A Study on Concrete Behavior With The Use of Crushed Tiles As Replacement of Coarse Aggregate And Reinforced With Nylon Fiber

B Durgaprasad[1], D Appanna[2]
[1]Dept of Civil Engineering
[2]Assistant Professor,Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

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 20%, 40% and 60% with M25 and M40 grade. From the point of view of effective utilization of these potential tile wastes in concrete, this research was undertaken to address several issues of concrete mix proportioning and its characterization. Two grades of concrete namely M25 and M40 are designed as per IS: 10262-2019 and the mix proportions are presented with crushed tiles waste as coarse aggregates. Experimental investigation like workability, Compressive strength test and split tensile strength for different concrete mixes with different percentages of waste crushed after 7 days and 28days curing period. Variations in the workability and compressive strength for these different mixes were studied and observed the optimum mix. Further added 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, workability, compressive strength, split tensile strength test, water absorption test.

I. INTRODUCTION

Industrial waste is being used nowadays as fine and coarse aggregates in various practical applications. This use is beneficial on one side and is becoming more and more desirable because it reduces the environmental impact and the cost of mining. In addition, the industry waste exposed to environment has an ecological impact as well. Thus, the application of waste in concrete as aggregates is not only viable but also resolves many problems related to their safe disposal. One such promising waste is the vitrified tile which is abundantly available in urban areas. This vitrified tile waste is impervious, hard and high resistant to physical, mechanical, biological and chemical attacks.

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 days. 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.

Generally in design of concrete mix, cement, fine aggregates and coarse aggregates are using from a long years back. These three materials only play a crucial role in designing of a particular grade of concrete. But now a days there is a scarcity in aggregates. So, some new materials which are very near to our surroundings and some type of materials have to be introduce for replacing the fine aggregates, coarse aggregates and as well as cement to get the same strength as that these basic materials can give.

Thus fibres are another to concrete to beat these disadvantages. The addition of fibres within the matrix has several vital effects. Fiber reinforced concrete has been recognized that addition of small, closely spaced and uniformly dispersed fibres to concrete would act as reinforcement to the concrete thereby improves the properties of concrete.

The Fibre concrete (FRC) could be a material primarily consisting of concrete strengthened by random placement of short discontinuous and distinct fine fibers of specific pure mathematics. It’s currently well established that the addition of short, discontinuous fibers plays a vital role within the improvement of the mechanical properties of concrete. In the FRC, the fibers facilitate to transfer load to the inner small cracks. Within the recent past, several developments are created within the fiber concrete.

Nylon fibers possess unique characteristics that make them suitable for enhancing the mechanical properties of concrete. Nylon fiber is an attractive reinforcement for concrete. Thus fibres are another to concrete to beat these disadvantages. The addition of fibres within the matrix has several vital effects. Fiber reinforced concrete has been recognized that addition of small, closely spaced and uniformly dispersed fibres to concrete would act as reinforcement to the concrete thereby improves the properties of concrete.

The present project involves a comprehensive laboratory experimentation study for the application of new waste materials in the preparation of concrete. The main objective of investigation is to study the strength behaviour i.e. compressive strength, split tensile strength and flexural strength of concrete with different percentages replacement of coarse aggregate with crushed tiles and to study the tensile behaviour on adding with nylon fibers.

The objective of the present study was to investigate experimentally the properties of Concrete with the following test results

- Workability
- Compressive strength
- Flexure strength
- Tensile strength

II. REVIEW OF LITERATURE

This chapter deals with the review of works previously carried out in the area of crushed tiles replacement experiments and the role of nylon fibers in the field of fibre reinforced concrete in the earlier studies are presented. Importance of fibres in toughness and tensile strength point of view and its optimum percentage is also discussed. 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, arecanut, and polypropylene and those with higher elastic moduli such as asbestos, glass, steel, and carbon.

Among all the fibers nylon fibers have been used in pavements, in shotcrete, and in a variety of other structures. Banana fibers are renewable and obtained from natural resources that present several advantages, including low density, acceptable specific strength properties, good sound abatement capability, low abrasivity, low cost, high biodegradability and existence of vast resources. In addition, at the end of their life cycle these can be incinerated for energy recovery, because they have a good calorific value. New application areas become available as new fiber types and new FRC production techniques are developed.

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.

ChandanaSukesh 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 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 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.

III. MATERIALS AND METHODS

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. Water
4. Crushed tiles
5. Nylon fibre

1. Cement

Ordinary Portland cement of 43 grades manufactured by Shree Ultratech Cement was used throughout the Experimental investigation. The quality of the cement was confirming to IS 8112:1989 was used in the field.

2. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

3. Coarse Aggregate

Coarse aggregate shall be of hard broken stone of granite shall be of hard stone, free from dust, dirt and other foreign matters. The stone ballast shall be of 20mm and down and should me retained in 5mm square mesh and well graded such that the voids do not exceed 42 percent. Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

4. Crushed tiles

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.

5. 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.

Fig 3.1 Nylon fiber

IV. MIX DESIGN

The property of workability, therefore, becomes of vital importance. The mix design is done as per IS 10262-2009. Percentage dosage of super plasticizer (high range water reducers) is an additional parameter to be considered for designing an OPC mix. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262-2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M25 &M40.

V. RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

In this chapter, concepts of experimental work are presented. Objective of testing, i.e. ordinary Portland cement, fine aggregate, coarse aggregate, potable water, crushed tiles, process of manufacturing of concrete, workability of fresh concrete and testing of hardened concrete procedures are explained in details.

It was proposed to investigate the properties of concrete, cast with partial replacement of coarse aggregate with 20%, 40% and 60% by crushed tiles. In this experimental work, physical properties of materials used in the experimental work were determined. M25 & M45 grade concrete was mixed and cured in potable water. Compressive strength, flexural strength for various mixes then studied the durability with addition of nyloon fibres of varied percentages.

5.2 SLUMP TEST

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability.

Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification. The minimum workability for MIX I may be due to the lesser fine particle size of cement which can result in higher water consumption thereby reducing workability.

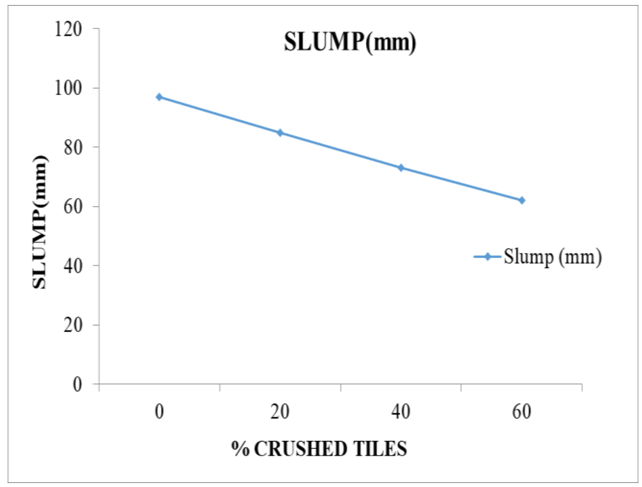

Fig 5.1: Plot shows the Variation of Slump Values for % replacement of crushed tiles

5.3 COMPRESSIVE STRENGTH

The main function of the concrete in structure is mainly to resist the compressive forces. When a plain concrete member is subjected to compression, the failure of the member takes place, in its vertical plane along the diagonal. The vertical cracks occur due to lateral tensile strain. A flow in the concrete, which is in the form of micro crack along the vertical axis of the member will take place on the application of axial compression load and propagate further due to the lateral tensile strain.

Cubes are prepared of size 150 mm x 150 mm x 150 mm are checked for compressive strength. The specimens tested for 7, 14 and 28 days. The specimen were tested for compressive strength parallel to the plane of the board by applying increasing compressive load until failure occur. The arrangement of load is applied to the specimen by placing the specimen length vertical between the surfaces of the testing machine. Prior to that, measurement for the thickness and width was carried out in order to get the values of cross section area for the test specimens.

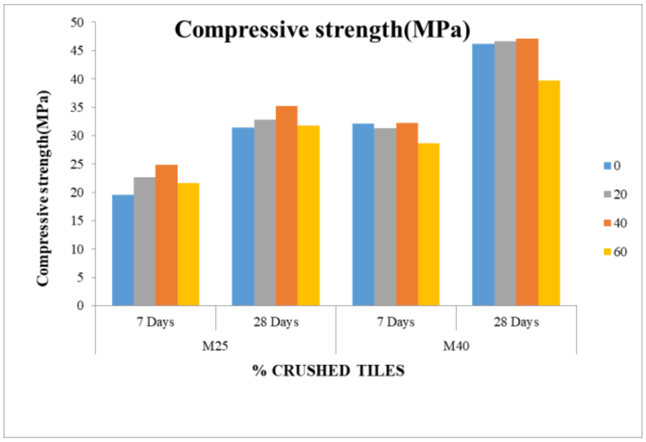

Fig 5.2 Plot shows the summarized results of variation in compressive strength for M25 & M40 Grade.

5.4 SPLIT TENSILE STRENGTH

The cylinder specimen is of the size 150 mm diameters and 300mm height was cast to determine the split tensile strength of concrete. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied until failure of cylinder, along its longitudinal direction.

The size of specimens 150 mm dia and 300 mm length was used and the specimens were cured in normal water. Concrete specimen cubes are used to determine split tensile strength of concrete and were tested as per as per IS 516 (1959) and IS 5816 (1999). Split tensile test is also used to determine the tensile stress in concrete; this method is also called as Brazilin test. In this we place the cylindrical specimen of size 300 mm height and 150 mm diameter is placed in horizontal between the loading surfaces of compression test machine and load is applied until the failure of the specimen along the vertical diameter. This test is performed as per IS: 5816 code.

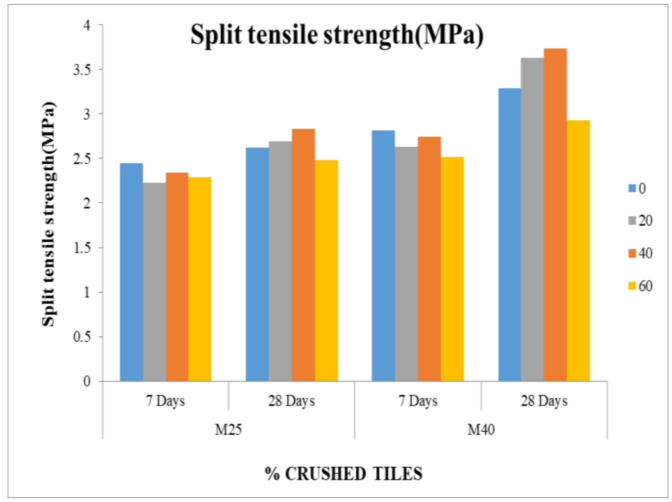

Fig 5.4 Fig 5.8: Plot shows the summarized results of variation in Split tensile strength for M25 & M40 Grade

5.5 FLEXURAL STRENGTH

The size of specimens 100 mm x 100 mm x 500 mm was used and the specimens were cured in water. Concrete specimen beams are used to determine flexural strength of concrete and were tested as per as per IS 516 (1959).

Flexural strength of concrete keeping 40% crushed tiles as constant and with different percentages of nylon fibre for curing period of 7-days, 14-days and 28-days respectively and table shows the summarized Split tensile strength Results for different curing periods– M30 grade.

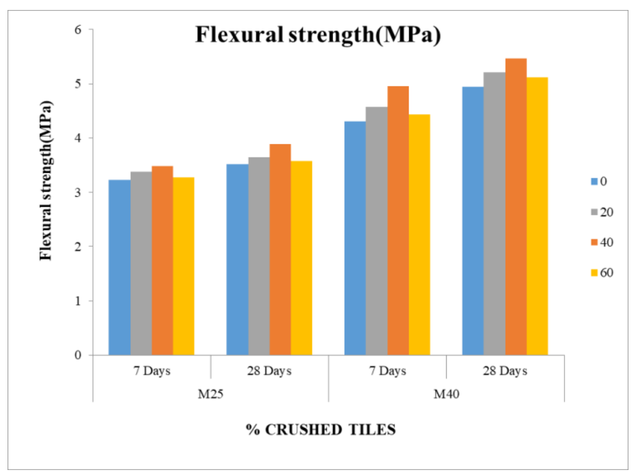

Fig 5.5: Plot shows the summarized results of variation in flexural strength for M25 & M40 Grade

As the percentage of crushed tiles increases the strength properties of concrete tends to increase up to certain percentage and then start's decreasing with the increase of crushed tiles content.

The strength of 40% crushed tiles concrete is more than 20% crushed tiles concrete and strength of 40% crushed tiles concrete is slightly more than normal concrete. This shows that till 40% crushed tiles concrete the strength increases while percentage of crushed tiles increases.

5.6 EVALUATING THE OPTIMUM PERCENTAGE OF NYLON FIBER

Strength properties of concrete keeping 40% crushed tiles as constant and with different percentages of nylon fibres for curing period of 7-days and 28-days respectively for M40 grade.

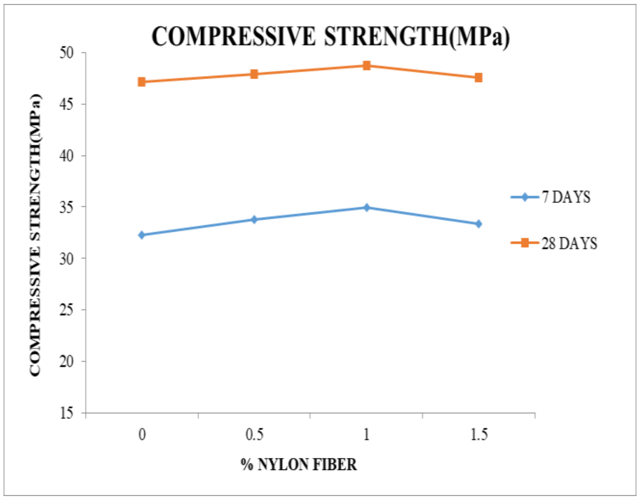

Fig 5.6: Plot shows the variation in compressive strength for different percentages of nylon fiber-M40 Grade

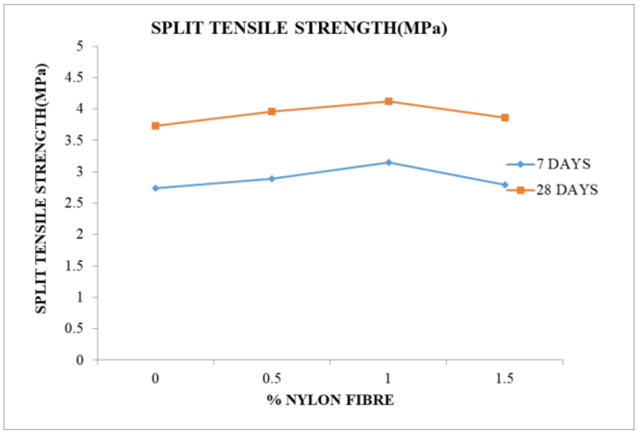

Fig 5.7: Plot shows the variation in split tensile strength for different percentages of nylon fiber-M40 Grade

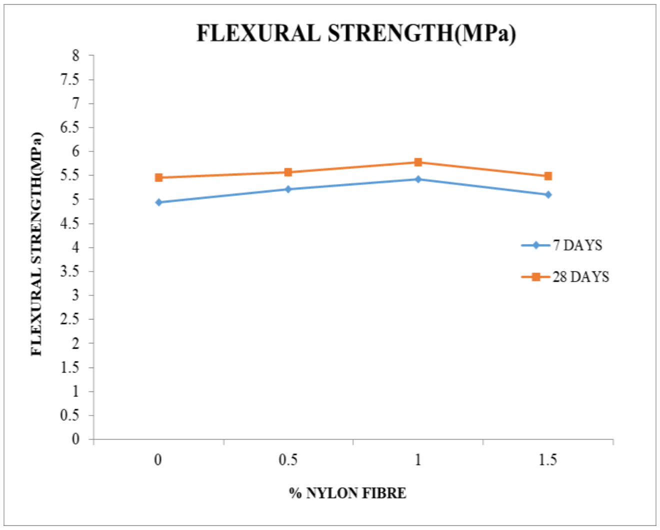

Fig 5.8: Plot shows the variation in flexural strength for different percentages of nylon fiber-M40 Grade

From the results it is evident that with the increase of fibre content the tensile nature of the concrete also increases results in higher values compared to that of Plain concrete. The figure shows that the test results of splitting tensile strength and flexural strength of specimens after water curing, it is concluded that the percentage increase in strength increases with the increase in percentage of fiber content. Also, from the results it is evident that compressive and flexural strength also increases with the increase of fiber content.

VI. CONCLUSIONS

- After completion of total experimental methodology, from the above investigations and from the test results some variations observed in workability and in strengths results of different concrete mixes having different percentages of replacing materials (Crushed tiles in place of coarse aggregate) and nylon fiber addition as reinforcement as mentioned below.
- After performing workability test observed that, when increasing percentage of waste crushed tiles in concrete leads to the decrease in workability of the concrete.
- For 40% of crushed tiles as an replacement in place of coarse aggregates, there is a increment in compressive strength when compare to the conventional mix compressive strength results after 7 days and 28 days curing periods. Further with 1% nylon fiber as reinforcement improves the strength properties.
- When crushed tiles percentage is increased to 60%, the compressive strength is decreased for 7 and 28 days curing period. The compressive strengths of M25 concrete for optimum values of crushed tiles (40%) and nylon fibre (1%) are 35.24 MPa for 28 days. The compressive

strengths of M40 concrete for optimum values of crushed tiles (40%) and nylon fibre (1%) is 48.71 MPa for 28 days.

- As like Split tensile strength and flexural strength of concrete of increases with increase in percentage of crushed tiles (40%) and nylon fibre (1%). There was 25% increase in the tensile strength and 17% increase in the flexural strength because of the high elastic modulus of nylon fiber. Due to the high stiffness of nylon fibres, resulted in a significant enhancement in split tensile strength and flexural strength.
- The use of crushed tiles and nylon fibre combined is economic in concrete. Likewise saves a great deal of waste disposal problems and reduces the aggregate usage.

REFERENCES

[1] IS 456 (2000): Plain and Reinforced Concrete - Code of Practice.
[2] IS 516 (1959): Method of Tests for Strength of Concrete.
[3] IS 5816 (1999): Method of Test Splitting Tensile Strength of Concrete.
[4] IS 10262 (2009): Guidelines for concrete mix design proportioning.
[5] KParmimdersingh, Dr. RakeshkumarSingla, Utilization Of Waste Ceramic Tiles As Coarse Aggregate In Concrete, Vol. 2 Issue 11, November - 2015
[6] Nishant Kumar1, AravindSagarB,An Experimental Laboratory Study on Utilization of Ceramic Waste as a Partial Replacement of Coarse aggregate in concrete, Volume: 05 Issue: 11 |Nov-2016.
[7] Hemanth Kumar Ch,Ananda Ramakrishna K, SateeshBabu K, Guravaiah T, Naveen N, JaniSk ,june-2015, Effect of Waste Ceramic Tiles in Partial Replacement of Coarse and Fine Aggregate of Concrete, Vol. 2, Issue 6, June 2015
[8] Sagoe-Crentsil, K. K., Brown, T. & Taylor, A. H. (2001). Performance of concrete made with commercially produced coarse recycled concrete aggregate. CCR, Vol. 031, pp.707-712.
[9] Chen, H., Yen, T. & Chen, K. (2003). Use of building rubbles as recycled aggregates. Cement and Concrete Research, Vol. 33, pp. 125-132.
[10] Mansur, M. A., Wee, T. H. &Cheran, L. S. (1999). Crushed bricks as coarse aggregate for concrete. ACI Materials Journal, Vol. 96, No. 4, pp. 478-484.
[11] Ramujee, K.; (2013), ‘Strength properties of polypropylene fiber reinforced concrete’, International Journal of Innovative Research in Science, Engineering and Technology, Vol 2, pages 3409-3413.
[12] Saxena, J., Saxena, A.; (2015), ‘Enhancement the Strength of Conventional Concrete by using Nylon Fiber International journal of engineering and science, Vol 5(2), pages 56-59..
[13] I. B. Topcu and M. Canbaz, Utlization of Crushed Tiles as Aggregate in Concrete, Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 31, No. B5, pp561- 565(2007).
[14] HakanElci, Utilisation of crushed floor and wall tile wastes as aggregate in concrete production, Journal of Cleaner Production, Vol. 112, Part.1, pp742-752 (2016).
[15] Derrick J. Anderson, Scott T. Smith and Francis T.K. Au, Mechanical properties of concrete utilising waste ceramic as coarse aggregate, Construction and Building Materials, Vol. 117, pp20-28 (2016).
[16] C. Medina, M.I. Sánchez de Rojas, C. Thomas, J.A. Polanco and M. Frias, Durability of recycled concrete made with recycled ceramic sanitary ware aggregate. Inter-indicatorrelationships, Construction and Building Materials, Vol. 105, pp480-486 (2016).