Partial Replacement of Aggregate with Ceramic Tile in Concrete

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Abstract— Due to the day-to-day innovations and development in construction field, the use of natural aggregates is increased tremendously and at the same time, the production of solid wastes from the demolitions of constructions is also quite high. Because of these reasons the reuse of demolished constructional wastes like ceramic tile and granite powder came into the picture to reduce the solid waste and to reduce the scarcity of natural aggregates for making concrete. The ceramic tile waste is not only occurring from the demolition of structures but also from the manufacturing unit. Studies show that about 20-30% of material prepared in the tile manufacturing plants are transforming into waste. This waste material should have to be reused in order to deal with the limited resource of natural aggregate and to reduce the construction wastes. Crushed waste ceramic tiles, crushed waste ceramic tile powder and Granite powder are used as a replacement to the coarse aggregates and fine aggregate. The ceramic waste crushed tiles were partially replaced in place of coarse aggregates by 10%, 20%, 30%, 40% and 50%. Granite powder and ceramic tile powder were replaced in place of fine aggregate by 10% along with the ceramic coarse tile. M25 grade of concrete was designed and tested. The mix design for different types of mixes were prepared by replacing the coarse aggregates and fine aggregate at different percentages of crushed tiles and granite powder. Experimental investigations like workability, Compressive strength test, split tensile strength test, Flexural strength test for different concrete mixes with different percentages of waste crushed and granite powder after 7-, 14- and 28-days curing period has done. It has been observed that the workability increases with increase in the percentage of replacement of granite powder and crushed tiles increases. The strength of concrete also increases with the ceramic coarse tile aggregate up to 30% percentage.

Index Terms— Crushed tiles, Compressive strength, Flexural strength, Granite powder, Split Tensile strength.

I. INTRODUCTION

A. General

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions. There is a huge usage of ceramic tiles in the present constructions is going on and it is increasing in day-by-day construction field. Ceramic products are part of the essential construction materials used in most buildings. Some common manufactured ceramics include wall tiles, floor tiles, sanitary ware, household ceramics and technical ceramics. They are mostly produced using natural materials that contain high content of clay minerals. However, despite the ornamental benefits of ceramics, its wastes among others cause a lot of disturbance to the environment. And also, in other side waste tile is also producing from demolished wastes from construction. Indian tiles production is 100 million ton per year in the ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present; however, the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces so, we selected these waste tiles as a replacement material to the basic natural aggregate to reuse them and to decrease the solid waste produced from demolitions of construction. Waste tiles and granite powder were collected from the surroundings.

B. Crushed Tile Concrete

Crushed tiles are replaced in place of coarse aggregate and granite powder in place of fine aggregate by the percentage of 10%. The fine and coarse aggregates were replaced individually by these crushed tiles and granite powder and also in combinations that is replacement of coarse and fine aggregates at a time in single mix. For analyzing the suitability of these crushed waste tiles and granite powder in the concrete mix, workability test was conducted for different mixes having different percentages of these materials. Slump cone test is used for performing workability tests on fresh concrete. And compressive strength test is also conducted for 3-, 7- and 28-days curing periods by casting cubes to analyze the strength variation by different percentage of this waste materials. This present study is to understand the behavior and performance of ceramic solid waste in concrete. The waste crushed tiles are used to partially replace coarse aggregate by 10%. Granite powder is also used partial replace fine aggregate by 10%.

C. ENVIRONMENTAL AND ECONOMIC BENEFITS OF TILE AGGREGATE CONCRETE

The usage of tile aggregate as replacement to coarse aggregate in concrete has the benefits in the aspects of cost and reduction of pollution from construction industry. The cost of concrete manufacturing will reduce considerably over conventional concrete by including tile aggregate and granite powder since it is readily available at very low cost and there-by reducing the construction pollution or effective usage of construction waste.

Objectives

1. 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.
2. To propose a suitable guideline for mix proportioning of ceramic tile aggregate and marble dust fine aggregate.
3. To study the engineering properties of fresh and hardened concrete made with Ceramic tile aggregate and marble dust fine aggregate.
4. To study the comparison of strengths obtained by using crushed stone aggregate and river sand with replaced materials.
5. To study the workability of replaced mix with conventional materials.

II. RESEARCH SIGNIFICANCE

The results show that partial cement replacement up to 20% produce, higher compressive strengths than control concretes, nevertheless the strength gain is less than 15%. In this paper we propose a model to evaluate the compressive strength of silica fume concrete at any time.

III. MATERIALS AND METHODOLOGY

A. Material required

1. Cement:

A binder, known as cement, is used to set, harden, and remain in other materials, binding them together. Cement, sand, and gravel combine to form concrete. OPC 53 grade cement was used throughout the project work.

2. Fine aggregate:

In this study, manufactured sand, which passes through a 4.75 mm sieve, is used as the fine aggregate. The samples are tested according to IS 2386.

3. Coarse aggregate:

The coarse aggregate, which has a maximum size of 12.5 mm and is retained on an IS 4.75 sieve, was chosen based on shape per IS 2386 (Part I) 1963. The aggregate's surface texture properties are classified using 383–1970. The nominal size of 20 mm coarse aggregate is used throughout the project work.

4. Ceramic tile aggregate:

Broken tiles were collected from the solid waste of ceramic manufacturing unit and from demolished building. The waste tiles were crushed into small pieces by manually and by using crusher.

5. Water:

Water plays a crucial role in both the mixing and curing processes of concrete, ensuring its strength and durability.

a. Tests on materials

S. No	Materials	Name of Tests	Results
1.	Cement	Fineness Test	8%
		Consistency Test	30%
2.	Ceramic tile aggregate	Specific gravity	2.45
		Water absorption	
		Impact test	13.71
3.	Fine aggregate	Fineness test	2.55
		Specific Gravity	2.62
4.	Coarse aggregate	Water absorption	1%
		Specific Gravity	2.74

TABLE 1.1 Test results on different materials.

b. Methodology

The methodology of research includes the collection of required materials from the various sources and determining the properties of all the materials gathered. Designing the concrete mix proportions for all types of replacements and Preparation of the concrete mix, Moulding and curing. The testing of concrete includes Slump cone test, compaction factor test for determining workability of concrete in fresh state and compressive strength, split tensile test and flexural test for determining the strength of concrete in hardened state.

Total 13 types of mixes are prepared along with conventional mixes. The coarse aggregates are replaced by 10%, 20%, 30%, 40% and 50% of crushed tiles and the fine aggregate is replaced by 10% of both crushed tile powder and granite powder individually but along with the coarse aggregate.

IV. EXPERIMENTAL INVESTIGATION

To develop a concrete mix design considering the partial replacement of aggregate with ceramic tiles. Prepare concrete samples with varying proportions of ceramic tile replacement (e.g., 10%, 20%, 30%, etc). Ensure consistency in mixing and batching procedures. Cast specimens in molds according to standard dimensions for testing (cubes, cylinders). Label each specimen with its respective mix design details. Cure the concrete specimens under controlled conditions (e.g., moisture curing at specific temperatures) to ensure proper hydration and strength development.

Figure(a): Ceramic tile aggregate

Figure(b): Fine Aggregate

B. Mix design

MIX DESIGN FOR M15 GRADE CONCRETE:
Final Mix Proportions:

Cement	Fine aggregate	Coarse aggregate	Water
320	695	1368	165
1	2.17	4.32	0.5

MIX DESIGN FOR M20 GRADE CONCRETE:
Final Mix Proportions:

Cement	Fine aggregate	Coarse aggregate	Water
355	683	1320	175
1	1.92	3.72	0.48

MIX DESIGN FOR M25 GRADE CONCRETE:
Final Mix Proportions:

Cement	Fine aggregate	Coarse aggregate	Water
380	634	1339	175
1	1.67	3.52	0.44

C. Casting and curing

Figure(c): Casting the concrete cubes

For the compressive strength test, 12 cubes were cast as shown in Fig. (c). Throughout the work, a suitable mix proportion was maintained. After 24 hours of casting, the cubes have been placed in water for the proper curing times (Fig. d).

Figure(d): Curing the cubes for 7, 14, & 28 days.

Figure(e): Cubes tested under compressive testing machine.

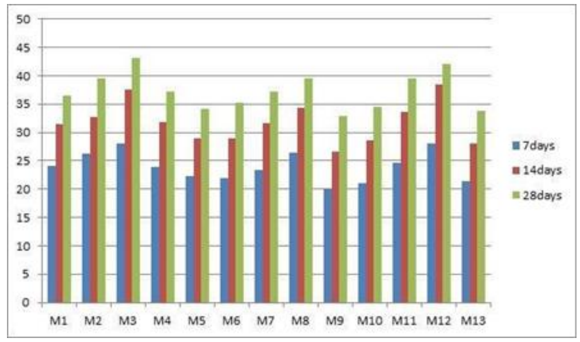
V. RESULTS AND DISCUSSION

a. Compressive strength of concrete cubes

A total of 126 cubes of size 150 x 150 x 150 mm were cast for 7 days, 14 days and 28 days testing. For each grade of concrete 42 cubes are tested, 14 each for 7, 14 and 28 days and the results are tabulated below:

S.No	MIX Code	Grade Of Concrete	Compressive strength at		
			7 days	14 days	28 days
1	M0	M15	12.96	18.06	21.25
2	M0	M20	16.56	22.87	28.0
3	M0	M25	20.57	28.54	33.18

TABLE 1.3 Compressive strength of concrete cubes for 7, 14, & 28 days



1.1: Strength comparison at 7, 14 and 28 days for M25 concrete.

CONCLUSION

- The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength and flexural strength considering the environmental aspects also.
- The workability of concrete increases with the increase in tile aggregate replacement. The workability is further increased with the addition of granite powder which acts as admixture due to its chemical properties.
- The properties of concrete increased linearly with the increase in ceramic aggregate up to 30% replacement later it is decreased linearly.
- M3 mix of concrete produced a better concrete in terms of compressive strength, split tensile strength and flexural strength than the other mixes. But the mixes up to 50% of ceramic coarse aggregate can be used.
- The usage of ceramic fine aggregate has some effect on the properties of concrete in decrement manner.
- Granite powder using as fine aggregate has more influence on the concrete than the ceramic fine because of chemical composition it is made of and works as admixture.
- The addition of granite powder along with the ceramic coarse aggregate improves the mechanical properties of concrete slightly since mineral and chemical properties are of granite.
- The split tensile strength of ceramic tile aggregate is very much in a straighter path compared to the conventional grades of concrete.

REFERENCES

[1] Aruna D, Rajendra Prabhu, Subhash C Yaragal, Katta Venkataramana IJRET:eISSN: 2319-1163 | pISSN: 2321-7308.

[2] Batriti Monhun R. Marwein, M. Sneha, I. Bharathidasan International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 ISSN 2229-5518.

[3] N.Naveen Prasad, P.Hanitha, N.C.Anil IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 6 Ver. V (Nov. - Dec. 2016), PP 168-176.

[4] Paul O. Awoyera , Julius M. Ndambuki , Joseph O. Akinmusuru , David O. Omole-4048 2016 Housing and Building National Research Center. Production and hosting by Elsevier B.V. 15 November 2016).

[5] P.Rajalakshmi, Dr.D.Suji, M. Perarasan, E.Niranjani International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online) Vol. 4, Issue 1, pp: (114-125), Month: April 2016 - September 2016.

[6] Prof. Shruthi. H. G, Prof. Gowtham Prasad. M. E Samreen Taj, Syed Ruman Pasha International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 07 | July-2016 p-ISSN: 2395-0072)

[7] Paul O. Awoyera , Julius M. Ndambuki , Joseph O. Akinmusuru , David O. Omole-4048 2016 Housing and Building National Research Center. Production and hosting by Elsevier B.V. 15 November 2016)

[8] P.Rajalakshmi, Dr.D.Suji, M. Perarasan, E.Niranjani International Journal of Civil and Structural Engineering Research ISSN 2348-7607 (Online) Vol. 4, Issue 1, pp: (114-125), Month: April 2016 - September 2016.

[9] Prof. Shruthi. H. G, Prof. Gowtham Prasad. M. E Samreen Taj, Syed Ruman Pasha

[10] International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 07 | July-2016 p-ISSN: 2395-0072)

[11] Int'l Journal of Research in Chemical, Metallurgical and Civil Engg. (IJRCMCE) Vol. 3, Issue 2 (2016) ISSN 2349-1442 EISSN 2349-1450.