Experimental Study On Glass Fibre Reinforced Concrete By Partial Replacement Of Coarse Aggregate By Waste Ceramic Tiles

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Abstract

A large quantity of ceramic materials changes into wastage during processing, transporting and fixing due to its brittle nature. Therefore, using these wastes in concrete production could be an effective measure in maintaining the environment and improving the properties of concrete. The increasing demand of construction material and degradation of environment, there is need to explore alternative construction material from industrial as well as household waste and recyclable materials. In this project control concrete is cast for M30 grade and the partial replacement of waste ceramic tiles 0f 10%, 15%, 20%, 25%, 30% by weight of coarse aggregate. Glass fiber is added at 0.4% and adding 1.2% of super plasticer should be kept at constant. Glass fiber-reinforced concrete consists of high-strength glass fiber embedded in a cementitious matrix. The inclusion of fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength. An experimental investigation of compressive strength, split tensile strength and flexural strength will be undertaken by partial replacement of coarse aggregate by waste ceramic tiles, with glass fiber.

KeyWords:wasteceramictiles,glassfiber,superplasticer-

1. INTRODUCTION

Concrete is the most versatile construction material because it is designed to withstand the harsh environments, with adequate strength and durability. Due to over usage of the concrete materials it become scared, and also the production at larger rate create many hazardous to the environment. On the other side the waste exposed to our environment is an impact to ecology cycle, among all industrial waste is the major source of waste, which will affect the environment. To overcome the issues these industrial waste can be recycled and reused for any useful purpose with acceptance levels. Ceramic broken tiles, slurry waste etc., which is disposed to landfill create pollution at larger rate. In India, ceramic production is 100 million ton per year and about 15-30% of ceramic waste is generating from the total production. Nearly 30% of waste is generated during the manufacturing, transportation and usage of ceramic products. Concrete is one of the major construction material being used worldwide. Reuse the solid waste from construction again as a material in the concrete to decrease the land fill of solid waste and decrease the scarcity of natural aggregates like gravel and sand.

In particular, Construction and Demolition (C&D) wastes contribute the highest percentage of wastes worldwide about 75%. Furthermore, ceramic materials contribute the highest percentage of wastes within the C&D wastes about 54%. The crushed waste ceramic as coarse aggregate had a number of improvements like good workability, low cost and ecofriendly when compared to usual conventional concrete, including better compressive strength. Superplasticizers are well known chemical admixtures for concrete used in the reduction of water to cement ratio without affecting workability, and to avoid particle aggregation in the concrete mixture. These are also known as high range water reducers (HRWR), fluidifiers, and dispersants as these are capable of reducing water to cement ratio by 40%.Superplasticizers can be classified into four types such as, Sulfonated melamine-formaldehyde condensates (SMF), Sulfonated naphthalene-formaldehyde condensates (SNF), Modified lignosulfonates (MLS), and Polycarboxylate derivatives (PC). The selection of concrete superplasticizer is based on the type of concrete used, namely ready mix, precast, high strength, high performance, self compacting, shotcrete, etc.

Glass fiber is a recent introduction in making fiber concrete. Glass fiber reinforced concrete (GFRC) consists of high strength glass fiber embedded in cementitious matrix. Fiber reinforced concrete is concrete containing fibrous material which enhances its structural integrity. So we can define fiber reinforced concrete as a composite material of cement concrete or mortar and discontinuous discrete and uniformly dispersed fiber. The cost of deposition of ceramic waste in landfill will be saved and, on the other, raw materials and natural resources will be replaced, thus saving energy and protecting the environment. Hence concrete is very well suitable for a wide range of applications.

2.OBJECTIVE OF THE STUDY

The main objective of this project is to study the strength concrete with waste ceramic tiles, glass fiber and super plasticer. Replacement materials are added at different percentage.The percentage of replacement ceramic tiles varies from 10% to 30% at 5% interval and glass fiber is added at constantly at 0.4%.

- Mechanical properties such as compressive strength, split tensile strength and flexural strength of unreinforced concrete beam by introducing glass fibre.
- To study the structural behaviour of reinforced concrete beams.

3. EXPERIMENTAL PROGRAMME

MATERIALS

CEMENT

Cement is the well-known building material with adhesive and cohesive properties, which is capable of binding mineral fragment into compact mass. There are several types of cement. The most popular Ordinary Portland cement (OPC-53) is used in this project.

Specific gravity =3.09, fineness=2.1%, consistency=32%, initial setting time=36 mins, final setting time= 300 mins.

FINE AGGREGATE

Aggregate which passed through 4.75mm IS Sieve and retained on 75micron (0.075mm) IS Sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Usually, the natural river sand is used as fine aggregate. Ordinary river sand conforming IS 383-1970 is used in this project.

Specific gravity=2.47, fineness modulus=3.66, moisture content=2.4%

COARSE AGGREGATE

Aggregate which passes through 20 mm IS sieve and retained on 4.75 mm IS sieve are known as coarse aggregate. Aggregates should be properly screened and if necessary washed before use. Coarse aggregates containing flat, elongated or flaky pieces should be rejected. The grading of coarse aggregates should be as per specifications of IS 383-1970. In this project, 20 mm size of coarse aggregate is used.

WATER

Water used for mixing and curing shall be clean and free from oils, acids, alkalis, salts etc. The water should conform to IS 456-2000 standards. The water inside the college campus is used for this study.

CERAMIC TILES

Eco friendly concrete, it is green and keeps the environment safe by using waste products to make resource saving concrete structures. The use of waste ceramic tiles in concrete effects the properties of fresh and hardened concrete, and makes it economical and also solves some of the disposal problems. In this project work ceramic waste tiles are collected and broken into 20mm size for partial replacement with coarse aggregate. Broken tiles are collected from the solid waste of ceramic manufacturing unit.

Fig 1. CERAMIC TILES

Table 1.Comparison of physical properties of ceramic tile aggregate and natural coarse aggregate

S.NO	PROPERTY	WASTE CERAMIC TILE AGGREGATE	NATURAL COARSE AGGREGATE
1.	Specific gravity	2.50	2.64
2.	Water absorption%	1.18	0.10
3.	Impact value %	22	18.6
4.	Crushing value %	20	15.3
5.	Abrasion value %	19	14.25
6.	Bulk density kg/m3 Loose state Dense state	 1069 1188	 1219 1425

Table 2. Chemical Properties Of Ceramic Tiles

MATERIALS	CERAMIC TILES (%)
SiO_2	63.29
Al_2O_3	18.29
Fe_2O_3	4.32
CaO	4.46
MgO	0.72
K_2O	2.18
CL-	0.005

GLASS FIBER

It is a lightweight material, reinforcement corrosion free and structural deterioration free. Glass fibers are relatively inexpensive and have high flexural strength. Fiber act as crack arrestors and prevent the propagation of the cracks. The addition of discrete fiber reinforcement to a concrete matrix leads to an increased flexural strength, energy absorption capacity.

Diameter=0.3mm, length=20mm, aspect ratio=60, tensile strength=600Mpa

Fig 2. GLASS FIBER

SUPER PLASTICER

Conplast SP430 is a chloride free, super plasticising admixture based on selected sulphonated napthalene polymers. Super plasticer is added to improve the workability, durability and reducing concrete permeability. And also Improved cohesion and particle dispersion minimizes segregation and bleeding of concrete.

CONCRETE MIX DESIGN

As per IS method, mix design for M30 grade concrete is carried out.

The ratio is **1 : 1.61 : 2.65 : 0.4**

4. EXPERIMENTAL INVESTIGATION

Compressive strength, split tensile strength, and flexural strength of M30 grade concrete and concrete containing 10%, 15%, 20%, 25%, 30% of ceramic tiles replaced as coarse aggregate and adding glass fiber as 0.4% and 1.2% of super plasticers are added experimentally investigated. Compression test is the most common test conducted on hardened concrete. Concrete is weak in tension and strong in compression so the concrete should be strong to attain high compression. The compressive test is carried out on specimens cubical in shape having a size of 150x150x150mm. The compression tests were conducted after 7 days, 28 days.

Fig 3. Experimental Setup for Compressive Strength& Split tensile strength Test

A standard test cylinder of concrete specimen of size 300mm x 150mm is used to determine the split tensile strength. The test is done using compression testing machine. Replacement of ceramic tiles will improve the tensile strength of concrete.

Flexural strength is a measure of an unreinforced concrete beam to resist failure in bending. It is measured by loading 100 x 100 mm x 500mm concrete beams with a span length of at least three times the depth.

Fig 4. Experimental setup for flexural strength

5. RESULTS AND DISCUSSION

MIX DESCRIPTION

SI.No.	MIX ID	DESCRIPTION
1	M30	Control concrete
2	MIX 1	Concrete with 10% waste ceramic tiles, 0.4%glass fiber&1.2% of conplast sp 430 super plasticers
3	MIX 2	Concrete with 15% waste ceramic tiles, 0.4%glass fiber&1.2% of conplast sp 430 super plasticers
4	MIX 3	Concrete with 20% waste ceramic tiles, 0.4%glass fiber&1.2% of conplast sp 430 super plasticers
5	MIX 4	Concrete with 25% waste ceramic tiles, 0.4%glass fiber&1.2% of conplast sp 430 super plasticers
6	MIX 5	Concrete with 30% waste ceramic tiles, 0.4%glass fiber&1.2% of conplast sp 430 super plasticers

A. COMPRESSIVE STRENGTH

From the experiments, the result obtained shows that the compressive strength was increasing as the replacement of natural coarse aggregate with ceramic tiles increase up to 25%. The increase in strength is shown in table 3 and its graphical representation in fig 5.

Table 3. Compressive strength of concrete by addition of glass fiber and various % replacement of ceramic tiles (N/mm^2).

Cube designation	Compressive strength(N/mm2)			
	7 days	% increase	28 days	% increase
M30	22.19	_	33.15	_
MIX 1	25.456	14.72	36.269	9.4
MIX 2	25.916	16.79	37.325	12.5
MIX 3	26.976	21.57	38.495	16.12
MIX 4	26.999	21.67	39.235	18.35
MIX 5	21.89	13.56	34.577	4.3

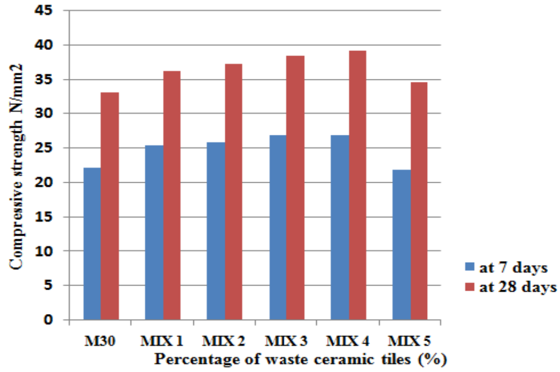

Fig 5. Graphical representation of Compressive strength at 7days and 28days

From 7th day and 28th day compressive strength results, it is found that the maximum compressive strength values are at mix 4 of 26.999N/mm^2 and 39.235N/mm^2. The strength was increased 21.67% on 7 day test and 18.35% on 28 day test when compared to conventional concrete. Further replacement shows the decrease in the compressive strength due the segregation of concrete.

B. SPLIT TENSILE STRENGTH

The increase in strength for various proportion ceramic tiles is shown in table 4 and its graphical representation in fig 6.

Table 4. Split tensile strength of concrete by addition of glass fiber to various % replacement of ceramic tiles (N/mm^2)

Cylinder designation	Split tensile Strength (N/mm^2)	
	28 days	% increase
M30	2.41	_
MIX 1	2.51	4.14
MIX 2	2.74	13.69
MIX 3	2.92	21.16
MIX 4	3.13	29.87
MIX 5	2.49	3.32

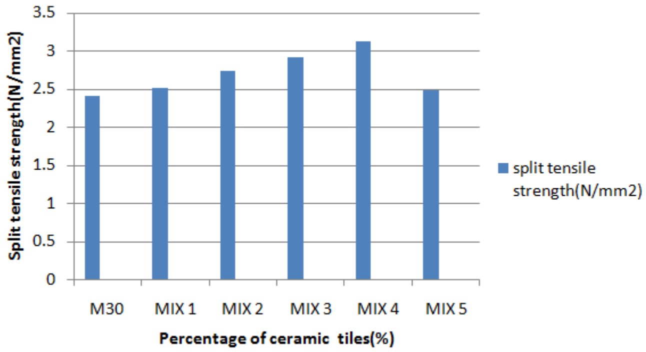

Fig 6. Graphical representation of Split tensile strength at 28days

From the split tensile strength results, it is found that the strength value for controlled concrete 2.41 N/mm^2. The maximum split tensile strength of concrete with 25% replacement of coarse aggregate was found to be 29.87% when compared with the conventional concrete whereas the value decreases to 3.32% for 30% replacement of coarse aggregate when compared to 25% replacement of coarse aggregate. Further increasing the replacement of coarse aggregate, results in decrease of Split tensile strength of the concrete due to the bonding between ceramic tiles and fiber.

C. FLEXURAL STRENGTH

From the flexural strength results, it is found that the strength value for controlled concrete 6.86 N/mm^2. The increase in strength for various proportion is shown in table III and its graphical representation in fig 5.

Table 5. Flexural strength of concrete by addition of glass fiber to various % replacement of ceramic tiles (N/mm^2)

prism designation	Flexural Strength (N/mm^2)	
	28 days	% increase
M30	6.86	–
MIX 1	8.53	24.34
MIX 2	8.94	30.32
MIX 3	9.40	37.02
MIX 4	9.93	44.75
MIX 5	8.05	17.34

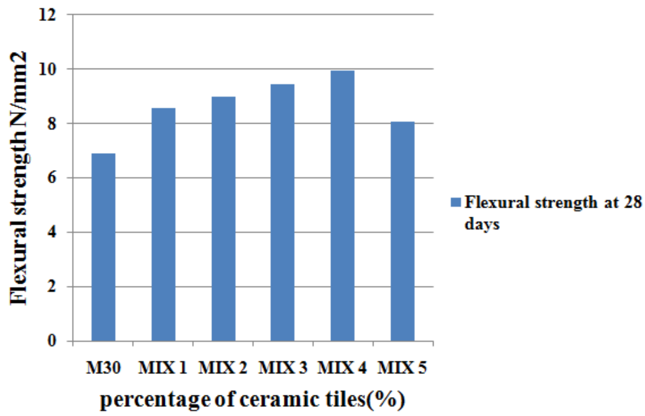

Fig 7. Graphical representation of Flexural strength at 28days

The flexural strength was increased 44.75 % at mix4 on 28 day test when comparing with control mix concrete. The compressive strength gradually decreases to 17.34% with 30% of replacement of coarse aggregate when compared to the 25% of replacement of coarse aggregate.

D. FLEXURAL BEHAVIOUR OF BEAM

Fig 8 Experimental Setup For Flexural Behaviour of Concrete

a. Load Carrying Capacity of Beams

Table 6 Load Carrying Capacity

S.No	LOAD (KN)	MID SPAN DEFLECTION (mm)
1	10	0.71
2	20	1.38
3	30	2.17
4	40	2.78
5	**50**	**3.47**
6	60	4.27
7	70	6.82
8	80	9.12
9	90	11.79
10	**100**	**14.85**

b. Crack Pattern

For the conventional beam, the first crak is formed at 60 KN and for glass fibre reinforced concrete beam the crack is formed at 70 KN.

c. Load deflection behavior

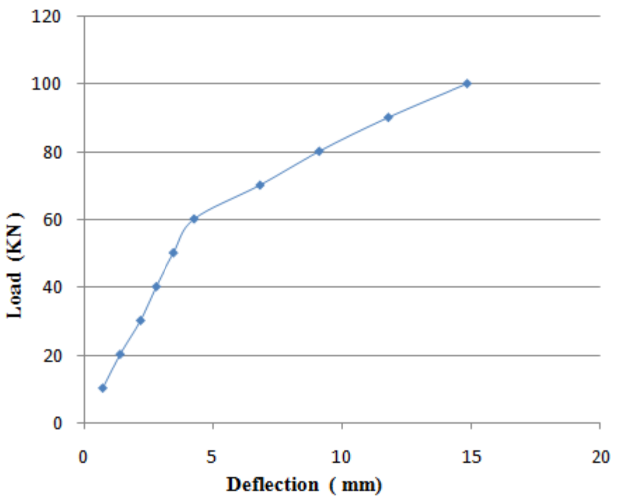

Fig 9 Load Deflection Curve

Fig shows the load vs deflection of ceramic tiles with 25% replacement of fibre reinforced concrete beam. Deflection is reduced by adding glass fibre.

6. CONCLUSION

- The maximum compressive strength of concrete value is 26.999N/mm^2 and 39.235N/mm^2 for 7 days and 28 days respectively obtained in the mix containing 25% replacement of ceramic tiles and 0.4% of glass fiber.
- The maximum split tensile strength of concrete is increased 29.87% % when compared with the conventional concrete at the mix of 25% replacement.
- The flexural strength was increased 44.75 % at 25% replacement on 28 day test when comparing with control mix concrete.
- The results obtained from the study it is clear that the mechanical properties will be improved by the partial replacement of coarse aggregate by ceramic tiles with glass fiber up to 25%.
- The reason of this phenomenon is due to the fact that the crushed ceramic tile has ability to absorb water in the mixture and decreasing water in the mix which leads to decreasing workability of fresh concrete, as well as the texture and surface of the crushed tiles.
- The strength of concrete is decreased with the replacement of waste ceramic tiles with glass fiber above 25%, because there is not sufficient bonding between ceramic tiles with fiber reinforced concrete and also the water absorption of ceramic tiles are very high.
- Crack formations are arrested by adding glass fibre.

REFERENCES

[1] Amit kumar., Indrajit patel and Jayesh kumar pitroda(2013) " Re-use of ceramic industry wastes for the elaboration of eco efficient concrete", International Journal of Advanced Engineering Research and studies, Vol 2, Issue 3, pp103-105 **.**

[2] A.V. Alves , T.F. Vieira , J. de Brito , J.R. Correia(2014) 'Mechanical properties of structural concrete with fine recycled ceramic aggregates', Construction and Building Materials 64 103–113.

[3] C.Medina, M.I.Sánchezde Rojas, M.Frías, 'Properties of recycled ceramic aggregate concretes: Water resistance', *Cement and Concrete Composites 40 (2013) 21-29.*

[4] IS:383-1970, "Specification for coarse and fine aggregates from natural sources for concrete," (Second Revision).

[5] IS:2386(Part III)-1963 Indian standard- "Method of testing for aggregates for concrete-Part-III specific gravity, density, voids, absorption and bulking," Bureau of Indian standard, 1997, New Delhi.

[6] O.Zimbili, W.Salim, M.Ndambuki 'A Review on the Usage of Ceramic Wastes in Concrete Production', International Jo Structural, Construction and Architectural Engineering Vol:8, No:1, 2014

[7] P. Asokan , M. Osmani , A.D.F. Price, ' Assessing the recycling potential of glass fibre reinforced plastic waste in concrete and cement composites', Journal of Cleaner Production 17 (2009) 821–829.

[8] S.T.Tassew, A.S.Lubell, 'Mechanical properties of glass fiber reinforced ceramic concrete', Construction and Building Materials51 (2014) 215–220

[9] T. Sekar, N. Ganesan, and NVN. Nampoothiri, "Strength Characteristics on Utilization of waste Materials as Coarse Aggregate in Concrete", International Journal of Engineering Science and Technology (IJEST), Vol 3, pp5436-5440, **2011.**

[10] Umapathy U, Mala C, Siva K, "Assessment of concrete strength using partial replacement of coarse aggregate for waste tiles and cement for rice husk ash in concrete", *International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol.4.,* Issue 5(Version 1), May 2014.