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Replacement of Fine Aggregate by Crumb Rubber and Plastic Fines

Aravind S
M Tech student, Civil Department
Ilahia College of Engineering & Technology
Kerala , India

Dr. Elson John
Asst.Professor, Civil Department
Mar Athanasius College of Engineering
Kerala, India

***Abstract*— Waste tyre and plastic management is a serious global concern. Dumping or disposal of these waste products causes environmental and health issues. This project investigates wide range of physical and mechanical properties of concrete containing recycled tyre and plastic aggregates. Waste tyre and plastics are crushed into fine particles of various sizes and are used to replace fine aggregate in concrete. Fine scrap tyre and plastic aggregates are added as 5%, 10%, 15% increment to replace fine aggregate, this study aims to investigate the optimal use of these wastes as fine aggregate in concrete composite. Compressive strength, split tensile strength, flexural strength of different mixes of concrete added with these wastes were found.**

Keywords*— Crumb Rubber,Plastic Fines,Compressive Strength,Split Tensile Strength,Flexural Strength.

I. INTRODUCTION

Scrap tires of various automobiles are continuously accumulated in the landfills all over the world. After the service life of truck and car tyres is over their storage and disposal becomes a challenging problem for the municipal authorities. The municipal authorities in many countries have already banned dumping of waste tires into the landfills due to the above-mentioned problems hence their disposal needs a viable and environmental friendly solution. Different methods have been adopted for the disposal of scrap tyres. They include use of tyres as fuel, ground rubber applications for play-ground or sports surfacing or use in new rubber products and use in asphalt rubber modified concrete. Some of the other civil engineering applications include road and landfill construction, septic tank construction etc. Remaining tyres are disposed of into the landfills. Use of waste tyre rubber particle in concrete can give an efficient way of utilizing rubber and by using rubber in concrete gives better environmental benefits. The waste tire rubber provides a concrete with good engineering properties by partial replacement of waste tyre crumb rubber particle to the fine aggregate in concrete. Plastic waste constitute 12.3 % of the total waste produced. Each of these waste products has provided a specific effect on the properties of fresh and hardened concrete. The use of waste products in concrete not only makes it economical, but also helps in reducing disposal problems. Reuse of bulky wastes is considered the best environmental alternative for solving the problem of disposal. Hence an attempt has been made for replacements of fine aggregate in concrete by plastic wastes reduce the quantity of river sand used and environmental benefits. Besides, it will also have an effect on decreasing concrete costs of cement representing more than 27% of the concrete cost.

II. MATERIALS

A. Cement

Ordinary Portland cement of grade 53 is used in the current study. The properties of cement were tabulated in table 1.

TABLE I. PROPERTIES OF CEMENT

Sl.No	**Properties**	**Magnitude**
1	Specific gravity	3.07
2	Standard consistency	35%
3	Initial setting time	75 minutes
4	Final setting time	310 minutes

B. Fine Aggregate

In the current study, M sand is used as fine aggregate. The properties of fine aggregate are shown in Table II.

TABLE II. PROPERTIES OF FINE AGGREGATE

Sl.No	Properties	Magnitude
1	Specific gravity	2.56
2	Bulk density, kg/m^3	1830
3	Porosity,%	29.67
5	Grading zone	Zone II
6	Fineness modulus	3.13
7	Water absorption	10%

C. Coarse Aggregate

The properties of coarse aggregate are shown in Table III.

TABLE III. COARSE AGGREGATE

Sl No	Properties	Natural Coarse Aggregate	Natural Coarse Aggregate
1	Particle shape	Angular	Angular
2	Particle size	20mm	12 mm
3	Specific gravity	2.75	2.625
4	Bulk density	1340 kg / m^3	1327 kg/ m^3
5	Water absorption	0.5 %	0.6%

D. Crumb Rubber

Crumb rubber is obtained as the waste product from the scrap tyres. The properties of fine aggregate are shown in Table IV.

TABLE IV. PROPERTIES OF CRUMB RUBBER

Sl No	Properties	Crumb rubber
1	Specific gravity	1.16
2	Bulk density	493.165 kg / m^3
3	Percentage of voids	57.5 %
4	Fineness modulus	7.77

Fig I. Crumb rubber

E. Plastic Fines

The crushed plastic powder is used in the experiment. The properties of fine aggregate are shown in Table V.

TABLE V. PROPERTIES OF PLASTIC AGGREGATE

Sl No	Properties	Plastic fine
1	Specific gravity	0.934
2	Bulk density	608.358 kg / m^3
3	Percentage of voids	34.9 %
4	Fineness modulus	4.925

Fig II. Plastic Fines

III. MIX PROPORTIONING

The process of selection of materials and their required proportions is known as mix design. M_{25} grade concrete is used in this study. Mix design is done according to the relevant IS specifications. Proportion of different materials for 1 m^3 of standard concrete mix is given in Table VII.

TABLE VI. IS METHOD OF DESIGN FOR M_{25} CONCRETE

Cement	**Water**	**Fine Aggregate**	**Coarse Aggregate**
413.3	186	707.2	1122
1	0.45	1.72	2.72

We have a total of 10 mixes of concrete with different proportion of crumb rubber aggregate and plastic fines (0%, 5%, 10%, and 15%) separate mixes and also combination mixes on which the experimental investigation is carried out.

- STD – OPC + FA + CA
- CR5 – OPC + CA +5% CR +95% FA
- CR10 – OPC + CA + 10% CR +90% FA
- CR15 – OPC + CA +15% CR +85% FA
- PF5 – OPC + CA + 5% PF +95 % FA
- PF10 – OPC + CA + 10% PF + 90% FA
- PF15 – OPC + CA+ 15% PF + 85% FA
- CR10PF10 – OPC + CA + 10% PF + 10% CR + 80% FA
- CR5PF10 – OPC + CA +10% PF + 5% CR + 85% FA
- CR10PF5 – OPC + CA + 5% PF + 10% CR + 85% FA

Where, OPC – Ordinary Portland Cement
FA – Fine Aggregate
CA – Coarse Aggregate
CR – Crumb rubber
PF – Plastic fines

For these mix proportions, required quantities of materials were weighed and concrete was prepared using a drum mixer. Fresh concrete properties such as slump flow, was determined according to an Indian Standard Specification IS:1199-1959.The 150 x 150 x 150 mm concrete cubes were cast for compressive strength, cylinders of size 150mm diameter 300mm height for splitting tensile strength and beams of size 150 mm x 150 mm x 700mm for flexural strength. After required period of curing, the specimens were taken out of the curing tank and their surfaces were wiped off. The various tests performed were compressive strength test of cubes at 7,28 days, splitting tensile strength of cylinders at 28 days and flexural strength of beams at 28 days, as per IS:516-1959.

IV. RESULTS AND DISCUSSIONS

A. Workability

Slump test was used to find the workability of concrete. Slump test for each mixes were done. The result are shown in Figure III.

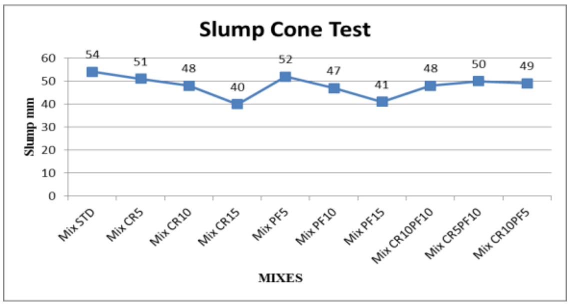

Fig III. Slump test values

The slump values show a decreasing tendency with increasing the percentage of crumb rubber and plastic fines. The differences in the slump value may due to the differences in the rate of water absorption of aggregates.

B. Compressive strength

Fig IV, V and VI presents the results of compressive strength test.

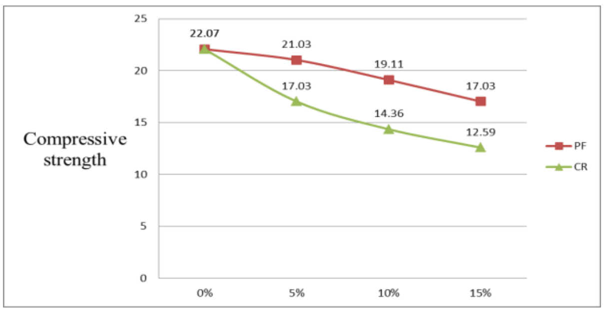

Fig IV. Variation of 7-day compressive strength

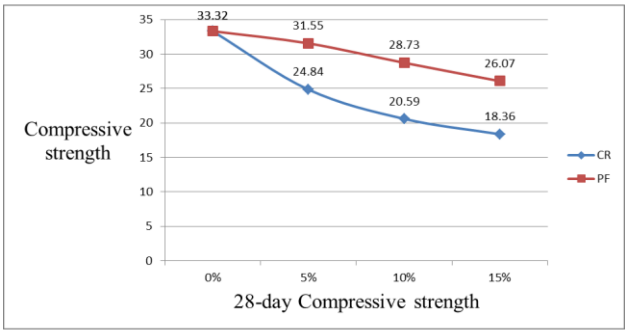

Fig V. Variation of 28-day compressive strength

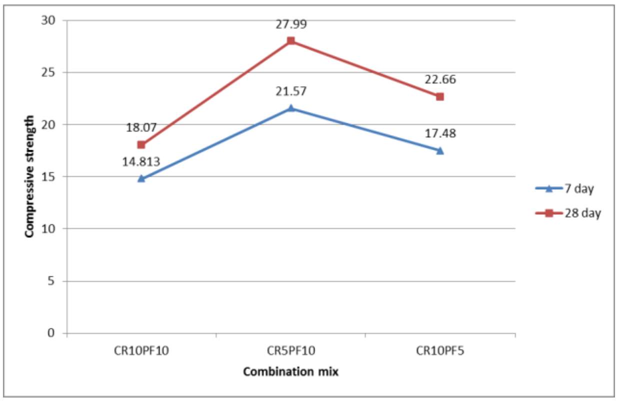

Fig VI. Combination mix

From the results, as the replacement percentage increases compressive strength reduces gradually. Maximum strength is obtained for 5% replacement of crumb rubber and plastic fines. For the combination mix of 5% crumb rubber and 10% plastic fines, compressive strength is maximum.

C. Split tensile strength

The influence of fine aggregate replacement by crumb rubber and plastic fines on the splitting tensile strength is shown in Fig VII and Fig VIII respectively.

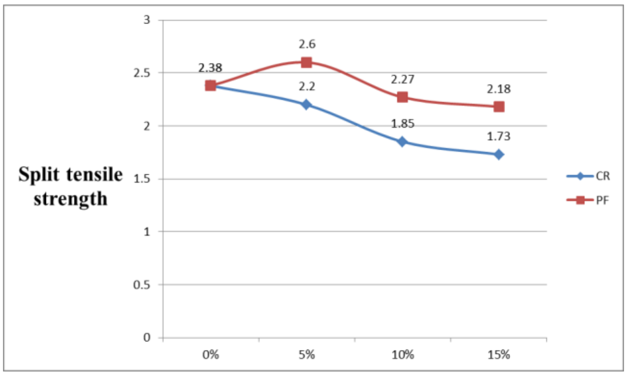

Fig VII. Variation of split tensile strength

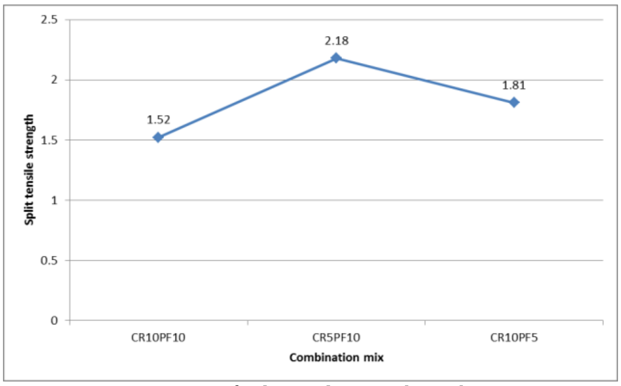

Fig VIII. Variation of split tensile strength-combination mix

Split tensile strength is getting reduced as the percentage replacement of crumb rubber and plastic fines increases. 5% plastic fine replacements gives higher strength than the standard mix. Combination ix of 5% crumb rubber and 10% plastic fines produces high split tensile strength.

D. Flexural strength

The influence of fine aggregate replacement by crumb rubber and plastic fines on the flexural strength of concrete is shown in Fig IX and Fig X respectively.

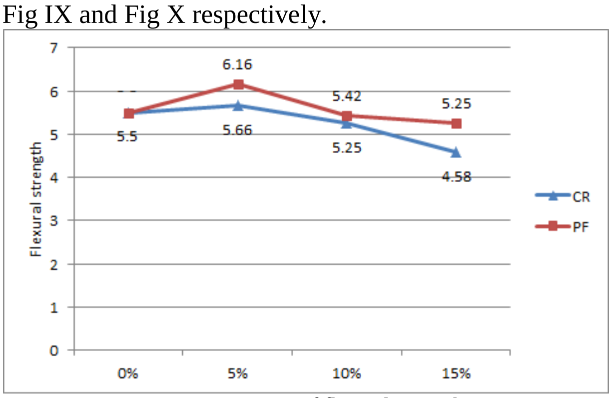

Fig IX. Variation of flexural strength

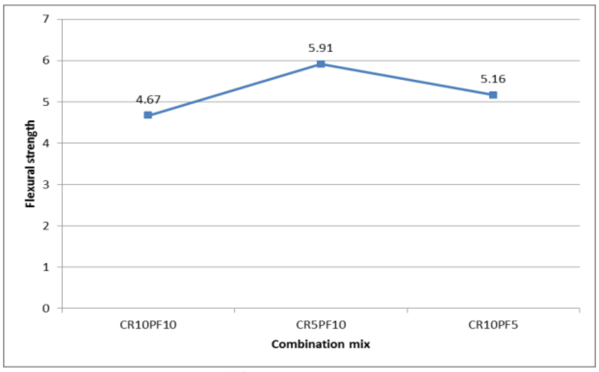

Fig X. Variation of flexural strength combination mix

Flexural strength decreases with the increasing percentage of crumb rubber and plastic fines. 5% replacement by crumb rubber and plastic fines results in better flexural strength than the standard mix. Combination ix of 5% crumb rubber and 10% plastic fines produces high flexural strength.

E. Water absorption

The influence of fine aggregate replacement by crumb rubber and plastic fines on water absorption is shown in Fig XI.

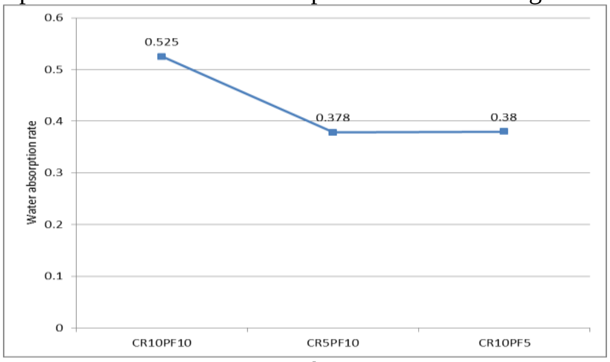

Fig XI. Water absorption rate

The water absorption rate is high for the combination mix of 10% crumb rubber and 10% plastic fines.

F. Conclusions

Studies were conducted by adding different percentages of crumb rubber and plastic fine aggregates. Gradual reduction in compressive strength, split tensile strength ,flexural strength was observed with the addition of crumb rubber and plastic fine aggregates. These wastes can be considered as a modifier in the concrete mix. This modified cement concrete mix is applicable in the construction of rigid pavements, temporary structures, small drainage works and concrete tiles for foot path walkers.

- Upto 10% of crumb rubber aggregate can be added into concrete mix without considerable reduction in strength.
- Optimum replacement of fine aggregate by plastic fines is 10%.
- For the combination mixes as the percentage of crumb rubber increases the strength reduces gradually.
- As the replacement by both wastes increases the flexural strength decreases.
- Split tensile strength reduces with more addition of waste aggregates.
- Water absorption is high for the combination mix of 10% crumb rubber and 10% plastic fine replacement.
- Combination mix consisting of 5% crumb rubber and 10% plastic fines produce good strength concrete.

Based on this study, the use of crumb rubber and plastic fines aggregates in concrete produces light weight concrete and is economical and environmentally effective.

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