Experimental Analysis of properties of Conventional and Light Weight Concrete mixed with Brick and Ceramic Tile Waste

Chaugule Rohit Shivram[1], Idarisi Mohammad Tarik Nuruddin[2], Chauhan Armaan Maksud[3], Ansari Md Arbaz Md Jawahar[4], Nikhil Ingale[5]
[1,2,3,4]*Rizvi College of Engineering*
[5]*Assistant Prof., Rizvi College of Engineering*

***Abstract* - Due to the day-to-day innovations and development in construction field, the use of natural aggregates is increased tremendously and at the same time, the production of solid wastes from the demolitions of constructions is also quite high. Because of these reasons the reuse of demolished constructional wastes like ceramic tile and brick waste came into the picture to reduce the solid waste and to reduce the scarcity of natural aggregates for making concrete. The ceramic tile waste and brick waste are not only occurring from the demolition of structures but also from the manufacturing unit.**

Studies show that about 20-30% of material prepared in the brick and tile manufacturing plants are transforming into waste. This waste material should have to be reused in order to deal with the limited resource of natural aggregate and to reduce the construction wastes.

Crushed waste ceramic tiles and brick waste are used as a replacement to the coarse aggregates. The ceramic waste crushed tiles and crushed brick waste were partially replaced in place of coarse aggregates by 0%, 25% and 50%. M25 grade of concrete was designed and tested. The mix design for different types of mixes were prepared by replacing the coarse aggregates at different percentages of crushed tiles and bricks. Experimental investigations like workability, Compressive strength test, Split tensile strength test, Flexural strength test for different concrete mixes with different percentages of waste crushed tile and brick waste after 14 days curing period has done.

***Index Terms* - Crushed tiles, brick waste, Compressive strength, Workability, Flexural strength, Split Tensile strength.**

I.INTRODUCTION

1.1 Concrete:

Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mass that can be easily moulded into desired shape can be formed by mixing these ingredients in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on large-scale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire.

1.2 Properties of Concrete:

Generally the Concrete is a material having high compressive strength than to tensile strength. As it has lower tensile stress it is generally reinforced with some materials that are strong in tension like steel. The elastic behavior of concrete at low stress levels is relatively constant but at higher stress levels start decreasing as matrix cracking develops. Concrete has a low coefficient of thermal expansion and its maturity leads to shrinkage. Due to the shrinkage and tension, all concrete structures crack to some extent. Concrete prone to creep when it is subjected to long-duration forces. For the applications various tests be performed to ensure the properties of concrete correspond to the specifications. Different strengths of concrete are attained by different mixes of concrete ingredients, which are measured in psi or Mpa. Different strengths of concrete are used for different purposes of constructions.

1.3 Light Weight Concrete:

One of the disadvantages of concrete is its high self weight. Density of normal concrete will be in the range of order of 2200 to 2600 kg/m3. This heavy self weight will make the concrete to some extent as an uneconomical structural material. Attempts have been done in the past to reduce the self weight of concrete to increase its efficiency of concrete as a structural material. The light weight concrete density varies from 300 to 1850 kg/m3 by the use of various ingredients. Lightweight concrete has become more popular in recent years and have more advantages over the conventional concrete.

1.4 Construction Waste in India:

In the present construction world, the solid waste is increasing day by day from the demolitions of constructions. There is a huge usage of ceramic tiles and bricks in the present constructions is going on and it is increasing in day by day construction field. They are mostly produced using natural materials that contain high content of clay minerals. However, despite the ornamental benefits of ceramics, its wastes among others cause a lot of nuisance to the environment. And also in other side waste tile and bricks are also producing from demolished wastes from construction.

Indian tiles production is 100 million ton per year in the ceramic industry and over 250 billion bricks are produced annually in India, about 15% to 30% waste material generated from the total production. This waste is not recycled in any form at present. There are some researches 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.

1.5 Tile and Brick Aggregate Concrete:

Crushed tiles and bricks are replaced in place of coarse aggregate by the percentage of 0%, 25% and 50%. For analyzing the suitability of these crushed waste tiles and bricks 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 14 days curing periods by casting cubes to analyze the strength variation by different percentage of this waste materials. This present study is to understand the behavior and performance of solid waste in concrete. The waste crushed tiles as well as crushed bricks are used to partially replace coarse aggregate by 0%, 25% and 50%.

1.5.1 Environmental and Economic Benefits of Tile and Brick Aggregate Concrete:

The usage of tile and brick aggregate as replacement to coarse aggregate in concrete has the benefits in the aspects of cost and reduction of pollution from construction industry. The cost of concrete manufacturing will reduce considerably over conventional concrete by including tile aggregate and brick aggregate since it is readily available at very low cost and there-by reducing the construction pollution or effective usage of construction waste.

II.MATERIALS USED

2.1 Materials Used:

In this investigation, the following materials were used:-

a. Ordinary Portland Cement of 53 Grade cement
b. Fine aggregate and coarse aggregate
c. Water.
d. Waste Bricks and tiles

2.1.1 Cement:

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most nonspecialty grout. It developed from other types of hydraulic lime in England in mid 19^{th} century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others. As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28th day shouldn’t be less than 53MPa or 530 kg/cm2. The colour of OPC is grey colour and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also.

Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements.

Sr. No.	Properties	Test Results
1.	Normal Consistency	34%
2.	Initial Setting Time	38 min.
3.	Final Setting Time	370 min.
4.	Specific Gravity	3.14

Table 2.1 : PROPERTIES OF CEMENT

2.1.2 Fine Aggregates:

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or $SiO2$), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence, it is used as fine aggregate in concrete.

River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements. The sand was surface dried before use.

Sr. No.	Description	Test Results
1.	Sand Zone	III
2.	Specific Gravity	2.56
3.	Free Moisture	2%
4.	Fineness Modulus	3.00

Table 2.2: PROPERTIES OF FINE AGGREGATE

2.1.3 Coarse Aggregates:

Crushed aggregates of less than 20mm size bought from local markets were used. The aggregate exclusively passing through 16mm sieve size and retained on 4.75mm sieve is selected. The aggregates were tested for their physical requirements. The individual aggregates were mixed to induce the required combined grading.

Sr. No.	Description	Test Results
1.	Nominal Size Used	16mm
2.	Specific Gravity	2.65
3.	Water Absorption	1%
4.	Dry Rodded Unit Weight	1612 kg/m^3

Table 2.3: PROPERTIES OF COARSE AGGREGATE

2.1.4 Water:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

2.1.5 Ceramic Tile Aggregate:

Broken tiles were collected from the solid waste of ceramic manufacturing unit and from demolished building. The waste tiles were crushed into small pieces manually. The required size of crushed tile aggregate was separated to use them as partial replacement to the natural coarse aggregate. The tile waste which is lesser than 4.75 mm size was neglected. The crushed tile aggregate passing through 16mm sieve and retained on 4.75mm sieve are used. Crushed tiles were partially replaced in place of coarse aggregate by the percentages of 0%, 25% and 50% individually.

2.1.6 Brick Aggregate:

Like ceramic tiles, brick waste is also collected from manufacturing unit and from demolished building. The waste bricks were crushed into small pieces manually. The required size of crushed brick aggregate was separated to use them as partial replacement to the natural coarse aggregate. The brick waste which is lesser than 4.75 mm size was neglected. The crushed brick aggregate passing through 16mm sieve and retained on 4.75mm sieve are used. Crushed bricks were partially replaced in place of coarse aggregate by the percentages of 0%, 25% and 50% individually.

III. MIX PROPRTIONING

In the present investigation M25 grade concrete is used with a constant w/c ratio 0.5. M25 grade concrete and mix designis done as per ACI 211.1-91 with the mix proportional 1:1.85:2.674. Concrete specimens were prepared varying the percentage of replacement of coarse aggregate with waste tiles and bricks by 0%, 25% and 50%.

IV. EXPERIMENTAL INVESTIGATION

4.1 Determination of Workability By Slump-Cone Test:

To find the workability of concrete thoroughly mix cement, sand and coarse aggregate according to designed mix proportions to form a homogenous mix of concrete.

Equipments Required for Concrete Slump Test:- Mould for slump test, non porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end.

1. Clean the internal surface of the mould and apply oil.
2. Place the mould on a smooth horizontal non-porous base plate.
3. Fill the mould with the prepared concrete mix in 3 approximately equal layers.
4. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.
5. Remove the excess concrete and level the surface with a trowel.
6. Clean away the mortar or water leaked out between the mould and the base plate.
7. Raise the mould from the concrete immediately and slowly in vertical direction.
8. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

The test was conducted for fresh concrete prepared before the moulding process. A total of 5 concrete mixes are prepared at different times. Workability Results obtained from slump cone test for M25 grade of concrete is shown in table .

Sr. No.	Mix Code	Aggregate Replacement (C.A.+T.A.+B.A.)	Workability (in mm)
1.	M0	100+0+0	64
2.	M1	75+25+0	69
3.	M2	50+50+0	79
4.	M3	75+0+25	57
5.	M4	50+0+50	51

Table 4.1: Test results from slump cone test for workability in mm

The workability from the slump cone test is in increasing manner as the mix proportion replacement by tiles increasing and decreasing as we replace by bricks. The workability range of concrete increasing as mentioned while being in medium range overall.

4.2 Compressive Strength:

Prepare the concrete in the required proportions and make the specimen by filling the concrete in the desired mould shape of 15cm x 15cm x 15cm cube with proper compaction, after 24 hrs place the specimen in water for curing.

1. Take away the specimen from water when such as natural process time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the closest 0.2m.
3. Clean the bearing surface of the testing machine.
4. Place the specimen within the machine in such a fashion that the load shall be applied to the other sides of the cube forged.
5. Align the specimen centrally on the bottom plate of the machine.
6. Rotate the movable portion gently by hand so it touches the highest surface of the specimen.
7. Apply the load step by step while not shock and incessantly at the speed of 140kg/cm2/minute until the specimen fails.
8. Record the utmost load and note any uncommon options within the form of failure.

COMPRESSIVE STRENGTH = (LOAD / AREA) in N/sq.mm

A total of 15 cubes of size 150 x 150 x 150mm were casted and tested for 14 days testing each of 3 specimens after conducting the workability tests. The results are tabulated below:

Table 4.2 : Test results for Compression test

Sr. No.	Mix Code	Aggregate Replacement	Split Tensile Strength in N/mm^2
1.	M0	100+0+0	3.60
2.	M1	75+25+0	2.17
3.	M2	50+50+0	2.76
4.	M3	75+0+25	2.55
5.	M4	50+0+50	2.62

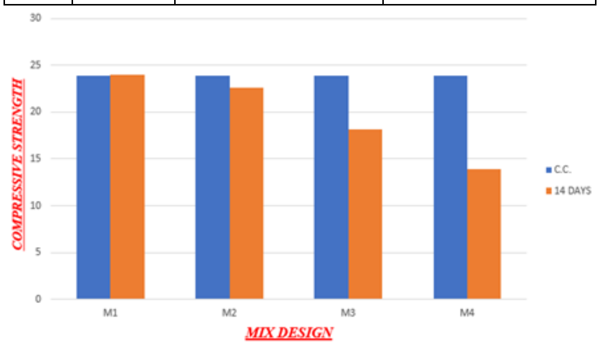

Fig. 4.1 Comparison of Compressive Strength

4.3 Split Tensile Strength:

Prepare the concrete in the required proportions and make the specimen by filling the concrete in the desired mould shape of 10 cm x 30 cm cylinder with proper compaction, after 24 hrs place the specimen in water for curing.

- Take the wet specimen from water when seven days of natural process
- Wipe out water from the surface of specimen
- Draw diametrical lines on the 2 ends of the specimen to make sure that they're on a similar axial place.
- Note the weight and dimension of the specimen.
- Set the compression testing machine for the specified vary.
- Keep are plywood strip on the lower plate and place the specimen.
- Align the specimen so the lines marked on the ends square measure vertical and targeted over very cheap plate.
- Place the other plywood strip above the specimen.
- Bring down the upper plate to touch the plywood strip.
- Apply the load incessantly while not shock at a rate of roughly 14- 21kg/cm2/minute (Which corresponds to a complete load of 9900kg/minute to 14850kg/minute)
- Note the breaking load(P)

The splitting tensile strength is calculated using the formula=2*P/(pi)*L*D

Where, P = applied load

D = diameter of the specimen

L = length of the specimen

The split tensile strength obtained by testing the cylindrical specimen for M25 grade of concrete to all the mixes designed for various replacements are given below:

Sr .No.	Mix Code	Aggregate Replacement (C.A.+T.A.+B.A.)	Compressive Strength of M25 grade in N/mm^2 (14 days)
1.	M0	100+0+0	23.93
2.	M1	75+25+0	23.95
3.	M2	50+50+0	22.56
4.	M3	75+0+25	18.19
5.	M4	50+0+50	13.87

Table 4.3: Split tensile strength results for M25 grade of concrete

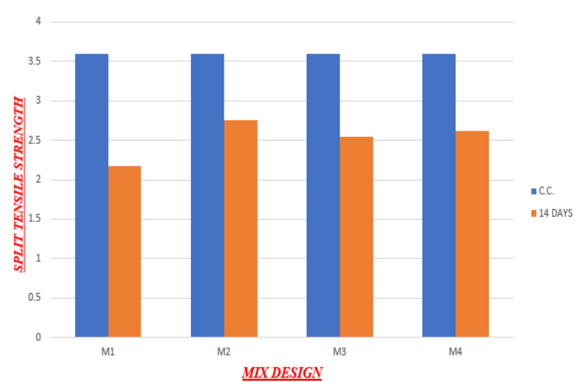

Fig. 4.3 Comparison of Split Tensile Strength at 14 day

4.1.4 Flexural Strength:

The flexural test was conducted for all mixes designed for various replacements. A Total of 5 beams were casted and tested as follows:

S. No.	Mix Code	Aggregate Replacement (C.A.+T.A.+B. A.)	Flexural Strength of M25 grade in N/mm^2 (14 days)
1.	M0	100+0+0	7.88
2.	M1	75+25+0	6.20
3.	M2	50+50+0	5.13
4.	M3	75+0+25	10.12
5.	M4	50+0+50	5.23

Table 4.4 Test results for Flexural Test at 14 days

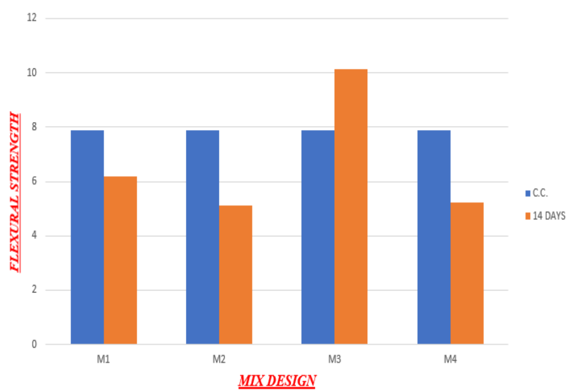

Fig. 4.3 Comparison of Flexural Strength at 14 day

V. CONCLUSION

5.1 General:

The basic objective of the study is to prepare a concrete much more stable and durable than the conventional by replacing coarse aggregates. Mix designs for all the replacements of materials has done and a total of 35 specimens (15 cubes, 15 cylinders, 5 beams) are prepared and tested in the aspect of strength calculation and also comparisons has done.

5.2 Conclusions:

The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength and flexural strength considering the—environmental aspects also:

- The workability of concrete increases with the increase in tile aggregate replacement.
- The workability of concrete decreases with the increase in brick aggregate replacement.
- M1 mix of concrete produced a better concrete in terms of compressive strength than the other mixes. But the mixes up to 50% of tile coarse aggregate can be used.
- The properties of concrete increased linearly with the increase in ceramic tile aggregate up to 25-30% replacement later it is decreased linearly.
- The tile coarse aggregate concrete is also good in flexural and split tensile strength.
- The 25% of replacement of brick aggregate gives an optimum effect on the physical and mechanical properties of concrete.
- The compressive strength of the brick aggregate concrete is decreasing by 24% and 42% for 25% and 50% replacements respectively.
- The compressive strength of the tile aggregate concrete is decreasing by 6% and almost equal for 25% and 50% replacements respectively.
- The higher the percentage of replacement of brick aggregate, the lower the compressive and flexural strength of the concrete. But for replacement of tile aggregate it is is observed that compressive strength is bit higher for 25% replacement. So, we can replace tile aggregate upto 25-30% for same compressive strength as that of conventional concrete.
- So it can be concluded that even though the weight of the concrete is decreasing, but the tile aggregate concrete(25%) has achieved higher strength.
- The Split Tensile strength of the tile aggregate concrete is decreasing by 39% and 23% for 25% and 50% replacements respectively.
- The Split Tensile strength of the brick aggregate concrete is decreasing by 29% and 27% for 25% and 50% replacements respectively.
- The flexural strength of the tile aggregate concrete is decreasing by 21% and 35% for 25% and 50% replacements respectively.
- The flexural strength of the brick aggregate concrete is increasing by 28% and decreasing by 33% for 25% and 50% replacements respectively.
- Flexural Strength for 25% replacement with brick aggregate
- The fewest cracking produce on concrete for tile aggregate concrete with 25% of replacement of NCA. With the small cracking produce, it shows that the concrete is in high density and compressive strength.

- Since the compressive strength of 25% replaced brick aggregate concrete is 24% less, So we can decrease the percentage of brick about 5-10% and we may get good strength.

VI. FUTURE SCOPE OF WORK

There is a vast scope of research in the waste tile and brick aggregate usage in concrete especially ceramic tile wastes in the future. The possible research investigations that can be done are mentioned below:

- The usage of brick and tile powder can be studied as replacement of fine aggregate to improve the workability of concrete and the strength parameters can also be studied at various percentages.
- A combination of different tiles (based on their usage) in different proportions in concrete and their effects on concrete properties like strength, workability etc can be determined.
- A study on properties of concrete made with combination of recycled aggregate and tile/brick aggregate in different proportions can be investigated to enhance the concrete properties and also to reduce the pollution or waste generation from construction industry.

REFERENCES

[1] ACI 211.1-91 for Mix Design
[2] Ilya Joohari, Nor Farhani Ishak, and Norliyati Mohd Amin, January 2018 E3S Web of Conferences 34:01029
[3] Salahaldein Alsadey, International Journal of Advances in Mechanical and Civil Engineering, ISSN: 2394-2827 Volume-6, Issue-3, Jun.-2019
[4] Rekha Kasi, Potharaju Malasani, International Journal of Engineering and Technology
[5] Ahmed Tareq Noaman, Ghassan Subhi Jameel, Shamil K Ahmed, Journal of King Saud University – Engineering Sciences
[6] Aruna D, Rajendra Prabhu, Subhash C Yaragal, Katta Venkataramana IJRET:eISSN: 2319-1163 | pISSN: 2321-7308.
[7] Batriti Monhun R. Marwein, M. Sneha, I. Bharathidasan International Journal of Scientific & Engineering Research, Volume 7, Issue 4, April-2016 ISSN 2229-5518.
[8] Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 31, No. B5, pp 561-565 Printed in The Islamic Republic of Iran, 2007
[9] Department of Engineering and Agricultural Sciences, University of Leon, Avenida Portugal 41, Leon 24071, Spain.
[10] International Journal of Innovative Research in Science, Engineering and Technology ISSN(Online): 2319-8753 ISSN (Print): 2347-6710.
[11] N.Naveen Prasad, P.Hanitha, N.C.Anil IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 13, Issue 6 Ver. V (Nov. - Dec. 2016), PP 168-176.