Studies on Strength Characteristics on Utilization of Waste Ceramic Tiles as Aggregate in Concrete

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Abstract: **This project presents an experimental study on the properties and behavior of concrete containing ceramic wastes. A large bulk of ceramic tile change into wastage, these waste materials are not reusable and recyclable due to the physical and chemical structure. The problem arising from continuous technological and industrial development is the disposal of waste material. Use of ceramic waste will ensure an effective measure in maintaining environment and improving properties of concrete. The replacement of aggregates in concrete by ceramic wastes will have major environmental benefits. In ceramic industry about 30% production goes as waste. The ceramic waste aggregate concrete shows good resistance to the chemical attack such as sulphate attack and chloride attack. The ceramic waste aggregate is hard and durable material than the conventional coarse aggregate. It has good thermal resistance. The durability properties of ceramic waste aggregate are also good. In this research studied the fine aggregate replaced by ceramic tiles fine aggregate accordingly in the range of 10% and coarse aggregate accordingly in the range of 30%, 60%,100% by weight of M-30 grade concrete. .Concrete mixtures were produced, tested and compared in terms of strength to the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 28 days This paper recommends that waste ceramic tiles can be used as an alternate construction material to coarse and fine aggregate in concrete.**

Keywords: **Ceramic tiles, workability, split tensile strength of concrete, compressive strength.**

1. INTRODUCTION

Concrete is one of the important construction material used in the world in all engineering works including the infrastructure development at all stages. It has been used in construction sector for a long time and proved that, it is a cheap material and its constituents are widely available in nature. Due to wide spread usage and fast infrastructure development in all over the world, there is shortage of natural aggregates. The quality of concrete is determined by its mechanical properties as well as its ability to resist the deterioration. The mechanical properties are classified into two categories; they are short-term properties and long-term properties. Strength, elasticity modulus and bonding characteristics come under short-term (instantaneous) properties. Creep, shrinkage, fatigue and durability come under long-term properties. It's a great opportunity for the concrete industry that they can save natural aggregate by replacing coarse aggregate with construction demolition waste and other waste materials like ceramic waste aggregates, granite waste aggregate and Cuddapah slab waste aggregate in the production of concrete. Pozzolanic concretes are used extensively throughout the world where oil, gas, nuclear and power industries are among the major users. The applications of such concretes are increasing day by day due to their superior structural performance, environmental friendliness, and energy conserving implications Research has been conducted on the use of fly ash, volcanic ash, volcanic pumice, pulverized-fuel ash, blast slag and silica fume etc. as cement replacement material. Fly ash and others are pozzolanic materials because of their reaction with lime liberated during the hydration of cement. These materials can also improve the durability of concrete and the rate of gain in strength and can also reduce the rate of liberation of heat, which is beneficial for mass concrete. Concretes containing mineral admixtures are used extensively throughout the world for their good performance and for ecological and economic reason. Ceramic is a taken from Greek word **'keramos'** means potter's clay. Ceramic materials are **nonmetallic, inorganic compounds** – primarily compounds of oxygen, but also compounds of carbon, nitrogen, boron, and silicon. Originally, the art of making pottery, now a general term for the science of manufacturing articles prepared from pliable, earthy materials that are made rigid by exposure to heat. Ceramics includes the manufacture of earthenware, porcelain, bricks, and some kinds of tile and stoneware. Ceramic products are used not only for artistic objects and tableware, but also for industrial and technical items, such as sewer pipe and electrical insulators. Ceramic insulators have a wide range of electrical properties. The electrical properties of a recently discovered family of ceramics based on a copper-oxide mixture allow these ceramics to become superconductive, or to conduct electricity with no resistance, at temperatures much higher than metals. In space technology, ceramic materials are used to make components for space vehicles. Products used for industrial or technical applications are known as industrial ceramics. The term industrial ceramics also refers to the science and technology of developing and manufacturing such products.

2. THE OBJECTIVES AND SCOPE OF PRESENT STUDY ARE

- To study the behavior of the concrete with replacing a part of coarse aggregate and fine aggregate.
- To study the literature review
- For utilizing waste ceramic materials. Use of hazardous industrial wastes in concrete-making will lead to greener environment, as reuse of the wastes from To Evaluate the compressive test, splitting tensile strength and modulus of construction and demolition is one of the most important purposes around the world.
- To reduce the cost of construction.
- To condut compression ,split tensile, modulus of Elasticity test on (ceramic tiles aggregate concrete + conventional concrete)

3. MATERIALS AND TEST RESULTS

3.1 Cement:

Cement is a binding material used in the preparation of concrete. It binds the coarse aggregate and fine aggregate with the help of water, to a monolithic matter and also it fills the fine voids in the concrete. Portland pozzolanic cement conforming to IS 1489(part1):1991 was used in this study. This cement is the most widely used one in the construction industry in india.

Table-1 Physical properties of cement

Properties of Coarse Aggregate Test	Relevant Code	Results
Specific gravity	(IS : 4031 – 1988 Part II)	3.16
Fineness	(IS : 4031 – 1996 part I)	10
Intial setting time	(IS : 4031 – 1988 Part 5	35 minutes
Final setting time	(IS : 4031 – 1988 Part 5)	8 hr 22 minutes
Crushing value	IS:2386-1963 (PART4)	20.2%

3.2 Fine aggregates:

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383-1970.

Table -2 Physical properties of fine aggregate

Description of Test	Results	Relevant code
Specific gravity	2.60	IS 2386 (Part I) 1963
Bulk relative density (kg/m^3)	1763 kg/m3	IS 387-1970
Water absorbtion	0.5%	IS 387-1970
Moisture content (%)	0.4	IS 2386 (Part III) 1963

3.3 Coarse Aggregate:

The coarse aggregate for the work should be river gravel or crushed stone. The maximum size of aggregate is generally limited to 20mm.Aggregate of 10 to 20 mm is desirable for structures having congested reinforcement. Well graded cubical or rounded aggregates are desirable. Aggregates should be of uniform in size. For this project 20 mm size aggregates were used. The results of test conducted on coarse aggregate are given in table

Table -3: properties of coarse aggregate

Properties of Coarse Aggregate Test	Relevant Code	Results
Specific gravity	IS:383-1970	2.7
Fineness	IS:2386-1963 (PART1)	5.85
Water absorption	IS:2386-1963 (PART3)	1%
Impact value	IS:2386-1963 (PART4)	15.426%
Crushing value	IS:2386-1963 (PART4)	20.2%

3.4 Water:

Water used for mixing and curing was potable water, which was free from any amounts of oils, acids, alkalis, sugar, salts and organic materials or other substances that may be deleterious to concrete or steel. The pH value should not be less than 6.

3.5 Ceramic tiles fine aggregate:

In this project, we had replaced only 10% of ceramic fine aggregate in concrete.As we got that much amount of fine aggregate during crushing of ceramic coarse aggregate. The physical properties procedure of ceramic fine aggregate is same as the procedure for conventional fine aggregate. From the crushed waste tiles, powder passed through 4.75 mm IS sieve to use as partial replacement to the fine aggregate

3.6 Ceramic tiles coarse aggregate:

The ceramic wastes were obtained from a local building that has been demolished and tile market. The waste ceramics are crushed into pieces manually. The aggregates passing through IS sieve 20mm and retained on 12.5mm were taken.

Fig 1 ceramic tiles aggregate

Table -4 : Physical properites of ceramic tiles aggregate

Description of Test	Results	Relevant code
Specific gravity	2.71	IS 2386 (Part III)
Bulk relative density (kg/m^3)	1612.63 kg/m3	IS 387-1970
Water absorbtion	0.8%	IS 2386 (Part III)
Impact value	18%	IS 2386 (Part IV)
Crushing value	20.4%	IS 2386 (Part IV)

4. MIX DESIGN

The mix design of concrete with replacement of 30%, 60% and 100% ceramic coarse aggregate and 10% ceramic fine aggregate is shown below. Mix has been design based on Indian standard recommended guidelines IS : 10262 – 2009The mix design for obtaining the amount of cement, fine aggregate and coarse aggregate are calculated based upon the code IS 10262:2009.

Table-5 DESIGN MIX PROPORTION FOR (M30 MIX)

Water(lit/$m^{3)}$	Cement(kg/$m^{3)}$	Fine Aggregate (kg/$m^{3)}$	Coarse Aggregate(kg/$m^{3)}$
0.45	1	1.36	2.15

5. TEST PROGRAMME

5.1 Compressive Strength:

According to the IS 516-1959, Cube specimens were cast of size 150 x150 x 150 mm and substituted natural coarse aggregate with ceramic waste aggregate. Compressive strength test was performed by using compression Testing Machine to find the 7 and 28 days, compressive strength of the concrete. mix design was prepared for M30 grade concrete and its target mean strength was 38.25 MPa ,total 24 cube specimens were cast. . The compressive strength of the specimen is calculated.

Compressive strength = P/A N/mm^2

Where, P=Load in N A=Area in mm^2

Fig 3 testing of cube specimen

5.2 SPLIT TENSILE STRENGTH TEST:

Split tensile strength of the cylinder is taken for the specimen of length 300mm and diameter 150mm made for control mix. After curing for required period the specimen were tested. The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of compressive testing machine and the load was applied until the failure of the cylinder along the vertical diameter take place. This is an indirect method of finding the tensile strength of concrete which is shown in figure

The split tensile strength is calculated using formula

Split tensile strength (MPa) = 2P/3.14LD

Where, P is the compressive load on the cylinder

L is the length of cylinder

D is the diameter of the cylinder

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Fig 4 Testing of cylinder

6. RESULT AND DISCUSSION

6.1 Workability of ceramic tiles aggregate Slump test:

Water absorption of ceramic tiles aggregate and natural aggregate was recorded as 10&60% and10&100% respectively.a little variation was observed between these aggregate. due to higher water absorbtion and irregular shape of ceramic waste aggregate ,workability of ceramic aggregate concrete decreases as the percentage of replacement of ceramic waste aggregate increased.

6.2 Compressive strength:

Compressive strength has been found out at the ages 7, 28 days for conventional concrete and ceramic tiles aggregate concrete, after moist curing the specimens continuously. The test results are presented in table

Table-6Compressive strength of the concrete with replacement of ceramic tiles aggregate

CERAMIC TILES OF FA+CA (%)	MIX NO	AREA (mm^2)	LOAD (KN)		COMPRESSIVE STRENGTH-N/mm^2		AVERAGE STRENGTH N/mm^2	
			7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
CONVENTIONAL CONCRETE	**CC1**	22500	420	715	18.66	31.78	19.1	**30.92**
	CC2		480	694	21.33	30.84		
	CC3		390	678	17.33	30.13		
10+30	CTA1	22500	480	700	21.3	31.11	20.55	31.70
	CTA2		500	730	22.55	32.41		
	CTA3		400	710	17.77	31.55		
10+60	CTB1	22500	490	750	21.77	33.33	24.92	34.61
	CTB2		685	771	30.44	34.27		
	CTB3		500	815	22.55	36.22		
10+100	CTC1	22500	528	637	23.46	28.31	23.34	28.34
	CTC2		535	645	23.77	28.67		
	CTC3		513	631	22.80	28.04		
CC=Conventional Concrete, CTA=10&30%Ceramic tiles aggreagate,ERAMIC TILES CTB=10&60%Ceramic tiles aggregate, CTC=10&100%Ceramic tiles aggregate								

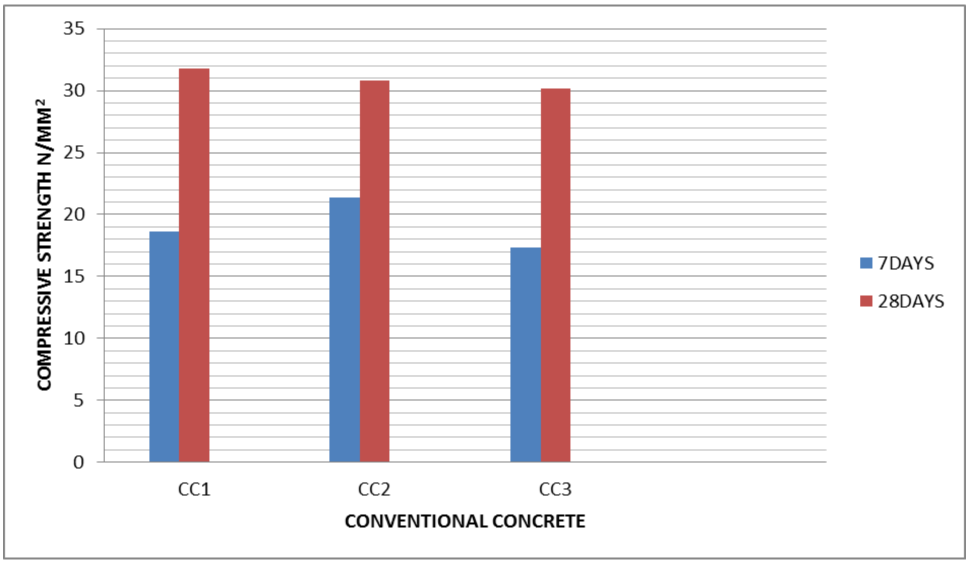

Fig 5 Conventional concrete v/s compressive strength concrete for M30 mix 7&28 days.

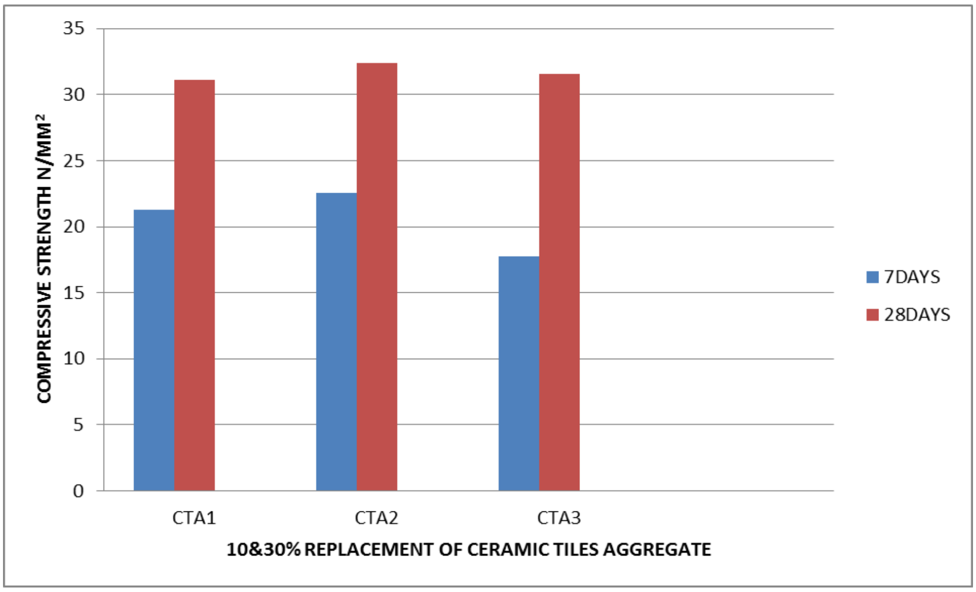

Fig 6 10&30% Replacement of ceramic tiles v/s compressive strength of concrete for M30 mix 7&28 days

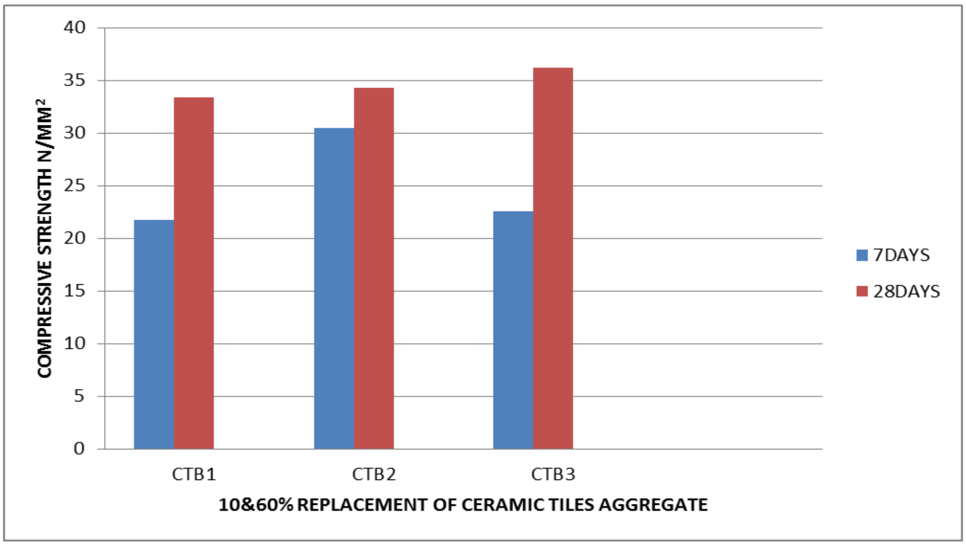

Fig 7 10&60% Replacement of ceramic tiles aggregate v/s compressive strength of concrete for M30 mix 7&28 days

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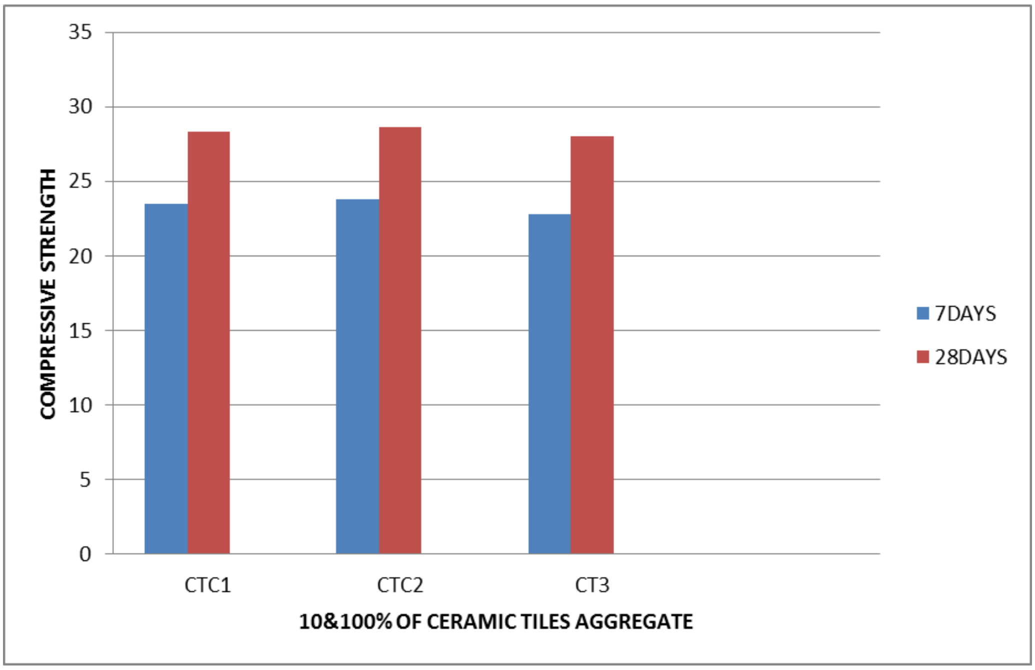

Fig 8 10&100% Replacement of ceramic tiles aggregate aggregate v/s compressive strength of concrete for M30 mix 7&28 days

SPLIT TENSILE STRENGTH OF CYLINDERS:

Split tensile strength of the cylinder for the specimen of length 300mm and diameter 150 mm made for control mix and tested and the results are tabulated for days and 28 days strength and the split tensile strength of cylinder for 7 and 28 days respectively.

Table-7 Split tensile strength of the concrete with replacement of ceramic tiles aggregate

CERAMIC TILES OF FA+CA (%)	SPECIMEN	AREA (mm^2)	LOAD (KN)		SPLIT TENSILE STRENGTH-N/mm^2		AVERAGE STRENGTH N/mm^2	
			7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
CONVENTIONAL CONCRETE	**CC1**	150X300					3.14	**3.10**
	CC2		207	207	2.93	2.93		
			250	240	3.53	3.40		
	CC3		211	211	2.99	2.90		
10+30	CTA1	150X300	250	290	3.53	4.10	3.25	4
	CTA2		230	290	3.25	4.10		
	CTA3		210	270	2.97	3.8		
10+60	CTB1	150X300	250	290	3.53	4.10	3.4	4.15
	CTB2		240	290	3.40	4.10		
	CTB3		250	300	3.53	4.24		
10+100	CTC1	150X300	190	260	3.9	3.6	3.4	3.8
	CTC2		250	290	3.5	4.10		
	CTC3		210	270	2.9	3.8		

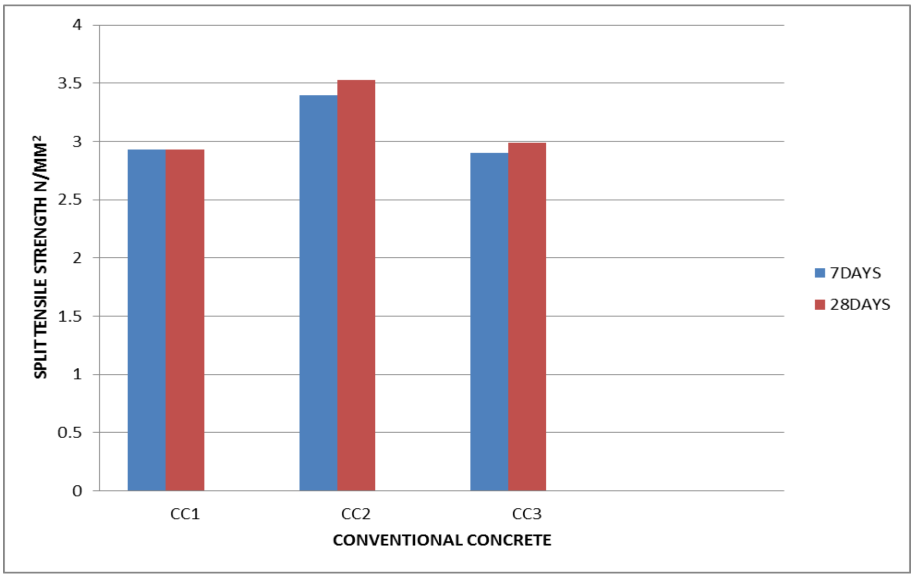

Fig 9 Conventional concrete v/s compressive strength of concrete for M30 mix 7&28 days

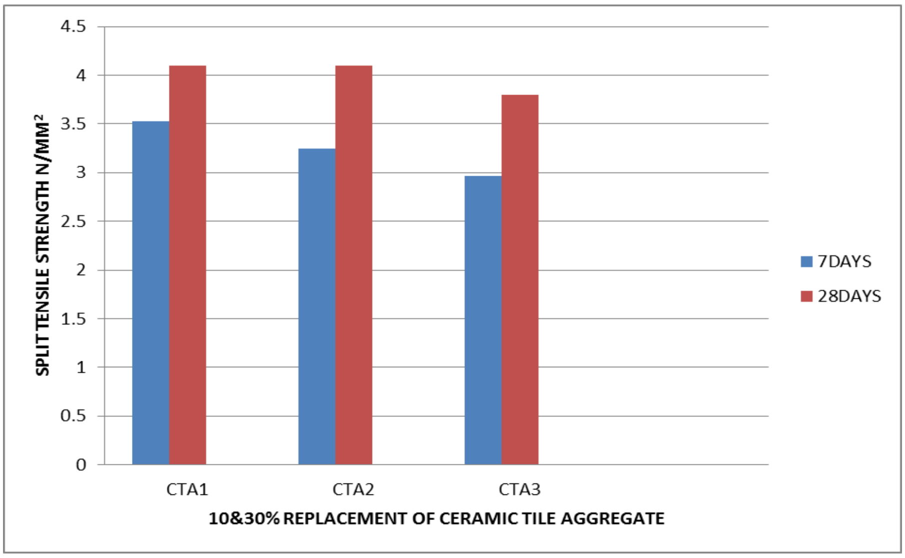

Fig 10 10&30% Replacement of ceramic tiles aggregate v/s compressive strength of concrete for M30 mix 7&28 days

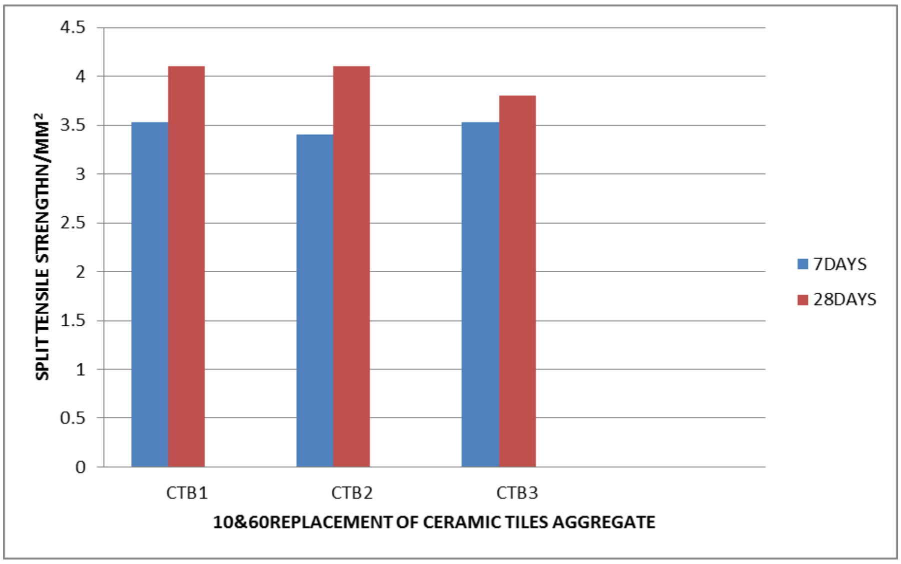

Fig 11 10&60% Replacement of ceramic tiles aggregate concrete v/s compressive strength of concrete for M30 mix 7&28 days

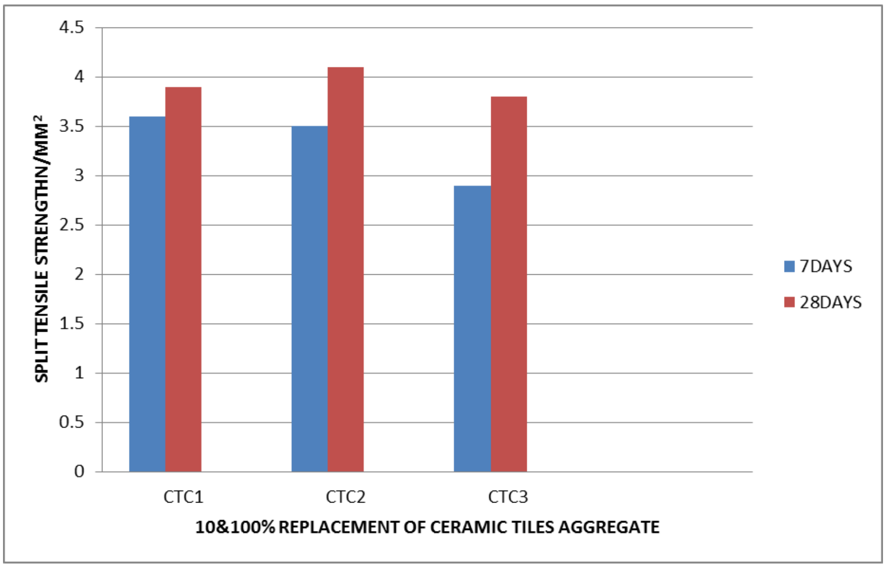

Fig 12 10&100% Replacement of ceramic tiles aggregate concrete v/s compressive strength of concrete for M30 mix 7&28 days

FLEXURAL STERNGTH TEST:

Concrete as we known is relatively strong in compression and weak in tension. Tensile stresses are likely to develop in concrete due to drying shrinkage, rusting of steel reinforcement, temperature gradients and many other reasons. The system of loading for finding out the flexural tension is centre point loading or third point loading. In the centre point loading, maximum fibre stress will come below the point of loading where the bending moment is maximum. In the case of symmetrical two point loading, the critical crack may appear at any section not strong enough to resist the stresses within the middle third where the bending moment is maximum. It can be expect that the two point loading will yield a lower value of the modulus of rupture than the centre point loading. The size of beam specimen is 500 x 100 x 100mm. The value of modulus of rupture depends upon the dimension of beam and manner of loading.

$$fb = pl/bd2$$

Where,

b = width of the specimen in mm

d = depth of the specimen in mm

l = length of the specimen in mm

p = maximum load in N applied to the specimens

Table-8 Flexural strength of the concrete with replacement of ceramic tiles aggregate

CERAMIC TILES OF FA+CA (%)	SPECIMEN	AREA (mm^2)	LOAD (KN)		FLEXURAL STRENGTH-N/mm^2		AVERAGE STRENGTH N/mm^2	
			7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
CONVENTIONAL CONCRETE	**CC1**	500X100x100	8.5	12.5	4.25	6.25	3.3	**5.46**
	CC2		6.0	10.5	3.0	5.25		
	CC3		5.5	9.75	2.75	4.88		
10+30	CTA1	500X100x100	9.0	12.25	4.5	6.13	3.54	5.75
	CTA2		6.75	11.5	3.38	5.75		
	CTA3		5.5	10.75	2.75	5.38		
10+60	CTB1	500X100x100	6.5	10.75	3.25	5.38	3.50	5.75
	CTB2		7.75	12.5	3.88	6.25		
	CTB3		6.75	11.25	3.38	5.63		
10+100	CTC1	500X100X100	5.5	10.25	2.75	5.13	3.20	5.29
	CTC2		6.25	10.5	3.13	5.25		
	CTC3		7.5	11.0	3.75	5.5		

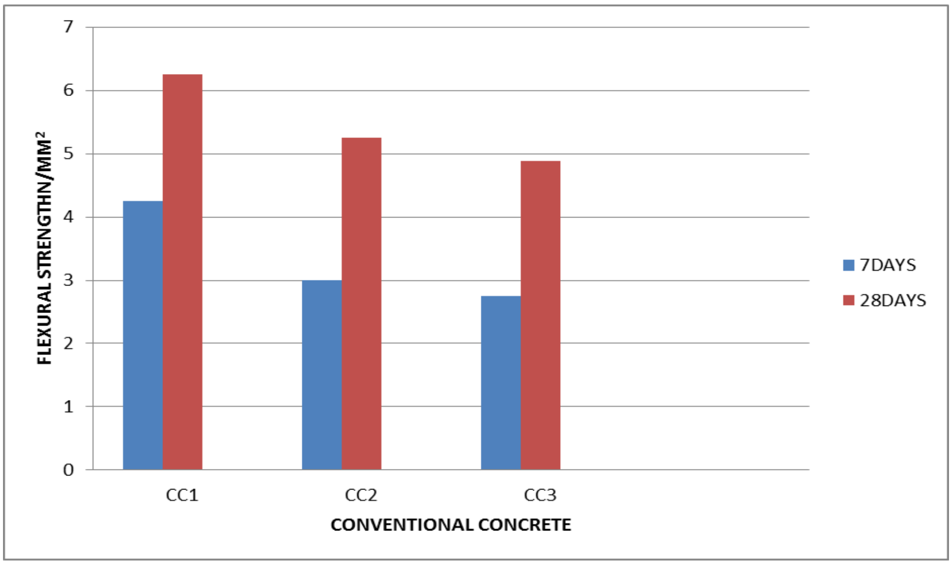

Fig 13 Conventional concrete v/s compressive strength of concrete for M30 mix 7&28 days

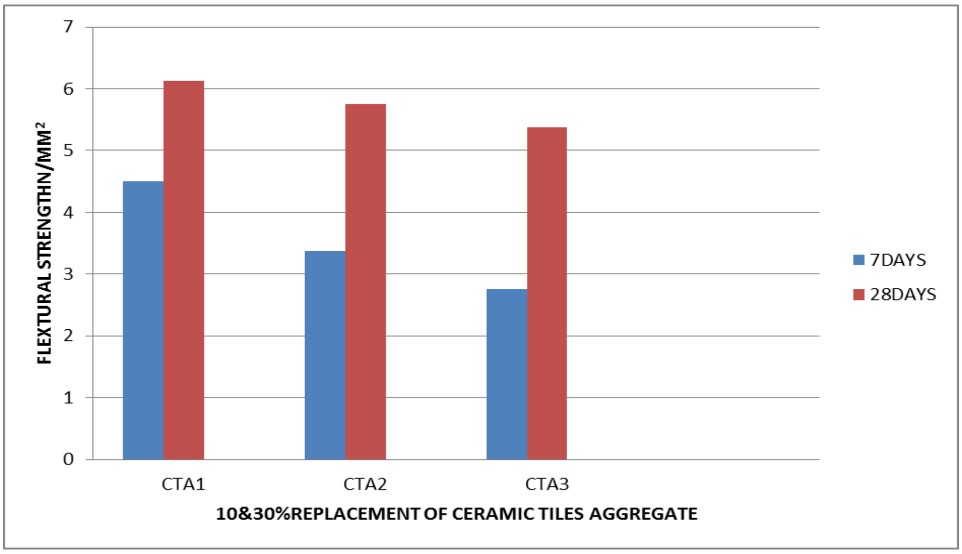

Fig 14 10&30% Replacement of ceramic tiles aggregate concrete v/s compressive strength of concrete for M30 mix 7&28 days

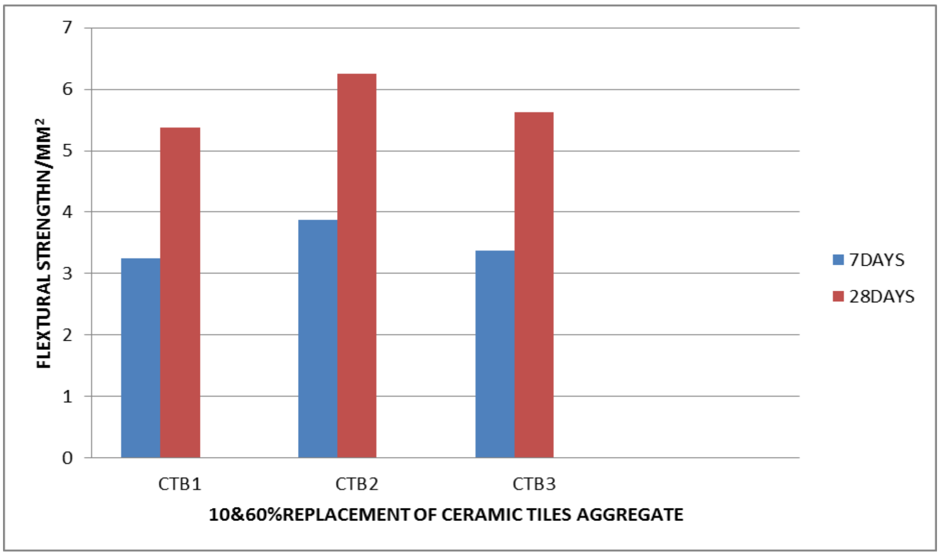

Fig 15 10&60% Replacement of ceramic tiles aggregate concrete v/s compressive strength of concrete for M30 mix 7&28 days

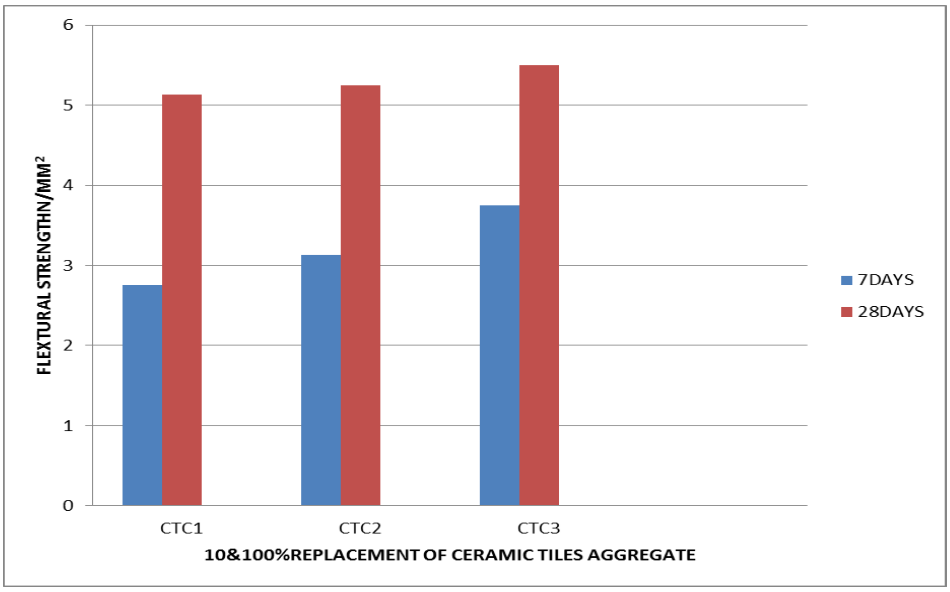

Fig 16 10&100% Replacement of ceramic tiles aggregate concrete v/s compressive strength of concrete for M30 mix 7&28 days

7. CONCLUSION

- While using ceramic tiles as replacement of(30,60,100%)coarse and(10%)fine aggregate, Workability increased with increased with replacement level.
- Compressive strength achieved by ceramic tiles aggregate concrete was good.
- It is observed that, compressive strength of concrete made using ceramic tiles are increased with replacement level (upto 10&60%).
- Optimum replacement level of coarse and fine aggregate with ceramic tiles are10&60%
- By using the replacement materials offers cost reduction and can overcome few environmental hazards

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