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A Study on Partial Replacement of Coarse Aggregate by Ceramic Tile Aggregate and Fine Aggregate by Marble Dust to Improve Concrete Strengths

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***Abstract*: In day by day innovations and development in construction field, the use of natural aggregates is very high and at the same time production of solid wastes from the demolitions of constructions is also very high. In this study we introduce the ceramic tile aggregate as coarse aggregate replacement and marble dust as fine aggregate replacement in order to reduce the environmental pollution due to this waste and also reduce the natural aggregates. The maximum percentage of ceramic tile aggregate used is about 30% of the mass of coarse aggregate. The percentages in which the ceramic tile aggregate was replaced were 0%, 5%, 10%, 15%, 20%, 25%, and 30%. In order to increase the strength, 10 % of marble dust is added to the concrete as a partial replacement of fine aggregate to achieve better results. Experimental tests are carried out to determine the fresh and hardened properties of concrete such as compressive strength, split tensile strength, flexure strength test, workability at 7, 14 & 28 days of curing were calculated.**

***Keywords*: Coarse aggregate, ceramic tile aggregate, fine aggregate, marble dust.**

1. Introduction

Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily moulded into desired shape can be formed by mixing these ingredients in certain proportions. Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily moulded into desired shape can be formed by mixing these ingredients in certain proportions. When aggregate is mixed together with dry Portland cement and water, the mixture forms fluid slurry that is easily poured and moulded into shape. Most concrete is poured with reinforcing materials embedded to provide tensile strength, yielding reinforced concrete.

In this study we are used the waste materials are:

1. Ceramic Tile Aggregate
2. Marble Dust

While taking these materials into consideration the points kept in mind are financial saving and Reduces the environmental pollution.

In this project the ceramic waste is used to replace the coarse aggregates and Ceramic waste is locally available at the ceramic manufactures in Vijayawada. The marble dust is used to replace the fine aggregate and marble dust is collecting from Vijayawada surroundings at marble manufacturers.

2. Literature reviews

N. Sivachandiran, A. Magesh (2018): This research focuses on ceramic tile waste as partial coarse aggregates replacement for concrete production, prevention of environmental pollution with considering the elements of sustainable and cost-saving construction projects, especially material usage. Percentages used for the replacement level in this study were 10%, 20%, 30%, 40% and 50% of ceramic as partial replacement of coarse aggregates. The concrete cube were tested as destructive test at last which is compression test that to find out compressive strength of specimens of hardened concrete at 3 days, 7 days and 28 days. From the results 20% & 30% ceramic coarse aggregate replacement has reached optimum strength. In this study M20 grade concrete were used.

Prof. Shruthi. H. G, Prof. Gowtham Prasad. M. E, Samreen Taj, Syed Ruman Pasha (2016): The reuse of ceramic waste as a substitute for coarse aggregate in concrete has been investigated. In the present study, Ceramic tile waste were used in concrete as a replacement for natural coarse aggregate with 0%, 10%, 20% and 30% of the substitution and M20 grade concrete were used. The concrete moulds were casted and tested for Compressive Strength and Split Tensile Strength after a curing period of 3, 7 & 28 days. The results indicate that, the maximum compressive strength is obtained for the 30% replacement of ceramic tile aggregate with natural coarse aggregate.

L. Satish Kumar (2017): The basic objective of this study was

to identify alternative source of good quality aggregates. The present investigation has been undertaken to study the effect of Marble dust on the mechanical properties of concrete, when Marble dust is replaced with fine aggregate in different percentages. In this work, M25 grade concrete mix was used. The test results use of replacing Marble dust by fine aggregates in different percentages i.e. 0%, 5%, 10%, 15%, 20%, 25%, 30%, 30% and 40%. For evaluation of strength parameters each grade of concrete for each proportion in the form of cubes casted for testing at 3 days, 7days and 28 days periods. The compressive strength increases with the increase in percentage of Marble dust up to 30%.

Table 1
Table title comes here

CEMENT	F.A	C.A	WATER
435.45	570.84	1202.70	191.60
1	1.31	2.76	0.44

Mix Proportion =1: 1.31: 2.76

Table 1
Percentage of Mix ratio proportion

S. No.	Concrete Mix	Mix Proportion
1	M1	M30
2	M2	M30+5% CTA
3	M3	M30+10% CTA
4	M4	M30+15% CTA
5	M5	M30+20% CTA
6	M6	M30+25% CTA
7	M7	M30+30% CTA
8	N1	M30+0% CTA+10% MD
9	N2	M30+5% CTA+10% MD
10	N3	M30+10% CTA+10% MD
11	N4	M30+15% CTA+10% MD
12	N5	M30+20% CTA+10% MD
13	N6	M30+25% CTA+10% MD
14	N7	M30+30% CTA+10% MD

M30 = Conventional Concrete
CTA = Ceramic Tile Aggregate
MD = Marble Dust

3. Objectives

- To study the properties of ceramic tile aggregate and marble dust fine aggregate and comparing the respective properties with crushed stone aggregate and river sand.
- To propose a suitable guideline for mix proportioning of ceramic tile aggregate and marble dust fine aggregate.
- To study the engineering properties of fresh and hardened concrete made with Ceramic tile aggregate and marble dust fine aggregate.
- To study the comparison of strengths obtained by using crushed stone aggregate and river sand with replaced materials.
- To study the workability of replaced mix with conventional materials.

4. Materials

- *Coarse aggregates:* The Coarse aggregate exclusively passing through 40mm sieve size and retained on 20mm sieve is selected.
- *Fine aggregates:* The sand which was locally available and passing through 4.75mm IS sieve is used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.
- *Cement:* OPC (Ordinary Portland Cement) 53 grade is used.
- Water: Portable water is used which should be free from organic matter and curing is done as per IS 456:2000.
- *Ceramic tile aggregates:* Ceramic tile aggregate is crushed to about size of 20mm. The crushed tile is used in concrete.
- *Marble dust:* Marble Dust is passing through 4.75mm IS sieve is used.

5. Mix proportion

The following table represents the mix proportions of

Table 2
Mix proportions of concrete for Coarse Aggregate Replacement

S.No.	Mix	% of Ceramic Tile Aggregate Replaced	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Ceramic Tile Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Water (Lit/m^3)
1	M1	0%	435.45	570.84	0	1202.70	191.60
2	M2	5%	435.45	570.84	60.135	1142.57	191.60
3	M3	10%	435.45	570.84	120.27	1082.43	191.60
4	M4	15%	435.45	570.84	180.405	1022.30	191.60
5	M5	20%	435.45	570.84	240.54	962.16	191.60
6	M6	25%	435.45	570.84	300.675	902.03	191.60
7	M7	30%	435.45	570.84	360.81	841.89	191.60

Table 3
Mix proportions of concrete for Coarse Aggregate and Fine Aggregate Replacement

S.No.	Mix	% of Ceramic Tile Aggregate Replaced	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Marble Dust Replaced (Kg/m^3)	Ceramic Tile Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)
1	N1	0%	435.45	513.756	57.084	0	1202.70
2	N2	5%	435.45	513.756	57.084	60.135	1142.57
3	N3	10%	435.45	513.756	57.084	120.27	1082.43
4	N4	15%	435.45	513.756	57.084	180.405	1022.30
5	N5	20%	435.45	513.756	57.084	240.54	962.16
6	N6	25%	435.45	513.756	57.084	300.675	902.03
7	N7	30%	435.45	513.756	57.084	360.81	841.89

concrete mixes for coarse aggregate replaced with ceramic tile aggregate. The percentages in which the coarse aggregate was replaced by ceramic tile aggregate are 5%, 10%, 15%, 20%, 25%, 30% with these percentages, concrete mixes were prepared and after 28 days, the strength properties have been studied. Later adding 10% of marble dust to be mixed and compare the marble dust with Ceramic tile aggregate in Concrete.

6. Results and discussion

A. *Compressive strength*

1) *Ceramic Tile Aggregate Concrete*

Table 4
Compressive Strength of CTA concrete at 7, 14 & 28 days

COMPRESSIVE STRENGTH OF CTA CONCRETE (N/mm^2)				
MIX	REPLACEMENT %	7 DAYS	14 DAYS	28 DAYS
M1	M30	18.62	25.15	29.97
M2	M30+5%CTA	25.10	28.23	36.38
M3	M30+10%CTA	25.94	29.89	37.12
M4	M30+15%CTA	26.20	29.65	39.54
M5	M30+20%CTA	26.89	30.34	40.99
M6	M30+25%CTA	26.47	29.44	39.30
M7	M30+30%CTA	25.96	28.93	38.78

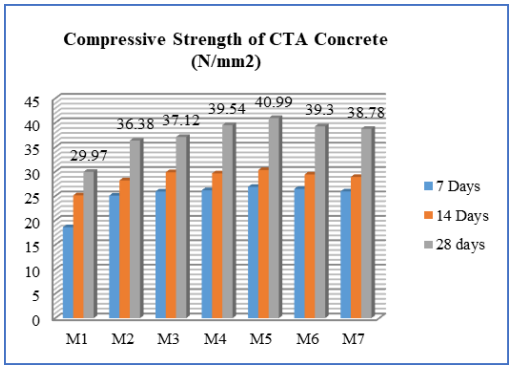

Fig. 1. Compressive Strength of CTAMD concrete at 7, 14 & 28 days

2) *Ceramic Tile Aggregate with Marble Dust Concrete*

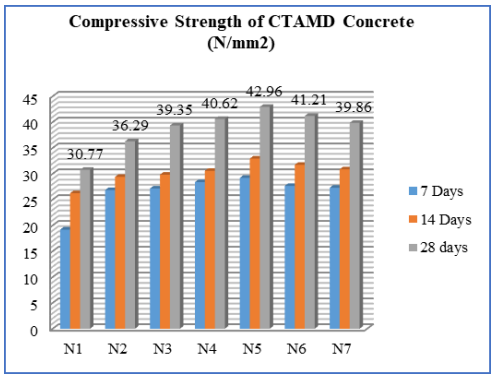

Fig. 2. Compressive Strength of CTAMD concrete at 7, 14 & 28 days

B. *Split tensile strength*

The split Tensile strength values of the replaced cylinder strength in an ascending manner compared to ceramic tile aggregate and ceramic tile aggregate marble dust Concrete. The

Table 5
Compressive Strength of CTAMD concrete at 7, 14 & 28 days

COMPRESSIVE STRENGTH OF CTAMD CONCRETE (N/mm^2)				
MIX	REPLACEMENT %	7 DAYS	14 DAYS	28 DAYS
N1	M30+0%CTA+10%MD	19.20	26.25	30.77
N2	M30+5%CTA+10%MD	26.84	29.41	36.29
N3	M30+10%CTA+10%MD	27.16	29.83	39.35
N4	M30+15%CTA+10%MD	28.38	30.58	40.62
N5	M30+20%CTA+10%MD	29.21	32.95	42.96
N6	M30+25%CTA+10%MD	27.65	31.74	41.21
N7	M30+30%CTA+10%MD	27.30	30.87	39.86

results are tabulated below:

1) *Ceramic tile aggregate concrete*

Spilt Tensile Strength of CTA Aggregate Concrete at 7, 14 & 28 days

Table 6
Spilt Tensile Strength of CTA Concrete at 7, 14 & 28 days

SPILT TENSILE STRENGTH OF CTA CONCRETE (N/mm^2)				
MIX	REPLACEMENT %	7 DAYS	14 DAYS	28 DAYS
M1	M30	2.16	3.05	3.49
M2	M30+5%CTA	2.35	3.17	3.62
M3	M30+10%CTA	2.47	3.36	3.78
M4	M30+15%CTA	2.63	3.49	3.95
M5	M30+20%CTA	2.26	3.24	3.47
M6	M30+25%CTA	2.06	3.04	3.37
M7	M30+30%CTA	1.98	2.77	3.19

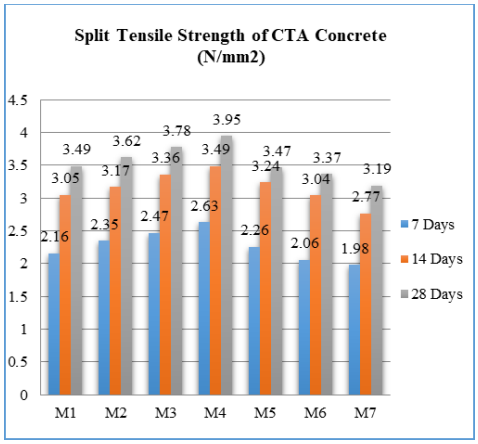

Fig. 3. Spilt Tensile Strength of CTA Concrete at 7, 14 & 28 days

2) *Ceramic Tile Aggregate with Marble Dust Concrete*

Spilt Tensile Strength of CWMD Aggregate Concrete at 7, 14 & 28 days.

Table 7
Spilt Tensile Strength of CWMD Aggregate Concrete at 7, 14 &28 days

SPILT TENSILE STRENGTH OF CTAMD CONCRETE (N/mm^2)				
MIX	REPLACEMENT %	7 DAYS	14 DAYS	28 DAYS
N1	M30+0%+10%MD	2.24	3.05	3.56
N2	M30+5%CTA+10%MD	2.39	3.17	3.61
N3	M30+10%CTA+10%MD	2.58	3.34	3.57
N4	M30+15%CTA+10%MD	2.61	3.41	3.75
N5	M30+20%CTA+10%MD	2.37	3.30	3.60
N6	M30+25%CTA+10%MD	2.18	3.23	3.47
N7	M30+30%CTA+10%MD	2.01	2.92	3.21

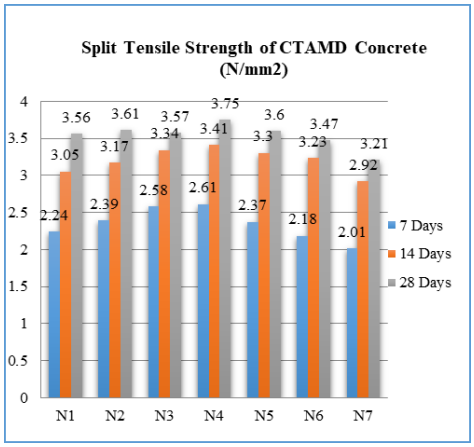

Fig. 4. Graph No.6.4 Spilt Tensile Strength of CTAMD Concrete at 7, 14 & 28 days

C. *Flexural strength test*

The flexure strength tests of both the replacements of 7, 14 & 28 days are noted and the values are tabulated below.

1) *Ceramic Tile Aggregate Concrete*

Table 8
Flexure Strength of CTA Concrete at 7, 14 & 28 days

FLEXURE STRENGTH TEST OF CTA CONCRETE (N/mm^2)				
MIX	REPLACEMENT %	7 DAYS	14 DAYS	28 DAYS
M1	M30	3.37	3.69	4.41
M2	M30+5%CTA	3.56	3.73	4.49
M3	M30+10%CTA	2.58	3.34	3.57
M4	M30+15%CTA	3.80	4.28	4.73
M5	M30+20%CTA	3.89	4.46	4.98
M6	M30+25%CTA	3.90	4.29	4.57
M7	M30+30%CTA	3.61	4.03	4.47

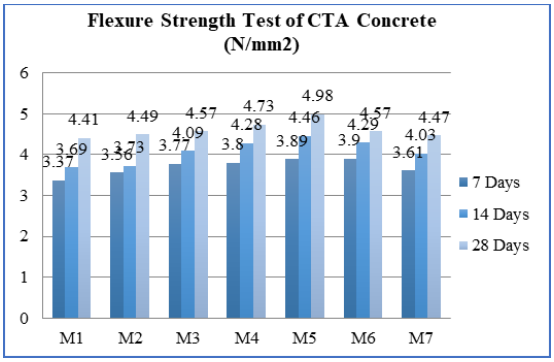

Fig. 5. Graph No.6.5 Flexure Strength of CTA Concrete at 7, 14 & 28 days

2) *Ceramic Tile Aggregate with Marble Dust Concrete*

Table 9
Flexure Strength of CTAMD Concrete at 7, 14 &28 days

FLEXURE STRENGTH TEST OF CTAMD CONCRETE (N/mm^2)				
MIX	REPLACEMENT %	7 DAYS	14 DAYS	28 DAYS
N1	M30+0%CTA+10%MD	3.41	3.63	4.44
N2	M30+5%CTA+10%MD	3.61	3.72	4.58
N3	M30+10%CTA+10%MD	3.83	4.32	4.66
N4	M30+15%CTA+10%MD	3.89	4.47	4.85
N5	M30+20%CTA+10%MD	3.97	4.65	5.02
N6	M30+25%CTA+10%MD	3.73	4.56	4.77
N7	M30+30%CTA+10%MD	3.58	4.12	4.23

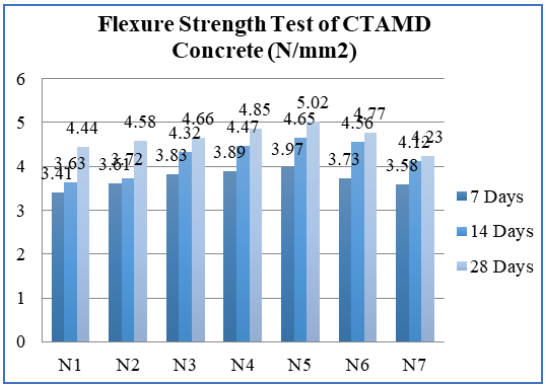

Fig. 6. Graph No.6.6 Flexure Strength of CTAMD Concrete 7, 14 & 28 days

7. Conclusions

1. The main objective of this study is to prepare a concrete much more stable and durable than the conventional concrete by replacing both coarse and fine aggregates by minimizing the water cement ratio.
2. Usage of ceramic tile aggregate and marble dust reduces the costs for construction.
3. Based on this work it has been concluded that the coarse aggregate was replaced by ceramic tile aggregate in the percentages of 0%, 5%, 10%, 15%, 20%, 25% and 30% and 10% fine aggregate replacement with marble dust achieved increment of strengths up to 20% ceramic tile aggregate and 10% marble dust replacement and later decreased in strengths.
4. The compressive strength of ordinary concrete is 29.97 N/mm^2 and the increased strength in replaced concrete at 20% was 40.99 N/mm2 at 28 days of curing.
5. The compressive strength of CTA concrete is 40.99 N/mm^2 and adding 10% marble dust the increased strength in replaced concrete at 20% was 42.96 N/mm^2 at 28 days of curing.
6. The maximum compression strength is obtained when 20% of ceramic tile aggregate was replaced with coarse aggregate and later decreased in strengths.
7. The maximum split tensile strength is obtained when 15% of Ceramic tile aggregate was replaced with coarse aggregate. As compared to ceramic tile aggregate with adding of 10% marble dust at 20% strength is obtained and later decreased in strengths.
8. The maximum flexural strength is obtained when 20% of Ceramic tile aggregate was replaced with coarse aggregate and also adding of 10% marble dust.
9. The ceramic waste to be used should be deglazed and a lower cement ratio should be adopted so as to achieve the desired targeted strength.
10. The Workability of the mix gradually decreases by increasing usage of marble dust. So, finally all the materials and their properties satisfied the IS CODE.

11. There is no doubt that the use of waste ceramic tiles is cost free materials which represents substantial savings for civil construction and also reduces waste produced from construction or demolishing works.

8. Future scope of work:

In future it can be increase the percentage of replacement of ceramic waste material so according to this research work coarse aggregate replaced by ceramic waste & fine aggregate replaced by marble dust also further investigation is required for that these replacement to find exact percentage replacement limit in future utilization. For using this replaced materials to reduce waste produced from Construction fields and also reduce environmental pollution.

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