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Evaluation of Roller Compaction Concrete With Partial Replacement Of Fine Aggregates By Ceramic Waste And Marble Dust

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Abstract:- In this RCC research study the (OPC) cement has been replaced by ceramic waste powder in the proportion of using 0%,and 20%, 30%, 40% of Ceramic waste and,10%, 20% of Marble dust and & 25% by weight of M_{30} grade concrete. The present investigation has been undertaken to study the effect of ceramic waste and marble powder on the mechanical properties of concrete. The main parameters investigated were cube compressive strength, split tensile strength and flexural strength. In this work, M_{30} grade concrete mix was developed using IS method of mix design. For evaluation of strength parameters of each grade of concrete samples are prepared in the form of cubes, cylinders and prisms and cured for 7, 14 and 28 days before testing. From the results it was observed that the compressive strength, split tensile strength and flexural strength increases with the increase in percentage of ceramic waste and marble powder up to 20%. But beyond 20 % the compressive strength, split tensile strength and flexural strength decreases. So the replacement of cement with ceramic waste and fine aggregate with marble dust is optimum at 20 percent only.

Keywords: Marble Dust, Ceramic Waste, Concrete, Mechanical Properties

1.Introduction

During my experience in civil engineering constructions also during my views of the situation of our constructed roads in India especially in Hyderabad highways connecting which the heavy trucks ways in the roads always are damaged because of bad design, bad executions of the road projects or the overload of the heavy trucks and equipments which always breaking the laws of road load limits. Therefore extra costs are added to all Road constructions by constructing reinforced concrete roads in trucks ways and highways or all the roads to prevent the damages to the road which costing our contry large quantities of concrete materials and steel reinforcement and more and more extra durations for executing. So that I made some searches in the internet for solutions to this case and I found something like a magic it is an invention and new development which I think it will solve all our problems in our high ways and roads and that was the Roller Compacted Concrete. Roller-compacted concrete, or RCC, takes its name from the construction method used to build it. It's placed with conventional or high-density asphalt paving equipment, and then compacted with rollers. RCC has the same basic ingredient as conventional concrete: cement, water, and aggregates, such as gravel or crushed stone. But unlike conventional concrete, it's a drier mix—stiff enough to be compacted by vibratory rollers. Typically, RCC is constructed without joints. It needs neither forms nor finishing, nor does it contain dowels or steel reinforcing. These characteristics make RCC simple, fast, and economical. RCC or Roller compacted concrete was limited to the sub-base of roads and airfield pavements and concrete dams, being called lean concrete or dry lean concrete. RCC became popular due to the fact that it is a simple material to produce and place. RCC (Rolled Compacted Concrete) has low cement content, about 110 to 120 kg/m3, and uses washed aggregate of concreting quality. American Concrete Institute (ACI)

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207.5R-89 defines roller compacted concrete (RCC) as concrete compacted by roller compaction.

2. Experimental Study

2.1 Materials used

2.1.1CEMENT

The Cement used was Bharathi Ordinary Portland Cement (OPC) of grade53 conforming to IS: 12269-1987. The various laboratory tests confirming to IS: 4031-1996 (PART 1 to 15) specification was carried out.

2.1.2 Ceramic waste

The principle waste coming into the ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pit refill, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use of ceramic waste produced.

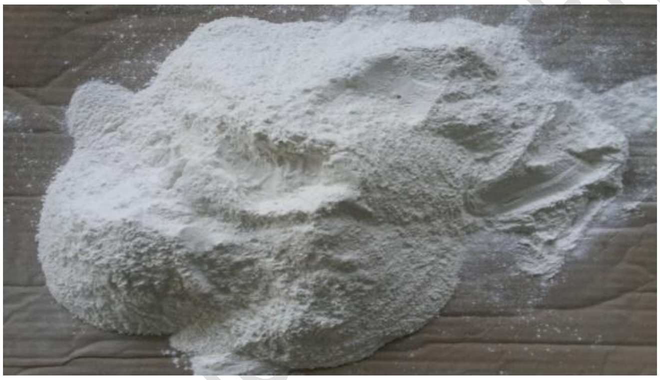

Fig 2.1 Ceramic Waste Powder

2.1.3 FINE AGGRIGATES

The Fine Aggregate used in this project is Robo sand. The Product is manufactured as per IS 383-11970 specifications and confirms to zone-ii standards. The gradation cubical shape of the particle helps in producing good concrete of high compressive strength and greater durability in construction.

Marble dust

Marble dust is a waste product formed during the production of marble. A large quantity of powder is generated during the cutting process. The result is that about 25% of the original marble mass is lost in the form of dust. Leaving these waste materials to the environment directly can cause environmental problems such as increase in the soil alkalinity, affects the plants, affects the human body etc.

Fig 2.2 Dumping of Marble dust

2.1.4 COARSE AGGREGATE

Locally available crushed stone with 20 mm graded size have been used as coarse aggregate.

Fig 2.3 Coarse Aggregate of 20 mm size

2.2 Mix Design

I: Stipulations for proportioning

II: Materials for SCC

III: Target mean strength

IV: Approximate air content

V: Selection of water cement ratio

VI:

VII: Proportioning for initial mix:

1. Selection of water content and cementitious content.
2. Admixture Content
3. Selection of Powder content and FA content
4. Selection of coarse content
5. Volume of powder content

VIII: Mix proportion fot trail no.1

S.no.	Material	Quantity(kg/m³)
1.	Cement	316.5
2.	Ceramic waste	105.5
3..	Water	190
4.	FA	890
5.	CA	926
6.	w/c ratio	0.45
7.	Marble dust content	520
8.	Water Marble dust ratio by volume	0.116

Since the mix obtained by 0.45 water cement ratio was more flowable, hence by adopting the 0.4 w/c ratio the mix proportions are being determined as trail number 2.

IX: Mix proportion fot trail no.2

S.no.	Material	Quantity(kg/m³)
1.	Cement	318.75
2.	Ceramic waste	106.25
3..	Water	170
4.	FA	863.34
5.	CA	959
6.	w/c ratio	0.4
7.	Marble dust content	520
8.	Water Marble dust ratio by volume	0.95

X: Mix proportion fot trail no.3

S.no.	Material	Quantity(kg/m³)
1.	Cement	318.75
2.	Ceramic waste	106.25
3..	Water	170
4.	FA	1045.45
5.	CA	794.6
6.	w/c ratio	0.4
7.	Marble dust content	540
8.	Water Marble dust ratio by volume	0.94

2.3 Mixing of concrete

Fig 2.4 Mixing of M_{30} Concrete

2.3.2TESTS ON HARDENED CONCRETE

- **Compressive Strength Test (IS: 516-1959)**

The cubes of standard 150 x 150 x 150 mm size were cast for carrying out tests for 7,14 and 28day's . The weight of the cube is recorded for calculation of density (kg/m^3) and tested for compression strength in 300T CTM as shown in Figure 4.8 and the cube was placed in the compression testing machine and the load on the cube is applied at a constant rate up to the failure of the specimen

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Fig.2.5 Compression testing machine

and the ultimate (maximum) load is noted. The load at which the specimen fails is recorded. The experimental compressive strength was obtained by dividing the maximum load applied on the specimen during the test by its cross sectional area. Average test results of the specimen were considered as the compressive strength (N/mm^2).

$$\text{Compressive strength} = P/A$$

Where, P = maximum load "kg" applied to the specimen, and

A = cross sectional area of the cube on which load is applied (150 x 150mm)

The results of compressive strength at 7,14 and 28 days were shown in results and discussion.

- **Splitting Tensile Strength Test (IS: 5816-1999)**

This test is conducted on 300T compression testing machine as shown in Figure 4.12. The cylinders prepared for testing are 150mm in diameter and 300mm long.

After noting the weight of the cylinder, then the cylinder is placed on the bottom compression plate of the testing machine. Then the top compression plate is brought into contact at the top of the cylinder. The load is applied at uniform rate, until the cylinder fails and the load is recorded. The average test results of the specimen were considered as the splitting tensile strength (N/mm^2).

$$\mathbf{F_{ct}} = \frac{2P}{\pi \times d \times l}$$

Where, p = Maximum load **in Newton's applied to the specimen**, d = diameter of the cylinder (150 mm),
l = Length of the cylinder (300 mm),

The results of splitting tensile strength were shown in results and discussion.

2.4 Casting of concrete mix

Fig.2.6 Casting of Cubes

Fig.2.7 Casting of Cylinders

Fig.2.7 Casting of Cubes and beams

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Fig 2.8 Curing of Specimens for 7, 14 and 28 days

3. Results and Discussions

Concrete specimens were casted using 0%,and 20%, 30%, 40% of Ceramic waste and,10%, 20% of Marble dust, replacement of fine aggregate with both marble powder and ceramic waste. The specimens are tested for compressive strength, flexural strength and split tensile strength for 7, 14 and 28 days curing.

Figure 3.1: compression test of cube

Figure 3.2: Flexural test of beam

Figure 3.3: split tensile strength

3.1 Compressive strength

The cubes were placed in the compression testing machine and the loads are applied gradually at a rate of 22.3 N/mm²/min. The average value of the compression strength of three cubes was taken as the compression strength.

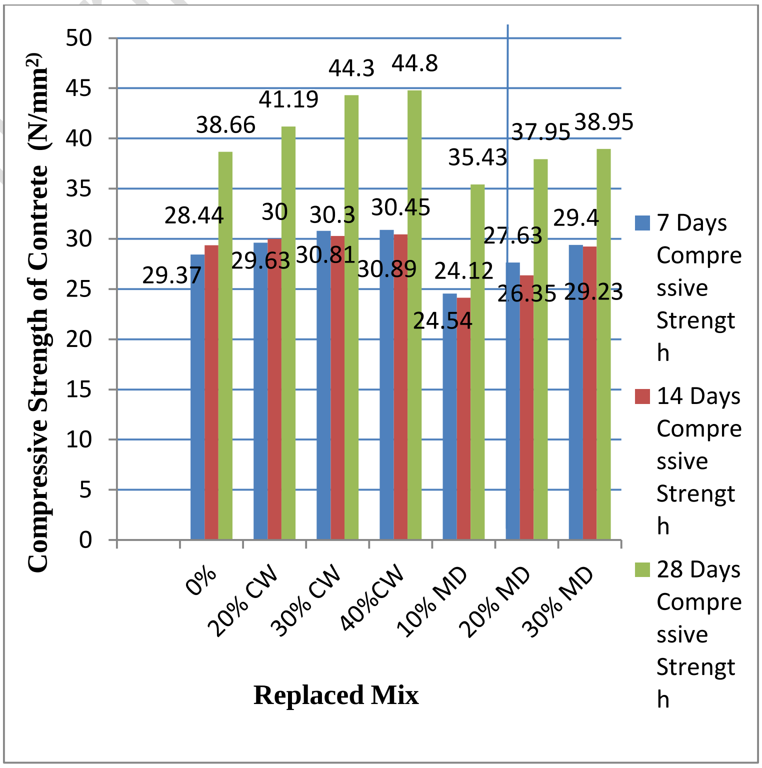

Fig 3.4 Compressive Test Results

With the increase in age of concrete, the compressive strength of normal RCC increases. By varying CW percentages there is an increment 16% of compressive strength at 28days curing when compared to normal concrete. But when compare compressive strengths at 30% CW and 40% CW there is no significant growth in strength. Whereas when fine aggregate replaced with MD% there is a reduction in strength in initial replacements and achieved strength nearly equal to normal concrete at 30% MD.. As the age of curing goes on the strength of CW replaced concrete has an increment of 59.5%, 55.79%, and 57.3% of strengths for 20% CW, 30% CW and 40% CW. Similar trend was observed in MD replaced concrete also.

5.3 Flexural strength

The beams of (500mm X 100mm X 100 mm) are casted and tested for flexural strength as per IS 516-1959. The effect on flexural strength by partial replacement of ceramic waste, marble dust, in varying percentages from 0% to 40% for varying ages of curing like 7days, 14days and 28 days

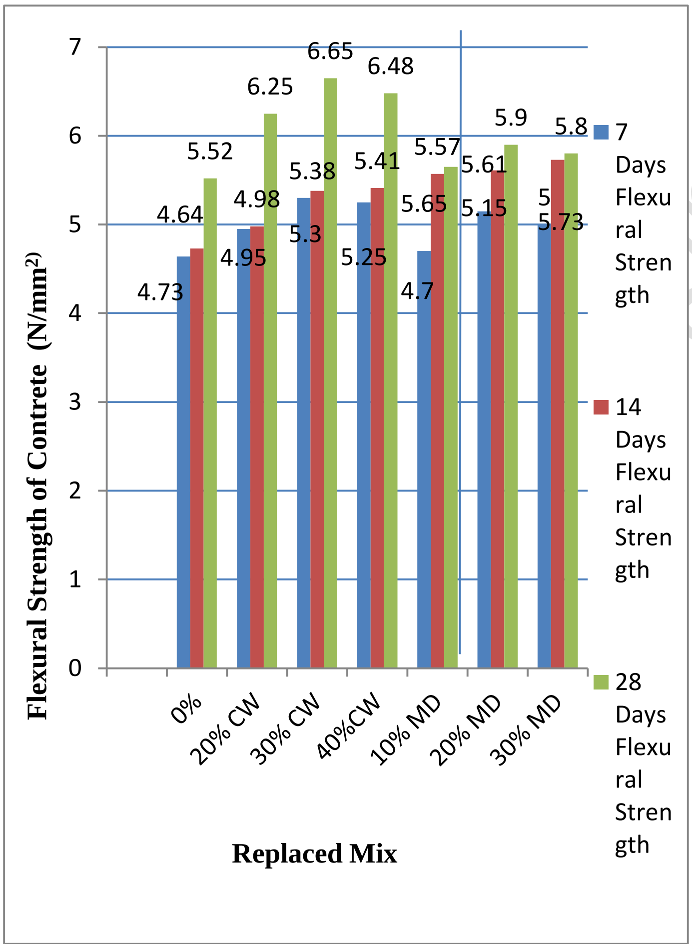

Fig 3.5 Flexural Test Results

The target flexural strength was achieved at 28 days curing for normal RCC. As the percentages of CW is increased the flexural strength increases by 13.22%, 20.47%, 17.39% with normal concrete at 28 days curing. Whereas the increase in flexural strength is very nominal for varying GP% i.e., 2.35%, 6.8% and 5.07% for 10%MD, 20%MD and 30%MD. As the curing age is increasing the flexural strength increased by 63.63%, 63.20%, 56.19% for 10% CW, 20% CW and 30% CW.

4 Split tensile strength

The cylindrical specimens of diameter 150mm and height 300mm were used to determine the split tensile strength. The specimens were tested in compression testing machine of capacity 2000 kN. (According to IS 5816-1999).Three cylindrical specimens were tested for each percentage of replacement.

The 7,14 and 28 days split tensile strength of the SCC specimens. It can be observed that the values of cylinder splitting-strength range between 2.36and 3.93 MPA,

From Fig 3.6, it is clear that the splitting-tensile strengths of RCC mixtures are increasing. with increase in percentage partial replacement of FA with MD and CWat 5%, increased the strength by1.01%, compared to reference mix. Further with increase in partial replacement from5-10,10-15 and 15-20% has decreased the strength by1.18 %,1.15% and 1.04%. After assessing the evaluated results of both compressive strength and split tensile strength it is found that the rate of increase in compressive stress is more as compared to the split tensile strength.

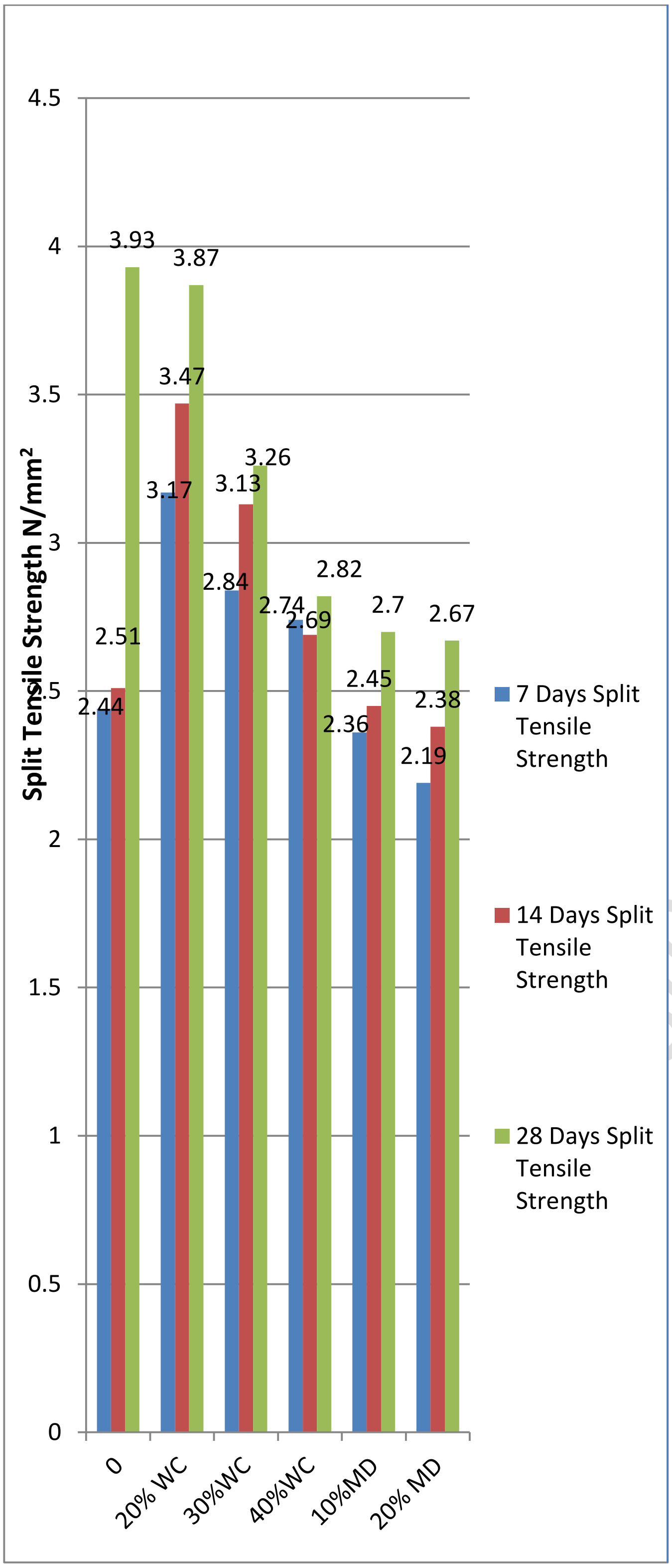

Fig 3.6 Split Tensile Test Results

4. CONCLUSIONS

- As compared to conventional concrete, on addition of marble dust and ceramic waste its characteristic strength is gradually increased.
- So the ceramic waste powder has been replaced by up to 250% by weight of cement without affecting the characteristic strength of M_{30} grade concrete.
- On further replacement of cement with marble dust and ceramic waste powder, the strength of concrete found decreased.
- As compared to conventional concrete, on addition of marble dust powder its compressive strength gradually increases up to a certain limit but then gradually decreases.
- The increase in strength of concrete is due to the fact that certain proportions of waste had been added to the concrete as very fine aggregate substitutes.
- This is an expected outcome due to the high specific gravity of marble dust powder and also filler effect of marble dust because it has finer particles than fine aggregate. As a matter of fact, marble dust powder had a filler effect and played a noticeable role in the hydration process.
- Ceramic waste also contains large amount of silica which affects the strength characteristics of concrete. Utilization of ceramic waste or marble dust and its application for the sustainable development of the construction industry is the most effective solution and also speak the high value application of such waste.
- It is the best possible alternative solution of safe disposal of the Ceramic waste and Marble dust powder thus stepping into a realm of solving the environmental pollution by cement production; being one of the primary objectives of Civil Engineers.

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