iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VII **Month of publication:** July 2022

DOI: https://doi.org/10.22214/ijraset.2022.45300

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

Improving Strength of Concrete Using Crushed Tiles and Nylon Fiber

Rakesh Kumar Jena[1], N Manoj Kumar[2]
[1]PG. Scholor, [2]Assistant Professor, Department of Civil Engineering, GIET University, Gunupur, India

***Abstract:** 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. Because of these reasons the reuse of demolished constructional wastes came into the picture to reduce the solid waste and to reduce the scarcity of natural aggregates. Crushed waste tiles are used as a replacement to the coarse aggregates.*

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 for these different mixes were studied and observed the optimum mix. Add nylon fibers from 0 to 2% with an interval of 0.5% to the optimum mix for improving the strength characteristics.
Keywords: Cement, Fine Aggregate, Coarse Aggregate, Crushed Tiles and Nylon Fiber.

I. INTRODUCTION

Concrete is composite material which consists of cement, coarse aggregate, fine aggregate, and water in required proportions. Concrete is a material which used for the purpose of construction in now a day. Due to its composite nature concrete is weak in tension but strong in compression. Basic Principle involved in the increase in strength of concrete is heat of Hydration.

Portland cement concrete is made with coarse aggregate, fine aggregate, Portland cement, water and in some cases selected admixtures (mineral & chemical). In the last decade, construction industry has been conducting research on the utilization of waste products in concrete; each waste product has its own specific effect on properties of fresh and hard concrete. Conservation of natural resources and preservation of environment is the essence of any development. The problem arising from continuous technological and industrial development is the disposal of waste material.

If some of the waste materials are found suitable in concrete making, not only cost of construction can be cut down, but also safe disposal of waste materials can be achieved. The use of waste products in concrete not only makes it economical but also solves some of the disposal problems.

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions.These waste materials are being generated and accumulated in vast quantities causing an increasing threat to the environment. Hazardous materials can be classified as chemical, toxic or non-decaying material accumulating with time. One of the major environmental challenges facing municipalities around the world is the disposal of broken tiles. Disposal of broken tiles has been banned in the most landfills because they are bulky and tend to flow to the surface. In this context, the use of broken tiles in the concrete is considered a potentially significant avenue.

Thus, the use of broken tiles in concrete manufacturing is a necessity than a desire. The use of scrap in concrete is a concept applied extensively over the world. The use of broken tiles in normal strength concrete is a new dimension in concrete mix design and if applied on a large scale would revolutionize the construction industry, by economizing the construction cost and increasing the worn-out tyre disposal.

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. This research 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. It is with this intension; an experimental study is proposed to be conducted by using crushed tiles as coarse aggregate in cement concrete and further reinforcing with nylon fibre.

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Volume 10 Issue VII July 2022- Available at www.ijraset.com

A. *Objective*

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 nylon fibre on:-

1) Compressive Strength
2) Slump Value

II. LITERATURE REVIEW

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. 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. Aggregates are generally considered as inert filler materials in the concrete mix. Aggregates characteristically make up about 60 to 75 percent of the volume of a concrete mixture. It is a necessary component that defines the concrete's thermal and elastic properties and dimensional stability. By a closer look it reveals that they can influence major role in the properties of fresh and hardened concrete. Changes in gradation, maximum size, unit weight, moisture content can alter the character and performance of concrete mix.

The current research is a bid towards exploring the possibility of incorporating wastes from ceramic wall tiles as partial substitute of coarse aggregates or cement in the making of concrete. From economic point of view, coarse aggregate contributes a bigger portion of costs in the production of concrete, thus to have them replaced by waste material of similar characteristics is a major economic gain, while being more environment friendly. Ceramic wastes are found to be suitable for usage as substitution for fine and coarse aggregates and partial substitution in cement production. Researchers have indicated their potential for usage in both structural and non-structural concrete and even for mortars. 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.

Chandana Sukesh, they have studied about the partial replacement of aggregate in concrete by use of waste materials like ceramic waste tile. This industrial waste material is termed as hazardous waste to environment. A concrete mix with cement, sand and crushed tiles had also prepared as well as a concrete mix with cement, natural sand, and coarse aggregates (W/B =0.45). Results show 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 (a1963) 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.

III. MATERIAL AND THEIR PROPERTIES

A. *Cement*

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. With a good distribution network this cement is available most abundantly in Gujarat.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
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B. Coarse Aggregate

Since approximately three-quarters of the volume of concrete is occupied by aggregate, it is not surprising that its quality is of considerable importance. Not only may the aggregate limit the strength of concrete but the aggregate properties greatly affect the durability and structural performance of concrete.

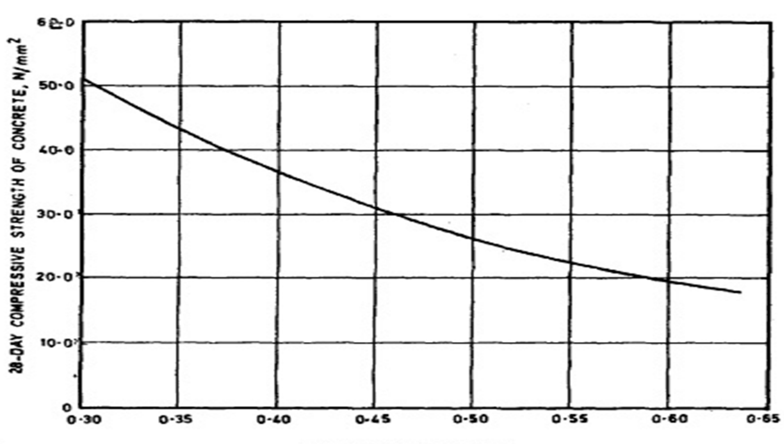
Material which retained on 4.75 mm size classified as a coarse aggregate. For most works, 20 mm aggregate is suitable. The locally available aggregate having nominal size of 20mm was used.

C. 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

D. Water

Water used for making concrete should be clean. It activates the hydration of cement and forms plastic mass. As it sets completely concrete becomes hard mass. Water gives workability to concrete which means water makes it possible to mix the concrete with ease and place it in final position. More the water better is the workability. However excess water reduces the strength of concrete. Fig.3.8 shows the variation of strength of concrete with water cement ratio. To achieve required workability and at the same time good strength a water cement ratio of 0.4 to 0.45 is used, in case of machine mixing and water cement ratio of 0.5 to 0.6 is used for hand mixing.



E. Crushed Tiles

Broken tiles were collected from the solid waste of ceramic manufacturing unit. Crushed them into small pieces by manually and by using crusher. And separated the coarse material to use them as partial replacement to the natural course aggregate. Separated the tile waste which is greater than 4.75 mm. Crushed tiles were partially replaced in place of coarse aggregate by the percentages of 10%, 20%, 30%, 40% and 50% individually.

Figure 3.9: Manual Crushing Of Waste Tiles

Figure 3.10: Materials Separated After Crushing

F. Nylon Fibre

Nylon was the first truly synthetic fiber to be commercialized. It is a polyamide fiber, derived from a diamine and a dicarboxylic acid, because a variety of diamines and dicarboxylic acids can be produced, there are a very large number of polyamide materials available to produce nylon fibers. The two most common versions are nylon 66 (polyhexamethyleneadiamide) and nylon 6 (Polycaprolactam, a cyclic nylon intermediate). Raw materials for these are variable and sources used commercially are benzene (from coke production or oil refining), furfural (from oat hulls or corn cobs) or 1,4-butadiene

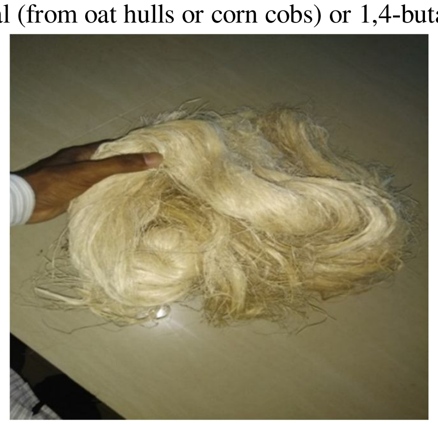


Figure 3.11: Nylon Fibers

Fiber types are produced commercially in various parts of the world. Nylon 66 has been preferred in North American markets, whereas nylon 6 is much more popular in Europe and elsewhere. Nylon is produced by melt spinning and is available in staple, tow, monofilament, and multi-filament form. The fiber has outstanding durability and excellent physical properties. Nylons are semi-crystalline polymers.

There are several commercial nylon products, such as nylon 6, 11, 12, 6/6, 6/10, 6/12, and so on. Of these, the most widely used nylon products in the textile industry are formed of nylon 6 and nylon 6/6. The others are mainly used in tubing extrusion, injection molding, and coatings of metal objects.

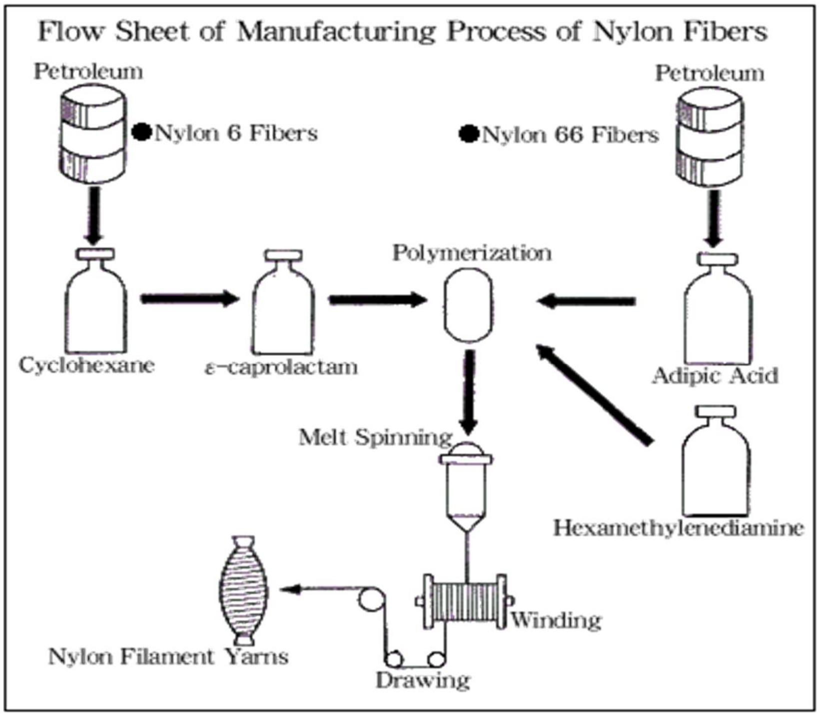


Figure 3.12: Fiber Formation

G. Physical Properties

1) Tenacity: 4-9 gm/den (dry), in wet 90% of dry.
2) Elasticity: Breaking extension is 20-40%.
3) Stiffness: 20-40 gm/den.
4) Moisture regain: 3.5-5%; (not absorbent due to crystallinity).
5) Specific gravity: 1.14.
6) Softening point: Nylon 6,6 – 229^0C, Nylon 6 – 149^0C.
7) Melting point: Nylon 6,6 – 252^0C, Nylon 6 – 215^0C.
8) Hand feel: Soft and smooth.

IV. EXPERIMENTAL PROGRAM

A. Types Of Mixes Prepared

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 will collect waste crushed tile by using 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 4.1 Material Percentages for Different Mixes

S.No	Mix Code	Cement (%)	Fine aggregate (%)	Coarse aggregate (%)	Crushed Tiles	Description
1	A0	100	100	100	0	Conventional
2	A1	100	100	90	10	Replacement with crushed Tiles
3	A2	100	100	80	20	
4	A3	100	100	70	30	
5	A4	100	100	60	40	
6	A5	100	100	50	50	

After we get maximum compressive strength, we are going to add nylon fibre from 0 to 2% to improve the strength characteristics of concrete.

Table 4.2 Material Percentages for Optimum Mix with Nylon Fibre

S.No	Mix Code	Cement (%)	Crushed Tiles	Description
1	A6	100	OPTIMUM+0.5%	Addition of nylon fibre to optimum crushed tiles
2	A7	100	OPTIMUM+1.0%	
3	A8	100	OPTIMUM+1.5%	
4	A9	100	OPTIMUM+2 %	

B. NO. OF Specimens Prepared

Total 10 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 2 trails of cubes having dimension 150 x 150 x 150 mm are prepared.
Total Cubes = 10(types of mixes) x 3 (curing periods) x 2 (cubes for each trail) = 90 cubes

Table 4.3 Specimens Details For Each Mix

S.No.	Mix code	No. of cubes prepared for the curing period of		
		3 days	7days	28days
1	A0	3	3	3
2	A1	3	3	3
3	A2	3	3	3
4	A3	3	3	3
5	A4	3	3	3
6	A5	3	3	3
7	A6	3	3	3
8	A7	3	3	3
9	A8	3	3	3
10	A9	3	3	3
Total cubes prepared		30	30	30

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

C. 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.

1) *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.

Figure 4.1: Weighed Material Ready For Mixing

2) *Slump Test:* Slump test was performed on fresh concrete for different concrete mix.
3) *Casting of Cubes*
- Fresh concrete is poured into the tightened moulds which are already prepared by applying grease for lubrication and having dimensions of 150 x 150 x 150 mm.
- Vibrator was used for the compaction process.
- And allowed the moulds free for 1 day to settle, harden and to demould.

4) *Demoulding and Curing*
- Demoulding was done after 1 day.
- Cubes are placed in water sump to allow the cubes for 7, 14 and 28 days curing period.

D. Tests Conducted On Cubes

Compressive strength test was conducted on cubes after 7, 14 and 28 days curing period to analyze the strength variation for different mixes.

Figure 4.2: Moulds

Figure 4.3 Curing Of Cube Specimen

Figure 4.4: Cubes After Completion Of Curing Period

V. RESULTS AND DISCUSSIONS

A. *Introduction*

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.

B. *General*

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

C. *Variation Of Slump Values For Percentage Replacement Of Crushed Tiles*

Figure 5.1, Table 5.1 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 5.1 Variation Of Slump Values

S.No	Mix Type	Slump (mm)
1	A0	50
2	A1	70
3	A2	90
4	A3	100
5	A4	110
6	A5	110

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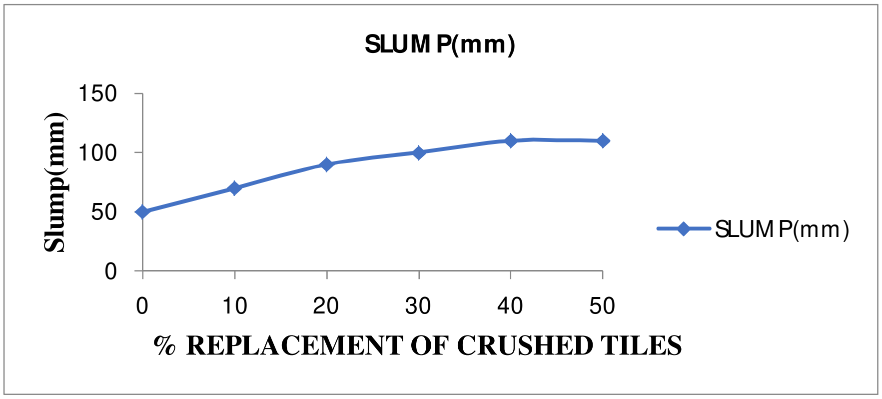

Figure 5.1 shows the variation of slump values for replacement of crushed tiles

D. Compressive Strength Test (IS 516:1959)

This test is a destructive method of testing to measure the compressive strength of the concrete. These tests have to perform on hardened concrete cubes under Compressive Testing Machine (CTM).

Compressive strength test was conducted on concrete cubes of size 150 x 150 x 150 mm cast from concrete of each series, to check quality by obtaining the 7-days,14-days and 28-days compressive strength. The maximum compressive load on the specimen was recorded as the load at which the specimen failed to take any further increase in the load. The average of three samples was taken as the representative value of compressive strength. The compressive strength was calculated by dividing the maximum compressive load by the cross-sectional area of the cube specimen.

Figure 5.2: Compressive Testing Machine

E. Variation Of Compressive Strength For Different Mixes

Showing compressive strength of concrete replaced with crushed tiles for curing period of 7-days, 14-days, 28-days respectively and figure 5.6 shows the summarized results for different curing periods.

Table 5.2: Evaluation Of Optimum Percentage Of Crushed Tiles

C+F.A+C.A+ % CT REPALCEMENT	COMRESSIVE STRENGTH(MPa)		
	7 DAYS	14 DAYS	28 DAYS
0	19.5	22.62	28.87
10	22.32	25.86	34.15
20	21.13	24.28	31.59
30	19.77	23.34	30.39
40	18.97	20.68	25.59
50	17.1	20.16	24.26

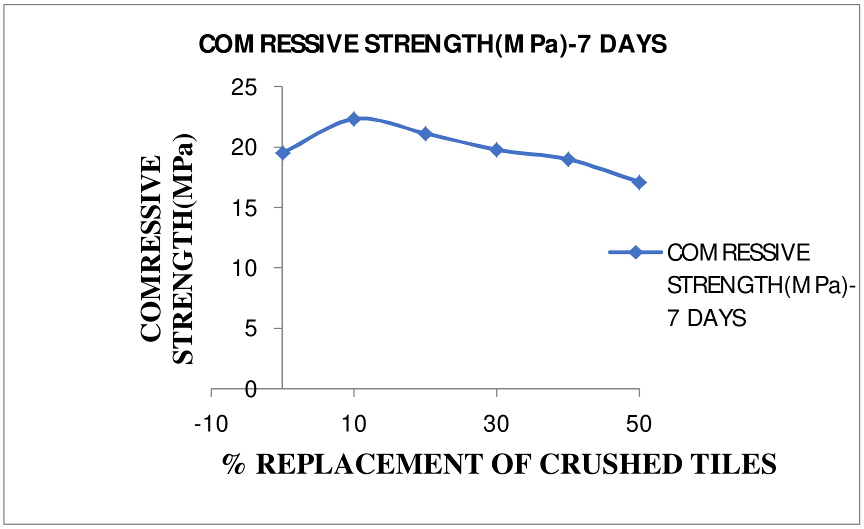

Figure 5.3 Shows The Variation Of Compressive Strength Results For Curing Period Of 7-Days

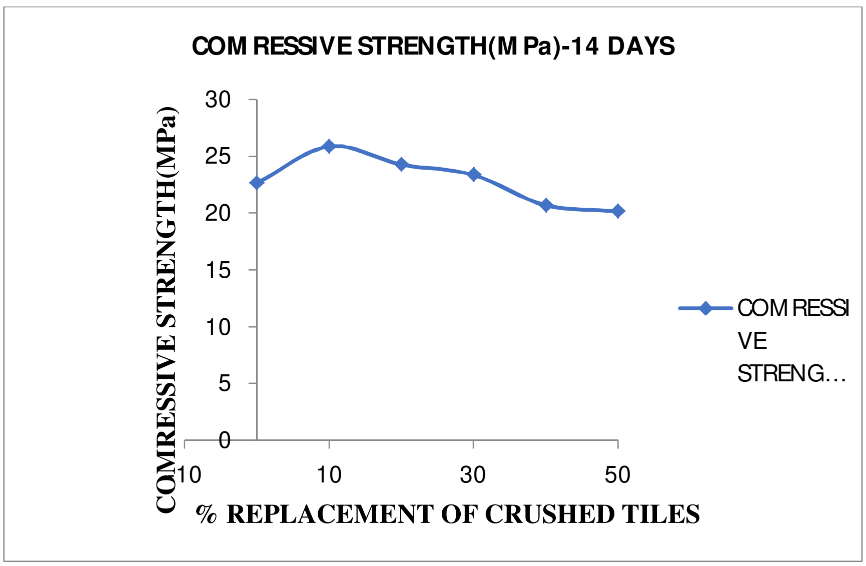

Figure 5.4 Shows The Variation Of Compressive Strength Results For Curing Period Of 14-Days

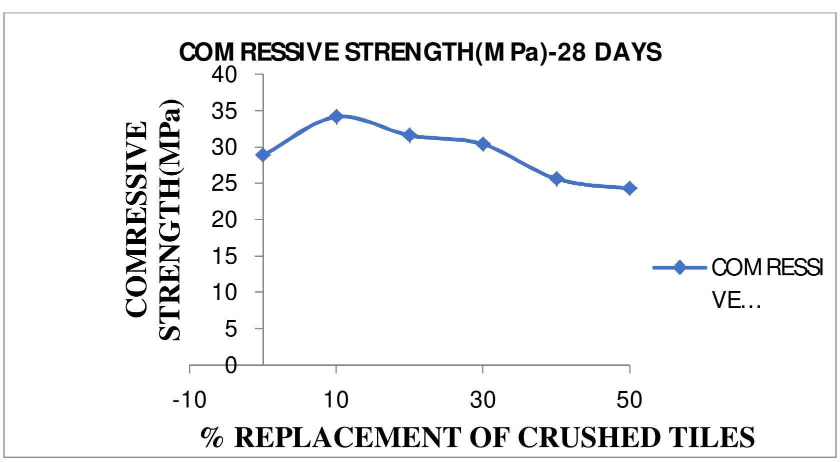

Figure 5.5 Shows The Variation Of Compressive Strength Results For Curing Period Of 28-Days

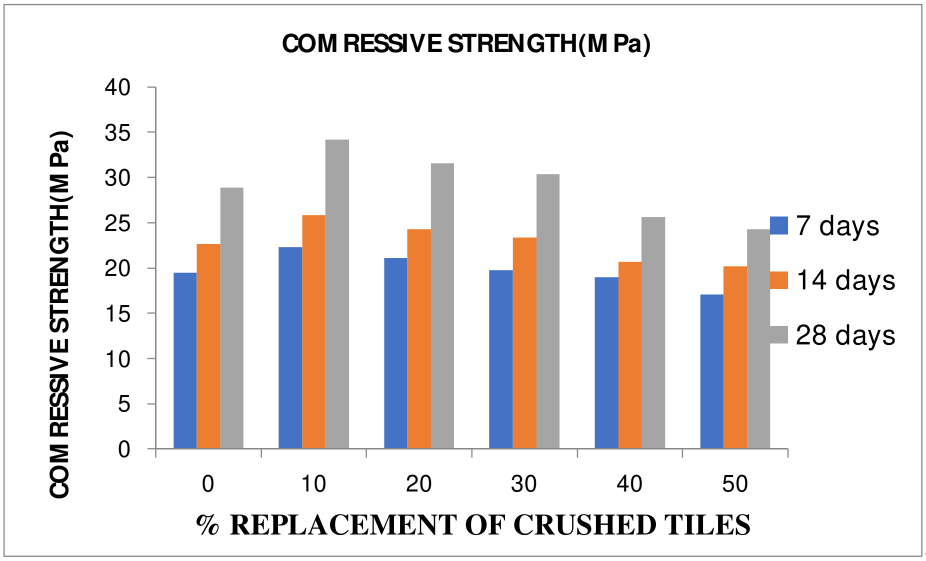

Figure 5.6 Shows The Variation Of Compressive Strength Results For Different Curing Periods

- 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 nylon fiber from 0 to 2% with an increment of 0.5%.

F. Variation Of Slump And Compressive Strength For Addition Of Nylon 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% nylon fiber and then gradually decreasing with increase in fiber content

Table 5.3: Evaluation Of Optimum Percentage Of Nylon Fiber To The Optimum Percentage Of Crushed Tiles

C+F.A+C. A+NYLON FIBRE	SLUMP(mm)	COMRESSIVE STRENGTH(MPa)		
		7 DAYS	14 DAYS	28 DAYS
0	70	22.32	27.86	34.15
0.5	60	23..23	28.32	36.89
1	80	24.23	29.75	37.23
1.5	60	20.4	23.12	35.56
2	40	21.85	24.24	31.69

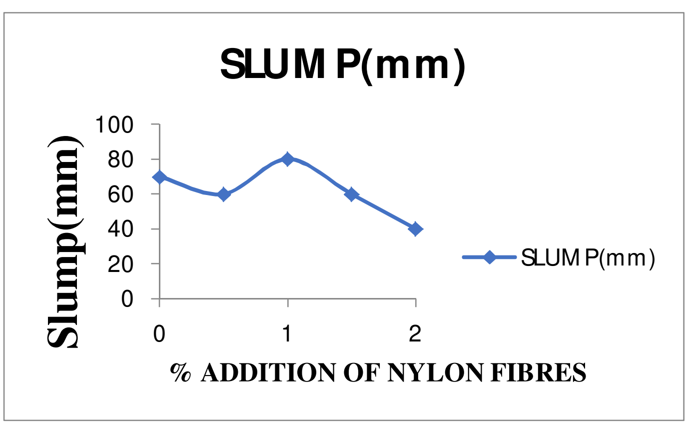

Figure 5.7 Shows The Variation Of Slump For Different Percentages Addition Of Nylon Fiber

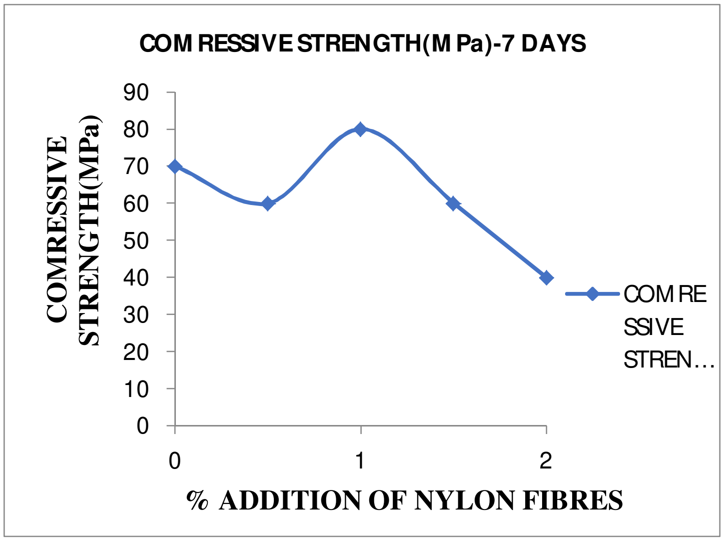

Figure 5.8 Shows The Variation Of Compressive Strength Results For Curing Period Of 7-Days

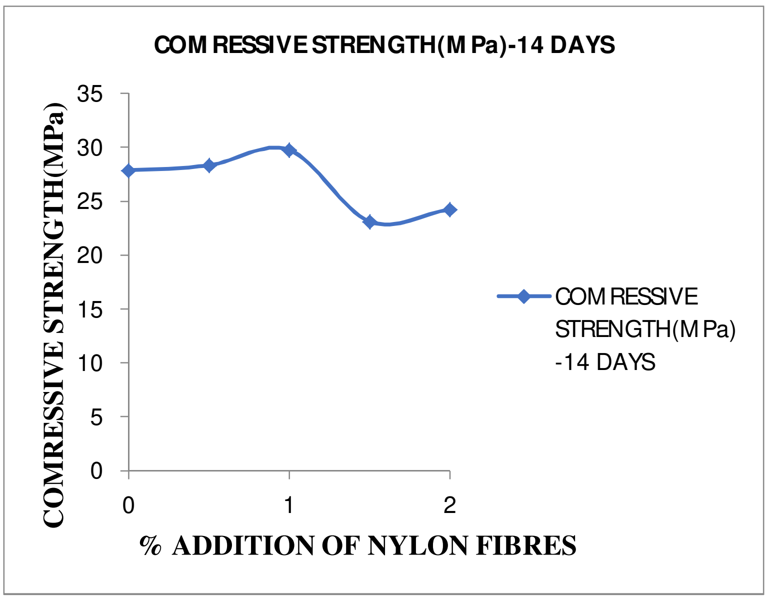

Figure 5.9 Shows The Variation Of Compressive Strength Results For Curing Period Of 14-Days

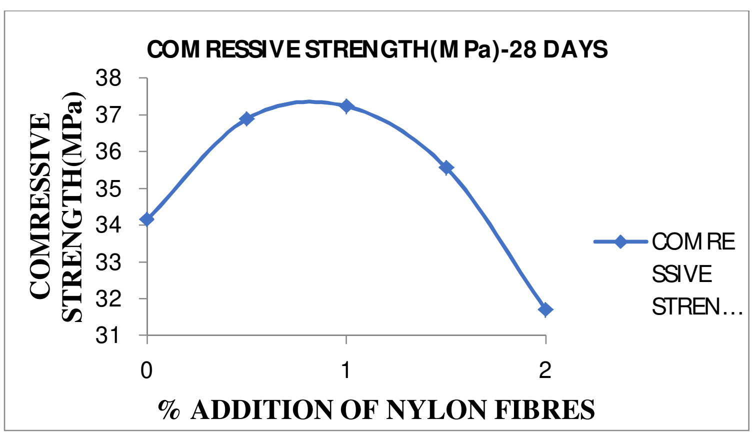

Figure 5.10 Shows The Variation Of Compressive Strength Results For Curing Period Of 28-Days

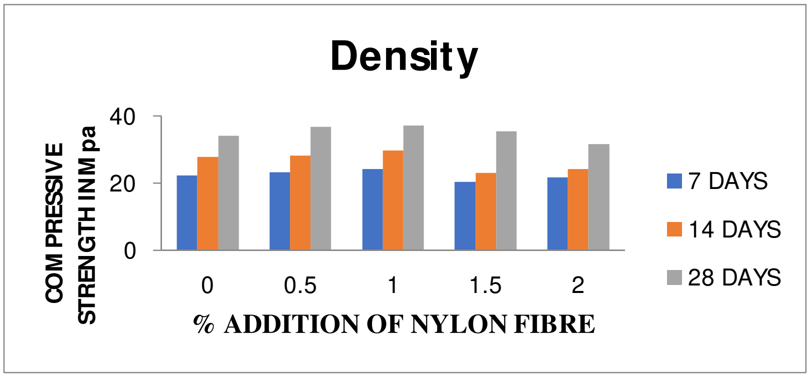

Figure 5.11 Shows The Variation Of Compressive Strength Results For Curing Period Of 28-Days

From the results it is concluded that 1% addition of nylon fibre shows maximum compressive strength.

From the above charts:

- Compressive strength of all mixes (A0 to A9) with replacing materials is less than the conventional mix (A0) compressive strength
- When increasing replacement of waste tiles percentage in mixes (A1 & A3): Observed that when 10% of coarse aggregates replaced by the tiles and granite powder compressive strength is increasing.
- But for 20% and 30% replacement compressive strength is decreasing. So, 10% is the feasible percentage to replace the coarse aggregate with waste crushed tiles.
- Further addition of nylon fibre to the optimum mix with crushed tiles, compressive strength increases with increase in fibre content up to 1%. Further addition of fiber decreases the compressive strength results

VI. CONCLUSION

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

1) After performing workability test observed that, when increasing percentage of waste crushed tiles in concrete leads to the increase in workability of the concrete.
2) For 10% of crushed tiles an replacement in place of coarse aggregates i.e., A1 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.
3) But when crushed tiles percentage is increased to 20% and 30% i.e., A2 and A3 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 (A4 to A7), compressive strength is decreasing for 7 days and 14 days curing period but it is increasing after 28 days curing period.
4) So, feasible usage of waste ceramic crushed tiles in replacement to coarse aggregate is 10% only (A1).
5) The maximum compressive strength obtained in A1, A2 and A3 mixes is for the concrete mix which was having only 10% of replacement coarse aggregate with tiles (A1). So, 10% of tiles can use in replacement to the coarse aggregate.
6) To the optimum mix of crushed tiles on further addition of nylon fibre, compressive strength increases with increase in fibre content up to 1%. Further addition of fiber decreases the compressive strength results.
7) Finally, it is concluded that Replacement of crushed tiles and addition of nylon fibers shown promising influence on the strength parameters and there by waste can be recycled.

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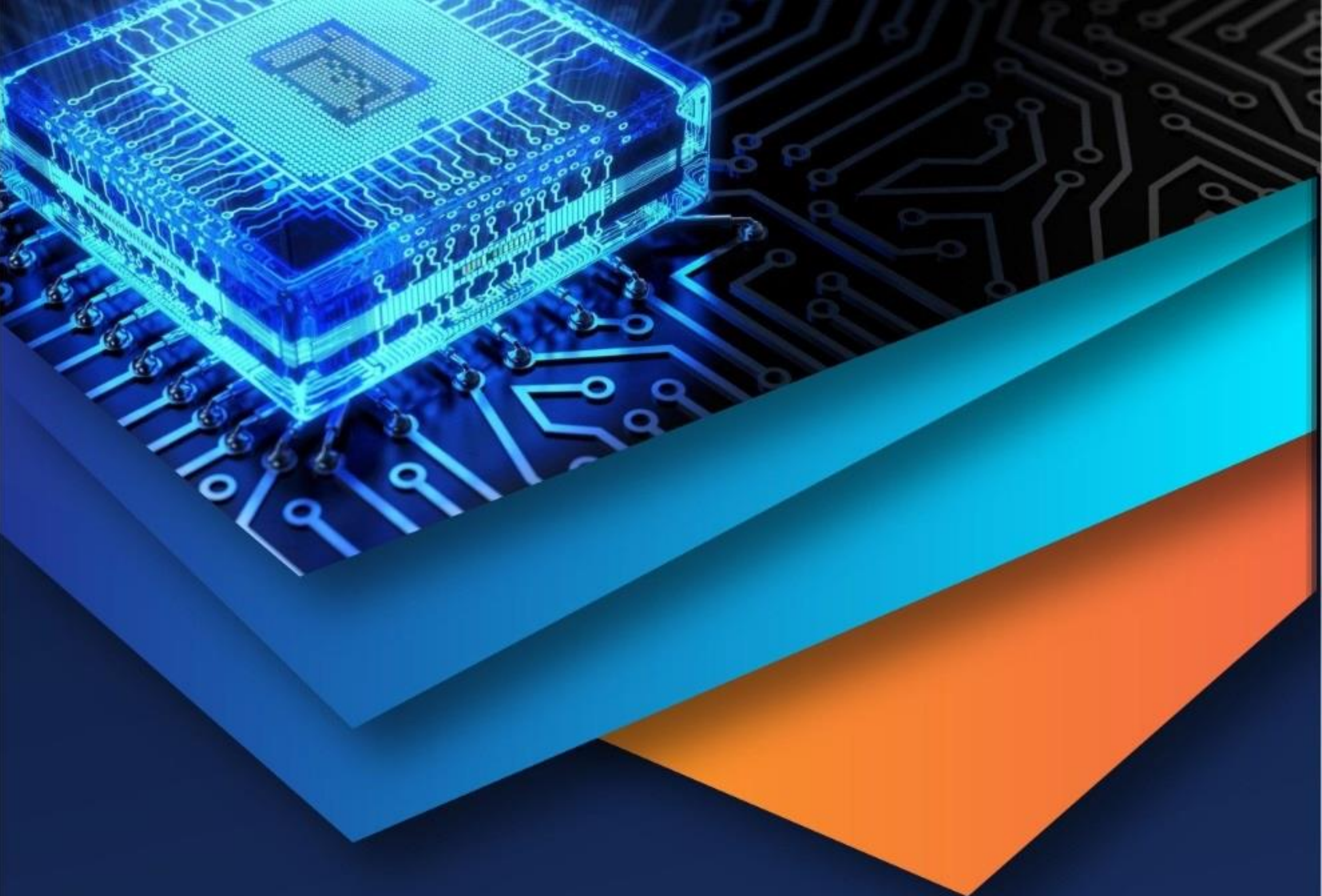

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