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Experimental Investigation on Partial Replacement of Aggregates in Concrete using Ceramic and Tyre Wastes

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Abstract:- At present, the use of waste materials in concrete is an efficient way of managing the non-degradable wastes. Also, the increase in demand of aggregates leads to the replacement of aggregates with waste materials. This paper focuses on replacement of fine aggregate and coarse aggregate partially with ceramic waste and crumb rubber. In this study, the fine aggregate in concrete is replaced with crumb rubber of about 0%, 5%, 10% and 15% and the coarse aggregate is replaced with ceramic tile wastes of about 0%, 5%, 10% and 15%. This paper represents a detailed experimental study on the strength of concrete in terms of compression, split tension and flexure at the age of 7, 14 and 28 days. The mechanical properties of the concrete determined shows better strength in comparison with the conventional concrete. The results concluded that the percentage increase of tile increases the strength of concrete whereas the percentage increase of rubber decreases the strength of concrete.

Keywords:- *crumb rubber; ceramic tile; compressive strength; split tensile strength; flexural strength.*

I. INTRODUCTION

In recent days, the scarcity and the availability of sand and aggregates at reasonable rates are giving anxiety to the construction industry. Because of the increase in requirements of aggregates, the construction industries started utilizing the non-degradable wastes as its disposal is one of the major issues facing the environment. In these wastes, the 'ceramic tile wastes' and 'tyre wastes' are considered as the critical wastes due to the day-by-day increase in production and disposal. The tyres which are burnt and dumped on the land create some problems such as land filling, health issues and environmental hazards. At present, it is estimated that 27% of waste tyres are sent to land fill. Also, it is estimated that 30% of day by day production in ceramic industry goes as waste. The discarding of ceramic waste leads to serious ecological pollution. As the ceramic wastes are increasing every day, it is necessary for the ceramic industries to find a way out for its removal. The utilization of replacement materials in concrete offers cost lessening, power savings and less hazards to the environment.

In automobile industries, all the small vehicles such as cycle to heavy vehicles such as trucks use tyres as a major part in the vehicle. The different types and quality of tyres are used for different type of vehicles. When the tyre is used to an extent, it loses its strength and gets weaker which are then replaced by new ones. Thus, the old used tyres are thrown into waste and it takes many years for a tyre to degrade. Till then, these tyres cause a lot of problems to the environment. These problems are listed below:

- Tyres are the breeding ground for the mosquitoes which leads to various diseases.
- Dumped tyres can catch up fire and produces acid smoke which are harmful to humans. These fires cannot be extinguished easily and some instances be on fire for a number of weeks.
- Tyres take up landfill gap and it also lead to illicit dumping. This causes the reduction of home values as the tyres are typically dumped near low income areas.
- In some occasions the dumping of tyres in huge piles can fall over the workers in the site and leads to the death of the workers.

II. NEED FOR THE STUDY

One of the major problems in construction industry is in demand of raw materials mainly aggregates. This is due to the world wide increase in construction rates. To overcome the demands, there is an urge in developing new ideas. Recently, there is an extensive investigation in replacing the aggregates with waste materials which is also proved to be effective. Early studies shows that the replacement of waste tyre with aggregates gives better tensile strength, increases the durability and also has the ductile property. Also, in road applications rubberized asphalt had increased durability and longer pavement life than conventional asphalt. In accordance with the early studies, there is a possibility to incorporate the waste tyre in concrete. As the concrete is used worldwide for the construction purpose, the partial replacement of fine aggregates by waste tyre would consume at least 50% of the waste tyre

rubber going for land fill. Also, some studies revealed that the partial replacement of waste tyre rubber with aggregates reduces the strength of concrete in terms of compression.

To overcome the loss in compressive strength, silica fumes, ceramic tiles and fibres can be used along with the waste tyre replaced concrete. When ceramic tile is used along with concrete, it improves the strength on compression of the concrete. To attain better strength properties in concrete, waste tyre rubber and ceramic tile waste can be used together by partially replacing the aggregates.

The study investigates the properties of concrete by replacing the fine aggregates partly with crumb rubber and partially replacing the coarse aggregate by waste tiles

III. SCOPE AND OBJECTIVES OF THE STUDY

- To investigate the feasibility of incorporating waste tyre rubber and ceramic tile waste as a partial replacement for natural aggregates.
- To study the outcome of crumb rubber and tile wastes on partial replacement of fine aggregate and coarse aggregate on strength improvement of concrete.
- To find out an optimum replacement percentage of crumb rubber and waste tile in concrete.

IV. MATERIAL PROPERTIES

A. Cement

Ordinary Portland Cement of 53 grade is used. The physical properties of cement obtained are: Fineness - 9.3%, initial and final setting time - 40 & 550 minutes, Specific gravity - 3.12, Consistency - 34%.

B. Water

Canned mineral water is used for casting the specimens. The water is visibly pure. It has no colour, and it is free from any odour.

C. Fine Aggregate(FA)

Due to the demand in availability of river sand, M-Sand is used as FA which is partly replaced with Tyre crumb rubber. S.G and fineness modulus of M-Sand is 2.67 & 2.82 respectively. Specific Gravity and water absorption of crumb rubber is 1.52 & 0.31%.

D. Coarse Aggregate

The coarse aggregate of size 12.5 mm retained is taken for casting the specimen. The coarse aggregate is partly replaced with ceramic tile waste. S.G & fineness modulus of coarse aggregate is 2.74 & 3.697 respectively. S.G of tile - 2.89, water absorption- 1.71%, crushing strength of tile- 25.8.

Fig 1:- Ceramic waste tiles

Fig 2:- Tyre crumb rubber

V. EXPERIMENTAL WORK

The mix proportions for aggregate replaced concrete with various percentages are listed below:

Mix proportion	Percentage of rubber (%)	Percentage of tile (%)
Mix 0	-	-
Mix 1	5	5
Mix 2	5	10
Mix 3	5	15
Mix 4	10	5
Mix 5	10	10
Mix 6	10	15
Mix 7	15	5
Mix 8	15	10
Mix 9	15	15

Table.1 Mix proportion for aggregate replaced concrete

A. Casting

The concrete cubes of size 150x150x150mm are casted to find the strength of concrete under compression. The cylinders of size 300x150mm are casted to find the strength of concrete under split tension. The beam of size 500x100x100mm is casted to find the strength of concrete on flexure.

B. Curing

The period of curing depends upon the type of cement, mix percentage, size and shape, weather and contact conditions and also the process of curing. As all the properties of concrete are enhanced with curing, the time period should be as long as possible. In general, 70% of the specified strength is attained in a minimum of 7days at a temperature above 5°C. The curing period can be reduced to 3days for early high strength if the temperature is above 10°C. The proper curing of concrete improves the strength, decreases the permeability. Be concerned about the overheating or freezing due to the setting of cement. The inappropriate curing leads to scaling, reduced strength, lack of resistance and cracking.

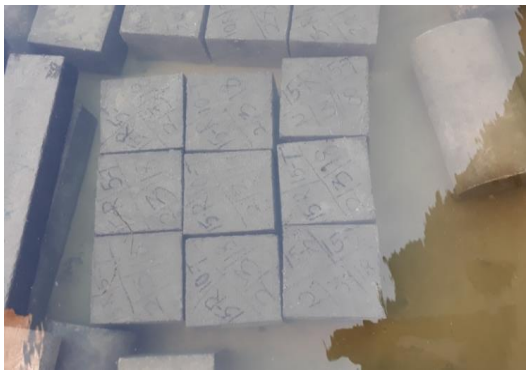

Fig 3:- Curing of Specimens

VI. RESULTS AND DISCUSSIONS

The mechanical properties such as compression, split tension and flexure tests were conducted on the casted specimens of varied mix proportions. The test results were plotted in the graph which is shown in the fig. 4 - 12.

A. Test on Compression

The strength of concrete in terms of compression increases on mix 3 and mix 2 and highly decreases on mix 8 and mix 9 at the age of 28 days. The percentage replacement of tile in concrete attains more compressive strength when compared to the percentage replacement of rubber.

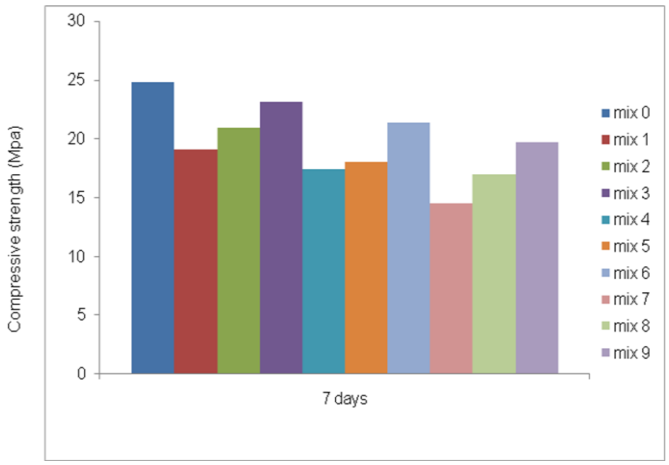

Fig 4:- Compressive strength at 7days

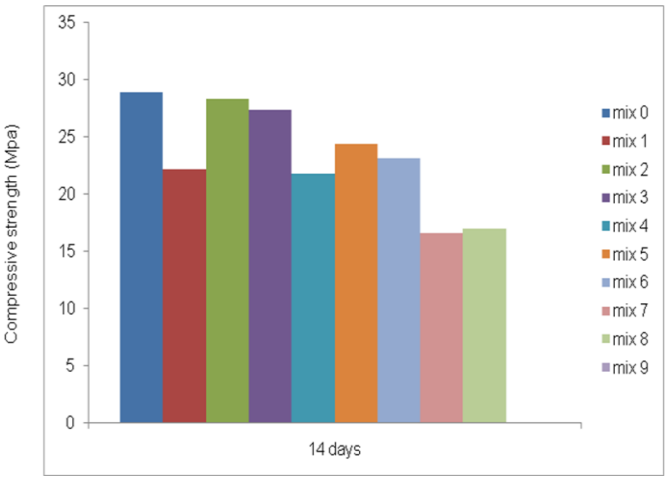

Fig 5:- Compressive strength at 14days

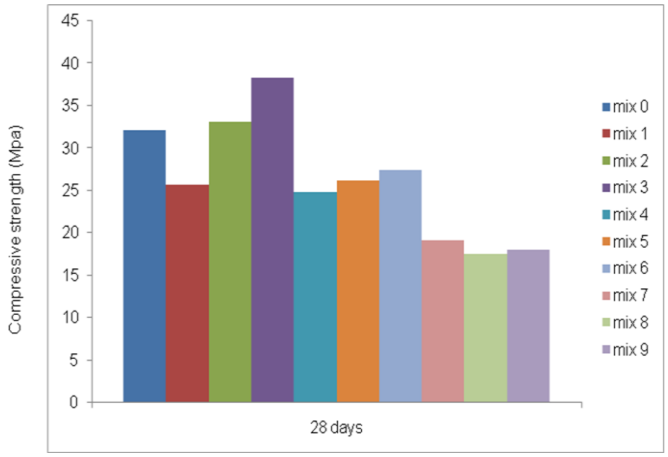

Fig 6:- Compressive strength at 28days

B. Test on split tension

The strength of concrete in terms of split tension increases on mix 2, mix 3 and mix 6 at the age of 7, 14 and 28 days. The increase in percentage of tile and the decrease in percentage of rubber increase the split tensile strength.

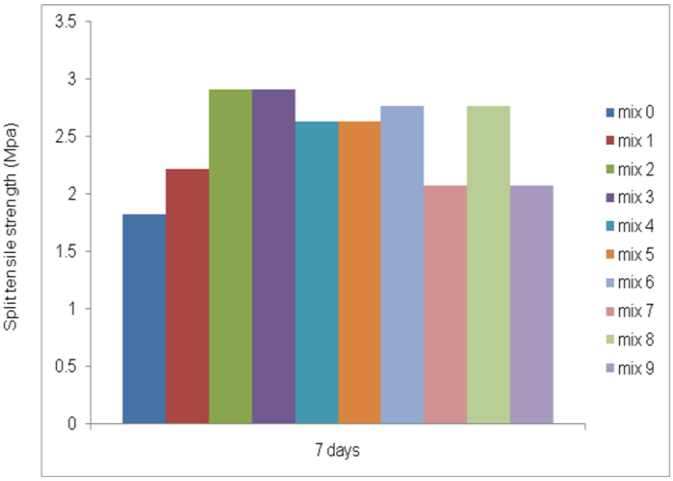

Fig 7:- Split tensile strength at 7days

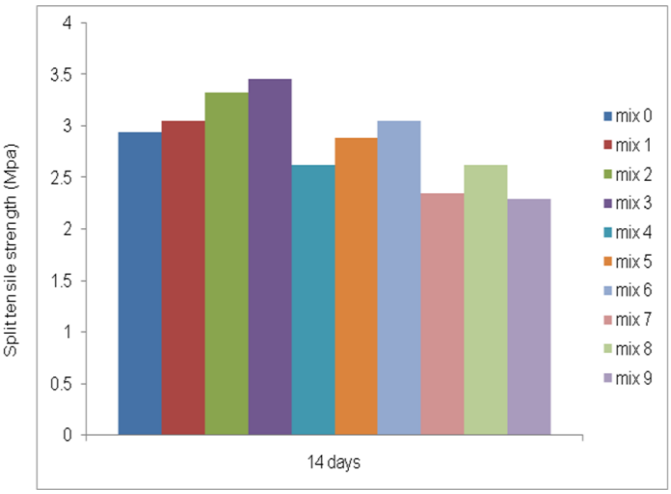

Fig 8:- Split tensile strength at 14days

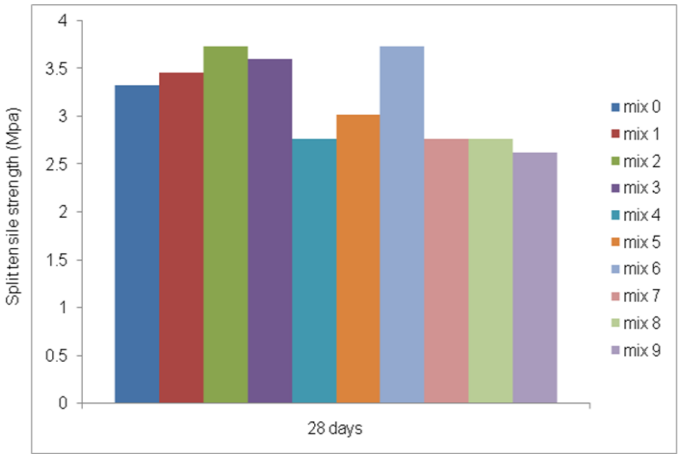

Fig 9:- Split tensile strength at 28 days

C. *Test on Flexure*

The flexural strength of concrete increases on mix 2 and mix 3 at the age of 7, 14 and 28 days. This shows the increase in percentage of rubber and the decrease in percentage of tile increases the strength of concrete.

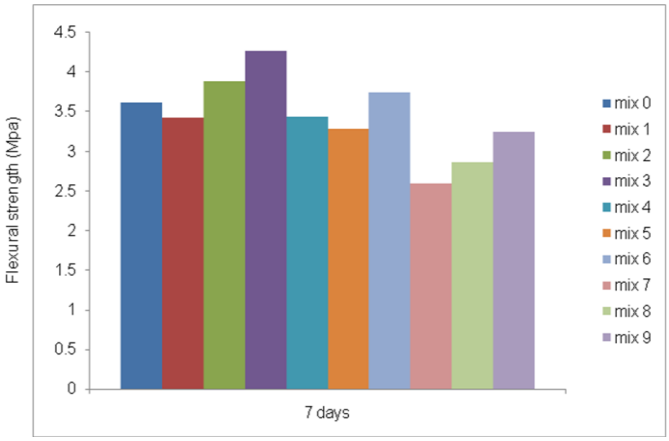

Fig 10:- Flexural strength at 7days

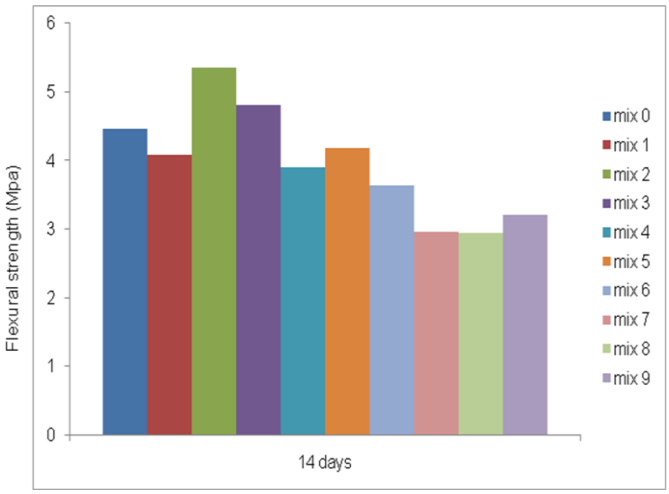

Fig 11:- Flexural strength at 14days

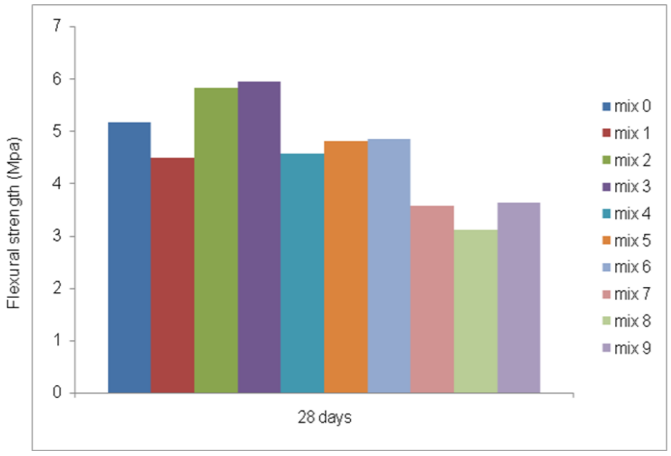

Fig 12:- Flexural strength at 28 days

D. *Comparison of Conventional concrete and Replaced Aggregate Concrete*

Based on the compression, split tension and the flexural tests carried out, the concrete replaced with 5% rubber with 10% and 15% tile attained better strength compared with the other mix proportions.

The fig.13 shows the comparison of conventional concrete with the replacement of 5% rubber with 10% and 15% tile.

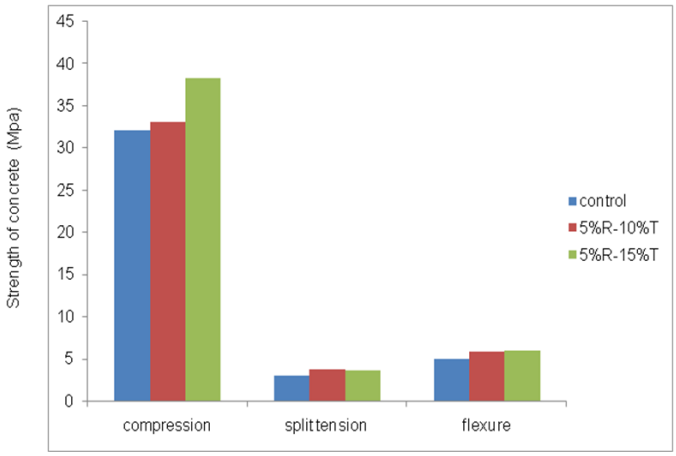

Fig 13:- Comparison of control concrete Vs 5%rubber-10%tile and 5%rubber-15%tile

VII. CONCLUSION

- Replacement of 5% rubber with 10% and 15% tile increases the mechanical properties of concrete compared to the control concrete.
- The optimum percentage replacement in concrete is 5% rubber with 15% of tile attains 20% increase in strength at compression.
- The split tension strength of the concrete replaced with 5% rubber and 15% tile shows an increase in strength of 9% than the control concrete.

- The flexural strength also increases to a maximum of 15% than the control concrete for an optimum replacement percentage of 5% rubber and 15% tile.
- The percentage increase of tile in concrete increases its strength whereas the percentage increase of rubber in concrete decreases its strength.
- From this study, it is inferred that a maximum of 5% rubber and a minimum of 15% tile can be used in concrete as a construction material for maintaining environmental sustainability.

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