Study of Mechanical & Durability Properties of Micro Concrete With Waste Ceramic Tiles

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Abstract: The main objective of this research is to study the utilization of waste ceramic tiles in the micro concrete. In this study, waste ceramic tiles are categorized in two categories, namely Ceramic Coarse Aggregate (CCA) and Ceramic Fine Aggregate (CFA). CCA is waste ceramic tiles with size ranges between 4.75 mm to 10 mm and CFA is waste ceramic tiles in powder form and size is less than 4.75 mm. This ceramic tile waste is added to three different types of micro concretes in different proportions and total 11 mixes are prepared for the testing. All the mixes are tested for compressive strength, split tensile strength & sorptivity to study mechanical & durability properties of micro concretes with waste ceramic tiles**.**

Keyword: **- Micro Concrete, Waste Ceramic Tiles, Compressive Strength Test, Split Tensile strength.**

I. INTRODUCTION

Today Micro concrete is used in repairing of structures. Micro concrete mainly latex modified concrete used for structural repair and strengthening, repair to damaged reinforcement concrete elements like beams, columns, walls, etc. [1]. Micro concrete is combination of cement, high quality graded fine aggregate, shrinkage compensates agents and spreading agents in powder form marketed as dry powder in packets by construction chemical companies (refer Figure 1).

The ceramic tile waste can be used as a coarse and fine aggregate in concrete. Natural materials are used to produce ceramic tile. There materials are heated at high temperature. This tile waste does not contain any hazardous material. These tiles are used for flooring in different types of structures. Every year approximately 2,50,000 tons of tiles are thrown away, while 100 million tiles are utilized for restoration. Ceramic waste can be changed into useful Fine and Coarse aggregate [2], which is 30 to 40% of the total production from manufacturing units [3]. So, waste tiles are chosen as adding material to micro concrete.

Recent study puts light on understanding the effect of addition of ceramic waste in micro concrete Physical properties of micro concrete are shown in Table I. Ceramic Coarse Aggregate (CCA) is added to three types of micro concrete in proportion of 10% & 20% for mixes M6 to M11 and Ceramic Fine Aggregate (CFA) is added to three types of micro concrete in proportion of 10%, 20%, 30%, 40% & 50% for mixes M1 to M5 as per Table II.

II. METHODS AND MATERIAL

2.1 Materials

The material in this study are micro concrete and ceramic tiles**.**

Micro concrete:

Commercially available Micro concrete is used for the study. The different micro concrete are named as MC1, MC2 and MC3 The properties of micro concrete are shown in Table I,

Table I
Physical Properties of Micro Concrete

Micro concrete	Property	Value
MC1	Compressive strength Tensile strength Bulk density Water powder ratio	45 N/mm^2 at 7days 65N/mm^2 at 28days 2.5N/mm^2 at 7days 2200 kg/m^3 0.15
MC2	Compressive strength Tensile strength Bulk density Water powder ratio	40 N/mm^2 at 7days 50N/mm^2 at 28days 2N/mm^2 at 7days 2250 kg/m^3 0.14
MC3	Compressive strength Tensile strength Bulk density Water powder ratio	40 N/mm^2 at 7days 50N/mm^2 at 28days 2N/mm^2 at 7days 2100-2200 kg/m^3 0.16

Figure1: Micro Concrete

Ceramic Fine Aggregate:
CFA is defined as tile powder passed through 4.75 mm sieve. It is used as fine aggregate. Specific gravity of CFA is 2.57. Figure 2 shows crushed CFA.

Ceramic Coarse Aggregate:
The broken tiles are taken from the solid waste of ceramic manufacturing unit. Tiles may be crushed into small pieces by manually or mechanically. It is used as coarse aggregate. Specific gravity and impact value of the CCA is 2.25 and 27.02%, respectively. Figure 3 shows crushed CCA.

Figure 2: Ceramic Fine Aggregate

Figure 3: Ceramic Coarse Aggregate

Water:
Normal tap water free from all impurities and organic matter is used for preparing the fresh micro concrete.

2.2 Experimental Program

Total 11 types of mix are prepared by adding percentages of CCA, CFA and CCA & CFA combined into the micro concrete. Water powder ratio was selected 0.15 for all mixes. Table II shows the details of all mixes. For compressive strength, concrete cubes size 70.6 × 70.6 × 70.6 mm are prepared for all mixes to check its compressive strength and cylinder size 100 mm diameter and 200 mm lengths are prepared for all mixes to check its split tensile strength. As porosity plays an important role in strength of micro concrete, the sorptivity test is also performed for normal micro concrete and for all mixes which have maximum compressive & split tensile strength among all mixes.

Table II

Percentage of CFA & CCA in three types of micro concrete (MC1, MC2 and MC3)

MIX	MICRO CONCRETE (%)	CFA (%)	CCA (%)
M1	100	0	0
M2	90	10	0
M3	80	20	0
M4	70	30	0
M5	60	40	0
M6	50	50	0
M7	90	0	10
M8	80	10	10
M9	70	10	20
M10	70	20	10
M11	60	20	20

III. Results and Discussion

3.1 Compressive strength test:

Compressive strength test is performed to find 7 and 28 days compressive strength of all mixes.

Table III

7 and 28 days Compressive Strength Test Result of MC1

MIX		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
MC1	7days	48.93	50.83	50.85	46.62	42.22	37.38	37.44	33.48	39.45	36.1	41.12
	% of 7days	-	3.88	3.92	-4.72	-13.7	-23.6	-23.4	-31.5	-19.3	-26.2	-19.9
	28 days	70.78	70.93	72.66	64.47	58.16	51.21	51.39	46.19	55.66	49.25	56.18
	% of 28 days	-	0.21	2.65	-8.91	-17.8	-27.6	-27.3	-34.7	-21.3	-30.4	-20.6

Table IV

7 and 28 days Compressive Strength Test Result of MC2

MIX		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
MC2	7days	31.97	36.44	36.77	43.12	27.75	27.08	37.44	33.41	39.45	21.06	35.77
	% of 7days	-	7.74	15.01	34.87	-13.1	-15.2	17.10	4.50	23.39	-34.1	11.88
	28 days	43.98	49.76	51.31	58.28	38.20	37.48	51.52	46.23	54.31	29.64	49.23
	% of 28 days	-	13.14	16.66	32.51	-13.1	-14.7	17.14	5.11	23.48	-32.6	11.93

Table V

7 and 28 days Compressive Strength Test Result of MC3

MIX		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
MC3	7days	45.80	50.83	46.14	42.79	32.43	30.75	36.77	33.76	37.45	30.75	37.44
	% of 7days	-	10.98	0.74	-6.57	-29.1	-32.8	-19.7	-26.2	-18.2	-32.8	-18.2
	28 days	61.81	69.33	63.89	59.14	44.80	42.2	50.62	46.68	52.74	41.80	51.26
	% of 28 days	-	12.16	3.36	-4.31	-27.5	-31.7	-18.6	-24.6	-14.6	-32.3	-17.1

The Figures 4 & 5 show that mixes M3(20% CFA), M4(30% CFA) & M2(10% CFA) give maximum compressive strength for MC1, MC2 & MC3 at 7 & 28 days respectively.

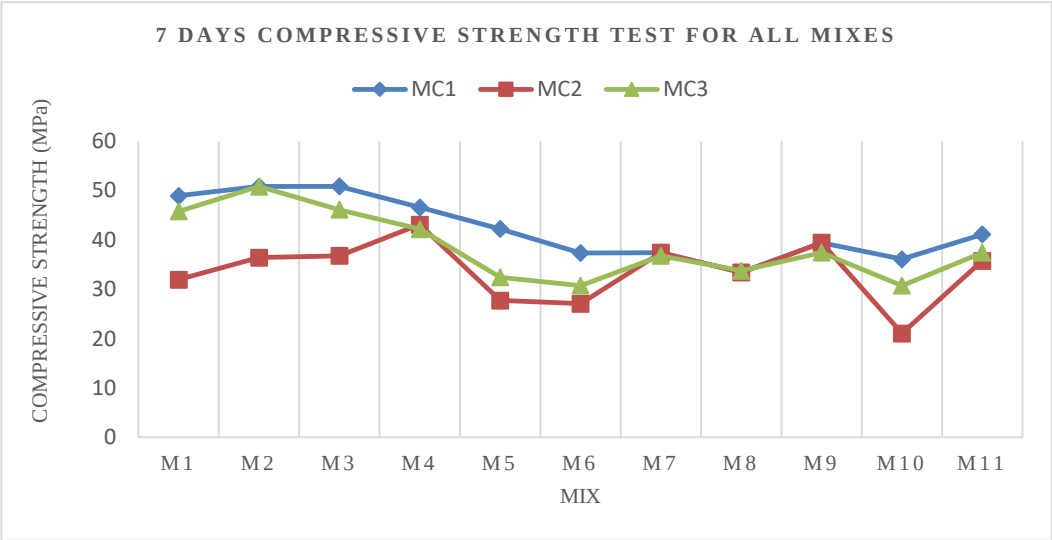

Figure 4: 7 Days Compressive Strength Test Result

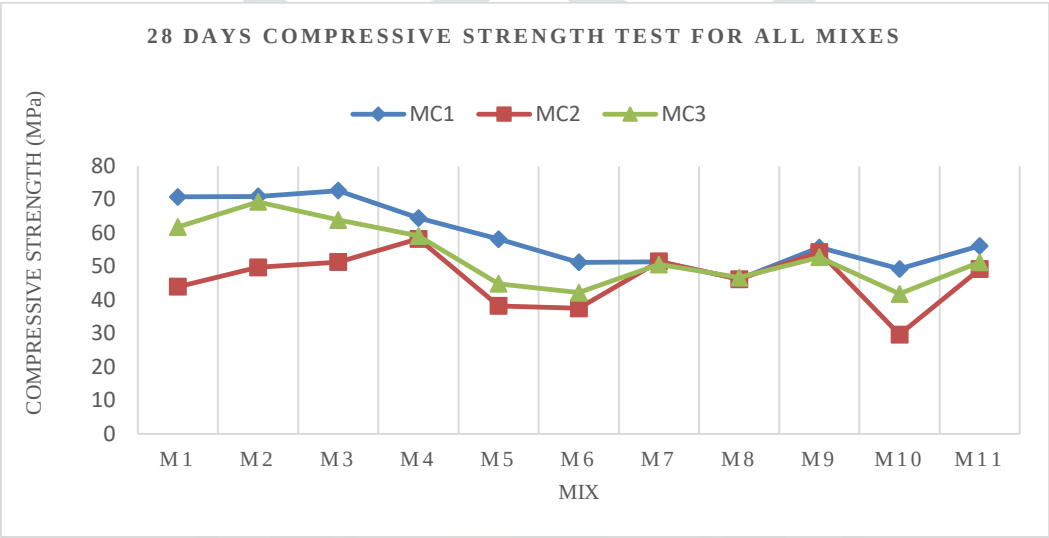

Figure 5: 28 Days Compressive Strength Test Result

3.2 Split Tensile Strength Test:

The cylinder is placed on the machine & vertical load is applied gradually at uniform rate until the specimens fail.

Table VI

7 and 28 Days Split Tensile Strength Test result of MC1

MIX		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
MC1	7days	2.67	3.14	3.11	2.38	2.00	1.77	1.36	0.79	3.18	0.74	2.59
	% of 7days	-	17.60	16.47	-10.8	-25.1	-33.7	-49.1	-70.4	19.10	-72.2	-2.99
	28 days	3.68	4.33	4.29	3.29	2.74	2.45	1.90	1.11	4.36	1.02	3.20
	% of 28 days	-	17.66	16.57	-10.5	-25.5	-33.4	-48.3	-69.8	18.47	-72.2	-13.1

Table VII

7 and 28 Days Split Tensile Strength Test result of MC2

MIX		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
MC2	7days	1.96	2.17	2.44	3.23	1.91	1.49	2.65	1.36	2.58	1.80	1.96
	% of 7days	-	10.71	24.48	64.79	-2.61	-24.6	36.12	-31.4	32.46	-8.37	0
	28 days	2.69	3.06	3.35	4.46	2.60	2.06	3.72	1.93	3.54	2.51	2.7
	% of 28 days	-	13.75	24.53	65.79	-3.34	-23.4	38.28	-28.2	31.59	-6.69	0.37

Table VIII

7 and 28 Days Split Tensile Strength Test result of MC3

MIX		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
MC3	7days	1.80	1.91	1.85	1.33	1.11	0.88	1.98	1.19	2.49	1.69	2.22
	% of 7days	-	6.11	2.77	-26.1	-38.3	-51.1	10	-33.8	38.33	-6.11	23.33
	28 days	2.5	2.78	2.65	1.81	1.51	1.22	2.79	1.68	3.50	2.36	3.00
	% of 28 days	-	11.2	6	-27.6	-39.6	-51.2	11.6	-32.8	40	-5.6	20

The figure 6 & 7 show that mixes M9(10% CFA & 20% CCA), M4(30%CFA) and M9(10% CFA & 20% CCA) give maximum split tensile strength for mixes MC1, MC2 &MC3 at 7 & 28 days respectively.

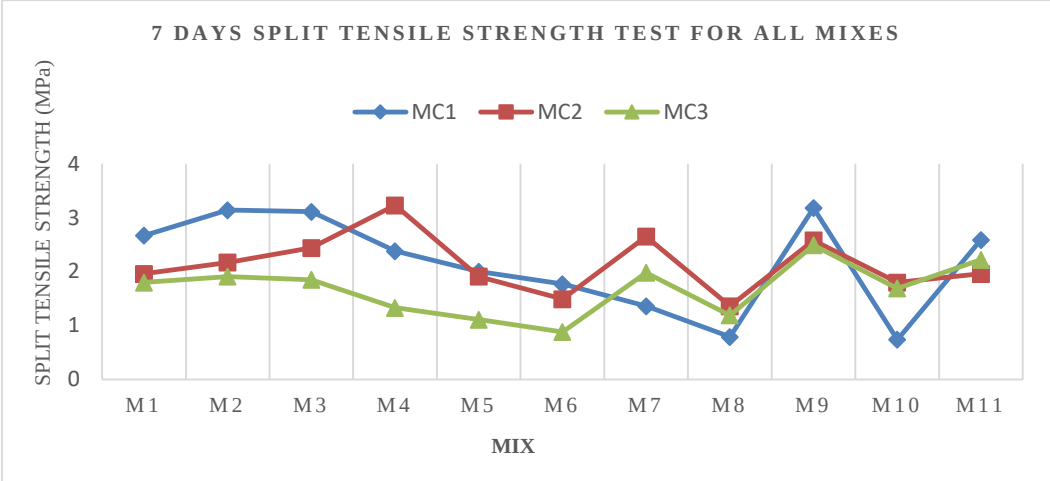

Figure 6: 7 Days Split Tensile Strength Test Result

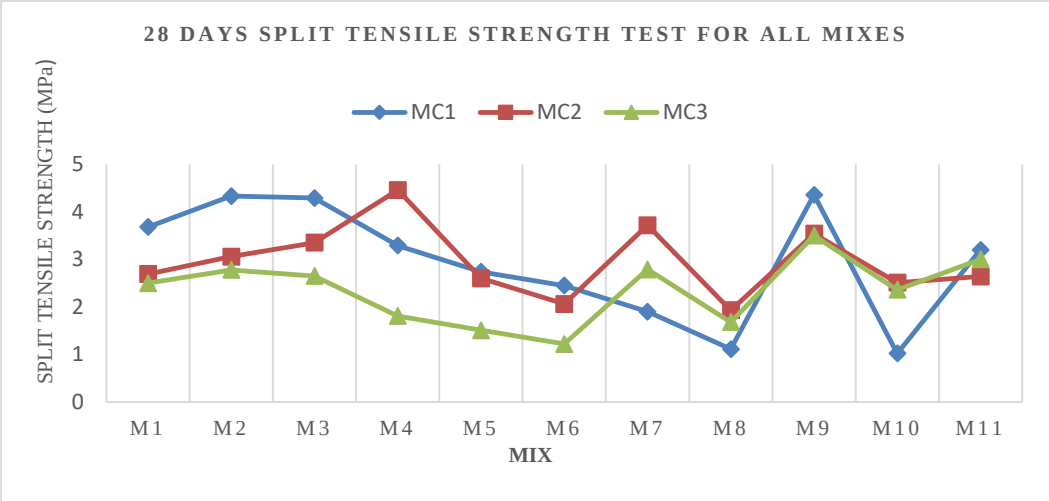

Figure 7: 28 Days Split Tensile Strength Test Result

3.3 SORPTIVITY

The sorptivity expresses the tendency of a material to absorb and transmit water and other liquids by capillarity. This soptivity test conducted for mixes which have high strength among all mixes.

$$S = I\sqrt{t}$$

where

S = sorptivity in mm

t = elapsed time in minute

I = is the cumulative infiltration at time = ΔW/Ad

ΔW = change in weight = W2-W1

W1 = Oven dry weight of the cylinder in grams

W2 = Weight of cylinder after30 minute capillary suction of water in grams

A = surface area of the specimen through which water penetrated

d = density of water

Table- IX

Sorptivity results at 28 days

MIX	NORMAL MICRO CONCRETE			MICRO CONCRETE WITH WASTE CERAMIC TILES		
	MC1- M1	MC2-M1	MC3-M1	MC1-M3	MC2-M4	MC3-M2
SORPTIVITY VALUE (10^{-4} mm/min)	0.20	0.16	0.24	0.16	0.12	0.2

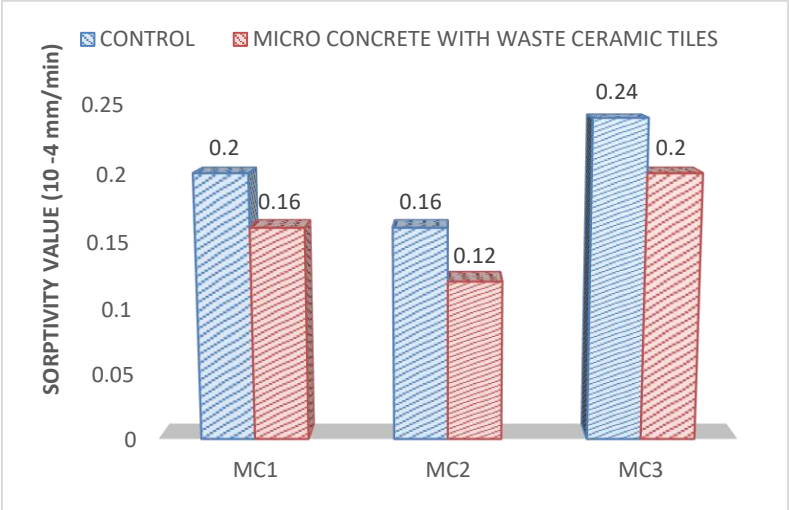

Figure 8: 28 Days Sorptivity Result

Figure 9: Sorptivity Test

IV. CONCLUSIONS

1. It is observed that the compressive strength and split tensile strength increase in MC1, MC2 & MC3 when CFA is added.
2. It is observed that for mixes M3 (20%CFA), M4 (30%CFA) & M2 (10%CFA) compressive strength at 28 days increases as 2.65%, 32.51% & 12.16% for micro concrete (MC1, MC2 & MC3), respectively.
3. It is observed that for mixes M9 (10%CFA & 20%CCA), M4 (30%CFA) & M9 (10%CFA & 20%CCA) split tensile strength at 28 days increases as 18.47%, 65.79% & 40% for micro concrete (MC1, MC2 & MC3), respectively.
4. The optimum mix for higher compressive strength in MC1, MC2 and MC3 are mix M3 (20%CFA), M4 (30%CFA) and M2 (10%CFA) and for higher split tensile strength are mix M9 (10%CFA & 20%CCA), M4 (30%CFA) and M9 (10%CFA & 20%CCA).
5. M1 absorbs more water as compared to mixes MC1(M3), MC2(M4) and MC3(M2).

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