A Study on Performance of Crushed Tiles As Partial Replacement of Coarse Aggregate And Effect of Coir Fibre on Crushed Tiles Mixed Concrete

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Abstract- *Concrete has several appealing characteristics that have made it as a widely used construction material. It is the material of choice where strength, performance, durability etc., are required and concrete is undoubtedly most versatile construction material. Due to the day by day innovations and development in construction field, the use of natural aggregates is very high and at the same time production of solid wastes from the demolitions of constructions is also very high. Hence, there is a compulsion on the part of civil engineering community, to take appropriate strategies so that the consumption of such potential waste by the construction industries will be on rise day-by-day leading to a green environment which is of course the need of the hour for our nation. The waste crushed tiles were replaced in place of coarse aggregates by 10%, 20%, 30%, 40%, and 50% without changing the mix design. M20 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 at different percentages of crushed tiles. Experimental investigation like Compressive strength test, workability for different concrete mixes with different percentages of waste crushed after 7, 14 and 28days curing period. Variations in the workability and compressive strength and split tensile strength for these different mixes were studied and observed the optimum mix. For the optimum percentage of crushed tiles, Coir fibers from 0 to 2% with an interval of 0.5% .This paper deals with the experimental studies made on compressive strength, split tensile strength of concrete made with ceramic tiles and coir fibre.*

Keywords- Cement, Fine Aggregate, Coarse Aggregate, Crushed Tiles and Coir Fiber, compressive strength, split tensile strength.

I. INTRODUCTION

GENERAL

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc. leading to utilization of large quantity of concrete. It has several appealing characteristics that have made it as a widely used construction material. It is the material of choice where strength, performance, durability etc., are required and concrete is undoubtedly most versatile construction material. It is a construction material composed of cement (commonly Portland cement) as well as other cementations materials such as fly ash and slag cement, aggregate (generally a coarse aggregate made of crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), and water.

The use of more and more concrete in construction not only results in scarcity of materials but also turns out to be expensive. In order to cope up with the depletion of conventional resources it would be worth to make use of suitable by-products to replace some of the conventional materials. The industrial wastes like fly ash and tile aggregates, which are produced in huge quantities that cause environmental pollution need safe disposal. But these materials possess potential characteristics, which can be tapped for various uses.

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions. There are some researchers are also going on solid waste from construction to reuse them again in the construction to reduce the solid waste and to preserve the natural basic aggregates. These researches promotes to use the recycled aggregates in the concrete mix and they got good result when adding some extent percentages of recycled aggregates in place of natural coarse aggregate.

There is a huge usage of ceramic tiles in the present constructions is going on and it is increasing in day by day construction field. And also in other side waste tile is also producing from demolished wastes from construction. Indian tiles production is 100 million ton per year in the ceramic industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present, however the ceramic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces so, we selected these waste tiles as a replacement material to the basic natural aggregate to reuse them and to decrease the solid waste produced from demolitions of construction. Waste tiles are collected from the surroundings. Crushed tiles are replaced in place of coarse aggregate and by the percentage of 10%, 20%, 30%, 40%, and 50% and to the optimum percentage of crushed tiles Percentage addition of 0, 0.5%, 1%, 1.5% and 2% coir fibre to the crushed tiles concrete.

For analyzing the suitability of these crushed waste tiles and Coir fibre in the concrete mix, workability test was conducted for different mixes having different percentages of these materials. Slump cone test is used for performing workability tests on fresh concrete. And compressive strength test is also conducted for 7, 14 and 28 days curing periods by casting cubes to analyze the strength variation by different percentage of this waste materials. In the present study to understand the behavior and performance of ceramic solid waste in concrete. The waste crushed tiles are used to partially replace coarse aggregate by 10%, 20%, 30%, 40%, and 50% and to the optimum percentage addition of 0, 0.5%, 1%, 1.5% and 2% of coir fibre.

FIBRE REINFORCED CONCRETE

The term fiber reinforced concrete (FRC) is defined by ACI Committee 544 as a concrete made of hydraulic cements containing fine or fine and coarse aggregates and discontinuous discrete fibers. Inherently concrete is brittle under tensile loading. Mechanical properties of concrete can be improved by reinforcement with randomly oriented short discrete fibers, which prevent and control initiation, propagation, or coalescence of cracks. FRC can continue to sustain considerable loads even at deflections exceeding fracture deflections of plain concrete. The character and performance of FRC changes depending on matrix properties as well as the fiber material, fiber concentration, fiber geometry, fiber orientation, and fiber distribution.

FRC can be regarded as a composite material with two phases in which concrete represents the matrix phase and the fiber constitutes the inclusion phase. Volume fraction of fiber inclusion is the most commonly used parameter attributed to the properties of FRC. Fiber count, fiber specific surface area, and fiber spacing are other parameters, which may also be used for this purpose. Another convenient numerical parameter describing a fiber is its aspect ratio, defined as the fiber length divided by its equivalent diameter. It is possible to make several classifications among fiber types. Fibers can be divided into two groups; those with elastic moduli lower than the cement matrix, such as cellulose, nylon, and polypropylene and those with higher elastic moduli such as asbestos, glass, steel, and carbon. Another classification can be made according to the origin of the fiber material such as metallic, polymeric, or natural.

There are various applications of FRC. Asbestos fibers have been used in pipes or thin sheet elements for a long time. Glass fibers are also used in thin sheet element production as well as shotcrete applications. Steel fibers have been used in pavements, in shotcrete, and in a variety of other structures.

Objectives

The present proposal involves a comprehensive laboratory study for the newer application of this waste material in the preparation of fibrous concrete. The primary objective of investigation is to study the strength behaviour i.e. compressive strength, and impact resistance of concrete with different percentage replacements of crushed tiles.

The proposed work is aimed to study the effect of crushed tiles and coir fibre on:-

- Compressive Strength
- Split tensile strength
- Slump Value

II. REVIEW OF LITERATURE

This research is supported with the related reading material previous research about the crushed tile waste material which had been done as the references to describe more and explain the characteristic and application of waste tile as partial replacement in the concrete production. So far the reutilization of crushed tile wastes and has been practiced, but the amount of wastes reused in that way is still negligible. Hence, the need for its application in other industries is becoming absolutely very useful for getting benefit. Construction industry can be the end user of all tile wastes and in the same way can contribute Green building practices.

Eldin and Senouci (1993), on the basis of test results, showed that there was about 85% reduction in compressive strength and 50% reduction in tensile strength when the coarse aggregate was fully replaced by broken tiles. However, specimens lost up to 10% of their compressive strength and up to 10% of their tensile strength when the coarse aggregate was fully replaced by broken tiles.. A more gradual failure was observed, either of a splitting (for coarse tyre chips) or a shear mode (for fine crumb rubber).

It was argued that since the cement paste is much weaker in tension than in compression the specimen containing coarse chips would start failing in tension before it reaches its compression limit The generated tensile stress concentrations at the top and bottom of the rubber aggregates result in many tensile micro cracks that form along the tested specimen .These micro cracks will rapidly propagate in the cement paste. Until they encounter a tile aggregate. Because of their ability to withstand large tensile deformations, the particles will act as springs delaying the widening of cracks and preventing full disintegration of the concrete mass. The continuous application of the compressive load will cause generation of more cracks as well as widening of existing ones. During this process, the failing specimen is capable of absorbing significant plastic energy and withstanding large deformations without full disintegration. This process will continue until the stresses overcome the bond between the cement paste and the broken tile aggregates.

Chandana Sukesh showed that concrete with partial aggregate replacement by ceramic tiles shows major strength gain possess and increase durability performance. Experiments have been conducted by replacing 10%, 20%, 30%, 40% and 50% of aggregates by weight of Ordinary crushed tiles. The properties of concrete, such as setting time, compressive strength, and expansion due to magnesium sulfate attack were investigated. The results revealed that the use of tiles in concretes caused delay in both initial and final setting times, depended on the fineness and degree of replacement of tiles. With these results it is very clear that we can effectively use these eco-friendly crushed tile materials in partial replacement of aggregate.

omualdi and Batson (1963) after conducting impact test on fibre reinforced concrete specimens, they concluded that first crack strength improved by addition of closely spaced continuous steel fibres in it. The steel fibres prevent the adverting of micro cracks by applying pinching forces at the crack tips and thus delaying the propagation of the cracks. Further, they established that the increase in strength of concrete is inversely proportional to the square root of the wire spacing.

Charles H.Henage (1976) developed an analytical method based on ultimate strength approach, which has taken into account of bond stress, fibres stress and volume fraction of fibres. After his investigations, he concluded that the incorporation of steel fibres significantly increases the ultimate flexural strength, reduces crack widths and first crack occurred at higher loads.

Batriti Monhun R. Marwein (2016)[2]: The ceramic waste adopted is broken tiles. Ceramic waste concrete (CWC)made with these tiles at 0%, 15%, 20%, 25% and 30%. M20 grade concrete is adopted; a constant water cement ratio of 0.48 is maintained for all the concrete mixes. The characteristics properties of concrete such 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 to ordinary mixes like M15 and M20.

(Kelleret al., 2005) investigated the shear behaviour of reinforced concrete beams strengthened by the attachment of different configurations and quantities of carbon fibres. The study revealed that the strengthening by using carbon fibres increased the resistance to shear and also spalling of concrete.

(Bhatia, 2001) studied the usefulness of fibre reinforced concrete in various civil engineering applications. Fibres include steel fibre, natural fibres and synthetic fibreseach of which lends varying properties to the concrete. The study revealed that the fibrous material increases the structural integrity. These studies made us adopt natural fibres which are abundantly available and cheap.

III. MATERIALS USED

MATERIALS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Fine aggregate
4. Water
5. Crushed tiles
6. Coir fibre

CEMENT

Ordinary Portland Cement (OPC) is manufactured in the form of different grades, the most common in India being Grade-53, Grade-43, and Grade-33. OPC is manufactured by burning siliceous materials like limestone at 1400 degree Celsius and thereafter grinding it with gypsum.

Ordinary Portland cement Grade 53: Having been certified with IS 12269:1987 standards, Grade 53 is known for its rich quality and is highly durable. Hence it is used for constructing bigger structures designed to with stand heavy pressure. Expert opinions and directions from technicians and engineers are a must in this regard.

Table No-1 Physical Properties of Cement

Sl. No.	Properties	Values
1	Specific Gravity	3.15
2.	Standard consistency	30%
3.	Initial setting time in min.	32
4.	Final setting time in min	600

COARSE AGGREGATE

Aggregate was originally viewed as an inert, inexpensive material dispersed throughout the cement paste so as to produce large volume of concrete. In fact, aggregate is not truly inert because it's physical, thermal and sometimes, chemical properties influence the performance of concrete. For example, by improving its volume stability and durability over that of the cement paste. From the economic view point, it is advantageous to use a mix with as much aggregate and as little cement as possible, but the cost benefit has to be balanced against the desired properties of concrete in its fresh and hardened state.

Material which retained on 4.75 mm size classified as a coarse aggregate. For most works, 20 mm aggregate is suitable. The locally available aggregate having nominal size of 20mm was used.

Table-2 Properties of Coarse Aggregate

Sl. No.	Properties	Values
1	Specific Gravity	2.9
2.	Fineness modulus	2.72
3.	Water absorption	0.15%
4	Aggregate Impact value	12.5

FINE AGGREGATES:

Fine aggregate is a material such as sand, crushed stones or crushed gravel passing through 4.75 mm size. Locally available sand is used as fine aggregate in the concrete mix.

Table-3 Properties of Fine Aggregate

Sl. No.	Properties	Values
1	Specific Gravity	2.75
2.	Fineness modulus	2.97
3.	Water absorption	0.3%
4.	Zone	III

CRUSHED TILES

Eco friendly concrete, it is green and keeps the environment safe by using waste products to make resource saving concrete structures. The use of waste ceramic tiles in concrete effects the properties of fresh and hardened concrete, and makes it economical and also solves some of the disposal problems. In this project work ceramic waste tiles are collected and broken into 20mm size for partial replacement with coarse aggregate. Broken tiles are collected from the solid waste of ceramic manufacturing unit.

Fig 1. Ceramic Crushed Tiles

Coir Fiber

It is the waste material obtained from mattress manufacturing and possess high degree of tensile strength of 21.5 MPa Figure 4.3. They are properly washed before use. This will remove dust and other residual particles left on the fibre so as to augment the surface of contact between the fibre and mix resulting in better binding between the reinforcement and concrete and ultimately higher strength. The fibres are then cut into square meshes of size 5cm x 5cm

Figure 2: Raw coconut fibre obtained from mattress waste

IV. METHODOLOGY

Conventional mix was prepared for M20 grade. 20 mm nominal size of coarse aggregate and Zone – III sand is used for preparing conventional mix. Crushed waste tiles were collected from demolished construction waste and crushed them by manually and by using crusher. From industry we collected the waste crushed tile and used as partial replacement for coarse aggregate.

Different types of mixes were prepared by changing the percentage of replacement of coarse aggregate with crushed tiles. Total 6 types of mixes are prepared along with conventional mix. 10%, 20%, 30%, 40% and 50% of coarse aggregate are replaced by using crushed waste tile. And also replacement of coarse aggregate is done at a time by changing the percentages of 10%, 20%, 30%, 40% and 50%.The details of mix designations are as follows.

Table 4 Various Mix designations

Mix Code	Cement (%)	F.A (%)	C.A (%)	Crushed Tiles
MIX 0	100	100	100	0
MIX 1	100	100	90	10
MIX 2	100	100	80	20
MIX 3	100	100	70	30
MIX 4	100	100	60	40
MIX 5	100	100	50	50

LABORATORY EXPERIMENTATION

In the present experimental investigation crushed tiles has been used as partial replacement of coarse aggregate in concrete mixes. On replacing coarse aggregate with different weight percentage of crushed tiles the compressive strength and tensile strength is studied at different ages of concrete cured in water and further studied effect of fibers on crushed tiles blended concrete. The details of laboratory experimentation are as follows.

LIST OF TESTS CONDUCTED

The following tests were conducted as per IS codes of practice.

- Specific gravity
- Fineness
- Normal Consistency
- Water absorption test
- Sieve Analysis
- Slump test
- Compressive strength test
- Split tensile strength test

V. RESULTS AND DISCUSSIONS

PREPARATION OF SPECIMEN:

Above mentioned 54 cubes are prepared by using the pan mixer. Total 6 types of mixes with different proportion of ingredients as mentioned on mix designation table are mixed in horizontal pan mixer by using following process.

Mixing Process:

- All materials are weighed according to mix design and according to the different mix proportions.
- The aggregate were added into the mixer and mixed thoroughly till the aggregates mixed properly.
- Cement was added into the mixer and mixed until the mix was uniform.
- Water was added into the mixer slowly after the cement was placed.
- The concrete was mixed around 3 minutes.
- The concrete in the mixer was poured out and the fully mixed concrete is ready for the workability test.

Details of the laboratory experimentation carried-out with different combinations of materials have been discussed in the previous chapters. In this chapter a detailed discussion on the results obtained from various laboratory tests done on concrete.

In the laboratory, various experiments were conducted for different mixes with crushed tiles and Coir Fibre in virgin concrete and make them curing under Normal water to compare the compressive strength.

5.1 VARIATION OF SLUMP VALUES FOR PERCENTAGE REPLACEMENT OF CRUSHED TILES

Figure 5, Table 5 shows that the variation of slump values with different percentage replacement of crushed tiles. Slump Value is get increases with increases with increase in replacement of crushed tiles.

Table 5 Variation of Slump Values

S.no	Mix type	Slump (mm)
1	MIX 0	53
2	MIX 1	72
3	MIX 2	89
4	MIX 3	98
5	MIX 4	109
6	MIX 5	109

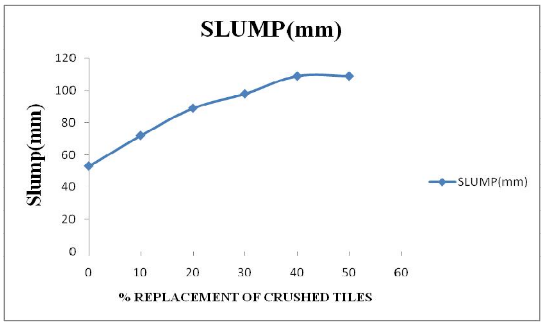

Figure 3 shows the variation of slump values for replacement of crushed tiles

Table 6 : Evaluation of optimum percentage of crushed tiles from compressive strength results

C+F.A+C.A+ % CT REPALCEMENT	COMRESSIVE STRENGTH(MPa)		
	7 DAYS	**14 DAYS**	**28 DAYS**
0	19.5	22.62	28.87
10	23.23	24.99	33.99
20	21.85	23.82	31.59
30	18.97	22.34	30.39
40	17.92	21.12	26.59
50	16.8	20.16	24.26

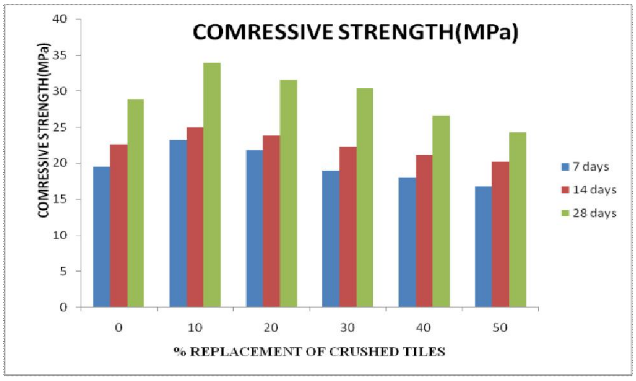

Figure 4 shows the variation of compressive strength results for different curing periods

Table 7: Evaluation of optimum percentage of crushed tiles from split tensile strength results

C+F.A+C.A+ % CT REPALCEMENT	SPLIT TENSILE STRENGTH(MPa)		
	7 DAYS	**14 DAYS**	**28 DAYS**
0	1.65	2.27	2.62
10	1.7	2.3	2.76
20	1.69	2.25	2.65
30	1.68	2.21	2.6
40	1.67	2.19	2.53
50	1.67	2.17	2.49

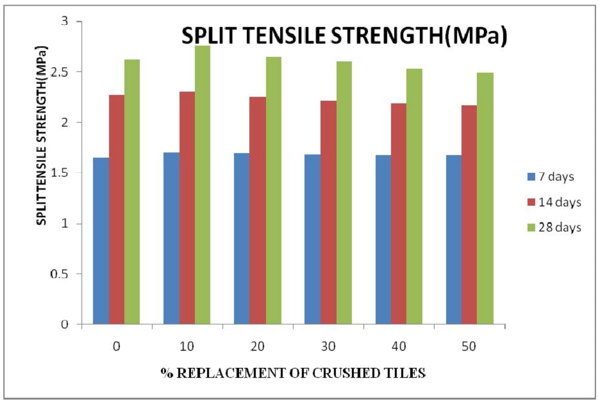

Figure 5 shows the variation of split tensile strength results for different curing periods

- From the above results 10% replacement of coarse aggregate with crushed tiles is taken as optimum.
- For the optimum percentage of crushed tiles, percentage addition of Coir fiber from 0 to 2% with an increment of 0.5%.

Table 8 Material percentages for optimum mix with Coir Fibre

S.No	Mix Code	Cement (%)	C.A + Crushed Tiles + Coir fibre	Description
1	MIX6	100	10%+0.5%	Addition of Coir Fibre to optimum crushed tiles
2	MIX7	100	10%+1.0%	
3	MIX8	100	10%+1.5%	
4	MIX9	100	10%+2 %	

NO. OF SPECIMENS PREPARED:

Total 4 types of mixes are prepared as mentioned on above table and are decided to do compressive strength test for 7, 14 and 28 days curing period. For each mix type 3 trails of cubes having dimension 150 x 150 x 150 mm are prepared.

Total Cubes =4(types of mixes) x 3 (curing periods) x 3 (cubes) = 36 cubes

Total cylinders= 4(types of mixes) x 3 (curing periods) x 3 (cubes) =36 cylinders

5.6 VARIATION OF SLUMP AND COMPRESSIVE STRENGTH FOR ADDITION OF COIR FIBER TO THE OPTIMUM PERCENTAGE OF CRUSHED TILES

Showing different slump values for different mixes and from the results it can be observed that slump values are gradually decreasing with increase in fiber content. The compressive strength results for different mixes for different curing periods and from the results it can be observed that compressive strength increases up to addition of 1% coir fiber and then gradually decreasing with increase in fiber content.

Table 9 shows the slump values for addition different percentages of coir fibre for optimum percentage of crushed tiles

C+F.A+C. A+COIR FIBRE	SLUMP(mm)
0	72
0.5	61
1	82
1.5	61
2	42

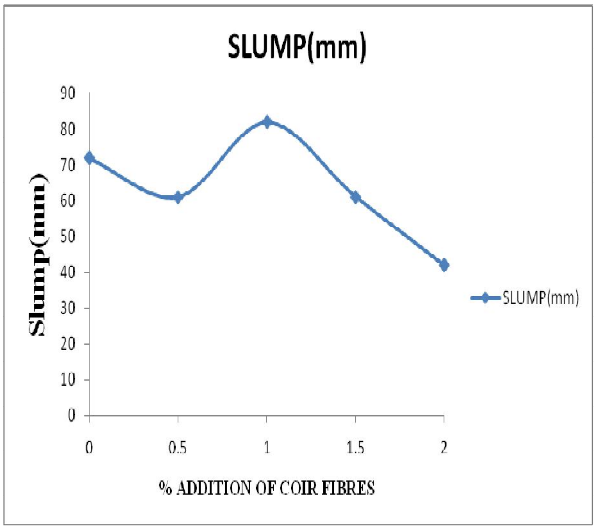

Figure 6 shows the variation of slump results for percentage addition of coir fibre

Table 10 shows the slump values for addition different percentages of coir fibre for optimum percentage of crushed tiles

C+F.A+ C. A+COIR FIBRE	COMRESSIVE STRENGTH(MPa)		
	7 DAYS	14 DAYS	28 DAYS
0	23.23	24.99	33.99
0.5	23..88	27.23	35.66
1	24.23	28.75	36.11
1.5	22.21	26.12	35.56
2	21.85	25.24	34.69

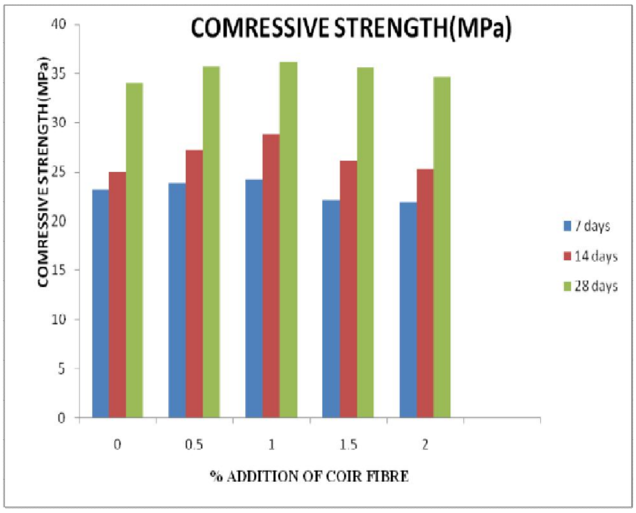

Figure 7 shows the variation of compressive strength results for different curing periods.

Table 11 shows the split tensile strength for addition different percentages of coir fibre for optimum percentage of crushed tiles

C+F.A+C. A+ COIR FIBRE	SPLIT TENSILE STRENGTH(MPa)		
	7 DAYS	**14 DAYS**	**28 DAYS**
0	1.65	2.27	2.62
0.5	1.93	2.71	2.79
1	2.31	2.85	2.99
1.5	1.81	2.51	2.71
2	1.75	2.40	2.53

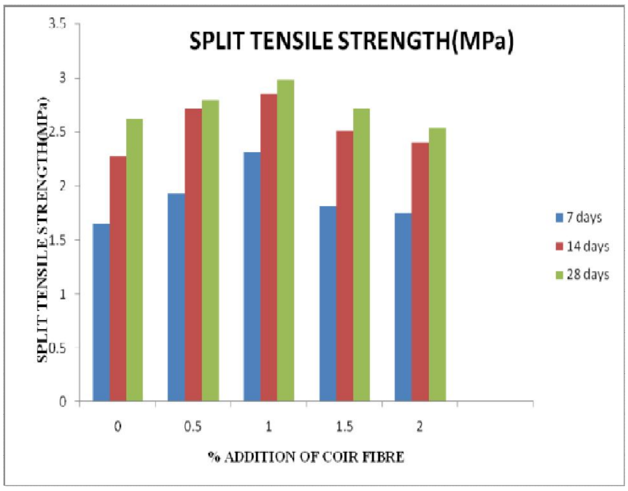

Figure 8 shows the variation of split tensile strength results for different curing periods

It can be inferred from the graphs, that there is a gradual increase in Properties of concrete with percentage replacement of crushed tiles and percentage addition of coir fibre.

From the results it is concluded that 1.0% addition of coir fibre shows maximum compressive strength, and Split Tensile strength when compared to crushed tiles individually.

VI. CONCLUSIONS

After completion of total experimental methodology, from the above investigations and from the test results some variations observed in workability and in compressive strength and split tensile strength of different concrete mixes having different percentages of replacing materials (Crushed tiles in place of coarse aggregate) as mentioned below.

- After performing workability test observed that, when increasing percentage of waste crushed tiles in concrete leads to the increase in workability of the concrete.
- For 10% of crushed tiles an replacement in place of coarse aggregates i.e., MIX1 sample, there is a increment in compressive strength when compare to the conventional mix compressive strength results after 7, 14 and 28 days curing periods.
- But when crushed tiles percentage is increased to 20% and 30% i.e., MIX2 and MIX3 samples the compressive strength is decreased for 7, 14 and 28 days curing period. When adding tiles to the concrete mix in replacement to the coarse aggregate (MIX4 to MIX7), compressive strength is decreasing for 7 days and 14 days curing period but it is increasing after 28 days curing period.
- So, feasible usage of waste ceramic crushed tiles in replacement to coarse aggregate is 10% only (MIX1).
- The maximum compressive strength obtained in MIX1, MIX2 and MIX3 mixes is for the concrete mix which was having only 10% of replacement coarse aggregate with tiles (MIX1). So, 10% of tiles can use in replacement to the coarse aggregate.
- To the optimum mix of crushed tiles on further addition of Coir fibre, compressive strength and tensile strength increases with increase in fibre content up to 1%. Further addition of fiber decreases the strength results.
- Finally, it is concluded that Replacement of crushed tiles and addition of Coir fibers shown promising influence on the strength parameters and there by waste can be recycled.

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