Use of Waste Ceramic Tile Aggregates as an Alternative Material of Coarse Aggregates in Cement Concrete

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Abstract - **Now a days, Climate change is major international issue. It is the time when governments and consumers have to respond through more environment friendly products and policies. Demand of construction material is increasing day by day and due to which degradation of environment occurs. It is a prime time to explore alternative sustainable construction material from industrial as well as domestic waste. The utilization of waste materials such as slag, fly ash, glass, plastic etc. in concrete manufacturing is significant due to its engineering, environmental, ecological and economic benefits. Thus to achieve the goal of sustainable construction utilization of waste material in concrete is very much helpful. So, this study intends to use of waste ceramic tile aggregates as an alternative material of coarse aggregates in concrete production. In this study, reports are prepared on the basis of performance of three different concrete mixes having different ratio of waste tile aggregates as an alternative material of coarse aggregates. Tests for compressive strength of specimen were carried out at different ages of concrete. From different test results, we concluded that in M-20 and M-25 mixes up to 20% replacement of normal 20 mm coarse aggregate with waste ceramic tile aggregates, there is no significant effect on compressive strength of concrete except M-30 mix. But beyond 20% replacement, compressive strength of cubes started decreasing gradually with increase in the ratio of waste ceramic tile aggregates in concrete.**

Keywords: Environment friendly, compressive strength, waste ceramic tile aggregates

I. INTRODUCTION

In concrete production, a large amount of natural aggregates, water and sand are being consumed. Consequently to minimize the use of natural aggregates researchers have concentrated on the use of various waste materials as alternatives in construction industry, especially in concrete construction. One of the prime research interests is utilization of waste material like slag, fly ash, plastics etc. in concrete construction to achieve the goal of sustainable development (construction). Aggregates consist of 70% to 75% of volume of concrete. So reduce the consumption of natural aggregates, waste ceramic tile or broken tiles as coarse aggregates can be a new scientific sobriety in the field of sustainable concrete. A huge amount of tiles get broken in the tile industries and construction projects. The residual and unused wastes are disposed off into the environment without any commercial return.

Large amount of money is spent for their disposal as well as environmental pollution occurs. Addition of waste material in concrete reduces the cost of construction and more or less maintains the properties of concrete. When we add waste material properly processed, it is effective as construction material and meet the design specifications.

The study focuses on producing concrete of acceptable strength with ceramic tile waste as an alternative material for coarse aggregates and determining the mix ratio of coarse aggregates to achieve the required strength.

II. MAIN OBJECTIVE OF STUDY

- Utilization of waste material properly to provide safeguard to environment
- To strength of concrete by use of waste ceramic tiles as an alternative material of coarse aggregate
- To reduce the waste from the environment
- To find an alternative of aggregates to achieve the sustainable development.
- To reduce the overall environmental effects of concrete production using waste tiles material as partial replacement.

III. LITERATURE REVIEW

Marcio performed experiments on water absorption, modulus of elasticity and compressed stress on the concrete which is made up of ceramic tile aggregates. In concrete casting crushed ceramic blocks were used as coarse aggregates. For 0 to 100 percent replacement specific density of aggregates changes from 2630 to 2310 kg/m^3.When replacement upto 20 percent compression resistance and young's modulus of elasticity was same as the conventional concrete.

Senthamarai concluded that based on strength of ceramic waste aggregates, it can be used effectively as a coarse aggregates in concrete. The crushing value, impact value, abrasion value for natural coarse aggregates 24, 17 and 20

percent correspondingly for ceramic scrap 27, 21 and 28 percent respectively. Ceramic waste tiles do not have much variation with respect to the natural aggregates.
Paulo cachim experimented on use of waste ceramic tile aggregates, collected from ceramic industrial waste from different sources water absorption was 15.81 and 18.91 percent respectively. The more value of water absorption influenced the workability of concrete. In first 2 minutes 75 percent of total absorption takes place and after 5 minutes at least 91 percent of the total absorption occurred.

Medina et al concluded that use of ceramic tile wastes with 4 mm and lower size as fine aggregates in concrete and density of concrete was 2.41 g/cm^3 and compressive strength and split tensile strength were increased due to lower fraction of ceramic waste usage in to the concrete composition.

Pinchatorkittikul and arnonchaipanich experimented that use of ceramic waste as fine aggregates in concrete composition and concluded that the density of concrete casted with 100 percent ceramic waste aggregates was 2.31 g/cm^3 which is 0.07 g/cm^3 lower than with respect to conventional controlled 28 days concrete due to low specific gravity and density of ceramic waste aggregates.
Veerareddy reported on ceramic waste's crushing value and impact value is 24.7 percent and 18.2 respectively. These values were within the permissible limit as per IS 383-1970 code, hence it was safe to use of ceramic tile waste as an alternative material to coarse aggregates.

Correia et al. reported that the recycled aggregates have more water absorption due to higher porosity of recycled aggregated. Due to which there is a need of additional water quantity to make concrete with proper workability. Correiain his previous study of 2006 reported that the abrasion resistance of ceramic aggregates concrete showed even better than the reference concrete in their experimentation work.

Sekar concluded that specific gravity of ceramic coarse aggregates varied between 2.2 and 2.56. These values were effected the density of ceramic aggregate concrete.

Pancheco-Torgail and said jalali experimented the strength and durability of ceramic tile waste concrete as compared to natural aggregate ceramic aggregates have higher value of water absorption.

Medina concluded on utilization of ceramic tile waste as an alternative material of coarse aggregates. It was produced by crushing of sanitary ware and shape curve is same as that of natural aggregates. Irregular shape provided that superior surface area and better bonding was observed in experimentation.

IV. EXPERIMENTAL PROGRAM

Three concrete mix designs M20, M25 and M30 has chosen to carry out the experiments for compressive strength of concrete after replacing the natural coarse aggregates with waste ceramic tile aggregates in proportions of 0%, 5%, 10% and 20%.

Only limited use of tile aggregate in concrete is possible because of tile aggregates are totally flaky in shape. If we used tile aggregates in excess then it will lead to poor strength because of flaky aggregates that tend to brake under pressure.

- Total number of concrete mix designs prepared – 3
- Number of proportions in which tile aggregates eplaced with normal aggregates in each design – 4 (i.e. 0%, 5%, 10% & 20%)
- Therefore, total concrete batches prepared – 12
- Number of concrete batches prepared in a day – 1
- Number of cubes filled in each batch – 6
- Number of cubes casted for each mix design – 24
  i.e.
  For M 20 – 24 cubes
  For M 25 – 24 cubes
  For M 30 – 24 cubes
- Total number of cubes casted including all 3 concrete mix designs – 24+24+24 = 72

TABLE –Material Test Result

Sr. No.	Test	Results
1	Specific Gravity Of Cement	2.74
2	Specific gravity of Coarse Aggregates	2.69
3	Specific gravity of Fine Aggregates	2.70
4	Fineness Modulus of Fine Aggregates	2.17
5	Specific Gravity of Tile Aggregates	2.24
6	Water Absorption of Tile Aggregates	14.8%
7	Impact Value of Tile Aggregates	20%

Table - Comparison of Properties Of Tile Aggregates And Normal Aggregates

Sr. No.	Properties	Normal aggregate	Tile aggregate
1	Shape	Angular	Flaky
2	Texture	Rough	All sides rough except top
3	Water absorption	0.5%	14.8%
4	Impact value	15%	20%
5	Specific gravity	2.69	2.24

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RATIOS USED FOR EXPERIMENT

M-20

Cement	Fine Aggregates	Coarse Aggregates	Water
1	2.9	3.40	0.55

M-25

Cement	Fine Aggregates	Coarse Aggregates	Water
1	1.87	3.04	0.50

M-30

Cement	Fine Aggregates	Coarse Aggregates	Water
1	1.64	2.67	0.45

COMPARISON OF CONCRETE RESULTS

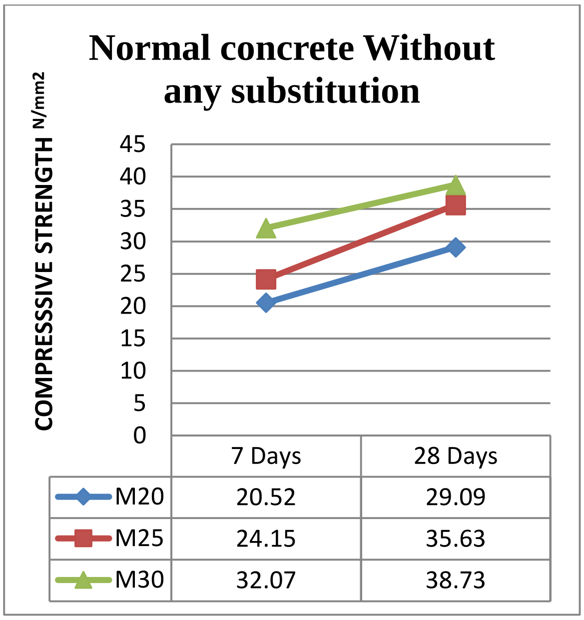

Figure – Different concrete grades without any aggregate replacement and their respective compressive strength at 7 & 28 days.

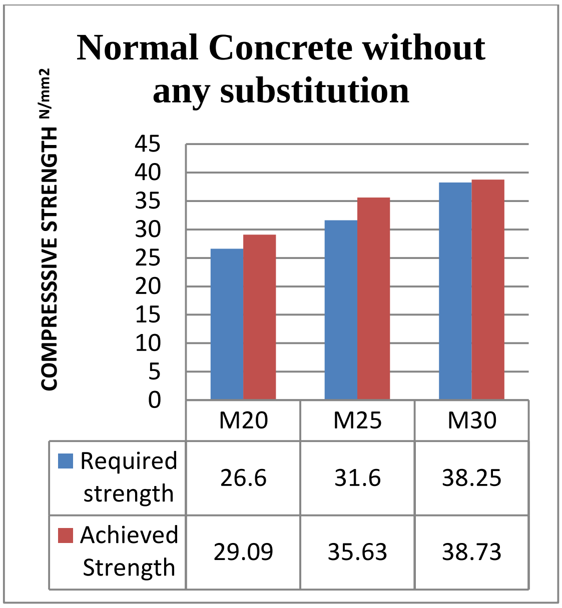

Figure – Different Concrete Grade represents their obtained compressive strength against their required Target Mean Strength.

- All three grades shows higher strength than required target mean strength, hence all concrete grades are accepted.

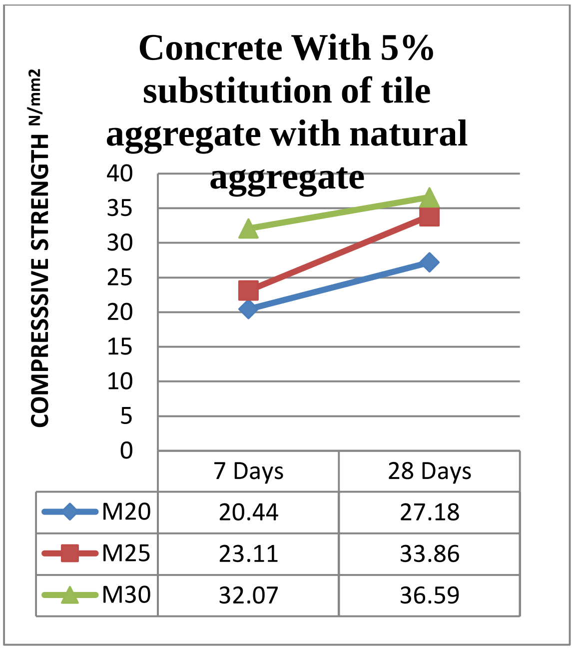

Figure - Different concrete grades with 5% replacement of natural aggregate with tile aggregate and their respective compressive strength at 7 & 28 days.

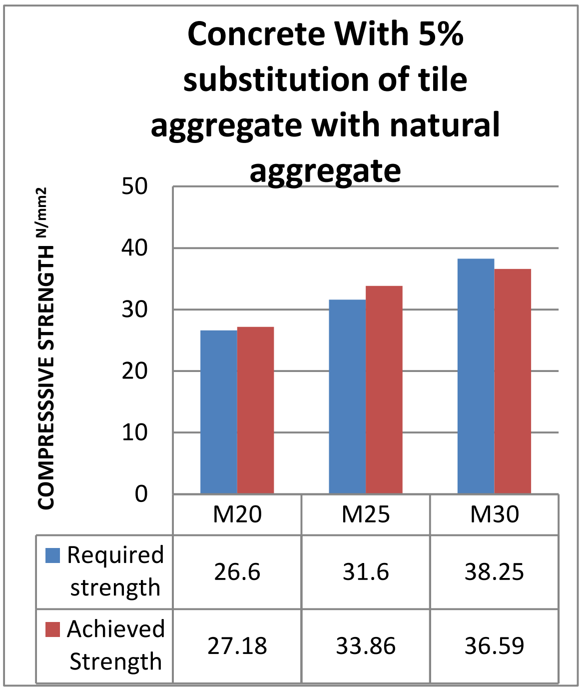

Figure – Different Concrete Grade With 5% Replacement Of Natural Aggregates With Tile Aggregates Represents Their Obtained Compressive Strength Against Their Required Target Mean Strength.

In this case also all concrete grades except M-30 show higher strength than required. M-20 and M-25 are accepted.

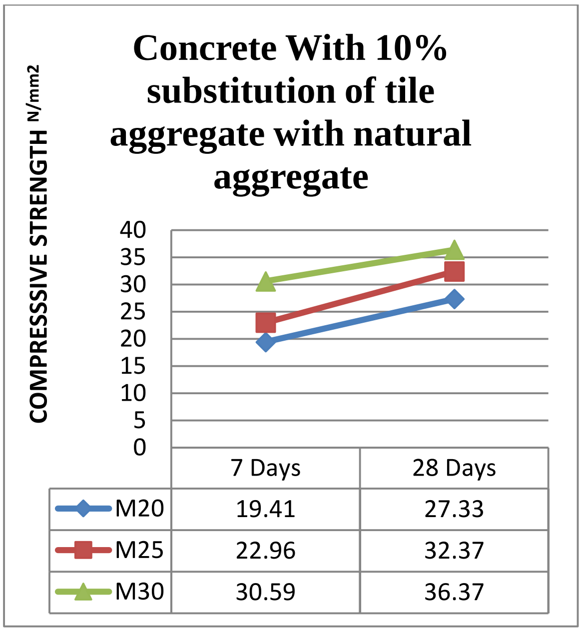

Figure - Different concrete grades with 10% replacement of natural aggregate with tile aggregate and their respective compressive strength at 7 & 28 days.

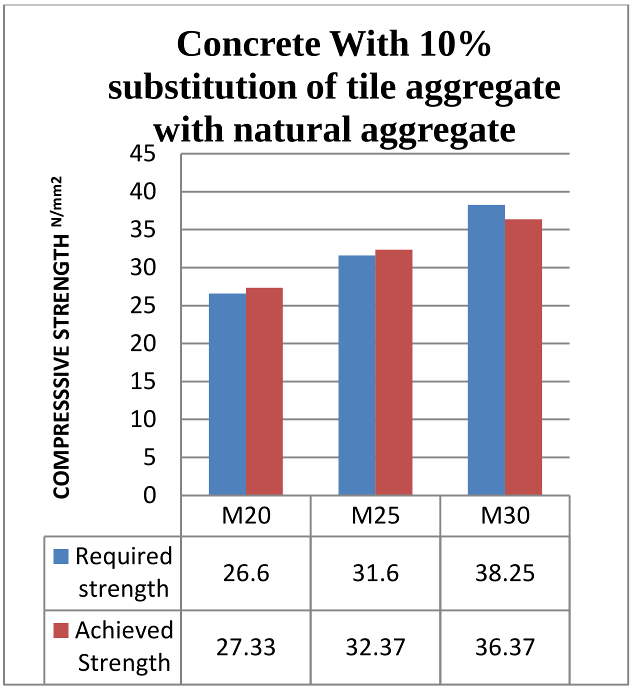

Figure - Different Concrete Grade With 10% Replacement Of Natural Aggregates With Tile Aggregates Represents Their Obtained Compressive Strength Against Their Required Target Mean Strength

Similarly, in this case all grade concrete possess higher strength than required except M-30 and are accepted.

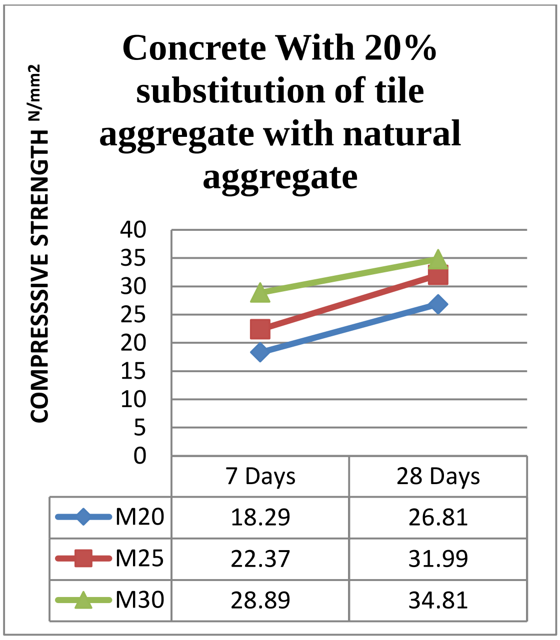

Figure Different concrete grades with 20% replacement of natural aggregate with tile aggregate and their respective compressive strength at 7 & 28 days.

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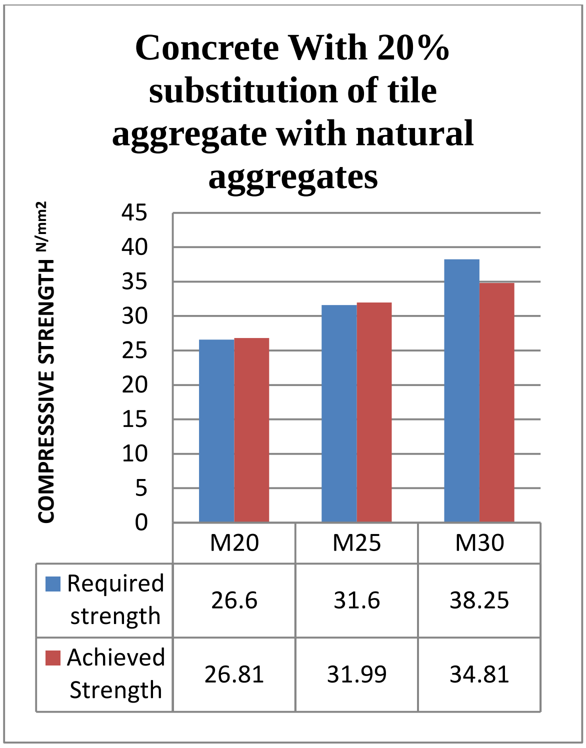

Figure - Different Concrete Grade with 20% replacement of natural aggregates with tile aggregates represents their obtained compressive strength against their Required Target Mean Strength

Here, M 20 & M 25 show acceptable strength but M 30 has lower strength than required. So, M 30 is rejected

Cost Analysis

Total cost of 20 mm aggregates to prepare 1 m^3 M 20 grade concrete –

Total volume of aggregates in M 20 concrete = 0.691 m^3

Total volume of coarse aggregates = 62 % of 0.691

Therefore, 62% of 0.691 = 0.428 (10 mm + 20 mm both)

Volume of 20 mm aggregates in total coarse aggregates = 40%

40% of 0.428 = 0.171 m^3

Now,Price of 1 m^3 of 20 mm natural aggregates = Rs. 1175 (as per CPWD rate analysis 2014)

Price of 0.171 m^3 20 mm natural aggregates

= 1175 × 0.171 = Rs. **200**

Now, Total saving by substituting natural aggregate with tile aggregate in M 20 concrete

Volume of 20 mm aggregates after 20 % replacement with tile aggregates

= 20/100 × 0.171 = 0.0342 m^3

= 0.171 – 0.0342 = 0.1368 m^3

Price of 0.1368 m^3 of aggregates = Rs.162

Total saving on 1m^3 M 20 grade concrete by replacing 20% tile aggregates with normal aggregates = 200 – 162 = Rs. **32**

Hence, total saving on aggregates in terms of rupees to produce 1 m^3 of M 20 grade concrete by using tile aggregates = **16%** (Without including labor and transportation charges)

V. CONCLUSION

Research on the usage of waste construction materials is very important due to the material waste is gradually increasing with the increase in population and increasing of urban development. The reasons that many investigations and analysis had been made on ceramic tile aggregate are because tile aggregates are easy to obtain and their cost is cheaper than the natural aggregates. For natural aggregates mining is needed but tile aggregate can ignore this process.

1. Based upon its properties ceramic tile aggregates are appropriate concrete material which is used as an alternative material to coarse aggregates in concrete.
2. Water absorption, impact value and crushing value are higher than the natural aggregates and specific gravity is lower than natural aggregates.
3. In M20 grade concrete it is possible to replace the 20 percent of normal 20 mm aggregates with waste ceramic tile aggregates.
4. In M30 grade concrete it is not possible even 5 percent replacement of normal 20 mm aggregates with waste ceramic tile aggregates because of less target strength. So it should be avoided.
5. For all concrete mixes as the proportion of tile aggregated increases the strength of concrete decreases gradually which is due to low specific gravity and higher porosity.
6. Use of tile aggregates is more economical than the conventional concrete. 16 percent money can be saved on total amount.

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