Investigation of Compressive Strength Characteristics of Concrete Formed with Partial Replacement of Cement by Ceramic Tile Powder

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Abstract **- The main constituent for constructing a building is concrete and at the same time majority of waste is produced during demolition of building. Now a day's construction sectors and manufacturing industries has increased the evolution of residues. On behalf of utilization of construction waste as well to minimize the construction material cost, some materials can replace as the by-product of concrete. In order to reduce the dumping of waste, it can be used as a replacement material in producing concrete which will make the environment pollution free. In the field of civil engineering and construction materials it has been found that ceramic waste is one of the major waste materials and become most effective research area. Ceramic tiles are used as building material in the field of construction. The ceramic tile waste at the construction site was used as replacement of cement in concrete. The aim of this study was to investigate the compressive strength characteristics of concrete formed with partial replacement of cement by ceramic tile powder. In this study, the Ordinary Portland Cement (OPC) in M30 grade of concrete was replaced by crushed ceramic tile powder of various percentage such as 5%, 10%, 15%, and 20%. Concrete cubes were casted, tested and compared with conventional cubes by finding their compressive strength through experimental investigation. The tests were carried out to evaluate the compressive strength characteristics of cubes for 7 and 28 days. On studying results it was found out that the compressive strength of the concrete decreases with addition of ceramic tile powder. But, the change in the compressive strength of the concrete was less, so ceramic tile powder can be used as a partial replacement of cement in concrete to a certain amount.**

Index Terms **- Constructional Waste, Ceramic Waste, Ceramic Tile Powder, Compressive Strength, Cubes**

1.INTRODUCTION

The natural resources in the world are continuously decreasing due to manufacturing of the products and their impact on the environment since disposing the unwanted products is becoming an issue which need to be addressed and resolved. This can be possible by adopting the policy of 3Rs; Reduce, Reuse, Recycle. To manufacture a new product, a lot of energy and material is required. Most of the construction materials are very expensive and the energy and cost required for their manufacture is very high. In this situation alternative materials need to be found in order to decrease the construction cost and save the natural resources.

It has been found that certain waste materials produced by different industrial processes can be very useful in construction; they can provide the required properties, strength and safety. These materials, if released into the environment and atmosphere, can severely harm human health and create pollution. So, the best way to protect the environment and human health from such waste materials is to reuse them in construction. As these are waste materials so there is no manufacture cost and hence, they are very cheap. The advantages of using these waste materials include cost saving, energy saving, reducing pollution and sustaining the environment of the future generations.

Recycling of waste materials is, therefore, necessary in order to generate useful products and protect the environment and future generations

The advancement of concrete technology can reduce the consumption of natural resources, which can be reused and find other alternatives. In India numbers of waste materials are produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well

as liquid waste management is one of the biggest problems of the whole world. Disposal of waste into the land causes serious impact on environment.

Now a day's large amount of tile powder is generated in tile industries with an impact on environment and humans. By using the replacement materials offers cost reduction, energy savings and few hazards in the environment.

Concrete is nothing but a combination of aggregates both fine and coarse, Cement and water. Comparing to all other ingredients in concrete, cement is considered to be the expensive material. This is because cement is manufactured using energy- intensive process. Cement is one of the major producers of carbon dioxide, which is the main cause of global warming. During the manufacturing process of cement the formation of clinker can be achieved only by heating the cement at very high temperature. This leads to the release of enormous amounts of carbon in the atmosphere. This was one among the major problems identified for climatic changes. Various research works has been carried out for the cost reduction in construction with some of the locally available materials as the partial or full replacement material for cement. Over the last few decades supplementary materials like fly ash, rice husk, silica fume, egg shell, groundnut shell, etc. are used as a replacing material. These supplementary materials have proven to be successful in meeting the needs of the concrete in construction. In India ceramic production is 100 million ton per year.

The tile industry has about 15% to 30% waste material generated from the total production. The tile waste which is dumped in land filling and pit or vacant spaces causes the environmental pollution which is dangerous for human health. This waste is not recycled in any form at present. However, the tile waste is durable, hard and highly resistant to biological, chemical, physical degradation forces. The tile waste which is dumped in land filling and pit or vacant spaces causes the environmental and dust pollution which is dangerous for human health. As the ceramic waste is piling up every day, there is a pressure on tile industries to find a solution for its disposal.

1.1OBJECTIVE:

The main objective is to investigate the compressive strength characteristics of concrete formed with partial replacement of cement by ceramic tile powder.

To achieve this goal sub-objectives, need to be considered which are as follows:

1. to study the compressive strength of the prepared samples of M30 grade of concrete
2. to identify the optimum percent of the waste ceramic content from compressive strength of the samples.

2.MATERIALS USED:

Cement: Ordinary Portland Cement of Grade 43 (OPC 43), manufactured was used in all concrete mixes. Physical properties of cement, i.e., fineness, soundness, standard consistency, initial and final setting time, compressive strength, specific gravity, are evaluated by the procedures given in Bureau of Indian Standard specifications.

Property	IS Code (IS : 8112 – 1989)
Specific gravity	3.15
Consistency	30
Initial setting time	30 minutes (minimum)
Final setting time	540 minutes (maximum)

Coarse Aggregate:

20mm nominal size aggregate was used as coarse aggregate concrete. Coarse aggregate was locally procured and conformed to Indian Standard Specifications given in BIS 383:1970.

TABLE: Physical Properties of Coarse Aggregate

Properties	20mm Nominal Size Coarse Aggregate
Specific Gravity	2.7
Water Absorption (%)	0.53
Bulk Density (kg/m^3)	1640
Moisture Content	Nil

Fine Aggregate

Locally procured river sand was used in the experimental program and it was conformed to Indian Standard Specifications given in BIS 383:1970

TABLE: Physical Properties of Fine Aggregate

Properties	Natural Sand
Specific Gravity	2.31
Water Absorption	1.21
Bulk Density (kg/m^3)	1430
Fineness Modulus	2.78
Silt Content (%)	0.5

Grading Zone	Zone II
Moisture Content	Nil

Ceramic Waste: Waste Ceramic tiles were collected from dumped construction sites. Then, these tiles were break into smaller particles by hammer. The smaller particles were then crushed using a crushing machine at a crushing plant to obtain crushed ceramic tile powder. This powder was then passed through 90-micron sieve to obtain the desired material.

TABLE: Physical Properties of Ceramic Waste

Physical quality parameters	Ceramic waste quality parameter result
Specific gravity	2.7
Loose bulk density (kg/m3)	610.6

3.METHODOLOGY

Experimental Program:

1. Collection of Materials
2. Testing of materials
3. Mix design
4. Sample Preparation
5. Compressive Strength Test
6. Results

Mix Proportioning of Concrete Ingredients:

Mix design of concrete was done as per IS 10262:2009. Grade of control concrete was chosen as M30 and target slump was 75 mm. Conditions for exposure were taken as moderate. As per the procedure of IS 10262:2009, first of all, target strength was calculated assuming suitable value of standard deviation. Estimated water content was calculated for the desired workability and free w/c ratio was chosen from experience as per the target strength of concrete to be achieved.

From estimated water content and free w/c ratio, cement content was calculated. Based on the volume of aggregate in concrete, quantity of coarse as well as fine aggregate was calculated as per their specific gravity and proportion.

Based upon the quantities of different ingredients in control concrete, mix proportions of concrete mixes with ceramic waste were calculated.

Concrete mixes with replacement of cement with ceramic tile powder in 5%, 10%, 15%, and 20%, were designated as CW5, CW10, CW15 and CW20.

TABLE: MIX PROPORTIONING FOR CONCRETE MIXES

Mix Designation	Cement (kg/m^3)	Ceramic Waste (kg/m^3)	Water Content (kg/m^3)	w/c	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)
CM	425.73	0	191.58	0.45	558.12	1110.75
CW05	404.44	21.29	191.58	0.45	558.12	1110.75
CW10	383.16	42.57	191.58	0.45	558.12	1110.75
CW15	361.88	63.85	191.58	0.45	558.12	1110.75
CW20	340.58	85.15	191.58	0.45	558.12	1110.75

TABLE: QUANTITY OF MATERIALS REQUIRED FOR CUBE SPECIMENS

Mix Designation	Cement (kg)	Ceramic Waste(kg)	Water (kg)	Fine Aggregate(kg)	Coarse Aggregate (kg)
CM	8.500	0	3.83	11.16	22.2
CW05	8.075	0.425	3.83	11.16	22.2
CW10	7.650	0.850	3.83	11.16	22.2
CW15	7.225	1.275	3.83	11.16	22.2
CW20	6.800	1.70	3.83	11.16	22.2

COMPRESSIVE STRENGTH TEST:

Compressive strength test is the most common test conducted on concrete, because it is the desirable characteristic properties of concrete are quantitatively related to its compressive strength. Compressive strength was determined by using Compression Testing Machine (CTM) of 2000 kN capacity. The compressive strength of concrete was tested using 150 mm x 150 mm x 150 mm cube specimens. The test was carried out by placing a specimen between the loading surfaces of a CTM and the load was applied until the specimen fails. Six specimens were cast for each proportion and used to measure the compressive strength for each test conditions and average value was considered.

The compressive strength was calculated according to the following formula: σ =P/A

where,

σ = Compressive Strength (N/ m 2)

P = Maximum load sustained by the cube (N)

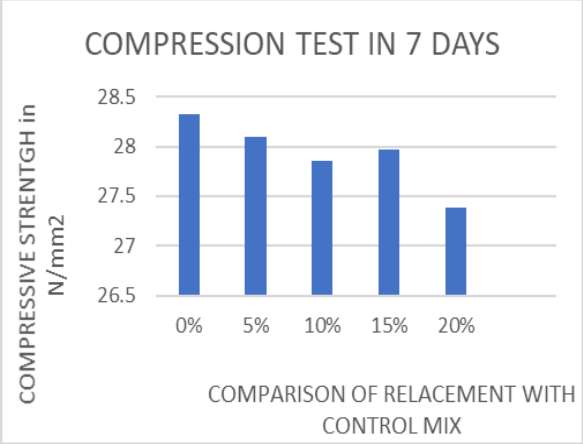
A = Area of cross section of cube (mm2)

The average value of compressive strength of specimens for each category at the age of 7 days, 14 days and 28 days are shown below.

4.RESULT

TABLE: Compressive strength results at 7 days

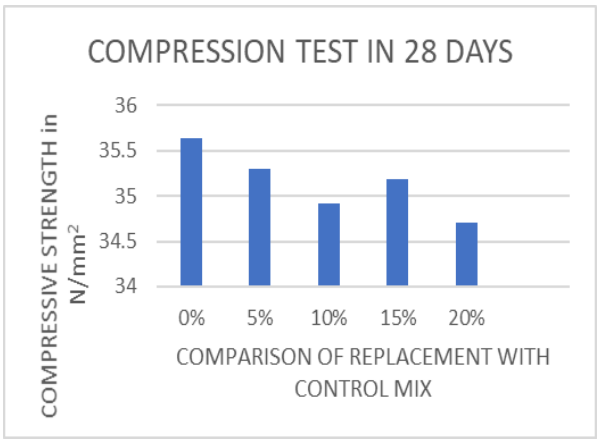
S. No.	Replacement level (in percentage)	Compressive strength at 7 days (in N/mm^2)	Comparison of replacement with control (in %)
1.	Control (0%)	28.32	100 %
2.	5% ceramic waste	28.10	99.22 %
3.	10%ceramic waste	27.86	98.36 %
4.	15%ceramic waste	27.97	98.76 %
5.	20%ceramic waste	27.38	96.68 %



For 7 Days Compressive Strength

TABLE: Compressive strength results at 28 days

S.N.	Replacement level (in percentage)	Compressive strength at 28 days (in N/mm^2)	Comparison of replacement with control (in %)
1.	Control (0%)	35.64	100 %
2.	5% ceramic waste	35.30	99.04 %
3.	10% ceramic waste	34.92	97.98 %
4.	15% ceramic waste	35.18	98.77 %
5.	20% ceramic waste	34.71	97.39 %



For 28 Days Compressive Strength

5.CONCLUSION

In concrete according to the test result of compressive strength test, ceramic tile powder replacement has been successful up to the limitation of 15 % replacement with cement.

1. According to the result of compressive strength of concrete at 7 days decreases with increase in the percentage of the ceramic replacement. It is more than 98% strength up to the 15% of replacement and at 20% of ceramic waste replacement its less than 98% strength as compare to control.
2. Compressive strength of concrete of control mix is observed 28.32 N/mm2 (M30) and at 15%replacement of cement with ceramic tile powder observed is 27.97 N/mm2.
3. At 20% of ceramic tile powder its less than 98% strength as compare to control. It is observed 27.38 N/mm2.
4. According to the result of compressive strength of concrete at 28 days decreases with increase in the percentage of the ceramic replacement. It is more than 98% strength up to the 15% of replacement and at 20% of ceramic waste replacement it's less than 98% strength as compare to control. So, the concrete performance is not good at 20% replacement.
5. Compressive strength of concrete of control mix is observed 35.64 N/mm2 (M25) and at 15%replacement of opc with ceramic insulator waste is observed 35.18 N/mm2.
6. At 20% of ceramic waste replacement its less than 98% strength as compare to control. It observed 34.71 N/mm2.

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