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The Variation of Concrete Strength using Wastetyre Rubber as Coarse Aggregate

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ABSTRACT
Waste tyre rubber constitutes a large portion of solid waste which has turned into a worldwide environmental concern. The waste tyres represent a significant environmental, human healthand aesthetic problem. The consumption of waste tyre rubber in concrete has gained more attention from the point of view of enhanced engineering properties. The objective of this study is to explore the effect of rubber tyres on mechanical properties of concrete. This study represents the results to the investigation of strength characteristics of concrete produced using waste tyres as substitutes for conventional coarse aggregate in replacement of 10%, 20%, 25%. Here 56 cylinders were prepared using waste tyres for this study. It has been observed that the use of tyre rubber particles provides a new type of concrete that inspires the use of waste tyres as a replacement of coarse aggregate.

Keywords:Tyre rubber, Solid waste, Engineering properties, Replacement, Coarse aggregate.

1. Introduction

Environmental pollution has been increased in developing country because of burning of waste tyres. In several countries, tyre rubber is being burned which can result in serious hazards. Scrap tyres dumped in sanitary landfills are a significant environmental hazard and result in possible contamination. Only small quantities of scrap tyres are being used or recycled as construction materials. Rubber from scrap tyres is one of the more recent waste materials investigated for its potential use in construction industry.

Materials like waste tyres can be used to replace aggregates in concrete. But these materials cannot replace fully but they are partially replaced to about 0% to 25%[1, 2]. Studies are made on both fresh as well as hardened properties of rubberized concrete and compare with normal concrete. In developing countries wastes are discharged but we can use these wastes as potential material or replacement material in the construction industries. If these wastes are used in the construction, this will have the double advantage of reduction in the cost of construction material and also as a means of disposal of waste. The recovery of waste tyres has normally grown in each year, for instance from 55% in the United States in 1994 and from 21% in Europe in 1994. The recovery of waste tires in Japan was already at 90% in 1994, and has kept steady at near that rate for approximately 20 years[3].

By replacing the coarse aggregate in concrete with waste tyres partially, a concrete has been developed which possesses the potential of being used in building construction as floor, pavement, water barrier etc. Generally concrete as time goes on through a process of hydration of the cement paste, producing a required strength to withstand the loads on it. So the use of waste tires as coarse aggregate in concrete has never been a usual practice among the average citizens, particularly in areas where light weight concrete is required for non-load bearing walls, non-structural floors, and strip footings. About 50% of the overall self- weight of concrete is responsible for coarse aggregate[4]. Sources of traditional aggregates occupy the most important part of the concrete[5].Thelargescale production of concrete in construction activities using conventional coarse aggregate such as granite immoderately reduces the natural stone deposits and affecting the environment hence causing ecological imbalance. Extraction and processing of aggregates is also a major concern for environment. Therefore consumption of alternate waste material in place of natural aggregate in concrete production not only protects environment but also makes a concrete a sustainable and environment friendly construction material. It is also important that the use of waste tyres reduces the cost of constructions which can be a help to the construction industries.

2. Methodology

Concrete is an artificial stone manufactured from a mixture of binding materials and inert materials with water.

Concrete = Binding Materials (cement) + Inert Materials (coarse aggregate and fine aggregate) + Water.

Waste tyres are used as a replacement of coarse aggregate to invent a new type of concrete in civil engineering application.

2.1 Mix Design Ratio

The concrete mix design for every specimen was based on the weight of materials. The weight portion of the concrete mixture was 1 (cement): 2 (fine aggregate): 4 (coarse aggregate), giving a water to cement ratio of 0.45

2.2 Test Specimens

4 in x 8 in cylindrical specimen were used. Portland composite cement (PCC), Stone chips and Sylhet sand were used for mixing.

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As a replacement of coarse aggregate waste tyres were replaced of0%, 10%, 20% and 25% in mixing.

For each percentage 14 cylinders were prepared**.**

2.3 Curing of Test Specimen

Fresh concrete gains strength most rapidly during the first few days and weeks. Structural design is generally based on the strength of 28days. Curing is the process of maintaining satisfactory moisture content in a favorable temperature in concrete during the hydration of the cementitious materials so that the desired properties of the concrete were developed. Curing is the procedure for promoting hydration of cement paste and controlling of concrete temperature and movement of moisture from and into the concrete.

2.4 Determination of Compressive Strength and Tensile Strength of Concrete

These specimens were tested by compression testing machine after 7 days and 28 days curing.The load was applied at a rate of movement corresponding to a stress rate on the specimen of 35 ± 7 psi/s (0.25 ± 0.05 MPa / s)

Fig.1 Equipment set-up of compressive strength test.

Compressive force was applied to the specimen by using compression strength machine and failure load was measured. Compressive strength was calculated by using equation,
C=P/A

Where, C= compressive strength, P = failure load; and A = contact area.
Specimen was positioned into the compression strength machine according to Brazilian test method. Load was applied to the specimen and failure load was measured.

For tensile strength,the load had been givenincreased continuously at the rate to produce a split tensile stress of approximately was 1.4 to 2.1 N/mm^2/min, until no greater load sustained.

Tensile strength was calculated by using equation, T=2P/πdl

Where, T= tensile strength; P= failure load; d = diameter of the cylinder and l= length of the cylinder.

Fig.2 Equipment set-up of splitting tensile strength test

3. Results

Tensile strength, Compressive strength and Stress-Strain Behavior is explained below.

3.1 Compressive Strength

14 cylinders were made for each percentage. The results showed that the compressive strength of the concrete decreased as waste tyres were used in concrete.It was observed that the maximum compressive strength of 16.5 MPa was attained at 0% replacement for 28 days curing, while the minimum strength of 4.6 MPa was attained at 25% coarse aggregate replacement for 7 days curing. The compressive strength for 7 days and 28 days value are shown below:

The failure pattern of Compressive strength is shown in Figure 3.

Fig.3 After compressive strength test

Table 1 The compressive strength variation with various percentages of waste tyres

SI. No	Percentage of waste tyres	Compressive strength (MPa) at 7	Decreasing in percentage	Compressive strength (MPa) at 28	Decreasing in percentage
01	0%	13.1	-	16.5	-
02	10%	9.1	30.5	14.6	11.5
03	20%	5.4	58.8	8.6	47.9
04	25%	4.6	64.9	5.6	66

The variation of compressive strength at 7 and 28 days are shown in the following figure-4.

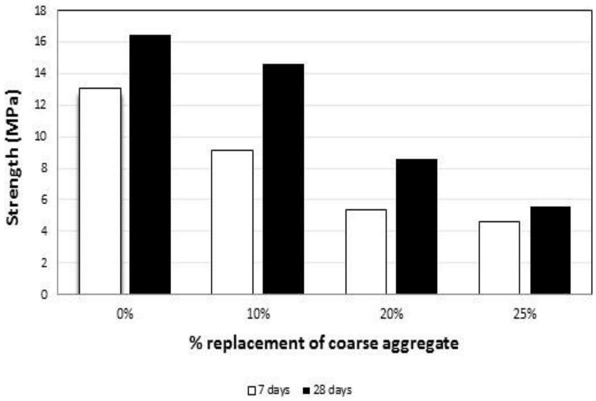

Fig.4 Compressive strength vs % replacement of coarse aggregate as waste tyres at 7 days and 28 days

3.2 Tensile Strength

The important property of concrete is Tensile strength because in the case of various kinds of effects and applied loading it is highly vulnerable. However, compressive strength is very high in contrast with its tensile strength of concrete.

Test was performed according to ASTM C496.

Fig.5 After tensile strength test

The results showed that the tensile strength of the concrete decreased as the percentage replacement of coarse aggregate. It was observed that the maximum tensile strength of 3.2 MPa attained at 0% replacement for 28 days.

The tensile strength for 7 days and 28 days value are shown below:

Table 2 The Tensile strength variation with various percentages of waste tyres

Sl. No.	Percentage of waste tyres	Tensile strength (MPa) at 7 days	Decreasing in percentage	Tensile strength (MPa) at 28 days	Decreasing in percentage
01	0%	2.7	-	3.2	-
02	10%	1.9	29.63	2.7	15.63
03	20%	1.6	40.7	2.2	31.25
04	25%	1.3	51.9	1.6	50

From tensile strength data we observed that the increasing in percentage of waste tyres in concrete then decreasing the tensile strength. 10% replacement then decreasing the tensile strength 29.6% at 7 days and 15.63% at 28 days

The variation of tensile strength at 7 days and 28 days are shown in figure-6.

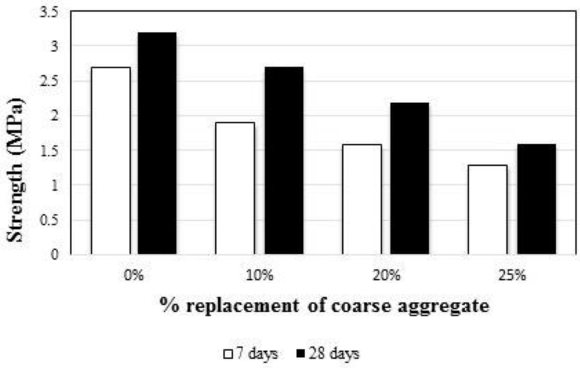

Fig.6 Tensile strength vs % replacement of coarse aggregate as waste tyres at 7 and 28 days

3.3 Stress-Strain Behavior

The stress-strain curve of concrete deceits between those of the aggregate and the cement paste. However the most of the range connection is non-linear over. The motive for this non-linear behavior is that the form of micro-cracks at the line between aggregate particles and cement paste as a result of the distinction movement between the two phases, and within the cement paste itself. These flaws are shaped as a result of ups and downs in temperature and moisture and the application of load.

The stress-strain diagram is plotted from the collected data for compression test.The four differentcurves representthe testing value of four different cylinders. From 0% to 25% of waste tyreused as coarse aggregate the stress is decreased dramatically with strain. The relationships between stress and strain for various percentage replacement of concrete at 28 days are presented between Figure 7 to Figure 10.

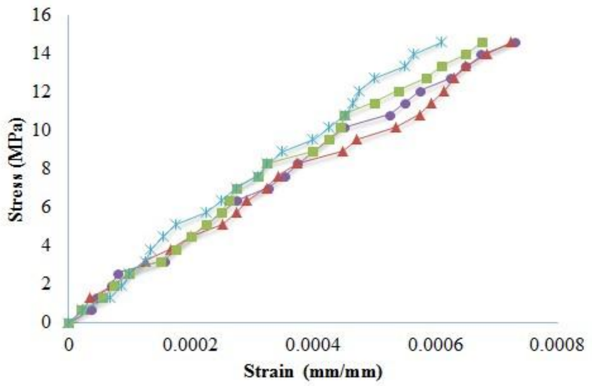

Fig.7 Stress-strain diagram for 0% waste tyres at 28 days

Here in figure 7, four different cylinders without waste tyre rubber were using to get theaccurate crushing point. The tests were done in compression state and around 14 MPa crushing stress were found in average for cylinders.

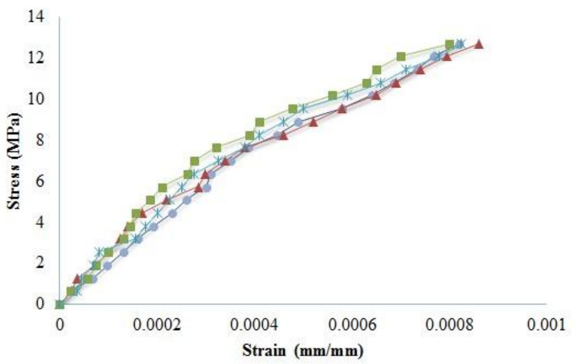

Fig.8 Stress-strain diagram for 10% waste tyres at 28 days

In the case of figure 8, 10% waste tyre rubbers were used as coarse aggregate in four different cylinders. The tests were done in compression state and the crushing point is decreased. It was found around 12 MPa.

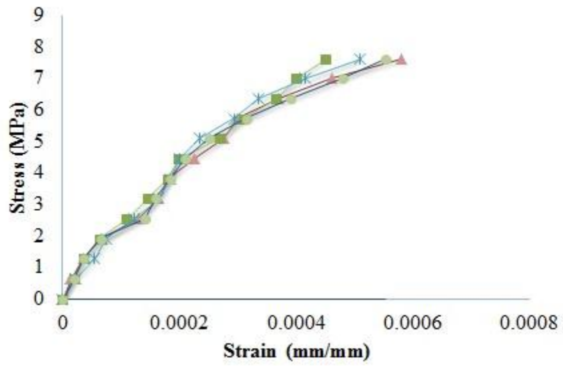

Fig.9 Stress-strain diagram for 20% waste tyres at 28 days

Here in figure 9, 20% waste tyre rubbers were used as coarse aggregate in four different cylinders. The tests were done in compression state and the crushing stress was found around 8 MPa.

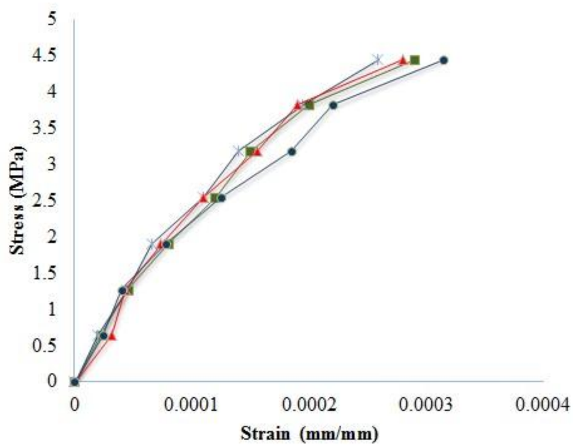

Fig.10 Stress-strain diagram for 25% waste tyres at 28 days

In figure 10, 25% waste tyre rubbers were used as coarse aggregate in four different cylinders. Similar scenario was seen in this case. The crushing point is dramatically decreased.

4. Conclusions

Reduction of compressive strength and tensile strength were analyzed when the coarse aggregate was replaced by tyres. From this research it is observed that concrete with tyre aggregate can be used up to 10% replacement for proper strength, however, 20% can be replaced in light-weight concrete applications. This type of concretewith rubber aggregate mixturecan be used for(a)architectural applications such as nailing concrete, false facades, stone backing, and interior construction because of its light unit weight (b)low-strength-concrete applications such as sidewalks, driveways, and selected road construction applications and (c)crash barriers around bridges and similar structures.

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