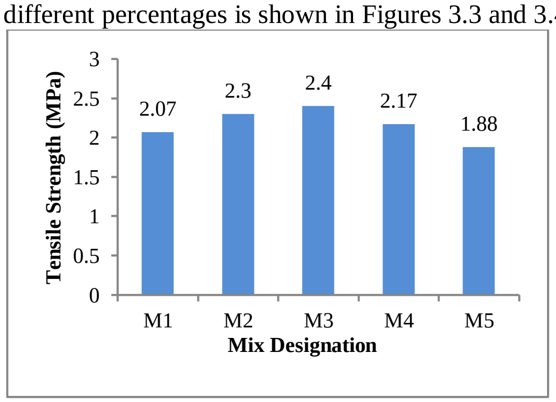

Figure 3.3 Comparison of Tensile Strength of Specimens at 7 days.

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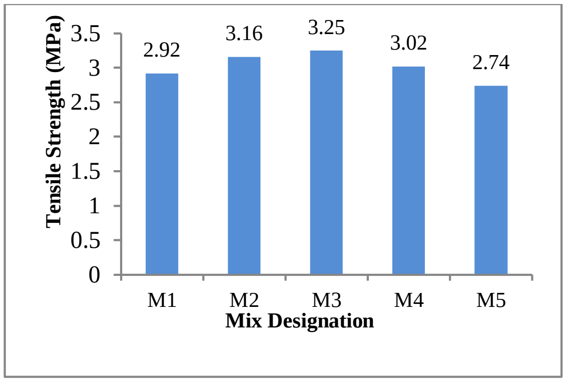

Figure 3.4 Comparison of Tensile Strength of Specimens at 28 days.

It can be seen from Figures 3.3 and 3.4 that the split tensile strength at 7 days and 28 days increased with replacement of natural aggregates by marble waste aggregates by 10%. For 20% and 30% replacement of natural aggregates by marble waste aggregates further increase in split strength was recorded. However, the maximum increase in compressive strength was obtained for 20% replacement of natural aggregates by marble waste aggregates. For the replacement of 30% of natural aggregates by marble waste aggregates the split tensile strength of mix decreased as compared to mix M2 and M3 containing 10% and 20% replacement with marble waste aggregates. When compared to the control mix M1, the split tensile strength recorded was comparable. For mix M4, 40% replacement of natural aggregates by marble waste aggregates, the split tensile strength recorded was reduced as compared to control mix M1, reason being the same as discussed in section of compressive strength. Therefore for the comparable strength 30% replacement appeared to be optimum.

Flexural Test

In order to investigate the effect of replacement of natural aggregates by marble waste aggregates, beam specimens were cast with replacements of natural aggregates by 10%, 20%, 30% and 40%.

The comparison of flexural strength at 7 days and 28 days for specimens with natural aggregates and the specimen containing marble waste aggregates in different percentages is shown in Figures 3.5 and 3.6.

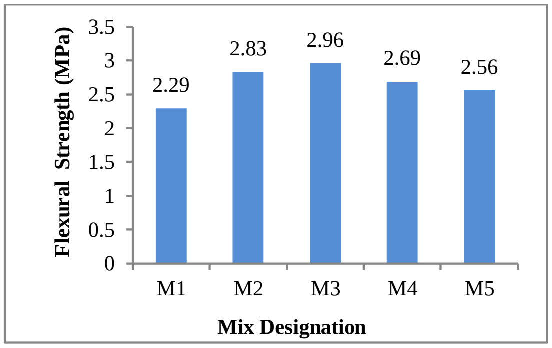

Figure 3.5 Comparison of Flexural Strength of Specimens at 7 Days

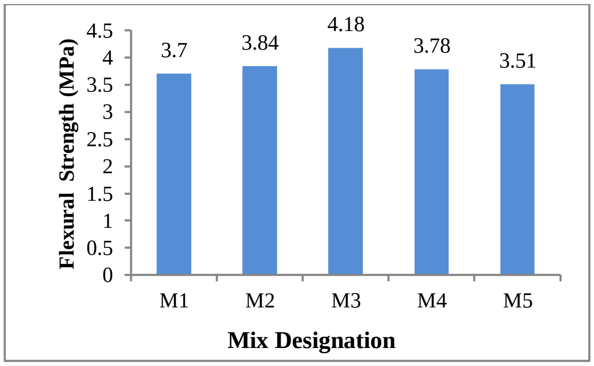

Figure 3.6 Comparison of Flexural Strength of Specimens at 28 Days

It can be seen from Figures 3.5 and 3.6 that the flexural strength at 7 days and 28 days increased with replacement of natural aggregates by marble waste aggregates by 10%. For 20% and 30% replacement of natural aggregates by marble waste aggregates further increase in flexural strength was recorded. However, the maximum increase in compressive strength was obtained for 20% replacement of natural aggregates by marble waste aggregates . For the mix containing 40% marble waste aggregates, the flexural strength at 7 days and 28 days are comparable with the mix containing natural aggregates, the reason being the same as discussed in case of compressive strength.

Regression Analysis

A regression analysis was carried out between the compressive strength and the tensile strength of various mixes with replacement of natural aggregate by varying percentage of marble aggregates and the following relationship as shown in Figure 3.7

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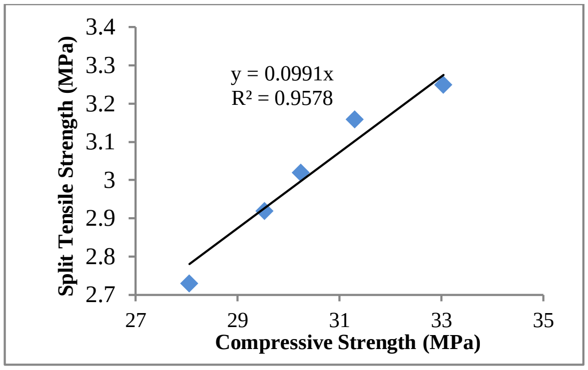

Figure 3.7 Correlation between Compressive Strength and Split Tensile at 28 Days

It can be seen from the Figure 3.7 that a good correlation was obtained between experimental and theoretical value.

A regression analysis was carried out between the compressive strength and the flexural strength of various mixes with replacement of natural aggregate by varying percentage of marble aggregates and the following relationship as shown in Figure 3.8 was obtained.

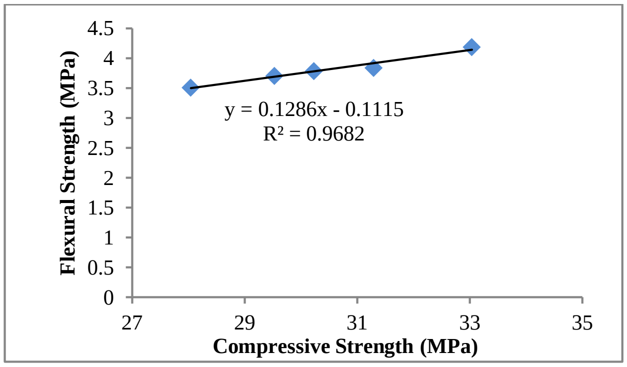

Figure 3.8 Correlation between Compressive Strength and Flexural Strength of Specimens

It can be seen from the Figure 3.8 that a good correlation was obtained between experimental and theoretical value.

CONCLUSIONS

The following conclusions can be drawn based on the results obtained in the present study.

(i) The results of the present study shows that the production of concrete of normal strength is feasible and viable by replacing the natural aggregates by the marble waste aggregates without compromising the strength characteristics.

(ii) The compressive strength of specimens containing marble waste aggregates increased for replacement of 10%, 20% and 30%. However for the 40% replacement of natural aggregates by marble waste aggregate a marginal decrease in compressive strength was recorded. For mix containing 10%, 20% and 30% waste marble aggregates the compressive strength at 28 days was increased by 6%, 12% and 3% when compared to the control mix.

(iii) The split tensile strength of specimens containing marble waste aggregates increased for replacement of 10%, 20% and 30%. However for the 40% replacement of natural aggregates by marble waste aggregate a marginal decrease in split tensile strength was recorded. For mix containing 10%, 20% and 30% waste marble aggregates the split tensile strength at 28 days was increased by 8.2%, 11.3% and 3.4% when compared to the control mix

(iv) The flexural strength of specimens containing marble waste aggregates increased for replacement of 10%, 20% and 30%. However for the 40% replacement of natural aggregates by marble waste aggregate a marginal decrease in flexural strength was recorded. For mix containing 10%, 20% and 30% waste marble aggregates the flexural strength at 28 days was increased by 4%, 12.9% and 2.2% when compared to the control mix.

(v) The regression analysis between compressive strength and split tensile strength and compressive strength and flexural strength showed that good correlation between experimental and predicted values.

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