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Experimental Investigation on Concrete byPartial Replacement of Fine Aggregate with Ceramic Powder

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Abstract: *An enormous amount of industrial waste is produced annually by India's manufacturing sector, and as long as resources are still being exploited and utilised, this waste problem will only become worse. This debris is made up of almost a million tonnes of ceramic trash. India makes up more than 6% of all manufacturing globally. India now holds the third-place spot globally in terms of consumption. Similar to this, a considerable amount of waste is generated after utilising these tiles, and it is placed there. Due to considerable construction and infrastructure development, natural sand is quickly disappearing from waterways. Finding a replacement or alternative material for fine aggregate is therefore essential. Therefore, using ceramic waste powder in concrete can solve the problems of fine aggregate replenishment and the disposal of broken ceramic tile.*

Key words: Compressive Strength, Split Tensile Strength, Flexural Strength, Ceramic powder

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I. INTRODUCTION

Most structures use necessary building supplies, some of which are ceramic products. A few examples of frequently produced ceramics include wall tiles, floor tiles, sanitary ware, household ceramics, and technical ceramics. They contain a lot of clay minerals and are primarily formed of organic elements.Nevertheless, despite ceramics' attractive qualities, its Wastes are quite annoying to the environment, among other reasons. One category is made up of burned ceramic wastes generated by structural ceramic producers who solely use red pastes to make brick, blocks, and roof tiles. Wall, floor and sanitary ware tiles fall within the second type of fired ceramic wastes produced of stoneware ceramic. Studies on the production of ceramics have shown that around 30% of the raw materials are wasted or not being used effectively at this time. This highlights the need to look for inventive ways to reuse surplus ceramic materials. Aggregates make up about 70% of all the materials used to build concrete. The price is increasing as a result of the high demand from both rural and urban communities. Numerous investigations have revealed that ceramics can substitute for natural aggregates.

According to various research, ceramic wastes may provide good substitutes for conventional aggregates in concrete.Recent studies examined the effects of waste from the production of ceramic tiles on the structural properties of laterite-based concrete. According to research, laterized concrete made with ceramics performs better than conventional concrete. Utilising ceramic waste can benefit numerous construction projects that lack aggregate. Additionally, it can decrease the environmental problems brought on by mining for aggregate and rubbish disposal. However, because the majority of older studies employed ceramics for sanitary ware and electrical insulators, there is little information available regarding the use of ceramic floor and wall tiles. Investigating the use of ceramic floor and wall tiles is vital since these ceramic goods are manufactured at varying temperatures, which inevitably determines their micro structures.As a result, the current study examines the mechanical characteristics of concrete made utilising leftover ceramic floor and wall tiles from construction and demolition sites as a partial replacement for natural aggregates.

II. LITERATURE REVIEW

1. "Investigation on Partial Replacement of Coarse Aggregate with Ceramic Waste and Addition of Steel Fiber in Concrete" Dr. Ch. Verendra, U. Brunda (2020)

In this project, we suggest replacing some of the coarse aggregate, which makes up the majority of the concrete, with discarded or broken ceramic tiles and adding steel fibre for additional support. Ceramic waste originates not just from the construction industry but also from manufacturers. These ceramic waste products are essentially unrecyclable and extremely resistant to the elements. These will be strong, resilient, and inert, meeting the requirements of aggregate. Additionally, they have a reduced density and make excellent insulation.

For this project, ceramic waste of various sizes will be mixed with M25 grade concrete, and 5%, 10%, and 15% of coarse aggregate will be substituted in situ, along with the addition of fifty percent steel fibre by weight of cement.

2. "Study of Partial Replacement of Coarse Aggregate by Mosaic Tile Chips" Mohd. Fazil Danish, Dr Kuldeep Dabhekar, Saurabh R More, Dr Isha P Khedikar (2020)

The garbage from manufacturing factories and building deconstruction both contribute to the waste of mosaic tiles. To manage the scarce natural aggregate and reduce construction waste, this waste material must be recycled.

3. "Characterization of ceramic waste aggregate concrete" Paul O. Awoyera , Julius M. Ndambuki , Joseph O. Akinmusuru ,(2016)

The use of waste materials as alternative aggregate materials for construction, such as ceramics, is gaining popularity. There aren't many research findings available on ceramic wall and floor tile wastes, compared to other ceramic product wastes like sanitary wares and electrical insulators. Therefore, the current study's main focus is on the mechanical characterization of aggregate concrete made from leftover ceramic wall and floor tiles. Separated from other debris, ceramic wastes from building and demolition wastes were smashed using a quarry hammer. According to specifications, ceramic tiles were sieved into fine and coarse particles. Cement, river sand, gravel, and potable water were other resources employed.

4. Utilization Of Waste Ceramic Tiles As Coarse Aggregate In Concrete Parminder Singh. (2015)..

The goal of sustainable construction can be greatly aided by the use of waste resources in the manufacturing of concrete. As a result, the purpose of this study is to produce concrete using ceramic tile aggregate. The performance of three distinct concrete mixes with varying amounts of crushed tiles with a maximum size of 20 mm as coarse aggregate is discussed in the study. Standard concrete cubes were created using common Portland Cement 53 grade and coarse sand. Concrete sample of varying ages underwent compression strength tests.

5. "Partial Replacement of Coarse aggregate by Crushed Tiles and Fine aggregate by Granite Powder to improve the Concrete Properties." N.Naveen Prasad, P.Hanitha , N.C.Anil. (2016).

To reduce solid waste and the shortage of natural aggregates, the reuse of demolished construction wastes and granite powder came into play. The coarse aggregates and fine aggregate are swapped out for crushed waste tiles and granite powder. Without altering the mix design, 10%, 20%, 30%, and 40% of the coarse aggregate was replaced by the combustion of waste broken tiles, and 10%, 20%, 30%, and 40% of the fine aggregate by granite powder. The typical mix was prepared using M25 grade concrete. By substituting crushed tiles and granite powder for fine and coarse aggregates in varying proportions, several types of mixes were created without altering the mix design.

6. Partial Replacement of Ceramic Tile Waste in ConcreteJaivik P. Babria , Dr. Jayeshkumar R. Pitroda, Prof. Kishor B. Vaghela, Prof. (Dr.) Indrajit N.Patel

A suitable form of arrangement is required to address society's waste problem in order to achieve sustainable development.The effects of employing waste from the ceramic industry in concrete on the properties of freshly-poured and cured concrete are investigated in this study. The majority of the studies on the use of wastes in the construction sector focus on the use of wastes in concrete. As the demand for building materials increases, it will involve the use of wastes and a decrease in the usage of naturally existing construction materials, helping to protect natural resources. Concrete will temporarily cost less as a result, and any problems with waste removal will be less of a concern.

7. Studies on usage potential of broken tiles as part replacement to coarse aggregates in concretes Aruna D, Rajendra Prabhu, Subhash C Yaragal, Katta Venkataramana

Concrete has a number of enticing qualities that make it a popular building material. Wherever strength, performance, durability, etc. are needed, it is the material of choice, and concrete is unquestionably the most adaptable building material. The goal of the current study is to evaluate the use of tile aggregate as a partial replacement for coarse aggregate in conventional pervious and blended concretes. The current work also discusses the usefulness of partially substituting tile waste for aggregates and partially substituting fly ash for OPC. Important findings are revealed after a study comparing the strength performance of these concretes—tile & fly ash based blended concretes, tile & waste based pervious concretes—with conventional concretes.

III. MATERIALS USED

1. Cement

The chemical composition of cement determines its many physical and chemical traits. The qualities and types of cement produced by varying the grinding fineness are oxide compositions cement. There are many distinct types of cements available as a result of the addition of additives, changing chemical composition, and usage of various raw materials. Ordinary Portland Cement, available in 53 grades and compliant with IS: 8112/1989, is the cement utilised in the experimental study.

2. Fine Aggregate

In order to determine the zone to which it belongs, fine aggregate is first graded. Sand from zone III is used in this project; its qualities are listed below. Usually, a 4.75 mm sieve is used to filter out fine material.

3. Coarse aggregate

Coarse aggregate is another fundamental raw material which gives strength, hardness and increases the volume of the concrete. Here, coarse aggregate of size 20 mm.

4. Ceramic Powder

Broken tiles were gathered from a demolished structure and the solid refuse of a ceramic production facility. Manual labour and a crusher were used to reduce the leftover tiles to powder. To partially replace the natural fine aggregate, the necessary size of powdered tile aggregate was separated. Tile powdered debris larger than 4.75 mm in size was disregarded. The material is crushed ceramic tile aggregate kept on a 0.150 mm screen after passing through a 4.75 mm filter. The percentages of 30%, 35%, 40%, and 45%, individually, were used to replace fine aggregate in place of powdered ceramic tile aggregates.

EXPERIMENTAL PROGRAM

The grade of concrete chosen is M25 Grade and the proportion of the mix is calculated as the thumb rule. The concrete selection criteria test performed are mentioned below

Various Tests on Cement

TEST	Fineness	Std. consistency	Initial setting time	Final setting time
RESULT	7.5%	32%	30 min	60 min

VARIOUS TESTS ON COARSE AGGREGATE

S.NO	PROPERTY	VALUES
1	Specific Gravity	2.7
2	Size of Aggregates	20mm
3	Fineness Modulus	5.96

VARIOUS TESTS ON FINE AGGREGATE

S.NO	PROPERTY	VALUES
1	Sand zone	Zone- III
2	Specific Gravity	2.6
3	Fineness Modulus	2.25
4	Water absorption	1.5%

CERAMIC POWDER

S.No	Description	Test Results
1	Origin Rock	Feldspar
2	Specific gravity of crushed tiles	2.6
3	Water absorption of crushed ceramictiles	0.19%

Mix calculations per unit volume for M25 grade concrete

Volume of concrete	1 m^3
Volume of cement	394 Kg/ m^3
Volume of water	197 Kg/ m^3
Volume of all in aggregate	1750.3 Kg/ m^3

MIX PROPORTION

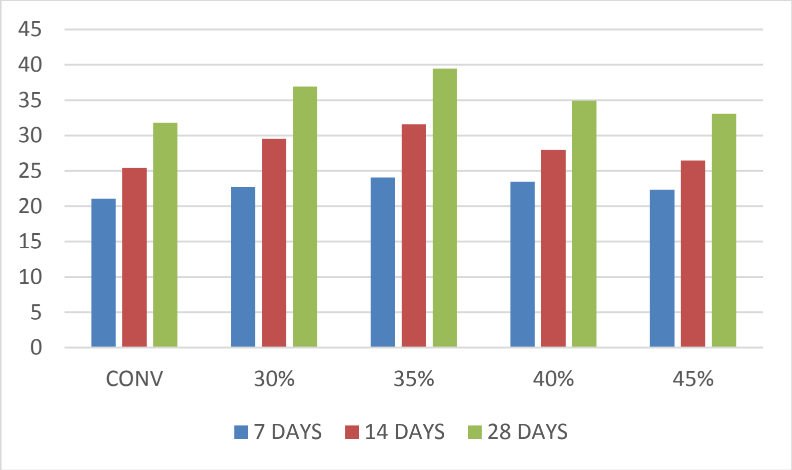
Replacement of ceramic powder	Cement	Fine aggregate	Coarse aggregate	Ceramic powder	Water
CONV	394	615	1135.3	0	197
30%	394	403.5	1135.3	184.5	197
35%	394	399.7	1135.3	215.3	197
40%	394	369	1135.3	246	197
45%	394	338.3	1135.3	1276.7	197

IV. RESULTS AND ANALYSIS

The experimental findings on various design mixtures are discussed in this section compressive strength tests, split tensile strength and flexural strength tests are all included in the results. In this investigation cubes ,beam and cylinders of each 18 specimens of each were cast and evaluated over the course of 7 days, 14 days, and 28 days. The comparison and findings are addressed in more detail in the following sections:

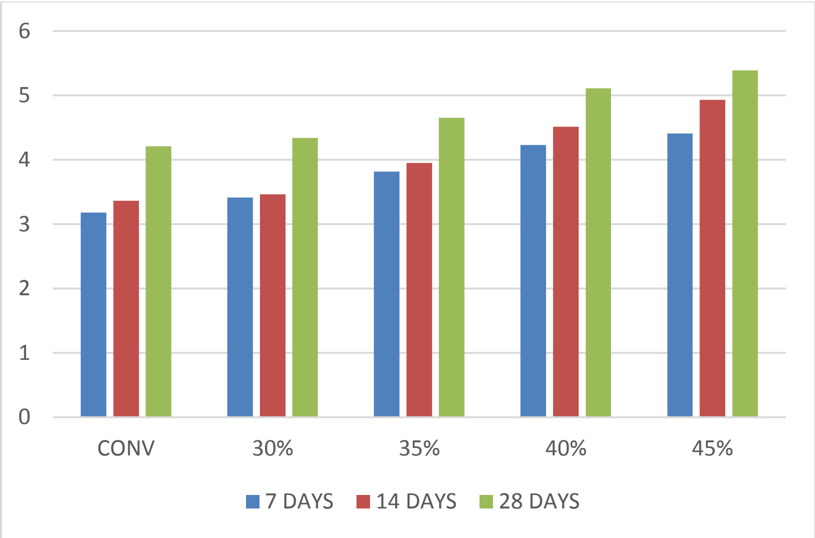
COMPRESSIVE STRENGTH TEST:

% CTA	7 Days N/mm^2	14 Days N/mm^2	28 Days N/mm^2
0%	21.09	25.44	31.80
30%	22.70	29.55	36.94
35%	24.06	31.59	39.48
40%	23.47	27.95	34.94
45%	22.34	26.46	33.08



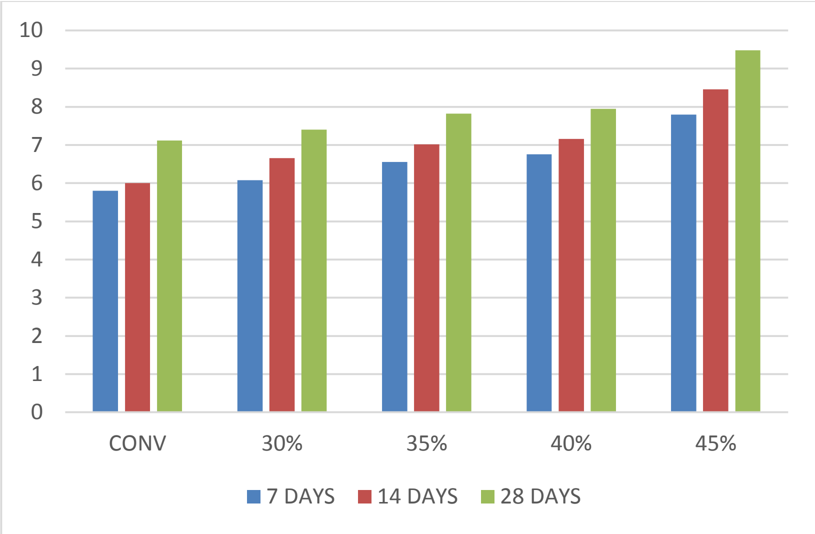
TENSILE STRENGTH TEST:

% CTA	7 Days N/mm^2	14 Days N/mm^2	28 Days N/mm^2
0%	3.177	3.36	4.21
30%	3.414	3.46	4.34
35%	3.814	3.95	4.65
40%	4.226	4.51	5.11
45%	4.407	4.93	5.39



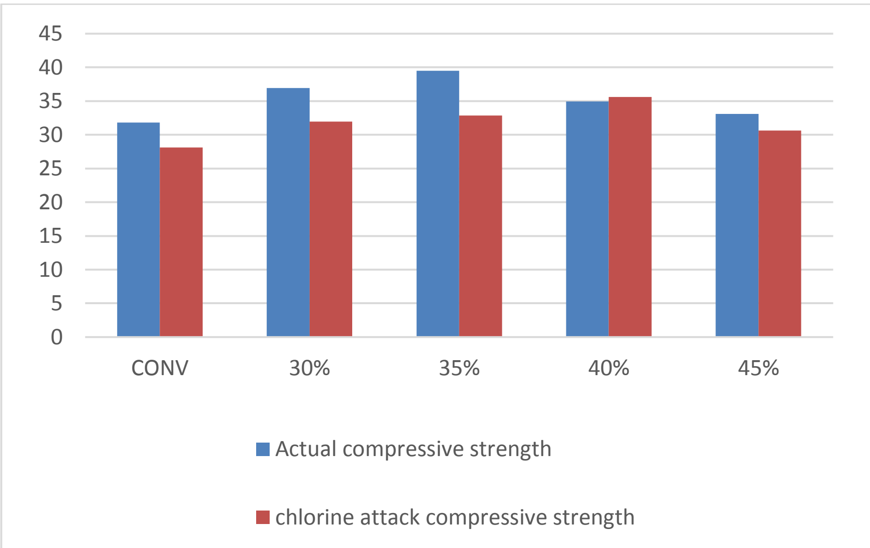
FLEXURAL STRENGTH TEST:

% CTA	7 Days N/mm^2	14 Days N/mm^2	28 Days N/mm^2
0%	5.80	6.0	7.12
30%	6.08	6.66	7.40
35%	6.56	7.02	7.82
40%	6.76	7.16	7.95
45%	7.8	8.46	9.48



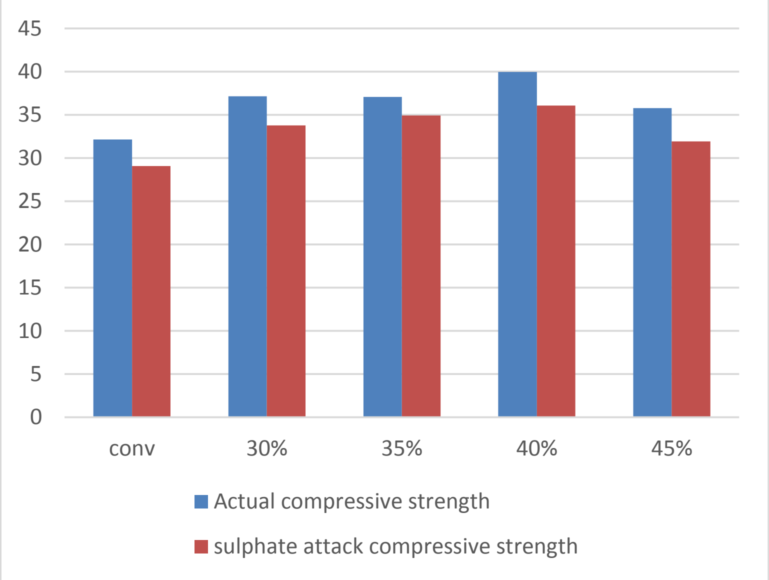
CHLORINE ATTACK

Type of concrete	Initial Weight (kg)	Final Weight (kg)	Weight Reduction (%)	Compressive strength (N/mm²)
0%	7.68	7.31	4.82	28.10
30%	7.33	6.96	5.05	31.95
35%	7.37	7.01	4.88	32.86
40%	7.39	6.99	5.41	35.63
45%	7.21	6.84	5.13	30.63



SULPHATE ATTACK

Type of concrete	Initial Weight (kg)	Final Weight (kg)	Weight Reduction (%)	Compressive strength (N/mm^2)
0%	7.68	7.3	3.78	29.07
30%	7.33	7.1	2.86	33.76
35%	7.37	7.0	3.94	34.91
40%	7.39	7.0	5.14	36.08
45%	7.21	6.8	4.58	31.94



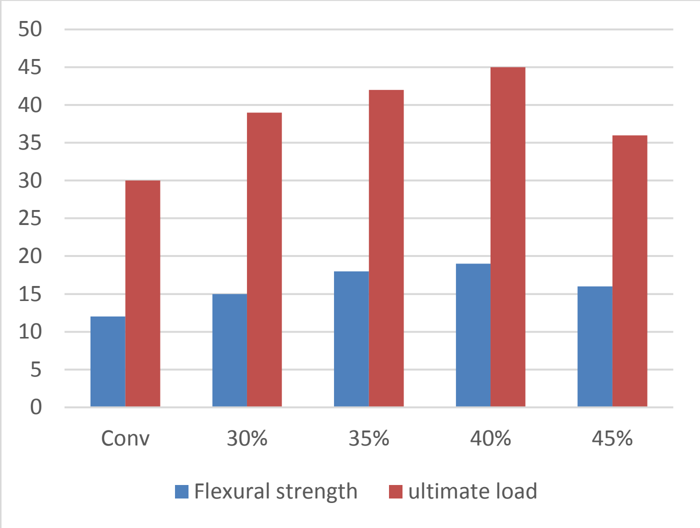
Details of RC beam design

The design of beam to find the flexural strength of concrete is done. A square shape beam of cross section 150mm x 150mm with 2000mm length is designed having 2nos of 10mm bars on tension side and 2nos of 8mm dia hanging bars with 8mm stripps at 100mm c/c spacing.

Experimental setup:

The load is applied to the beam with the help of hydraulic jack and the data is recorded from the data acquisition system, which is attached with the load cell. One LVDT (Linear Variable Deflection Transformer) is placed at the center of the specimen. The value of deflection is obtained from LVDT.

S. No	% of Ceramic Powder	Flexural Strength (N/mm^2)	Ultimate Load KN
1.	0%	12	30
2.	30%	15	39
3.	35%	18	42
4.	40%	19	45
5.	45%	16	36



V. CONCLUSION

- The compressive strength has increasing by 24.15% with (35%) of Ceramic Powder aggregate than start increasing and then decreases by with increase the Ceramic Powder aggregate quantities.
- The results of the splitting tensile strength tests show that, there is a increase in strength by increasing Ceramic Powder aggregate. it was foundthat highest splitting tensile strength was achieved by 45% of Ceramic Powder aggregate, which was found about 5.39 N/mm^2 compared with other mix. The load carrying capacity is increased to 28.02 % compared with the conventional specimen.
- The experimental test result there is an improvement in Flexural strength of the 2.5% mix is higher at age of 7,14 &28 days respectively compared to all other mixes.
- From chloride attack, It has been observed that the compressive strength decreases maximum upto 10.81% at 40% replacement of cermic powder after chloride attack and after 40% replacement of cermic powder it starts more decreasing and decreases upto 12% at 45% replacement of cermic powder.
- From Sulpahte attack, It has been observed that the compressive strength decreases maximum upto 8.6% at 40% replacement of cermic powder after acid attack and after 40% replacement of cermic powder it starts more decreasing and decreases upto 9% at 45% replacement of cermic powder.

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