Experimental Study on Concrete with Partial Replacement of Cement with Fly Ash & Coarse Aggregate by Ceramic Tiles

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Abstract

The main aim of this research is to study the utilization of waste ceramic tiles as a partial replacement of coarse aggregate (20mm) and 10% fly ash as a replaced of cement in concrete. For all the materials physical properties shall be carried out and mechanical properties such as compressive strength & split tensile strength of concrete were examined and compared with normal concrete. M30 grade of concrete was designed to prepare the conventional mix. The cubes and cylinders are determined at the age of 7 & 28 days. Cubes for compressive strength as size 15X15X15 cm and cylinder for split tensile strength as size 15X30 cm were casted by adopting weight batching and hand mixing. The mix were designated with various percentage of waste ceramic tiles such as 0%,10%,20%,30%,40% & 50% to evaluate various properties. The results which come out from the research work are shows that the strength developed in concrete is increased, it can be equated to higher strength concrete and it can be easily used as construction material in construction work.

Keywords: Ceramic Tiles (CT), Fly Ash (FA), Compressive strength, Split tensile strength

I. INTRODUCTION

The amount of ceramic tile waste on earth is enough for use as a coarse aggregate in concrete. Ceramic tile is produced from natural materials sintered at high temperatures. There are no harmful chemicals in tile. Waste tiles cause only the hazard of pollution. So due to such reasons waste tiles are stored in factory fields because of their economic value. Nevertheless, every year approximately 250,000 tons of tiles are washed out, while 100 million tiles are used for repairs. Ceramic waste can be transformed into useful Coarse aggregate. It has been calculated that about 30% of the daily production in the ceramic industry left as a waste. This waste is not recycled in any form at present.

The demand of construction materials for project is increasing. Therefore, there is a need to explore alternative building materials from industrial waste materials that can be recycled. Ceramic tiles are often discarded as waste after defined as useless. But it can be recycled and can be used as a construction material in present world which is seeking for alternative construction materials which are economical, environment friendly as well as provides same quality as that of a normal aggregate made of regular aggregates. Ceramic wastes can be used safely with no need for dramatic change in production and application process.

In this experimental work the waste materials are used as partial replacements for concreting materials in varying percentages. The quantity of fly ash produced from thermal power plants in India is approximately 80 million tons each year, and its percentage utilization is less than 10%. Majority of fly ash produced is of Class F type. Fly ash is generally used as replacement of cement, as an admixture in concrete, and in manufacturing of cement. FA has two roles in concrete manufacture, as a substitute for cement, reducing the cost and weight of concrete in the production of low cost buildings.

II. OBJECTIVES AND SCOPE OF PRESENT STUDY

1) To study the physical properties of fresh & hardened concrete with FA and CT as partial replacement for cement & coarse aggregate.
2) To relate mechanical properties between control specimens and specimens FA and specimen's FA + CT.
3) To study the effect of FA as cement and CT as coarse aggregate for various mix proportions.
4) To study the strength developed in concrete with CT as a coarse aggregate.
5) To determine the effect of various percentage of ceramic tiles (CT) as partial replacement of coarse aggregates towards compressive strength of concrete.
6) These replacements will reduce the cost of the project at greater percentage because aggregates are more costly than cement for concrete production.
7) To determine the optimum coarse aggregate mix ratio (M30) to achieve this strength.
8) CT is waste products which are released directly into the environmental and can cause environmental pollution. So it can be transformed into useful coarse aggregate in concrete.
9) Using CT aggregate in concrete not only will be cost effective, but also will be good from environment point of view.

III. LITERATURE REVIEW

A. J.Swathi [1]

This paper has studied the control concrete is casted for M40 grade and the partial replacement of concrete materials were decided to reuse industrial waste such as copper slag as fine aggregate replacement in range of 20%, 40%, 60% by weight of sand and the ceramic waste tiles as coarse aggregate replacement in 10%, 20%, 30% by weight of coarse aggregate. In compression strength, the maximum strength attained is 58.54Mpa at 28days at 40% copper slag replacement compared to normal M40 grade concrete. The replacement of copper slag as sand attained high strength of at 40% replacement than conventional concrete, further replacements also has increased strength. The replacement of ceramic tiles alone will not have sufficient strength, so it is replaced with optimum slag content as constant also have increased strength compared to control concrete.

B. Parminder Singh [2]

The authors has defined as for natural aggregates mining is needed but tile aggregate can ignore this process. It is possible in M 20 grade concrete to substitute 20% of normal 20 mm aggregates with ceramic tile aggregates without compromising its required compressive strength. For all concrete mixes (M 20, M25, M30) compression strength of concrete decreases with increase in the proportion of replacement of natural aggregates with tile aggregates. In M 30 grade concrete with 5% substitution of tile aggregates its strength decreases from 38.73 to 36.73 N/mm2, which is less than target mean strength. So, as per results substitution should be avoided for this grade of concrete. M 20 and M 25 concretes are suitable for the replacement of aggregates. As an estimate for making 1 m3 of concrete by substituting 20% normal 20 mm aggregates with tile aggregates about 16% money can be saved on total amount of 20 mm aggregates.

IV. METHODOLOGY AND PROPERTIES OF MATERIALS

The evaluation of fly ash use as a replacement of cement material begins with the concrete testing. Concrete contains cement, water, fine aggregate and coarse aggregate. With the normal concrete, i.e. 10%, 20%, 30%, 40%, and 50% of the cement is replaced with fly ash, the results from the fly ash concrete is compared with results from a normal concrete without use of ceramic tiles as a coarse aggregate. After gaining highest strength at mix 10% fly ash + 90% cement then the percentage of coarse aggregate is replaced with ceramic tiles were 10%, 20%, 30%, 40% and 50% the results of concrete is compared with normal concrete and with use of ceramic tiles. Six cube samples were cast on the mould of size 15x15x15 cm and six cylinder samples were cast on the mould size of 15x30 cm. After about 24 h the specimens were demould and keep it in water curing tank. Tests were done as per following codes of Bureau of Indian Standards. The test for Compressive Strength on cubes were measured at 7 and 28 days of curing as per IS:516-1959, and test for Split Tensile Strength on cylinder was measured at 7 and 28 days of curing as per IS:5816-1999.

A. Mix Design

M30 grade of concrete was designed by following the specification given in the IS 10262: 1982.
Water cement ratio (w/c) was selected as 0.38 based on conducting slump tests for different design trails. Mix proportion obtained for M30 mix is 1: 1.20: 2.29.

Table – 1
Combinations of materials & casting of specimens

S.No	Mix	Cement %	Fly Ash %	Fine aggregate %	Coarse aggregate %	Ceramic tiles %	No of cubes and cylinders	
							7 days	28 days
1	AK 0	100	0	100	100	0	3	3
2	AK 1	90	10	100	100	0	3	3
3	AK 2	80	20	100	100	0	3	3
4	AK 3	70	30	100	100	0	3	3
5	AK 4	60	40	100	100	0	3	3
6	AK 5	50	50	100	100	0	3	3
7	AK 6	90	10	100	90	10	3	3
8	AK 7	90	10	100	80	20	3	3
9	AK 8	90	10	100	70	30	3	3
10	AK 9	90	10	100	60	40	3	3
11	AK 10	90	10	100	50	50	3	3

B. Properties of Material

1) Cement:
2) Fine Aggregate:

Table – 2
Properties of Cement

S.No	Description	Result
1	Fineness of cement	93%
2	Normal Consistency	32%
3	Initial Setting time	30 min
4	Final Setting time	240 min
5	Specific gravity	3.10
6	Compressive strength 7 days 28 days	29.24 N/mm^2

Table – 3
Properties of Fine Aggregate

S.No	Description	Results
1	Sand zone	Zone- II
2	Specific gravity	2.64
3	Water absorption	5%
4	Bulk density	1560 Kg/m^3
5	Fineness modulus	3.2
6	Moisture content	1.50%

3) Coarse Aggregate:

Table 5: Properties of Fly Ash

S.No	Description	Results
1	Specific gravity	2.72
2	Impact value	14.5
3	Water absorption	1.17%
4	Crushing value	17.9%
5	Bulk density	1935.3 kg/m^3
6	Moisture content	1.20%

V. REPLACEMENT TO CEMENT

From thermal power plant Fly ash has been collected. It was sieved through 90micron sieve for the purpose of concreting samples as a partial replacement of cement. Fly ash was partially replaced in place of cement by the percentages of 10%, 20%, 30%, 40% and 50% individually and along with replacement of coarse aggregate with ceramic tiles also. The various characteristics of fly ash were tested as per Indian Standards IS: 3812-1981.

VI. REPLACEMENT OF COARSE AGGREGATE

Broken tiles were collected from the solid waste of ceramic manufacturing company. Crushed them into small pieces by manually and separated the coarse aggregate 20mm to use them as partial replacement to the natural course aggregate. Crushed tiles were partially replaced in place of coarse aggregate by the percentages of 10%, 20%, 30%, 40% & 50% individually and along with replacement of fine aggregate with cement.

Table – 4
Properties of Coarse Aggregate

S.No	*Description*	*Result*
1	*Specific gravity*	*2.10*
2	*Fineness*	*310 m^3/kg*
3	*Bulk density*	*0.749 gm/cm^3*

Table – 5
Properties of Ceramic tiles

S.No	*Description*	*Results*
1	*Specific gravity*	*2.28*
2	*Impact value*	*20%*
3	*Water absorption*	*9.13%*
4	*Crushing value*	*13.6%*
5	*Bulk density*	*1612.67 kg/m^3*

VII. RESULTS AND DISCUSSION

A. Compressive Strength Test

In this investigation for each mix 6-samples were tested and the average strength is compared with normal concrete of M30 grade. Totally 66-cubes of size 15x15x15 cm were casted and tested at 7 & 28 days from curing. The normal concrete strength is compared with the replaced concrete at 10%, 20%, 30%, 40%, & 50% by FA for cement and optimum level is found, with optimum level of FA concrete is replaced with ceramic tiles by 10%, 20%, 30%, 40% & 50% for coarse aggregate strength. The values of the compressive strength for normal and other variation mix are shown in tables and are clearly differentiated by a graph.

Fig. 1: Compressive strength test

Table – 7
Compressive Strength of concrete with different % age of Ceramic Tiles

S.No	*Mix*	*7 days Compressive Strength N/mm^2*	*28 days Compressive Strength N/mm^2*
1	*AK 0*	*38.37*	*45.12*
2	*AK 1*	*39.68*	*49.72*
3	*AK 2*	*34.20*	*44.72*
4	*AK 3*	*25.53*	*40.04*
5	*AK 4*	*22.32*	*33.49*
6	*AK 5*	*16.13*	*27.68*
7	*AK 6*	*39.73*	*46.84*
8	*AK 7*	*40.27*	*48.11*
9	*AK 8*	*34.91*	*39.94*
10	*AK 9*	*28.51*	*36.48*
11	*AK 10*	*26.26*	*32.24*

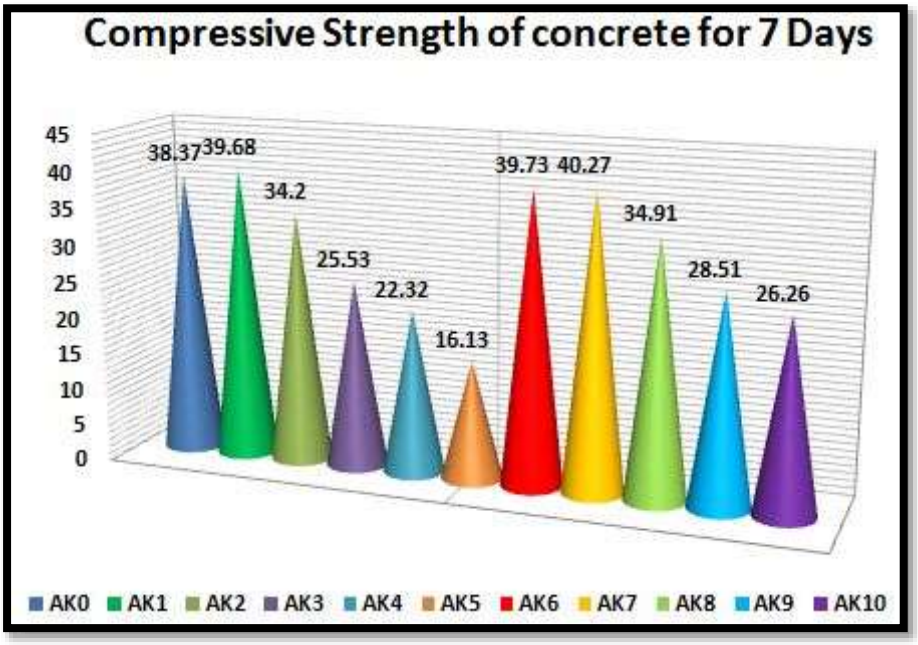

Fig. 2: Compressive strength for 7 days

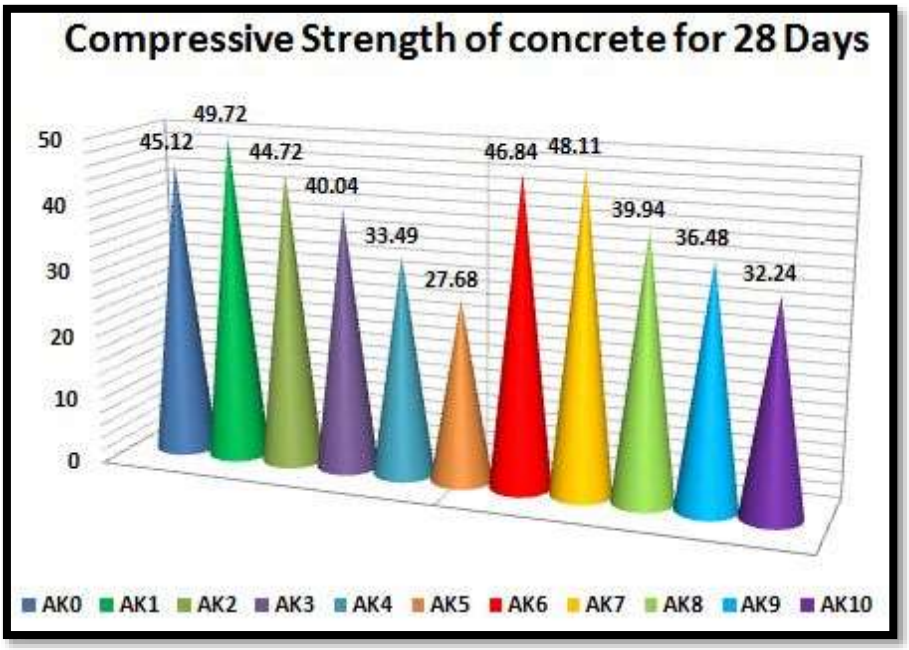

Fig. 3: Compressive strength for 28 days

B. Split Tensile Strength Test

The split tensile strength of concrete casting cylinder of size 15x30 cm and is continuously cured for 7 & 28 days are testing. Totally 66 cylinders were casted for normal M30 grade and for 10%, 20%, 30%, 40% & 50% partial replacement of fly ash for cement, with optimum level of fly ash is found and the ceramic tiles are partially replaced by 10%, 20%, 30%, 40% & 50% with optimum fly ash in normal concrete and is cured for testing, for each mix 6 samples are tested and the average values is taken as tensile strength of concrete. The values of the split tensile strength for normal and other variation mix are shown in tables and are clearly differentiated by a graph.

Fig. 4: Split tensile strength test

Table – 8
Split Tensile Strength of concrete with different % age of Ceramic Tiles

S.No	*Mix*	*7 days Split Tensile Strength N/mm²*	*28 days Split Tensile Strength N/mm²*
1	*AK 0*	*2.43*	*3.30*
2	*AK 1*	*2.57*	*3.59*
3	*AK 2*	*2.07*	*3.33*
4	*AK 3*	*1.75*	*2.46*
5	*AK 4*	*1.42*	*2.26*
6	*AK 5*	*1.04*	*1.90*
7	*AK 6*	*2.49*	*3.51*
8	*AK 7*	*2.61*	*3.61*
9	*AK 8*	*2.33*	*3.06*
10	*AK 9*	*2.03*	*2.20*
11	*AK 10*	*1.45*	*1.89*

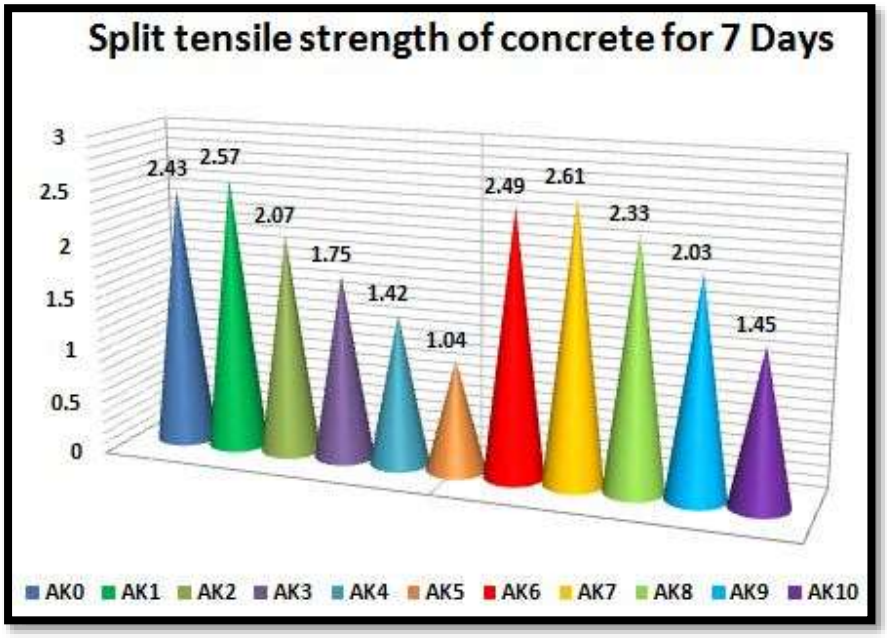

Fig. 5: Split tensile strength for 7 days

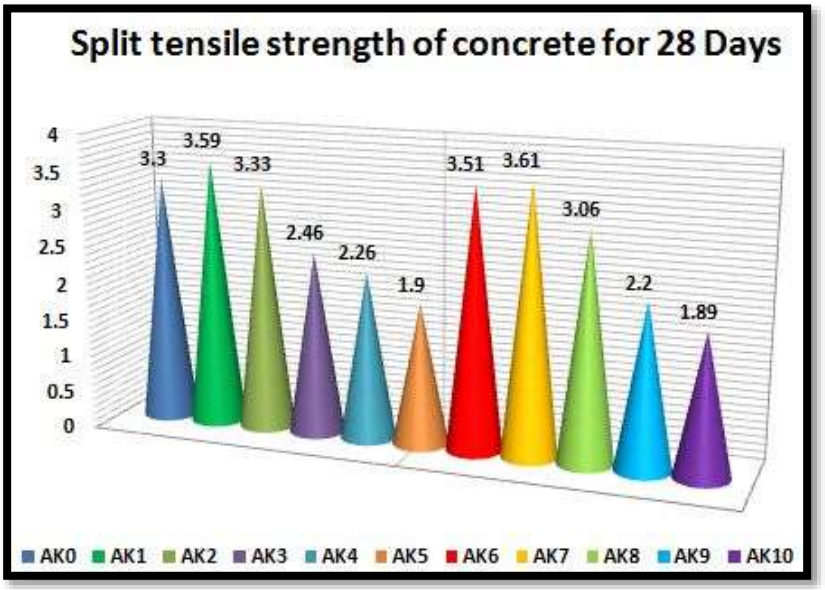

Fig. 6: Split tensile strength for 28 days

VIII. CONCLUSION

After completion of total project work, from the above investigations and from the test results some variations observed in compressive strength of different concrete mixes having different percentages of replacing ceramic tiles in place of coarse aggregate as mentioned below.

1) The concrete is cast by partially replacing coarse aggregate with ceramic tiles in various proportions such as 10%, 20%, 30%, 40% and 50%.
2) The compressive strength and split tensile strength reveals high strength of 20% replacement of ceramic tiles as a coarse aggregate.
3) At the age of 28 days curing, the compressive strength of 10% replacement is 3.81% higher; at 20% replacement is 6.62% higher than the conventional concrete.
4) At the age of 28 days curing, the split tensile strength of 10% replacement is 6.36% higher; at 20% replacement is 9.39% higher than the conventional concrete.
5) Thus ceramic tiles can be utilized in the manufacture of concrete at replacement of 20%.

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