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Research Article

Experimental Study On Flexure Behavior Of Partial Replacement Ceramic Waste Tiles

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ABSTRACT

Reinforced concrete beams are of one the basic fundamental structural elements for construction project now days to build residence buildings, bridges, dam and various types of the civil engineering structure. To construct the various types of structures project to understanding their flexural behavior of the beam is most important for ensuring the safety and reliability of such structures. In this study to analysis the flexural behavior of reinforced concrete beams, with various composite materials like cement, fine aggregate, coarse aggregate, steel and also partial replacement of coarse aggregate with the ceramic tiles are adding 10%, 20%, 30%. The objectives were to analyze load-deflection responses, crack patterns, and failure modes under different loading conditions. The results revealed significant insights into the behavior of these beams, highlighting the influence of reinforcement detailing, concrete quality, and loading arrangements on their performance.

Keywords: M30 concrete, waste ceramic tiles, flexural behavior.

1 Introduction

The global construction industry is increasingly espousal sustainable practices to reduce its environmental path and increase resource effectiveness In this research the integration of recycled materials into construction processes has emerged as a hopeful way to achieve both environmental and economic benefits. In conjunction with the recycled materials under concern, ceramic waste tiles stand out as an environmentally responsible alternative due to their plenty and recyclable properties. There estimated utilization in the construction segment as a partial replacement for predictable aggregates has grained concrete as it addresses two challenges, the responsible dumping of ceramic waste tiles and the insist for sustainable construction practices.
The flexural behavior of concrete, especial in structural application, is of supreme magnitude as it reflects the resources ability to endure bending loads, which is fundamental for the recital of beam, slab, and other structural members. The assimilation of ceramic waste tile in concrete as a partial replacement for aggregate, it can be innovative solution to improve the flexural properties and along with reducing the environment impact of concrete production.

Objective of study:

1. To investigate the flexure behavior of concrete specimens with varying percentages of ceramic waste tile replacement.
2. Assess the properties of concrete and steel, including their strength, elasticity, and ductility, to accurately predict beam behavior.

2. Methodology

From the below given flow chart diagram represents that steps are followed to analyse the concrete structure strength and the flexural behavior.

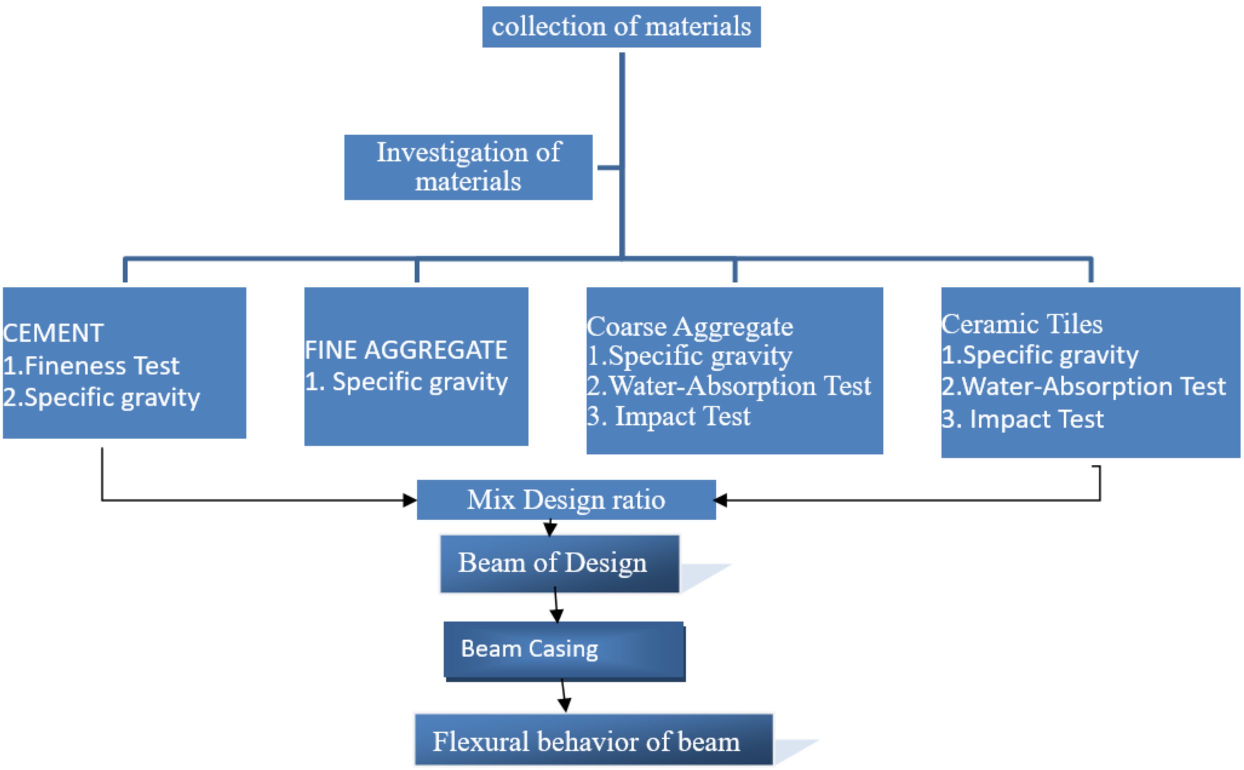

Fig:2.1 Flow Chart Methodology

3. 0 Experiential Investigation of materials

The experimental investigation carried out to find the various parameter strength of concrete. Preliminary tests carried out results of property presented below in Table 3.1

Table 3.1 Preliminary Test Results for Materials.

MATERIAL	PROPERTY	VALUE
CEMENT	Fineness Test	7%
	Specific gravity	3.16
	Normal Consistency Test	30%
	Initial Setting Time	40min
FINE AGGREGATE	Specific gravity	2.64
COARSEAGGREGATE	Specific gravity	2.72
	Water-Absorption Test	0.28%
	Impact test	26.44
BROKEN TILES		
SPECIFIC GRAVITY	0% of replacement	2.43
SPECIFIC GRAVITY	5 % of replacement	2.43
SPECIFIC GRAVITY	10 % of replacement	2.44
SPECIFIC GRAVITY	15 % of replacement	2.43
SPECIFIC GRAVITY	20% of replacement	2.44
SPECIFIC GRAVITY	25 % of replacement	2.45
SPECIFIC GRAVITY	30% of replacement	2.43
SPECIFIC GRAVITY	35% of replacement	2.42
SPECIFIC GRAVITY	40 % of replacement	2.41
IMPACT TEST	0 % of replacement	22.44
IMPACT TEST	5 % of replacement	22.44
IMPACT TEST	10 % of replacement	22.44
IMPACT TEST	15 % of replacement	22.34
IMPACT TEST	20% of replacement	22.24
IMPACT TEST	25 % of replacement	22.48

3.1 STIPULATIONS FOR PROPORTIONING

a) Grade designation: M30

b) Type of cement: OPC 53 Grade conforming IS 12269
c) Maximum nominal size of aggregate: 20mm
d) Minimum cement content: 320 kg/m^3 (IS 456:2000)
e) Maximum water-cement ratio : 0.45 (Table 5 of IS 456:2000)
f) Workability: 100-120mm slump
g) Exposure condition: Moderate (For Reinforced Concrete)
h) Method of concrete placing: Pumping
i) Degree of supervision: Good
j) Type of aggregate: Crushed Angular Aggregates
k) Maximum cement content: 360 kg/m^3

3.2 TARGET STRENGTH FOR MIX PROPORTIONING

f'ck =fck + 1.65s

Where,
f'ck = target average compressive strength at 28 days,
fck = characteristics compressive strength at 28 days, and
s = standard deviation.
From Table I of IS 10262:2009, Standard Deviation, s = 5 N/mm^2.
Therefore, targetstrength = 30 + 1.65 x 5 = 38.25 N/mm^2.
Exposure maximum Water Cement Ratio is 0.45 0.44 < 0.45 Hence ok.

3.3 SELECTION OF WATER CONTENT

From Table 2 of IS 10262:2009, maximum water content for 20 mm aggregate = 186 liter(for 25 to 50 mm slump range) Estimated water content for 100 mm slump =186+ (6/186) = 197 liter.

3.4 CALCULATION OF CEMENT CONTENT

Adopted w/c Ratio = 0.44 Cement Content = 197/0.44 = 359

3.5 SELECTION OF WATER CEMENT RATIO

Adopted maximum water-cement ratio = 0.44. From the Table 5 of IS 456 for Verysevere kg/m^3
From Table 5 of IS 456, Minimum cement content for 'Moderate' exposure conditions320kg/m^3
= 359 kg/m^3 > 340 kg/m^3 hence

3.6 MIX PROPORTIONS

Table 3.2 Mix design ratio for M30

CEMENT	F.A	C.A	WATER
1	1.67	2.71	0.45

3.7 DESIGN OF BEAM

Dead Load = Self Weight = 1 kN
Live Load = 5 kN + 1 kN Self Weight **as per IS875 Part – 2 – Pg 11**
Live Load = 6 kN
b = 100 mm h = 150 mm l = 1520 mm d = l/d
l /d = 20 **as per IS456 – Pg 37 (2000) Clause 23.2.1**
l /d = 20 = 1520/20 = d d = 1520/20
d = 76 mm
Take it as 100mm
d = effective depth d '= effective cover
D = d+d' = over all depth d' = 50mm cover block D = d+d' = 100+50
D = 150mm
l = 1520mm = Clear Span
Effective Span = Clear Span + Effective Depth Effective
Span = Center to Center of Clear
Condition 1 as per IS456 (2000) – Pg 34 Clause 22.2
Clear Span = 0.10 + 1.52
Clear Span = 1.62
Condition 2 as per IS456 (2000) – Pg 34 Clause 22.2
Effective Span = 150/2 + 1.52 + 150/2
Effective Span = 1.67 m
b = 100 mm d = 100 mm d '= 50 mm D = 150 mm l = 1.67 m

3.8 LOAD CALCULATION

(i) Self Weight (g) = (l x b x d x Density Of Concrete) (25kN)
Self Weight = (1 x 0.1x 0.15 x 25)
Self Weight = 1 kN
(ii) Live Load (q) = 6 kN
Total (g+q) = 1 + 6 = 7 kN/m
Limit State Have To Multiply Factor Of Safety (1.5) LMS = 7 x 1.5

3.9 MOMENT CALCULATION - ULTIMATE MOMEMTS & SHEAR FORCE

a. BENDING MOMENT

0.125 x wl^2
0.125 x 10.5 x 1.67^2
3.66 kN/m

b. SHEAR FORCE

0.5 wl
0.5 x 10.5 x 1.67
8.7675kN

3.10 TENSION IN REINFORCEMENT

Mu= 0.138 x fck x b x d2 as per IS456 (2000) Pg 96
Mu= 0.138 x 30 x 100 x 1502
Mu= 7.452 kN/m Under Reinforcement Mu<Mu Limit
As per Is456:2000 – Pg 96
Mu= 0.87 x fy x Ast x d (1-Ast fY/bd fck)

3.11 MOMENT OF RESISTANCE

Ast = 0.5 fck/fy x b x d (1 - √1 – 4.6Mu/fckbd2)
Ast= 0.5 x 30/415 x 120 x 150 x (1 - √1 – 4.6 x 7/30x100x1502)
Ast = 542.16 (0.52296)
Ast = 283.012 mm2
Assume = 12mm – Diameter of Steel as per IS 456 (2000) Pg 46 and Pg 49
ast = $\pi/4$ x d^2
ast = $\pi/4$ x 12^2 = 113.04
Ast/ast = 283.012/113.04 = 2.5036 = 3 bars 3 x $\pi/4$ x d^2 = 3 x $\pi/4$ x 113.04 = 339 mm^2
Min Ast = 0.85 x bd /fy= 0.85 x 100 x 150 /415 = 30.72mm^2 Max Ast = 0.04 x b x d = 0.04 x 100 x 150 = 600 mm^2
Hence Ok

3.12 NOMINAL SHEAR STRESS

τV = Vu/b x d = 16.59 permissible
τv = 16.57/100 x 150 = 0.00110 N/mm^2 = 0.11 N/m^2
% of Tension (pg 72)P = Ast / bd x 100
P = 2.26 %
Design of Shear Strength Concrete For M30 **as per IS 456 (2000) Pg 46**
X1 1- 0.66y1
X2 1.25 – 0.71 y2 – 1.0

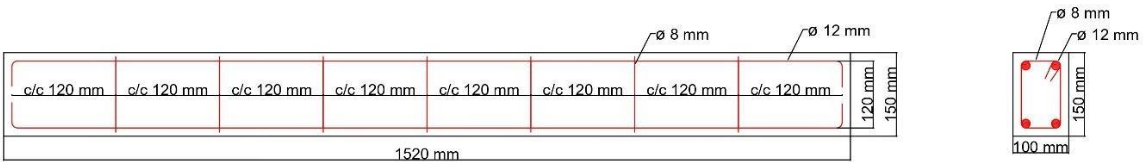

Fig -3.1Design of beam

3.13 ULTRASONIC PULSE VELOCITY TEST ON BEAM

In this Table 3.3 and Fig 3.2 represent the ultrasonic pulse velocity of M30 Grade Concrete value. The specimen size of beam is 1520mm*150mm*100mm is casted as per the mixdesign ratio with composed of fine aggregate, coarse aggregate and also partially replacement of waste broken ceramic tiles from 0% to 30% together of cement and water. After the re-mould of concrete are wetted in water tank for of 28 days to increases of the strength of concrete. Then ultrasonic pulse velocity tested by ultrasonic pulse velocity testing machine on 7days and 28 days of concrete age. The value is represented in the table 3.3 value is ranging increasing and decreasing in their limits.


Fig -3.2 UPV Test on beam


Fig -3.3 RH Test on beam

Table 3.3 Ultrasonic Pulse Velocity test value

Waste Ceramic Tiles Replacement on Coarse Aggregate.	Ultrasonic Pulse Velocity m/s
	28 days
Replacement of 0%	324
Replacement 10%	372
Replacement of 20%	425
Replacement of 30%	379

3.14 REBOUND HAMMER TEST ON BEAM

In this Table 3.4 and Fig 3.3 represent the rebound hammer test of M30 Grade Concrete value. The specimen size of beam is 1520mm*150mm*100mm is casted as per the mix design ratio with composed of fine aggregate, coarse aggregate and also partially replacement of waste broken ceramic tiles from 0% to 30% together of cement and water. After the re-mould of concrete are wetted in water tank for of 28 days to increases of the strength of concrete. Then rebound hammer test by rebound hammer testing machine 28 days of concrete age. The value are represented below its ranging increasing and decreasing in their limits.

Table 3.4 Rebound Hammer Test value:

Waste Ceramic Tiles Replacement on Coarse Aggregate.	Rebound Hammer Test N/mm²		
	28 days		
	Left End	Middle	Right End
Replacement of 0%	26	32	30
Replacement 10%	27	31	29
Replacement of 20%	25	30	27
Replacement of 30%	26	27	25

3.15 FLEXURAL TEST ON BEAM

In the Table 3.5 represent the flexural strength of M30 Grade Concrete value. The specimen size of cube is size 150mm*150mm*150mm Concrete is casted as per the mix design ratio with composed of fine aggregate, coarse aggregate, and also partially replacement of waste broken ceramic tiles from 0% to 30% together of cement and water. After the re-mould of concrete are wetted in water tank for 28 days to increases of the strength of concrete. Then Flexural strength tested by load frame testing machine on 28 days of concrete age. It also calculated by the formula load/ area.


Fig -3.4 Flexural Test on beam

Table 3.5 Flexural test on beam

Waste Ceramic Tiles Replacement on Coarse Aggregate.	Flexural Strength Test on Beam kN/m²
	28 days
Replacement of 0%	43

Replacement 10%	38
Replacement of 20%	27
Replacement of 30%	22

CONCLUSION:

The performance of concrete made with recycled ceramic waste tiles from the various industrial, replacing with natural coarse aggregates and to find out strength of concrete. So their required to find of basic preliminary test to carryout for the materials testing like fine aggregate, coarse aggregate, ceramic tile & cement with using the standard equipment's and as per standardcode, from the preliminary test result value are within the limits as per the norms. For theconcrete mixture M30 grade is used, fine aggregate, broken waste ceramic tiles with partial replacement of coarse aggregate ranges of percentage 0% ,10%, 20%, and 30% with maximum size of 20mm used, a water-cement ratio of 0.45. After casting beam sample is to be soaked in water for 28 days to increases the strength of beam, samples are tested at age of 28 days for Flexural behavior on beam the test report obtain that strength increasing upto the 25% Finally concluded that waste ceramic tiles can replacewith coarse aggregate up to 25%.

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