USE OF CERAMIC TILE WASTE IN CONCRETE MIX BY PARTIAL REPLACEMENT OF COARSE AGGREGATE: AN EXPERIMENTAL STUDY

[1]Sherin Khan, [2]Dr. S.S.Goliya, [3]Dr. Rakesh Mehar
[1]PG Student, [2]Associate professor, SATI Vidisha, [3]Assistant professor, SATI Vidisha
[1]Civil Engineering Department,
[1]SATI Vidisha, Vidisha, India

Abstract: As we can see that because of the innovations and development emerging in the construction area, the consumption of natural aggregates is getting very high which in turns leads to the scarcity of the material and hence increasing the construction cost. The main focus of this research is to find out the strength characteristics of concrete by somewhat replacing the natural coarse aggregate by the wastes from ceramic industries. The production of wastes from the ceramic industry is rising year by year. The ceramic tile waste can be collected from the production unit and also from the structures where the demolition work is going on. It can be an effective measure to use ceramic tile wastes in concrete production. This can help in sustaining the environment and can also enhance the properties of concrete. M30 grade concrete mix was designed with various percentage of waste ceramic tiles such 0%, 10%, 20%, 30%, 40% & 50% to evaluate various properties for M30 grade of concrete. Cubes for compressive strength as size 15×15×15 cm^3 and beam for flexural strength as size 15×15×70 cm^3 and cylinders of 10 cm × 30cm (height × diameter) were cast by adopting weight batching and hand mixing. Investigational studies like compressive strength, split tensile and flexural strength (after 7, 14 and 28 days) are taken into account. After looking up at the results, the most favourable value of replacement of natural coarse aggregate by waste material from ceramic tile which can be brought into play in the mix of concrete is concluded as about 30%. The findings revealed that the use of ceramic tile waste for partial replacement of coarse aggregate leads towards enhancing the valuable concrete properties which in turns can be easily used as construction material in construction work. The utilization of ceramic waste materials in the construction of the road is based on technical, cost efficiency, and ecological criteria. Because of the efficient utilization of ceramic wastes in constructing the highway, the pollution from wastes and the problem of disposal of wastes is partly reduced.

***IndexTerms* – Scarcity, solid wastes, ceramic tile wastes, demolition, partial replacement, ecological criteria.**

1.INTRODUCTION

Industrial development is causing severe difficulties all over the world which includes exhaustion of natural coarse aggregates and generates a massive quantity of waste material from the construction as well as from activities such as demolition. These wastes can be utilized in various ways to reduce the number of such wastes. A huge amount of wastages generates every year in all countries and ceramic materials add up to the highest percentage of wastes within the construction and demolition wastes about 55%. The recycling of solid wastes and waste aggregates evolved from activities like construction and destruction is proving a budding application in construction and also as a replacement to natural aggregates. Furthermore, it saves natural resources and even lower down the space required for landfill disposal of the wastes. As the requirement of construction materials is increasing enormously. Therefore, there is a necessity to discover a substitute for building materials from industrial waste materials which can be recycled and utilized for the following stated purposes. Tile wastes often are thrown away as waste after it was defined as of no use so it can be reused and hence can be utilized as a construction material in today's world. This is an alternative construction material which is economical, environment-friendly, hard, durable and provides us with the same quality as that of natural coarse aggregates which we are using conventionally. According to various studies, ceramic waste is found out to be durable, tough, strong and even shows resistance to biological, chemical and physical degradation and therefore such wastes can be used safely with no dramatic change in production and application process. Aggregates from ceramic wastes are considered hard as they are having an appropriate value of specific gravity. They usually have a rough surface on one side and the other side is smoother and flat, are lighter in weight as compared to natural coarse aggregates. Utilizing ceramic wastes as aggregate in concrete will be economic, reduces overall construction cost and also it is environment-friendly. The following parts here provides us with concise knowledge and some of the vital investigations that were carried out to the considered work. Researches performed for investigating the employment of waste ceramic tile in the production of concrete found out to be very helpful in reaching the objective of sustainable composition. This investigation intends to use of waste ceramic aggregate having 20 mm maximum size of in substitute to coarse aggregate. Along with this the Portland pozzolana cement and natural sand are used to form a mix as per requirement. Strength tests were carried out, the test results show that except M30 mix the natural coarse aggregate replacement by ceramic tile aggregate shows no such significant result on M20 and M25 concrete mixes.

1.1 Problem statement

As the requirement of construction materials is increasing enormously, therefore there is a necessity to discover a substitute for building materials from industrial waste materials which can be recycled and utilized for the following stated purposes. Ceramic tile wastes are effortlessly available from the manufacturing industries which manufacture ceramic items as well as from the activities like the demolition of the structures and it can be profitably recycled. It is emerging as an efficient construction material in the present demanding world. As we can see that there is a huge demand for some substitute to conventional construction materials which can be utilized economically and are environment-friendly as well as provides us with approximately the same properties as that of a normal aggregate. Ceramic tile wastes can be utilized safely with no enhancement or dramatic change in the process of application and production. It is having approximately the same properties as that of the conventional coarse aggregate.

1.2 Objectives of the study

Following are the aim of the research :

i). To find out the strength of hardened concrete with replacement by ceramic tile aggregate.

ii) To study the effect of inclusion of a various proportion of ceramic tile waste as conventional coarse aggregates towards different concrete strength.

iii) To determine the optimum coarse aggregate mix ratio (M30) to achieve this strength.

iv) To use waste ceramic tile efficiently for CC road.

2. LITERATURE REVIEW

Some of the previous studies have been investigated the use of ceramic tile as coarse aggregate.

Aruna D (2015) For tile waste-based concrete, coarse aggregates were replaced by 20mm downsize, tile wastes by 0%, 5%, 10%, 15%, 20% and 25% and also the cement are partially replaced by fly-ash. The average maximum compressive strength of roof tile aggregate concrete is obtained at a replacement of 25%. A reduction of 10-15% of strength is observed compared to conventional concrete at 25% of roof tile aggregate replacement. The workability of roof tile waste concrete is in the range of medium. Overall, the replacement of tiles in concrete is satisfactory for small constructions.

Marwein B. (2016) The ceramic waste adopted is broken tiles. Ceramic tile waste concrete(CWC) made with these tiles at 0%, 15%, 20%, 25% and 30%. M20 grade concrete is adopted; a constant water ratio of 0.48 is maintained for all the concrete mixes. The characteristics properties of concrete as workability for fresh concrete, also Compressive Strength, Split Tensile Strength are found at 3, 7 and 28 days. The paper suggests that the replacement of waste tile aggregate should be in the range of 5-30% and also it is suitable for ordinary mixes like M15 and M20.

Pozo J. and Romero M. (2014) The study concentrates on the ceramic waste from industries in Spain. The concrete design is done as per the Spanish concrete code and the recycled ceramic aggregates met all the technical requirements imposed by current Spanish legislation. The ceramic aggregates are replaced up to 100% replacement of coarse aggregate. Appropriate tests were conducted to compare the mechanical properties with conventional concrete. The ceramic ware aggregate concrete was exhibited feasible concrete properties as like the normal gravel concrete.

Daniyal M. and Ahmad S. (2015) A large number of ceramic materials go into wastage during processing, transporting and fixing due to its brittle nature. The crushed waste ceramic tiles were used in concrete as a replacement for natural coarse aggregates with 10%, 20%, 30%, 40% enhances its properties and it has been observed an increase in both compression and flexural and 50% of substitution in concrete. The study states that the use of ceramic tile aggregate in concrete strength.

Prasad N. (2016) Crushed waste tiles and Granite powder was used as a replacement to the coarse aggregates and fine aggregate. The combustion of waste crushed tiles was replaced in place of coarse aggregates by 10%, 20%, 30% and 40% and Granite powder were replaced in place of fine aggregate by 10%, 20%, 30% and 40% without changing the mix design. M25 grade of concrete was designed to prepare the conventional mix. Without changing the mix design different types of mixes were prepared by replacing the coarse aggregates and fine aggregate at different percentages of crushed tiles and granite powder. The experimental investigation is carried out.

Singh P. and Singla R. (2015) A research paper on the utilization of ceramic waste tiles from industries. A partial replacement to coarse aggregate has been studied. Three different grades of concrete have been prepared and tested. The results are not appropriate with the conventional but considering the strength properties, it is advisable to use ceramic tile aggregate in concrete. It is finally concluded that about 20% of ceramic tile usage in M20 grade of concrete is preferable.

Awoyera P. (2016) The usage of ceramic tiles in concrete was observed in this paper. In this, both the coarse and fine aggregates are replaced with ceramic fine and ceramic coarse aggregates obtained from construction sites of Ota, Lagos and Nigeria in various percentages. The ceramic fine and coarse aggregates are replaced in conventional concrete individually and the strength parameters are studied. Finally, it states that the usage of ceramic waste in concrete gives a considerable increase in strength coMPared to conventional concrete.

Rajalakshmi P. (2016) Use of ceramic waste will ensure an effective measure in maintaining the environment and improving properties of concrete. The replacement of aggregates in concrete by ceramic wastes will have major environmental benefits. In the ceramic industry, about 30% production goes as waste. 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. This research studied the fine aggregate replacement by ceramic tiles fine aggregate accordingly in the range of 10% and coarse aggregate in the range of 30%, 60%,100% by weight of M-30 grade concrete. This paper recommends that waste ceramic tiles can be used as an alternate construction material to coarse and fine aggregate in concrete irrespective of the conventional concrete, it has good strength properties i.e., 10% CFA and 60% CCA being the maximum strength

Tawfeeq W. (2016) This study investigated the effects of using crushed tiles (CT) as coarse aggregates in the concrete mix. The technology of concrete recycling is well established in the U.S. Recycling of Portland cement concrete, as well as asphaltic concrete is a cost-effective alternative for road, street and highway construction. It includes not only the water content and tiles but also the gravel/sand ratio. They concluded that as the water-cement ratio decrease, the compressive strength increases. The paper consists of the replacement of crushed tiles to 50% and 100% only. The results show that replacement of crushed tiles as coarse aggregate below 50% will have considerable properties.

3. MATERIALS SPECIFICATIONS

For the following study, the materials required are cement, sand, conventional coarse aggregate and waste ceramic tile aggregate.

3.1 CEMENT

Cement can be defined as a fine powder, which if we mix with water and when left to rest, then it starts to set and with time it hardens. It is able of combining pieces or masses of solid particles to provide us with a mechanically strong product. The cement which is used generally for construction is portland pozzolana cement confirming to IS 1489 (Part 1) -1991. Normal consistency test, setting time test, specific gravity and fineness etc are some of the test which is must be conducted on cement and are summarized in Table- 3.1

Table - 3.1: Properties of cement(PPC).

S.No.	Properties	Test Results
1	Normal consistency	0.30
2	Initial setting time	30 minutes
3	Final setting time	600 minutes
4	Specific gravity	2.90

3.2 FINE AGGREGATE (SAND)

Sand can be defined as a locally available construction material which is free of debris. Usually, river bed sand is used as a fine aggregate. The particle which falls into the range between 4.75 mm and 150 microns are generally known as fine aggregate. The sand fractions should be so that it packs up to provide us with a minimum void ratio. If the sand is having higher voids content then the requirement of mixing water increases further. For this particular study, the sand which conforms to zone III with a maximum size of 2.36 mm as per the Indian standards is taken into account. Fineness test, specific gravity, and water absorption test are some of the important tests which should be conducted on fine aggregates and the results obtained are summarized in the Table-3.2.

Table - 3.2: Properties of fine aggregate(Sand).

S.No.	Properties	Test Results	Reference
1	Sand zone	III	IS:2386 (P – I)
2	Specific gravity	2.65	IS:2386(P-III)
3	Water absorption	1%	IS:2386 (P-III)

3.3 NATURAL COARSE AGGREGATE (NCA)

The particles greater than 4.75 mm falls into the category of coarse aggregate. Here for this study, we are using 20 mm nominal maximum size aggregate. Confirming to Indian standards. water absorption, flakiness index test, specific gravity, and elongation index, aggregate crushing value, and impact test are the various test which must be conducted on the natural coarse aggregates. The results of the following tests are summarized in the Table-3.3

Table - 3.3: Properties of natural coarse aggregate.

S.No.	Properties	Test Results	Reference	Specification as per MORTH Table 500-8
1	Specific gravity	2.70	IS:2386 (P - III)	-
2	Water absorption	0.6%	IS:2386(P-III)	Max 2%
3	Aggregate crushing value	20.16%	IS:2386 (P-IV)	Max 10-25%
4	Flakiness and elongation index	23.53%	IS:2386 (P-I)	Max 30 %

3.4 CERAMIC COARSE AGGREGATE (CCA)

Ceramic wastes, using a hammer are crushed evenly and with the help of 20 mm IS sieve, the ceramic tile waste should be sieved. These crushed ceramic tile waste now will be used for the replacement of natural coarse aggregate. The various test was conducted on the ceramic tiles are water absorption, flakiness, specific gravity, and elongation index, aggregate crushing value, and impact test. The results of the following tests are summarized in the Table-3.4.

Table - 3.4: Properties of ceramic coarse aggregate.

S.No.	Properties	Test Results	Reference	Specification as per MORTH Table 500-8
1	Specific gravity	2.45	IS:2386 (P - III)	-
2	Water absorption	0.9%	IS:2386(P-III)	Max 2%
3	Aggregate crushing value	20.4%	IS:2386 (P-IV)	Max 10-25%
4	Flakiness and elongation Index	25.5%	IS:2386 (P-I)	Max 30%

3.5 WATER

Water which is accessible from the locally available sources is generally used. Here water conforming to the IS: 456-2000 is employed for curing and concreting. Concrete generally requires about 3/10th of its total weight of water for entire hydration. The water here has a significant job in attaining the concrete strength. For the conventional concrete minimum water-cement ratio of 0.35 is adequate. The water added in the concrete takes part in the chemical reaction. Cement and water here form a paste which then binds up with fine and coarse aggregates to form a consistent paste. If the amount of water being used is increased, segregation and bleeding of concrete take place, which results in the weakening of concrete. If the amount of water is used is less, then the achievement of required workability is not possible. The water which is required to be used in the concrete should be potable water which is fit for drinking. The water with pH value ranging from 6 to 9 is used.

4. MIX DESIGN

4.1 TARGET STRENGTH FOR MIX PROPORTIONING

The margin over characteristic strength is given by the following relation:-

$$f'_{ck} = f_{ck} + 1.65\ S$$

For M30 mix f_{ck} = 30 and S= 5 from Table 1 of IS 10262:2009

$$f'_{ck} = 30 + (1.65 \times 5) = 38.25\ \text{MPa}$$

4.2 SELECTION OF WATER-CEMENT RATIO

The water-cement ratio given in Table 5 of IS 456:2000 (given below) for respective environment exposure conditions may be used as the starting point.

From Table 5 of IS 456:2000, the maximum water-cement ratio for M30 grade of concrete for the severe condition is 0.45. Let us here adopt the water-cement ratio as 0.43.

4.3 SELECTION OF WATER CONTENT

The quantity of maximum mixing water per unit volume of concrete may be determined from Table 2 of IS 10262:2009. The maximum water content which can be used for aggregates (20 mm size) is 186 litres which can be obtained from Table 2 of IS 10262:2009. Let us assume the water content of 165 litres.

4.4 CALCULATION OF CEMENTITIOUS MATERIAL CONTENT

The cement content per unit volume of concrete may be calculated from the free water-cement ratio (Table 5 of IS 456:2000, Plain and reinforced concrete -code of practice, Fourth Revision)

Cement Content = 165/0.43

= 383.7 Kg/m^3

The minimum cement content is 300 kg/m^3 for severe exposure which is mentioned in table 5 of IS 10262:2009.

4.5 ESTIMATION OF COARSE AGGREGATE PROPORTION

According to IS 10262-2009 table no. 3, we found that the volume of coarse aggregate corresponding to the size of aggregate 20 mm and Zone III of fine aggregate with a water-cement ratio of 0.50 is 0.64 %

Here, in this case, the water-cement ratio is 0.43. And hence, the coarse aggregate amount is necessary to be raised (at the rate of -/+ 0.01 for every ± 0.05 change in the water-cement ratio) to reduce the content of fine aggregate. And hence, correction should be applied. The volume of coarse aggregate corresponding to water-cement ratio 0.43 = 0.64 + 0.014

= 0.654 %

4.6 ESTIMATION OF FINE AGGREGATE PROPORTION

The total volume of fine aggregates = 1- total volume of C.A.

= 1- 0.654

= 0.346%

4.7 TRIAL MIXES

Total Volume Required (A) = 1 m^3

Volume of Entrapped air (B) = 0.02 m^3

Volume of Cement (C) = 383.7/(2.90 X 1000)

= 0.132 m^3

Volume of Water (D) = 165/(1 × 1000)

= 0.165 m^3

Volume of all in aggregates (E) = A-(B+C+D)

= 1- (0.02+0.132+0.165)

= 0.683 m^3

Mass of Coarse aggregate (C.A.) = E × Total Vol. of C.A. × Specific gravity of C.A. × 1000

= 0.683 × 0.654 × 2.70 × 1000

= 1206.05 kg/m^3

Mass of Fine aggregate (F.A.) = E × Total Vol. of F.A. × Specific gravity of F.A. × 1000

= 0.683 × 0.346 × 2.65 × 1000

= 626.24 kg/m^3

Final quantities of materials after corrections/adjustments are tabulated in Table 4.1

Table - 4.1: Materials for different ratios

S.NO.	NCA(%)	CCA(%)	Cement (Kg/ m^3)	Sand (Kg/ m^3)	NCA (Kg/ m^3)	CCA (Kg/ m^3)	Water (Kg/ m^3)
1	100	0	383.7	626.24	1206.5	0	165
2	90	10	383.7	626.24	1085.85	109.44	165
3	80	20	383.7	626.24	965.2	218.87	165
4	70	30	383.7	626.24	844.55	328.31	165
5	60	40	383.7	626.24	723.9	437.75	165
6	50	50	383.7	626.24	603.25	547.18	165

5. METHODOLOGY

By altering the amount(%) of substitution of conventional coarse aggregate with waste crushed ceramic tiles the concrete mixes are prepared. The conventional coarse aggregates are substituted by 10%, 20%, 30%, 40% and 50% of waste ceramic tile aggregate. The composition of trial mixes is tabulated in Table 5.1:-

Table - 5.1: Trial mix

S.No.	Trial mix	Cement(%)	FA(%)	NCA(%)	CCA(%)
1	C0	100	100	100	00
2	C1	100	100	90	10
3	C2	100	100	80	20
4	C3	100	100	70	30
5	C4	100	100	60	40
6	C5	100	100	50	50

Different specimens of M30 mix such as the cube of 15×15×15 cm^3, the flexural beam of 15×15×70 cm^3, and cylinder of 10 cm × 30 cm are cast and tested for compressive strength, flexural strength, and split tensile strength respectively after a curing period of 7, 14 and 28 days. The concrete specimens are shown in Image 5.1

Image 5.1- Concrete specimens

6. RESULTS

6.1 Slump Test

The test result data for the slump test is given below in Table 6.1

Table 6.1 – Slump test result

S.No	Trial mix	NCA(%)	CCA(%)	Slump(mm)
1	C0	100	0	73
2	C1	90	10	68
3	C2	80	20	65
4	C3	70	30	64
5	C4	60	40	59
6	C5	50	50	54

6.2 Compressive strength test

The compressive strength test result data for 7 days, 14 days and 28 days is summarized below in Table 6.2

Table 6.2 – Compressive strength test result

S.No	Trial mix		NCA (%)	CCA (%)	Compressive strength (MPa)		
					7 Days	14 Days	28 Days
1	C0	I	100	0	25.01	31.25	35.87
		II			25.47	30.89	36.13
2	C1	I	90	10	22.91	28.67	33.8
		II			23.54	29.13	33.42
3	C2	I	80	20	21.93	25.37	30.4
		II			22.58	25.82	30.57
4	C3	I	70	30	25.07	31.04	35.42
		II			24.67	30.69	35.754
5	C4	I	60	40	22.75	28.13	30.6
		II			22.46	28.9	30.27
6	C5	I	50	50	20.67	24.66	29.02
		II			20.13	24.28	29.87

Image 6.2- Testing of the specimens

6.3 Split tensile strength test

The split tensile strength test result data for 7 days, 14 days and 28 days is summarized below in Table 6.3

Table 6.3 – Split tensile strength test result

S.No	Trial mix	NCA(%)	CCA(%)	Split tensile strength (MPa)		
				7 Days	14 Days	28 Days
1	C0	100	0	2.57	3.24	3.70
2	C1	90	10	2.49	2.99	3.67
3	C2	80	20	2.47	2.73	3.64
4	C3	70	30	2.56	3.12	3.69
5	C4	60	40	2.48	2.82	3.67
6	C5	50	50	2.45	2.72	3.62

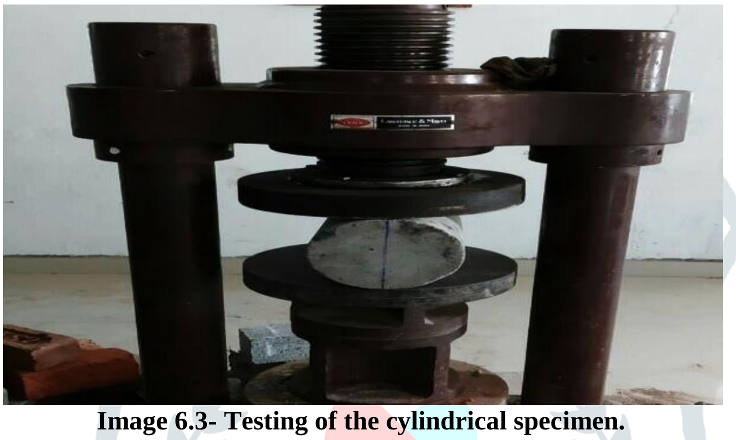

Image 6.3- Testing of the cylindrical specimen.

6.4 Flexural Strength Test

The flexural strength test result data for 7 days, 14 days and 28 days is summarized below in Table 6.4

Table 6.4 – Flexural strength test result

S.No	Trial mix	NCA (%)	CCA (%)	Flexural strength (Mpa)		
				7 Days	14 Days	28 Days
1	C0	100	0	3.62	4.25	4.46
2	C1	90	10	3.45	3.98	4.12
3	C2	80	20	3.14	3.75	3.73
4	C3	70	30	3.59	4.17	4.45
5	C4	60	40	3.38	3.85	4.27
6	C5	50	50	3.12	3.68	3.64

Image 6.4- Testing of flexural beam

7. DISCUSSION

7.1 Slump test

The workability as measured from slump test varies as 73 mm, 68 mm, 65 mm, 64 mm, 59 mm and 54 mm for C0, C1, C2, C3, C4 and C5 mix designation.

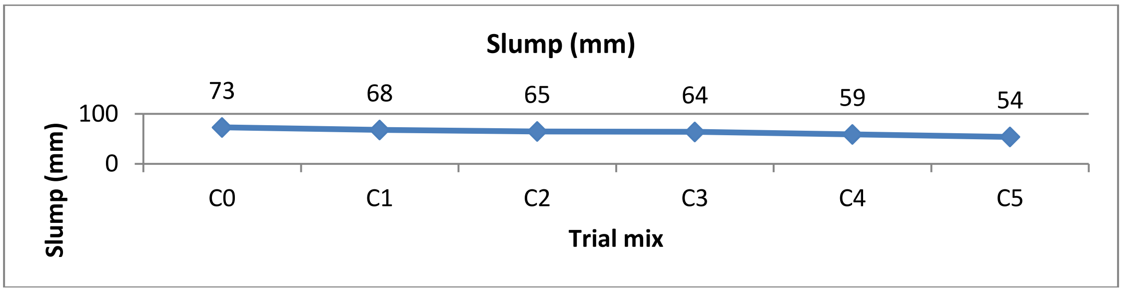

Figure 7.1 –Comparison of slump test(mm)

7.2 Compressive strength test

The compressive strength of specimens varies as 25.24, 23.225, 22.255, 24.87, 22.605 and 20.4 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 7 days of curing period.

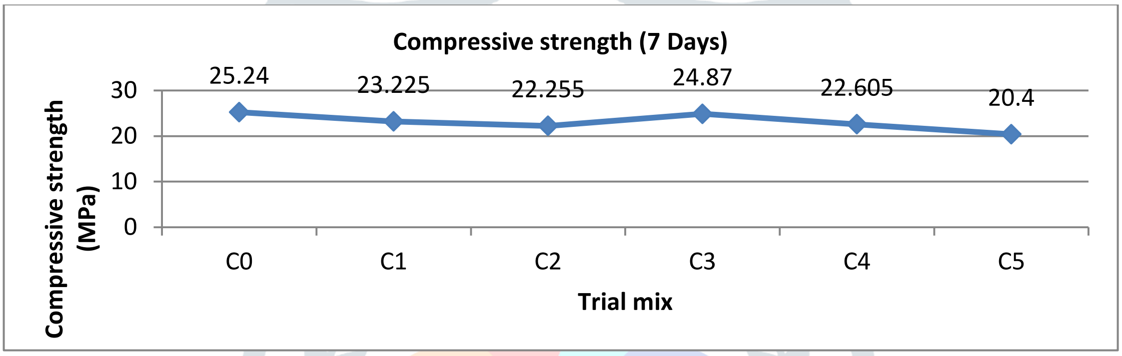

Figure 7.2 –Comparison of compressive strength test (7 days)

The compressive strength of specimens varies as 31.07, 28.9, 25.59, 30.865, 28.515 and 24.47 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 14 days of curing period.

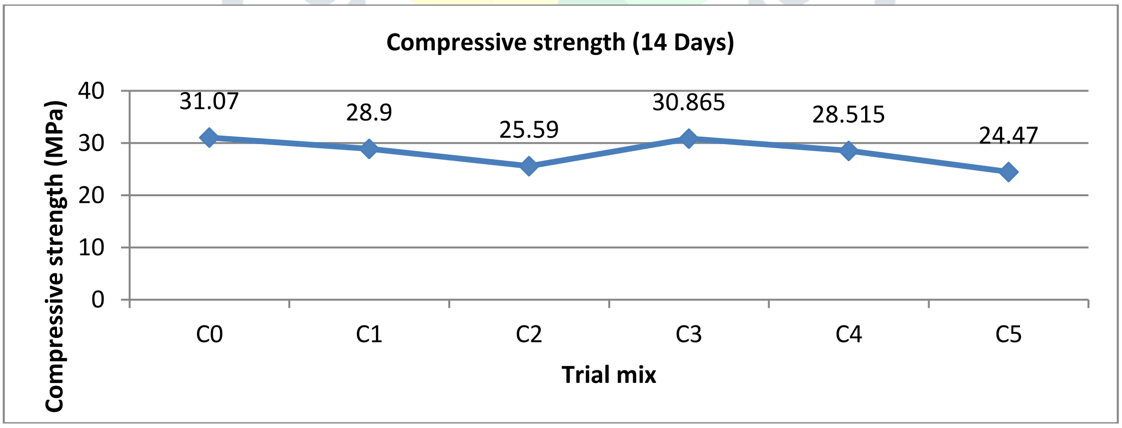

Figure 7.3 –Comparison of compressive strength test (14 days)

The compressive strength varies as 36, 33.61, 30.485, 35.587, 30.435 and 24.445 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 28 days of curing.

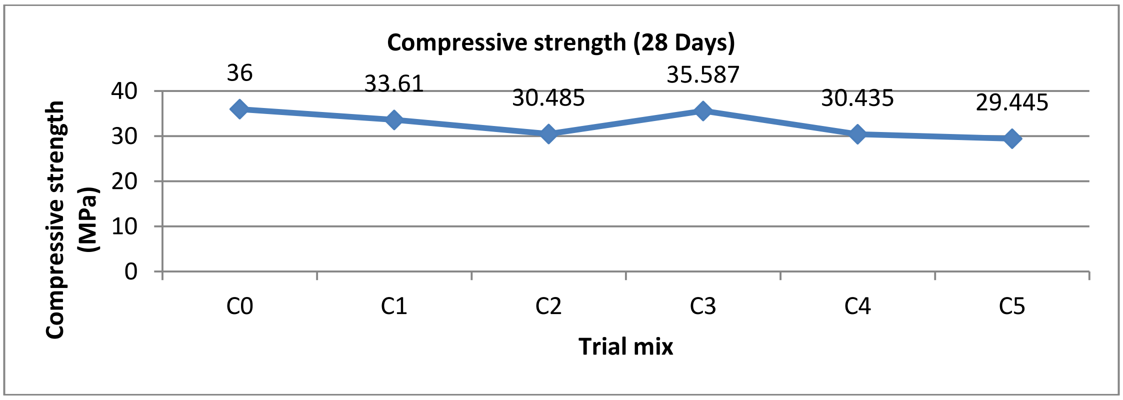

Figure 7.4 –Comparison of compressive strength test (28 days)

Following data for compressive strength test shows that replacing natural coarse aggregate by waste ceramic tile aggregate by 30% provides us with the maximum compressive strength.

7.3 Split tensile strength test

The split tensile strength of specimens varies as 2.57, 2.49, 2.47, 2.56, 2.48 and 2.45 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 7 days of curing period.

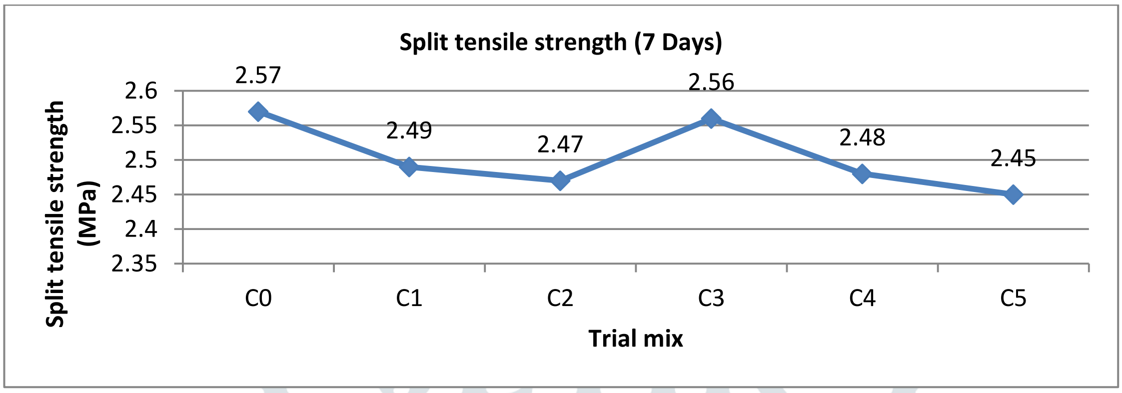

Figure 7.5 –Comparison of split tensile strength test (7 days)

The split tensile strength of specimens varies as 3.24, 2.99, 2.73, 3.12, 2.82 and 2.72 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 14 days of curing period.

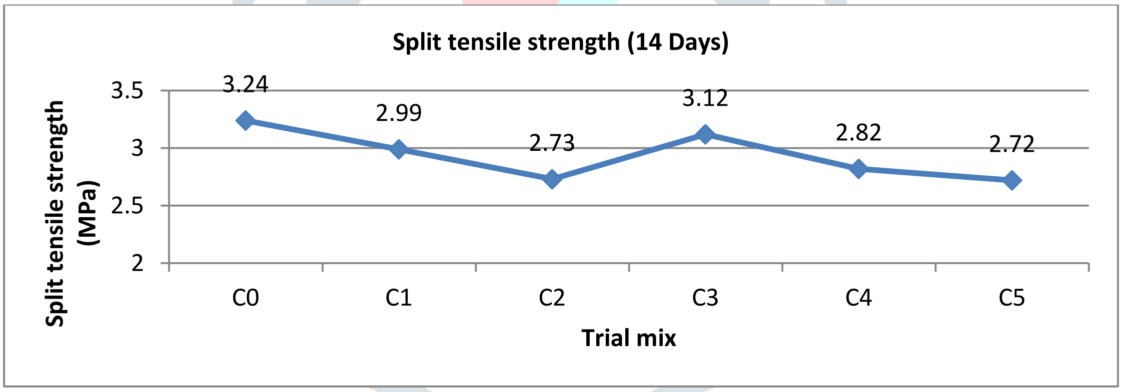

Figure 7.6 –Comparison of split tensile strength test (14 days)

The split tensile strength of specimens varies as 3.70, 3.67, 3.64, 3.69, 3.6 and 3.62 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 28 days of curing period.

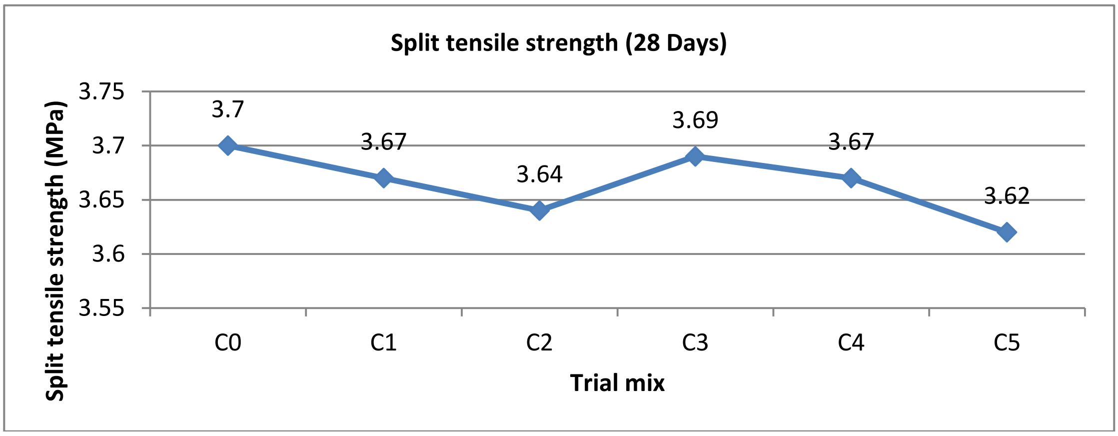

Figure 7.7 –Comparison of split tensile strength test (28 days)

The following data for split tensile strength test mentioned above shows that replacing natural coarse aggregate by waste ceramic tile aggregate by 30% provides us with the maximum split tensile strength.

7.4 Flexural Strength Test

The flexural strength of specimens varies as 3.62, 3.45, 3.14, 3.59, 3.38 and 3.12 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 7 days of curing period.

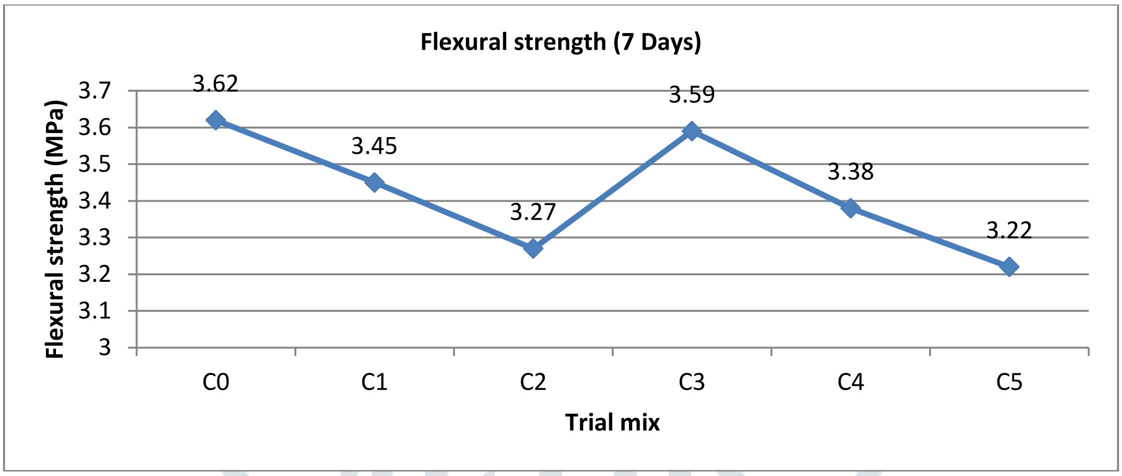

Figure 7.8 –Comparison of flexural strength test (7 days)

The flexural strength of specimens varies as 4.25, 3.98, 3.75, 4.17, 3.85 and 3.68 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 14 days of curing period.

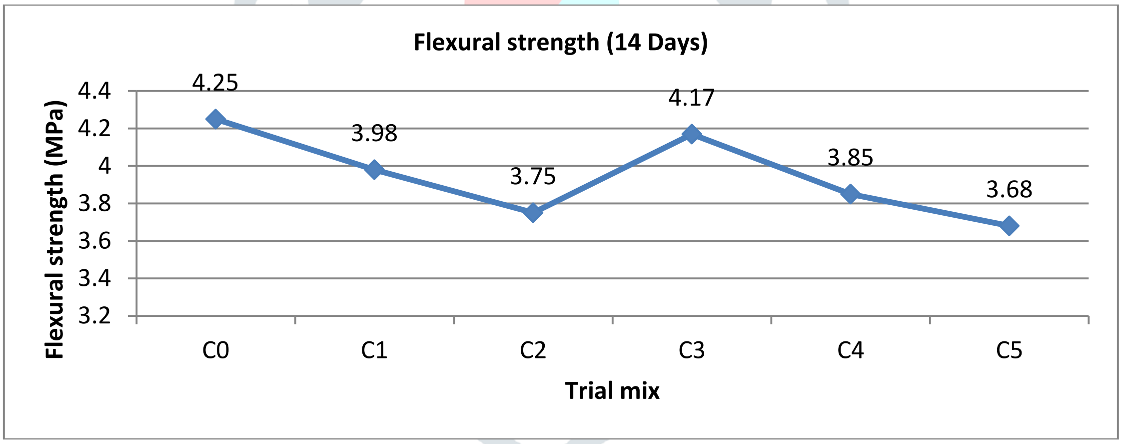

Figure 7.9 –Comparison of flexural strength test (14 days)

The flexural strength of specimens varies as 4.46, 4.12, 3.73, 4.45, 4.27 and 3.64 MPa for C0, C1, C2, C3, C4 and C5 mix designation after 28 days of curing period.

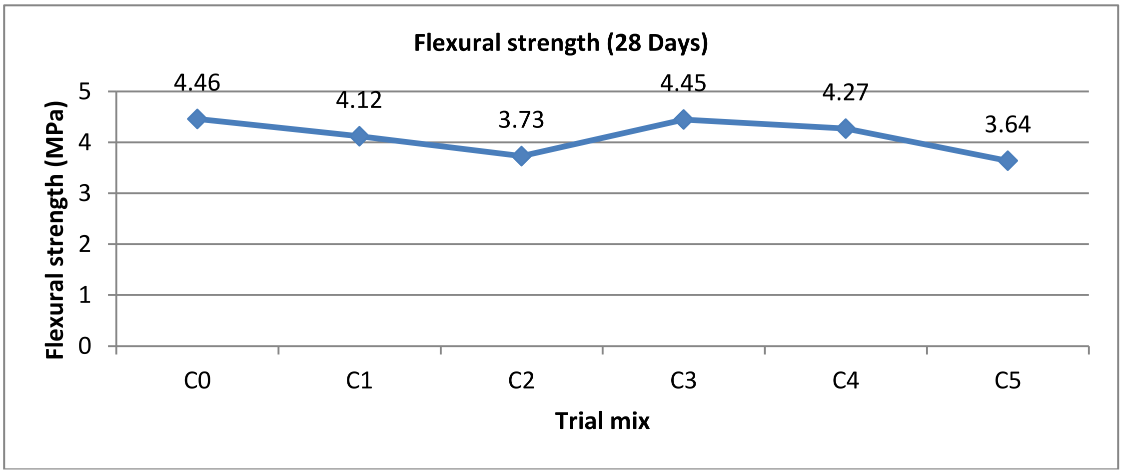

Figure 7.10 –Comparison of flexural strength test(28 Days)

The following data for flexural strength test mentioned above shows that replacing of natural coarse aggregate by waste ceramic tile aggregate by 30% provides us with the maximum flexural strength.

8. CONCLUSION

Based on the experimental investigations performed on concrete specimens for slump cone test, compressive strength test, split tensile strength test and flexural strength test these conclusions can be drawn out:-

1. The results of compressive strength test performed on the concrete specimens show that by increasing the percentage of the coarse ceramic tiles aggregates up to 30% the compressive strength of specimens increases, and after that, the strength starts decreasing gradually when compared with the conventional concrete.
2. The maximum strength which can be achieved for the cube, beam, and the cylinder by replacing the natural coarse aggregate with waste ceramic tile aggregate is 30%. Following are the maximum strength of the cube, cylinder, and beam after 7 days of curing period - 24.87 MPa, 2.56 MPa and 3.59 MPa, after 14 days curing period - 30.865 MPa, 3.12 MPa and 4.17 MPa and that after 28 days curing period - 35.587 MPa, 3.69 MPa and 4.45 MPa.
3. A positive effect on the environment can be seen by replacing the conventional coarse aggregate by coarse ceramic waste tiles aggregate in a very less percentage as it saves natural resources and even lower down the space required for landfill disposal of the ceramic wastes which in turns reduces environmental pollution.
4. With the increase in replacement of ceramic tile aggregate up to 30% the valuable properties of concrete such as compressive strength, split tensile strength, flexural strength etc firstly decreases and then achieve peak value at 30%. Later on by increasing the same the properties of concrete decreases linearly.
5. Concrete mix C3 corresponding to 30% replacement of natural coarse aggregate with waste ceramic tile aggregate concrete here produces concrete with enhanced properties in terms of compressive strength, split tensile strength and flexural strength than the further mixes such as C1, C2, C4, and C5.
6. Replacement of natural coarse aggregate by ceramic coarse aggregate up to 50% can be used resourcefully for various purposes, but further increasing the percentage of ceramic coarse aggregate in concrete leads to decrease invaluable properties of concrete.
7. The results are satisfactory and hence waste ceramic tile can be used for partial replacement of natural coarse aggregate in concrete as well as rigid pavement design.
8. Total saving on replacing natural coarse aggregates by the ceramic waste aggregate in terms of rupees to produce 1 m^3 of M 30 grade concrete = 16.60%.

ACKNOWLEDGMENT

Indeed it is a matter of great felicity and privilege for me to take an opportunity to work under the guidance of Dr S.S.Goliya, Assistant professor, S.A.T.I Vidisha, and Dr Rakesh Mehar, Assistant professor, S.A.T.I Vidisha who constantly supported and encouraged at every step of research work.

I am thankful to all the faculty of the Department of Civil Engineering SATI, Vidisha who helped me in one or other way during my study.

And finally all glory to family members, without their grace this work was merely a dream.

REFERENCES

- Aruna D, Prabhu R., Yaragal S., Venkataramana K., IJRET:eISSN: 2319-1163 | pISSN: 2321-7308.
- Batriti Monhun R. Marwin, M. Sneha, I. Bharathidasan International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 ISSN 2229-5518.
- Deepthi C, September-2016, Study on Compressive Strength of Concrete with Dolomite Powder and Crushed Tiles, Vol. 5, Issue 9, September 2016
- Kumar N., Sagar A., An Experimental Laboratory Study on Utilization of Ceramic Waste as a Partial Replacement of Coarse aggregate in concrete, Volume: 05 Issue: 11 Nov-2016
- Kumar H., Ramakrishna A., Sateesh Babu K3, Guravaiah T4, Naveen N5, Jani Sk, June-2015, Effect of Waste Ceramic Tiles in Partial Replacement of Coarse and Fine Aggregate of Concrete, Vol. 2, Issue 6, June 2015
- Ikponmwosa E. E., and Ehikhuenmen O., the effect of ceramic waste as coarse aggregate on strength properties of concrete, Vol. 36, No. 3, July 2017
- International Journal of Innovative Research in Science, Engineering and Technology ISSN (Online): 2319-8753 ISSN (Print): 2347-6710.
- Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 31, No. B5, pp 561-565 Printed in The Islamic Republic of Iran, 2007

- Journal of Multidisciplinary Engineering Science and Technology (JMEST) ISSN:3159-0040 Vol. 2 Issue 11, November – 2015
- Paul A., Ndambuki J., Akinmusuru J., David O. Omole-4048 2016 Housing and Building National Research Center. Production and hosting by Elsevier B.V. 15 November 2016)
- Prasad N., Hanitha P., N.C.Anil, Dec. (2016), Partial Replacement of Coarse aggregate by Crushed Tiles and Fine aggregate by Granite Powder to improve the Concrete Properties, Volume 13, Issue 6 Ver. V (Nov. - Dec. 2016).
- Singh P., Singla R, Utilization Of Waste Ceramic Tiles As Coarse Aggregate In Concrete, Vol. 2 Issue 11, November – 2015
- Tawfeeq W., AlSaidi M., Al-Kamzari A., Al-Shibli M., and Al-Mamari Z.,2016, Using Crushed Tiles as Coarse Aggregate in Concrete Mix, Vol. 3, Issue 2 (2016)
- IS 10262:2009, “Concrete mix proportioning -guidelines”, First revision.
- IS 456:2000, “Plain and reinforced concrete -code of practice”, Fourth revision.
- Central Public Works Department, Delhi, Schedule of rates analysis 2018, Volume I.
- IS 1489 (Part 1): 1991, “Portland – pozzolana cement specification”, Part I fly ash based (Third revision).
- IS 2386 (Part I) – 1963, “Methods of test for aggregates for concrete”, Part I (Particle size and shape).
- IS 2386 (Part III) – 1963 (Reaffirmed 1990), “Methods of test for aggregates for concrete”, Part III (Specific gravity, density, voids, absorption and bulking).
- IS 2366 (Part IV) – 1963 (Reaffirmed 1990), “Methods of test for aggregates for concrete”, Part IV (Mechanical properties).
- IS 383 – 1970 (Reaffirmed 2005), “Specification for coarse and fine aggregates from natural sources for concrete” (Second revision).
- IS 516 – 2000, “Methods of tests for strength of concrete”.
- Rates from Shree tirupati balajee stone crusher, Sagar road. Mirjapur, Vidisha.