Experimental Study on Effect of Crumb Rubber in Concrete Mix

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Abstract— Concrete is considered to be the most widely used and versatile material of construction all over the world. In recent years, concrete technology has made significant advances which have resulted in economical improvements in strength of concrete. This economic development depends upon the intelligent use of locally available materials. One of the important ingredients of conventional concrete is natural sand or river sand. Scarcity of good quality Natural River sand due to depletion of resources and restriction due to environmental consideration has made concrete manufactures to look for suitable alternative fine aggregate. One such alternative is "crumb rubber". Because of crushing quarries and converting them as fine aggregates, demand for coarse aggregates also increases. To meet this demand, another alternative to river sand is crumb rubber which can be used as fine aggregates in manufacturing concrete. An attempt has been made in this study to determine the compressive strength of M20 grade concrete using crumb rubber as replacement for fine aggregate.

Key words: Ordinary Portland Cement, Natural Fine Aggregate, Crumb Rubber, Fly Ash and Compressive Strength

I. INTRODUCTION

Concrete is most widely used building material in the world, as well as the largest user of natural resources with annual consumption of 12.6 billion tons. The major part of concrete besides the cement is the aggregates. Aggregate include sand and crushed stone / Gravel. Use of these conventional materials in concrete is likely to deplete the resources unless there is a suitable substitute. In order to prevent the environmental problem from growing, recycling tyre is an innovative idea or way in this case. Recycling tyre is the process of recycling vehicles tyres that are no longer suitable for use on vehicles due to wear or irreparable damage (such as punctures). The cracker mill process tears apart or reduces the size of tyre rubber by passing the material between rotating corrugated steel drums. By this process an irregularly shaped torn particles having large surface area are produced and these particles are called as crumb rubber.

The use of rubber product is increasing every year in worldwide. India is also one the largest country in population which exceeds 120cr. So the use of vehicles also increased, according to that the tyres for the vehicles are also very much used and the amount of tyre rubber usage is increasing. This creates a major problem for the earth and their livings. For this issue, the easiest and cheapest way of decomposing of the rubber is by burning it. This creates smoke pollution and other toxic emission and it creates global warming. Currently 75-80% of scrap tyres are buried in landfills. Only 25% or fewer are utilized as a fuel substitute or as raw material for the manufacture of a number of miscellaneous rubber goods. Burying scrap tyres in landfills is not only wasteful, but also costly. Disposal of whole tyre has been banned in the majority of landfill operations because of the bulkiness of the fires and their tendency to float to the surface with time. Thus, tyres must be shredded before they are accepted in most landfills. So many recycling methods for the rubber tyre are carried according to the need. From this one the processes are to make the tyre rubber into crumb rubber. It is used in many works such as road construction, mould making etc.

Crumb rubber (CR) is a commodity made by re-processing (shredding) disposed automobile tires. Shredding waste tires and removing steel debris found in steel-belted tires generates crumb rubber. There are three mechanical methods used to shred apart these tires to CR: the cracker mill, granulator, and micro mill methods. CR can also be manufactured through the cryogenation method; this method involves fracturing the rubber after reducing the temperature with liquid nitrogen. CR is fine rubber particles ranging in size from 0.075-mm to no more than 4.75-mm. In the concrete mix, CR constitutes a portion of the aggregate in the concrete mix. In this project we are studying the effect of crumb rubber as a partial replacement for fine aggregates in M20 concrete mix. Hence the project is aimed at studying the effectiveness of rubber as substitute for fine aggregate and utilizes the crumb rubber tyres in concrete, to minimize global warming. Aggregate properties viz., specific gravity, water absorption were to be conducted and to ascertain the strength properties concrete specimens were to be casted and tested for concrete mix with various percentage of replacement (5%,10%,15%) and its viability for replacement are discussed in this project.

II. MATERIALS

A. Cement

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. Of the various ingredients used in concrete, cement is the most energetically and expensive. In the present investigation OPC 43 grade cement is used.

B. Water

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. Lower water to concrete ratio yields a stronger, more durable concrete, while more water gives a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

C. Fine Aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieved depending upon its grading zone.

D. Crumb rubber

Crumb rubber is the name given to any material derived by reducing scrap tires or other rubber into uniform granules with the inherent reinforcing materials such as steel and fiber removed along with any other type of inert contaminants such as dust, glass, or rock.

Crumb rubber is manufactured from two primary feedstocks: Tire buffing, a by-product of tire retreading and scrap tire rubber. Scrap tire rubber comes from three types of tires: passenger car tires, which represent about 84 percent of units or approximately 65 percent of the total weight of U.S. scrap tires; truck tires, which constitute 15 percent of units, or 20 percent of the total weight of U.S. scrap tires; and off-the-road tires, which account for 1 percent of units, or 15 percent of the total weight of U.S. scrap tires. End product yields for each of these tire types are affected by the tire's construction, strength and weight. On average, 10 to 12 pounds of crumb rubber can be derived from one passenger tire.

E. Fly ash

Fly ash, also known as "pulverized fuel ash" in the United Kingdom, is a coal combustion product that is composed of the particulates(fine particles of fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial of silicon-dioxide (SiO_2) & crystalline, aluminium (AlO_3) & calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata. 35% of cement content was replaced by fly ash in each moulds.

F. Coarse Aggregates

Crushed stone aggregates of 20mm size obtained from local quarry site were used for the experiment.

G. Preparation of crumb rubber

NAOH solution is prepared by mixing 10gm of NAOH crystals with 1 litre of water. Crumb rubber is soaked in that solution for 20min. Then the crumb rubber is removed and washed with water, dried and then it is used in concrete mix.

III. METHODOLOGY

A. Tests on materials

1) Cement

Oxides	Percentages
Cao	62.85
SiO_2	20.98
Al_2O_3	5.42
Fe_2O_3	3.92
MgO	1.76
SO_3	2.36
Na_2O	0.28
K_2O	0.53
Loss of Ignition	1.90

Table 3.3: Physical properties of fine aggregate

Sl No	Particulars	Obtained values
1	Specific gravity	2.65
2	Fineness Modulus	4.74%
3	Bulk Density	1750 kg/m^3
4	Water absorption	2.0%

Table 3.5: Physical properties of coarse aggregate

Sl No	Particulars	Obtained values
1	Specific gravity	2.80
2	Sieve analysis	2.26%
3	Water absorption	1.0%

Table 3.5: Physical properties of fly ash

Sl No	Particulars	Obtained values
1	Specific gravity	.1
2	Sieve analysis	2.26%
3	Water absorption	1.0%

IV. RESULTS & DISCUSSIONS

Crumb rubber is partially replaced with fine aggregate by 5%, 10% and 15%. Fly ash is replaced with cement up to 35% to increase the strength of concrete mix. Concrete moulds of 150x150x150mm are casted to determine the compressive strength. Cylinder of 150mm diameter and 300mm height is casted to determine the split tensile strength. Beams of 150x150x500mm are casted to determine the flexural strength. The hardened concrete strength parameters of the above moulds are compared with conventional concrete strength properties.

% replacement of crumb rubber	Compressive strength after No. of days of curing in (MPa)			
	3 days	7days	14 days	28days
0% (NC)	7.2	11.16	16.60	18.23
5%	7.69	11.37	16.87	18.67
10%	7.98	12.15	19.36	19.87
15%	7.42	11.63	18.54	19.43

Table 4.1: Compressive Strength at 3, 7, 14 and 28 days for M20 grade concrete & concrete mix with 5%, 10% and 15% crumb rubber as replacement for fine aggregate

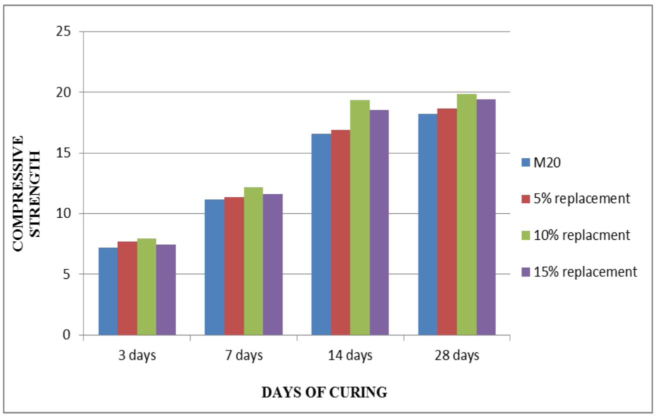


Fig 4.2: Variation of Compressive Strength at 3, 7, 14 and 28 days for M20 grade concrete & concrete mix with 5%, 10% and 15% crumb rubber as replacement for fine aggregate

The above graph indicates the variation of Compressive Strength of concrete at 3, 7, 14 and 28days of curing for M20 grade concrete & concrete with different percentages of crumb rubber replacing fine aggregate. It was observed that, strength of concrete decrease gradually with increases in percentage of crumb rubber.

% replacement of crumb rubber	Split tensile after No. Of days of curing in (MPa)	
	7 days	28 days
0% (NC)	4.74	5.34
5%	5.02	5.74
10%	5.22	6.195
15%	5.22	6.17

Table 4.2: Tensile Strength at 7 and 28 days for M20 grade concrete & concrete mix with 5%, 10% and 15% crumb rubber as replacement for fine aggregate

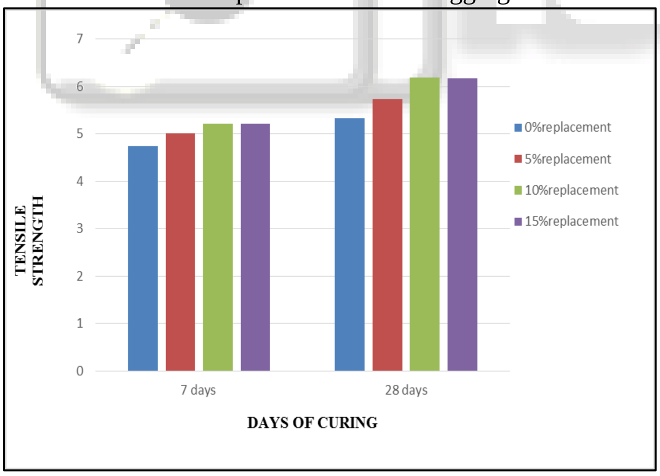
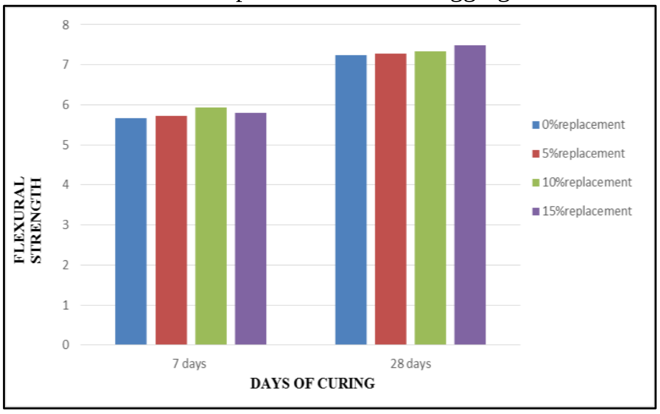


Fig 4.3: Variation of Tensile Strength at 7 and 28 days for M20 grade concrete & concrete mix with 5%, 10% and 15% crumb rubber as replacement for fine aggregate

The above graph indicates the variation of Tensile Strength of concrete at 7 and 28days of curing for M20 grade concrete with different percentages crumb rubber replacing fine aggregate. It was observed that, strength of concrete decrease gradually with increases in percentage of replacement and strength of concrete at 28 days of curing.

% replacement of crumb rubber	Flexural strength after No. Of days of curing in (MPa)	
	7 days	28 days
0% (NC)	5.676	7.25
5%	5.732	7.258
10%	5.925	7.340
15%	5.797	7.493

Table 4.3: Flexural Strength at 7 and 28 days for M20 grade concrete & concrete mix with 5%, 10% and 15% crumb rubber as replacement for fine aggregate



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The above graph indicates the variation of Flexural Strength of concrete at 7 and 28days of curing for M20 grade concrete with different percentages crumb rubber replacing fine aggregate. It was observed that, strength of concrete decrease gradually with increases in percentage of replacement and strength of concrete at 28 days of curing.

V. CONCLUSION

From this study the effective utilization of rubber tyre waste as been developed and it made to used in the concrete mixture as fine aggregate. Based on the test results the following conclusions were made. Even if rubber tyre aggregate was used at relatively low percentages in concrete, the amount of waste tyre rubber could be greatly reduced due to the very large market for concrete products worldwide. Therefore the use of discarded tyre rubber aggregates in concrete shows promise for developing an additional route for used tyres.

1) By utilizing the crumb rubber as partial replacement of aggregate, there will be considerable reduction in the rubber waste & contributes to sustainable construction.
2) Since the weight of the crumb rubber is less than fine aggregates, there is a gradual reduction in the dead load of the structural element.
3) The NaOH treatment enhances the adhesion of tire rubber particles to cement paste.
4) The compressive strength of crumb rubber concrete with 10% replacement is absorbed to be greater than 9% than the strength of normal concrete on 28th day.
5) The flexural strength of crumb rubber concrete with 10% replacement is absorbed to be greater than 16% than the strength of normal concrete on 28th day.
6) The split tensile strength of crumb rubber concrete with 10% replacement is absorbed to be greater than 3.35% than the strength of normal concrete on 28th day.
7) Concrete with 10% replacement of crumb rubber as fine aggregate is found out to be optimum in terms of strength characteristics.

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