

A Study On Partial Replacement of Aggregates With Ceramic Tiles And Granite Powder 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. 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 the compressive strength greater than 42mpa as high strength concrete.

Keywords- Crushed tiles; compressive strength; Granite powder.

I. PROPERTIES OF CONCRETE

Generally, the Concrete is a material having high compressive strength than to tensile strength. As it has lower tensile stress it is generally reinforced with some materials that are strong in tension like steel. The elastic behavior of concrete at low stress levels is relatively constant but at higher stress levels start decreasing as matrix cracking develops. Concrete has a low coefficient of thermal expansion and its maturity leads to shrinkage.

Due to the shrinkage and tension, all concrete structures crack to some extent. Concrete prone to creep when it is subjected to long-duration forces. For the applications various tests, be performed to ensure the properties of concrete correspond to the specifications. Different strengths of concrete are attained by different mixes of concrete ingredients, which are measured in psi or Mpa. Different strengths of concrete are used for different purposes of constructions. If the concrete must be light weight a very low strength concrete may be used. The Lightweight concrete is

achieved by the addition of lightweight aggregates, air or foam, the side effect is that the strength of concrete will get reduced. The concrete with 3000-psi to 4000-psi is frequently used for routine works. Although the concrete with 5000- psi is more expensive option is commercially available as a more durable one. For larger civil projects the concrete with 5000-psi is frequently used. The concrete strength above 5000 psi was often used for specific building elements. For example, the high-rise concrete buildings composed of the lower floor columns may use 12,000 psi or more strength concrete, to keep the columns sizes small.

Bridges may use concrete of strength 10,000 psi in long beams to minimize the number of spans required. The other structural needs may occasionally require high- strength concrete. The concrete of very high strength may be specified if the structure must be very rigid, even much stronger than required to bear the service loads. For these commercial reasons the concrete of strength as high as 19000-psi has been used.

Literature Review

Aruna D (2015) [Partial replacement of aggregate with ceramic tile in concrete] : For tile waste-based concrete, coarse aggregates were replaced by 20mm down size, tile wastes by 0%, 5%, 10%, 15%, 20% and 25% and also the cement is partially replaced by fly-ash. The average maximum compressive strength of roof tile aggregate concrete is obtained at a replacement of 25%. A reduction of 1015% of strength is observed compared to conventional concrete at 25% of roof tile aggregate replacement. The workability of roof tile waste concrete is in the range of medium. Overall, the replacement of tiles 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.

II. INTRODUCTION CONCRETE

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. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on large-scale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire.

HISTORICAL BACKGROUND

Although high strength concrete is considered as relatively a new material, its development has been gradually increasing over years. In 1950s, USA considered the concrete with a compressive strength of 34mpa as high strength. In 1960's, the concrete with compressive strength 41mpa to 52mpa was used commercially. Inthe early 1970's, 62mpa concrete was been made. Within the world state of affairs, however, within the last fifteen years, concrete of terribly high strength entered into the construction sector of high-rise buildings and long span bridges. The compressive strength over 110mpa has been thought-about by IS 456- 2000 for the applications in pre- stressed concrete members and cast-in-place buildings.

The colosseum in Rome was built largely of concrete and the dome of the pantheon is the World's largest unreinforced concrete structure. After the collapse of Roman Empire in the mid-18th century, the technology was re-pioneered as the usage of concrete has become rare. Today, the widely used man made material is concrete in terms of tonnage.

However, recently reactive concrete could be the one that having a compressive strength of nearly 250mpa. It is fully supported by pozzolanic materials. The first distinction between high-strength concrete and nominal- strength concrete refers to the relation of utmost resistance offered by compressive strength of the concrete sample for the application of any type of load. Though there is no correct separation between high- strength concrete and normal-strength concrete, he Yankee Concrete Institute defined the compressive strength greater than 42mpa as high strength concrete.

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III. LITERATURE REVIEW

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replacement of tiles in concrete is satisfactory for small constructions.

Batriti Monhun R. Marwein (2016) : A Review paper on utilization of ceramic waste in concrete [IJSER volume 7, issue 4, April 2016]: The ceramic waste adopted is broken tiles. Ceramic waste concrete (CWC) made with these tiles at 0%, 15%, 20%, 25% and 30%. M20 grade concrete is adopted; a constant water cement ratio of 0.48 is maintained for all the concrete mixes. The characteristics properties of concrete such as workability for fresh concrete, also Compressive Strength, Split Tensile Strength are found at 3, 7 and 28 days. The paper suggests that the replacement of waste tile aggregate should be in the range of 5-30% and also it is suitable to ordinary mixes like M15 and M20.

B. TOPÇU AND M. CANBAZ (2010): The amount of tile waste generation is enough to use in concrete as a replacement to coarse aggregate. The use of ceramic tile waste has a positive effect on environment and in the cost aspects too. By the use of tile aggregate, the self-weight of concrete is reduced about 4% which makes the structure economical. Coming to the strength aspect, the tile aggregate replacement has a negative effect on both the compressive and split tensile strength of concrete. But this paper studied maximum replacements of tile waste which can be further divided into smaller percentages and can be utilized in concrete with desirable properties.

Julia García-González, Desirée Rodríguez-Robles, Andrés Juan- Valdés, Julia Ma Morán-del Pozo and M. Ignacio Guerra-Romero (2014) : The study concentrates on the ceramic waste from industries in Spain. The concrete design is done as per the Spanish concrete code and the recycled ceramic aggregates met all the technical requirements imposed by current Spanish legislation. The ceramic aggregates are replaced up to 100% replacement of coarse aggregate. Appropriate tests were conducted to compare the mechanical properties with conventional concrete. The ceramic waste aggregate concrete was exhibited a feasible concrete property as like the normal gravel concrete.

Md Daniyal and Shakeel Ahmad (2015) : A large quantity of ceramic materials goes into wastage during processing, transporting and fixing due to its brittle nature. The crushed waste ceramic tiles were used in concrete as a replacement for natural coarse aggregates with 10%, 20%, 30%, 40% and 50% of substitution in concrete. The study states that the use of ceramic tile aggregate in concrete enhances its properties and it has been observed an increase in both compression and flexural strength.

N. Naveen Prasad (2016) : Crushed waste tiles and Granite powder were used as a replacement to the coarse aggregates and fine aggregate. The combustion of waste crushed tiles was replaced in place of coarse aggregates by 10%, 20%, 30% and 40% and Granite powder was replaced in place of fine aggregate by 10%, 20%, 30% and 40% without changing the mix design. M25 grade of concrete was designed to prepare the conventional mix. Without changing the mix design different types of mixes were prepared by replacing the coarse aggregates and fine aggregate at different percentages of crushed tiles and granite powder. Experimental investigation is carried out. The workability of concrete increased with increase in granite powder and it has been observed that the compressive strength is maximum at 30% of coarse aggregate replacement.

Parminder Singh and Dr. Rakesh Kumar Singla (2015): A research paper on utilization of ceramic waste tiles from industries. A partial replacement to coarse aggregate has been studied. Three different grades of concrete have been prepared and tested. The results are not appropriate with the conventional but considering the strength properties, it is advisable to use ceramic tile aggregate in concrete. It is finally concluded that, about 20% of ceramic tile usage in M20 grade of concrete is preferable.

Paul O. Awoyera (2016) : The usage of ceramic tiles in concrete was observed in this paper. In this, both the coarse and fine aggregates are replaced with ceramic fine and ceramic coarse aggregates obtained from construction sites of Ota, Lagos and Nigeria in various percentages. The ceramic fine and coarse aggregates are replaced in conventional concrete individually and the strength parameters are studied. Finally, it states that usage of ceramic waste in concrete gives considerable increase in strength compared to conventional concrete.

P. Rajalakshmi (2016) : Use of ceramic waste will ensure an effective measure in maintaining environment and improving properties of concrete. The replacement of aggregates in concrete by ceramic wastes will have major environmental benefits. In ceramic industry about 30% production goes as waste. The ceramic waste aggregate is hard and durable material than the conventional coarse aggregate. It has good thermal resistance. The durability properties of ceramic waste aggregate are also good. This research studied the fine aggregate replacement by ceramic tiles fine aggregate accordingly in the range of 10% and coarse aggregate accordingly in the range of 30%, 60%, 100% by weight of M-30 grade concrete. This paper recommends that waste ceramic tiles can be used as an alternate construction material to coarse and fine aggregate in concrete irrespective of the conventional

concrete, it has good strength properties i.e., 10% CFA and 60% CCA being the maximum strength.

Vignesh. S : This paper recommends that waste seashells can be used as an alternate construction material to coarse aggregate in concrete. In their experimental study, seashells are partially replaced in place of coarse aggregate by 10%, 20%, and 30% without affecting the design strength. The compressive strength of the concrete with different percentages of seashells is tested and the values at 30% replacement is 20 N/mm² and 25 N/mm² at 7 days and 28 days respectively.

In this paper the concrete grades M25 is designed with a suitable water- cement ratio at which the desired concrete strength attained and also for various mix replacements of both fine and coarse aggregate.



Mixing of concrete



Placing of concrete in moulds

The ideal concrete is the one which is workable in all conditions i.e., can prepared easily placed, compacted and moulded. In this chapter, the workability is assessed by two methods as follows:

Slump Cone Test

TEST RESULTS

The test was conducted for fresh concrete prepared before the moulding process. A total of 14 concrete mixes are prepared at different times. Workability Results obtained from slump cone test for M25 grade of concrete is shown in table 1.

S.No	Mix Designation	Aggregate Replacements % (CCA+CFA+GP)	Compaction Factor
			M25 grade
1	Mix 0	0+0+0	0.82
2	Mix 1	10+0+0	0.84
3	Mix 2	20+0+0	0.855
4	Mix 3	30+0+0	0.87
5	Mix 4	40+0+0	0.89
6	Mix 5	50+0+0	0.93
7	Mix 6	10+10+0	0.83
8	Mix 7	20+10+0	0.86
9	Mix 8	30+10+0	0.88
10	Mix 9	40+10+0	0.91
11	Mix 10	10+0+10	0.85
12	Mix 11	20+0+10	0.90
13	Mix 12	30+0+10	0.93
14	Mix 13	40+0+10	0.95

Table 1: Test results from slump cone test for workability in mm

The workability from the slump cone test is in increasing manner as the mix proportion replacement increasing. The workability range of concrete increasing as mentioned while being in medium range overall.

Compaction Factor Test:

The compaction factor test was conducted to the same mix that tested for workability by slump cone. The results obtained from the compaction factor test for the workability of various mixes of replacements of M25 grade of concrete are tabulated as follows:

Table 2: Test results of compaction factor test for workability

S.No	Mix Designation	Aggregate Replacements (CCA+CFA+GP) %	Compaction Factor % M25 grade
1	Mix 0	0+0+0	0.82
2	Mix 1	10+0+0	0.84
3	Mix 2	20+0+0	0.855
4	Mix 3	30+0+0	0.87
5	Mix 4	40+0+0	0.89
6	Mix 5	50+0+0	0.93
7	Mix 6	10+10+0	0.83
8	Mix 7	20+10+0	0.86
9	Mix 8	30+10+0	0.88
10	Mix 9	40+10+0	0.91

11	Mix 10	10+0+10	21.05	28.64	34.5
12	Mix 11	20+0+10	24.6	33.58	39.5
13	Mix 12	30+0+10	28.1	38.4	42.14
14	Mix 13	40+0+10	21.32	28.09	33.84

11	Mix 10	10+0+10	0.85
12	Mix 11	20+0+10	0.90
13	Mix 12	30+0+10	0.93
14	Mix 13	40+0+10	0.95

The workability of M25 grade of concrete by compaction factor test is similar to that of slump cone test. The pattern of increment for the mixes is quite same which will be discussed in detail further.

Compressive strength:

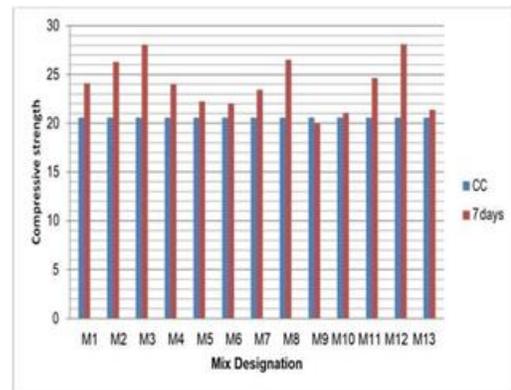
A total of 42 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days testing each of 13 specimens after conducting the workability tests. The results are tabulated below:

Table 3: Compressive strength results of M25 grade of concrete for 7, 24 and 28 days

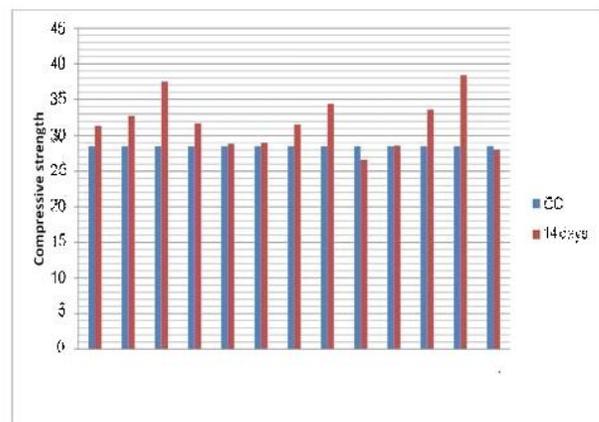
S.No	Mix Designation	Aggregate Replacements (CCA+CFA+GP) %	Compressive strength of M25 grade in N/mm ²		
			7 days	14 days	28 days
1	Mix 0	0+0+0	20.57	28.54	33.18
2	Mix 1	10+0+0	24.09	31.39	36.5
3	Mix 2	20+0+0	26.27	32.8	39.5
4	Mix 3	30+0+0	28.05	37.53	43.14
5	Mix 4	40+0+0	23.96	31.77	37.16
6	Mix 5	50+0+0	22.22	28.88	34.18
7	Mix 6	10+10+0	21.98	29	35.17
8	Mix 7	20+10+0	23.41	31.6	37.16
9	Mix 8	30+10+0	26.5	34.4	39.5
10	Mix 9	40+10+0	20.01	26.65	32.9

The analysis of the compressive strength of M25 grade of concrete obtained by replacing the coarse and fine aggregates with the ceramic tiles and granite powder in different proportions is presented below. The analysis of the 7, 14 and 28 days strength of the concrete is shown in the form of graph which shows the comparison of the compressive strength of the conventional concrete and the in different proportions with ceramic tiles and granite.

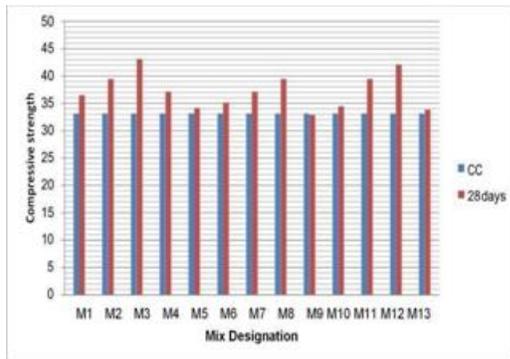
in different proportions with ceramic tiles and granite powder.



Graph 1: Comparison of Compressive strength of M25 at 7 days Figure



Graph 2: Compressive strength of M25 concrete at 14 days

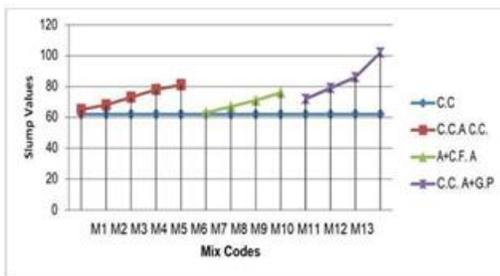


Graph 3: Compressive strength of M25 concrete at 28 days

The results obtained from compression testing gives comprehensive outcome of the work as the replacement the replacement of tile aggregates produces a concrete with suitable properties as conventional.

Workability :

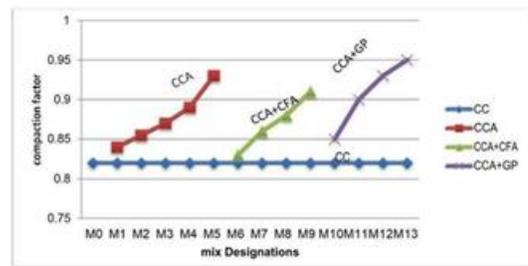
Slump cone test :



Graph 4: Comparison of workability of various mixes for M25 grade concrete with conventional concrete

From the results it is observed that the workability is increased by an amount of 4.8%, 9.6%, 17.7%, 25.8%, 30.6%, 1.6%, 8%, 14.5%, 22.5%, 16.1%, 27.4%, 38.7% and 64.5% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13 mixes which are obtained by replacing the coarse and fine aggregates in concrete with ceramic tiles and the granite powder in varying proportions respectively over conventional M25 concrete grade(M0) which consists of the conventional coarse and fine aggregates i.e. the crushed granite and the natural sand.

Compaction Factor Test



Graph 4: Comparison of compaction factor for various mixes with conventional concrete for M25 grade

From the results it is observed that the workability is increased by an amount of 2.4%, 4.3%, 6.1%, 8.5%, 13.4%, 1.2%, 4.9%, 7.3%, 10.9%, 3.6%, 9.7%, 13.4% and 15.8% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13 mixes which are obtained by replacing the coarse and fine aggregates in concrete with ceramic tiles and the granite powder in varying proportions respectively over conventional M25 concrete grade(M0) which consists of the conventional coarse and fine aggregates i.e. the crushed granite and the natural sand..

The workability from both slump cone and compaction factor tests is similar in increasing manner. The workability increases with increase in ceramic coarse tile aggregate but a little deviation with the addition of ceramic fine aggregate. The addition of granite powder has significant improvement on the workability of concrete.

Compressive Strength :

The Compressive strength of concrete varies as 17.11%, 27.7%, 36.36%, 16.4%, 8.02%, 6.85%, 13.8%, 28.82%, -2.72%, 2.33%, 19.59%, 36.6% and 3.64% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12 and M13 compared with the conventional concrete after 7days of curing.

The Compressive strength of concrete varies as 9.99%, 14.92%, 31.49%, 11.31%, 1.19%, 1.61%, 10.72%, M20.53%, -6.62%, 0.3%, 17.65%, 34.54% and -1.57% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12 and M13 compared with the conventional concrete after 14days of curing.

The Compressive strength of concrete varies as 10%, 19.04%, 30%, 11.99%, 3.01%, 5.99%, 11.99%, 19.04%, 0.8%, 3.97%, 19.04%, 27% and 1.98% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12 and M13 compared with the conventional concrete after 28days of curing.

On comparing the strengths of all mixes, M3, M8 and M12 has the highest i.e., 30% replacement of coarse aggregate. The addition of granite powder has positive effect on strength while improving the workability also.

IV. CONCLUSION

The basic objective of the study is to prepare a concrete much more stable and durable than the conventional by replacing aggregates both coarse and fine. Mix designs for all the replacements of materials has done and a total of 42 specimens (42 cubes,) are prepared and tested in the aspect of strength calculation and also comparisons has done.

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.
- 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.

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