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RESEARCH ARTICLE

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STRENGTH PROPERTIES OF CONCRETE WITH PARTIAL REPLACEMENT OF FINE AGGREGATE BY SCRAP TYRE

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ABSTRACT

The disposal of used tyres is a major environmental problem throughout the world which causes environmental hazards. Scrap tyre is a waste material that is ideal for use in concrete applications. The aim of this study is achieved to use of rubber waste as partial replacement of fine aggregate to produce rubberize concrete in M20 mix. Different partial replacements of scrap tyre (0, 5,10,15 and 20%) by weight of fine aggregate, and ground granulated blast furnace slag (GGBS) is used as 5% are cast and test for compressive strength, workability, young's modulus, and densities.

In this work a plain cement concrete cube of size 150x150x150 mm were cast for testing after 7 days and 28 days curing. The results showed that there is a reduction in all type of strength for scrap tyre mixture, but slump values increase as the scrap tyre content increase from 0% to 20%. So it is more workable compare to normal concrete and also it is useful in making light weight concrete. It is recommended to use the rubberized concrete for non structural applications. In this an attempt is made to find a solution to reduce an impact of scrap on green environment and human health.

Key words: Scrap tyre, fine aggregate, coarse aggregate, Workability, Compressive strength, modulus of elasticity, density and flexural strength.

INTRODUCTION

In the construction industry there are two commonly used structural materials i.e. concrete and steel. While coming to concrete the major ingredients are aggregate, cement and water. Further aggregate is classified as coarse and fine

aggregate. Due to increasing the industrial by products and wastes in nature has become a major environmental problem. These industrial by products and wastes are not only difficult to dispose but they also cause serious health hazards. From the earlier studies it appears that much less attention has been paid towards the study of using scrap tyre. Concrete is considered as durable and strong material. Reinforced concrete is one of the most popular materials used for construction around the world. Recently so many advanced techniques are introduced in the construction industry. This research is an attempt to find a practical and environmentally sound solution of the problem of scrap tyres by developing a light weight with low thermal conductivity composite construction materials using waste tyres. Scrap tyres being coarser and less pozzolonic is not being used or more importantly in places where the fine aggregate is contaminated with harmful chemicals such as sulphates and chlorides and scrap tyres accumulation posing environmental problems. The main aim of the environmental agencies and governments to minimize the problems of disposal of different types of industrial wastes like scrap tyres produced by automobile industry, fly ash, pond ash, meta kaolin, blast furnace, cinder, silica fume etc., due to scope of health hazards of these wastes and by-products. In the same manner scrap tyre is the byproduct coming from automobile industry. Due to the continuous usage of these scrap tyres within short length of time these scrap accumulation is high in nature and causing stagnation of drainage and rain water etc. and its impact on human health.

1.1 SCRAP TYRE

The scrap tyre is used in this study was procured from Bangalore tyre Recycling Company. The scrap tyre was derived from used tyres. Due to its cross-linked structure, rubber needs a long time for natural degradation. The tyre may be divided into two types- car and truck tyres. Car tyres are different from truck tyres with regard to constituent materials (e.g. natural and synthetic rubber).

Fig 1. Scrap tyre rubber in rubber industry

2. MATERIALS

2.1. Cement: Cement is binding material in the cement concrete. This concrete is used for different engineering works where strength and durability are of prime importance.

Table1: Composition limits of Portland cement

INGRADIENT	% CONTENT
CaO (Lime)	60 to 67
Sio_2 (Silica)	17 to 25
Al_2O_3 (Alumina)	3 to 8
Fe_2O_3 (Iron Oxide)	0.5 to 6
Mgo (Magnesia)	0.1 to 4
Alkalies (K_2O, Na_2O)	0.4 to 1.3
Sulphur (SO_3)	1.3 to 3.0

Table2: Chemical Compounds in cement

Compound	Composition as %
C_3S	48-52%
C_2S	22-26%
C_3A	6-10%
C_4AF	13-16%
Free lime	1-2%

Table 3: Physical properties of cement

Fineness (m^2/kg)	326
Normal consistency	32.5
Initial setting time (mints)	195
Final setting time (mints)	295
Soundness (mm)	0.9
Compressive strength (MPa)	
At 3 days	27.8
At 7 days	39.2
At 28 days	62.4

2.2 Fine Aggregate: Fine aggregates consist of small angular or rounded grains of silica. River sand is commonly used as the fine aggregate in cement concrete. Both natural and artificial sands are used for this purpose.

2.3 Coarse Aggregate: Coarse aggregate used may be crushed stone, gravel and broken bricks.

2.4 Scrap tyre: In the present investigation the old rubber from heavy vehicles (i.e truck tyres) was used. The scrap tyre is used in this study was procured from Bangalore Tire Recycling Company, and manufactured through cracker mill process. There two stages of magnetic separation and screening.

In this investigation scrap rubber was cut into smaller particles

Fig 2. Ground rubber

Fig. 3 Chipped rubber

Crumb rubber

Fig. 3 types of scrap tyre

In this investigation scrap tyre tire particles passing through the 2.36 mm sieve size were used in this study.

Table 4. Properties of scrap tyre

Specific Gravity	1.05
Water absorption (%)	2.00
Bulk density (Kg/m^3)	412
Fineness modulus	3.19

2.6 Water: Water is an important ingredient of concrete as it actually participates in the hydration. Ordinary tap water is used in this work.

3. RESULTS AND DISCUSSION

In this present investigation M20 grade was used and mix design was carried out according to IS 10262-2009 recommendations. The mix proportion of designed mix was given in table 7.

Table 5: Mix proportions per Cubic meter of concrete

Material	Quantity	Ratio
Cement (Kgs)	383	1
Fine aggregate (Kgs)	665	1.734
Coarse aggregate(Kgs)	1091	2.85
Water (litres)	192	0.5

The fine aggregate was replaced with scrap with varying percentages, the corresponding mix proportions various trial mix were given in following table 8.

In the present work the scrap tyre was replaced to fine aggregate of proportions 0, 5, 10, 15 and 20 percentages of total fine aggregate proportions.

TABLE: 6 MIXTURE PROPORTIONS

PARAMETERS	PERCENTAGE OF PARTIAL REPLACEMENT OF SAND BY SCRAP TYRE				
	CONTROL MIX	MIX 1 (5 %)	MIX 2 (10%)	MIX 3 (15%)	MIX 3 (20%)
Notation	(ST-0)	(ST-5)	(ST-10)	(ST-15)	(ST-20)
W/C Ratio	0.50	0.50	0.50	0.50	0.5
Water (kg/cu.m)	191.6	191.6	191.6	191.6	191.6
Cement (kg/cu.m)	383	383	383	383	383
Fine aggregates (Kg/cu.m)	664.048	630.85	597.64	564.44	531.24
Coarse aggregates (kg/cu.m)	1090.74	1090.74	1090.74	1090.74	1090.74

Scrap tyre (kg/cu.m)	0	33.20	66.40	99.61	132.81
Mix proportions (C:FA:CA:S.T)	1:1.734:2.85:0	1:1.65:2.85:0.5	1:1.56:2.85:0.1	1:1.47:2.85:0.15	1:1.47:1.39:0.2

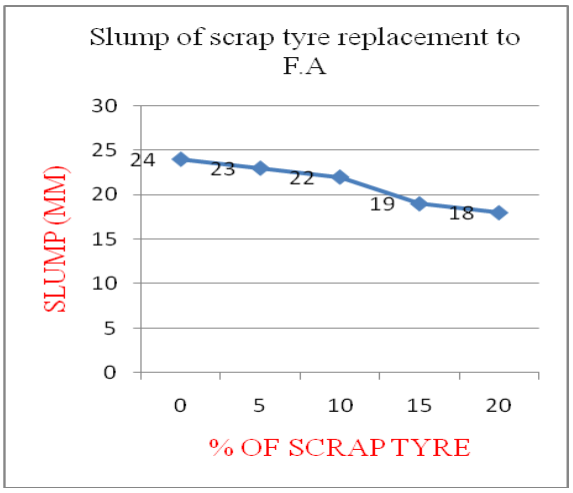
C=Cement; FA=fine aggregate;
CA=Coarse aggregate; S.T = Scrap tyre

3.1 SLUMP CONE TEST: The slump cone test is the one of the common test conducted in site to determine the workability of fresh concrete. This test was carried out according to IS: 7320-1974.

Fig.4 Slump cone test of scrap rubber

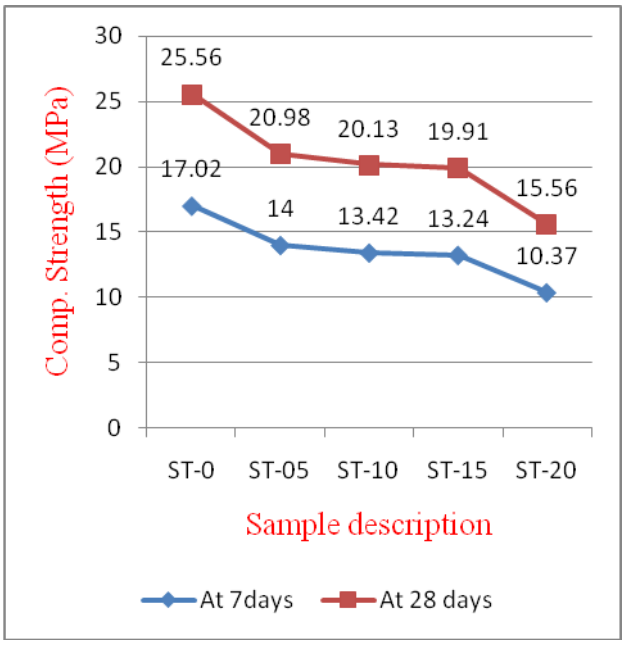
The slump of present work is shown in below graph 1.

3.2 Compressive strength: The concrete strength is generally represented by compressive strength. The 5 sets of 150mm × 150mm × 150mm concrete cubes were casted by increasing the scrap tyre replacement from 0 to 20 % by gradual increment of 5% of 6 cubes for each set.

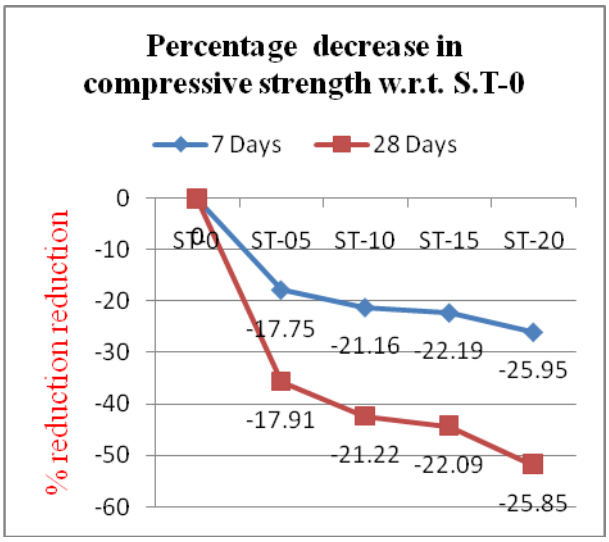


Graph.1 Slump of scrap type concrete

All those cubes were kept in curing tank. The 3 cubes of each set were taken after 7 and 28 days and conducted compression test. The test results were shown in graph 2 and graph 3 and percentage reduction in compression strength at 7 days and 28 days of scrap tyre replacement was compared with conventional concrete.



Graph. 2 Compressive strength of scrape trye replaced concrete

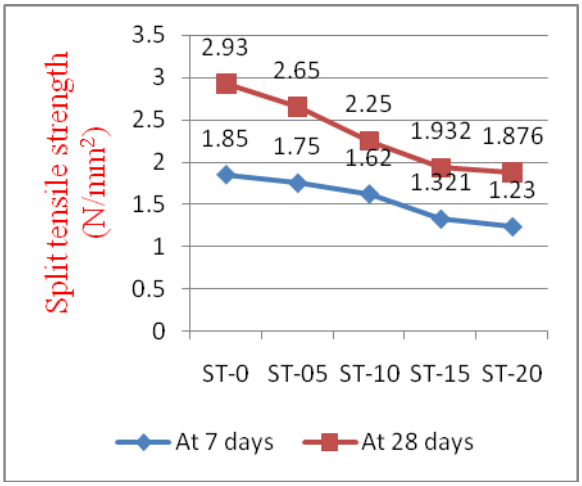


Graph. 3 - Percentage decrease in Compressive strength of scrap tyre replaced concrete

3.3 Split tensile strength: The split tensile strength was calculated according to IS 5816: 1999. The 5 sets of 150mm dia and 300mm height cylinders were casted by replacing of scrap tyre from 0 to 20 % by gradually increasing of 5 %. The each set consist of 6 cylinders. All those 5 sets of cylinders were allowed to cure for 7 and 28 days. The 3 cylinders of each set were taken from curing tank and conducted split tensile test by applying the load along the length of the cylinder.

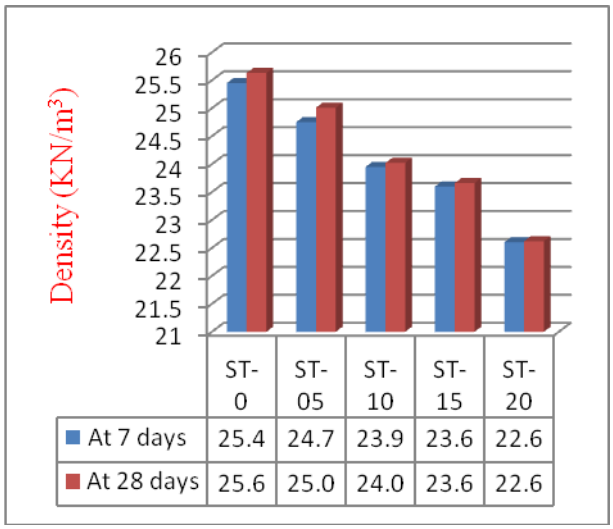
The load (P) required to split the cylinder were noted, and split tensile strength were calculated by following formula and results were shown in graph 4.

Split tensile strength (σ_{split}) = $\frac{2P}{\pi dl}$



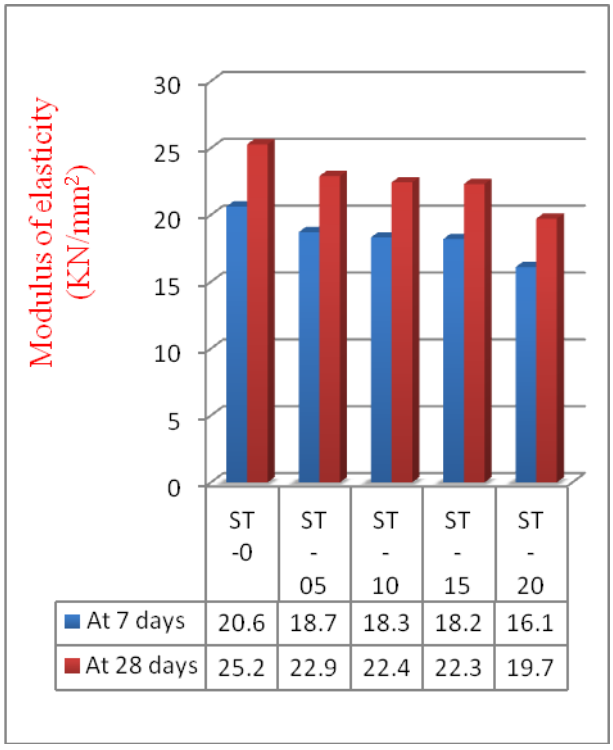
Graph 4 – Split tensile strength of scrap tyre replaced concrete

3.4 Density : The density of concrete is calculated by taking the ration of weights of concrete cubes to its volumes. The density of conventional concrete and scrap tyre replaced concrete were shown graph 5.



Graph 5 - Density of scrap tyre replaced concrete

3.5 Young's modulus of elasticity: The young's modulus of elasticity is calculated by taking the ratio of stress to strain by conducting concrete compression test. The test result of young's modulus of elasticity is shown in graph 6.



Graph 6- Modulus of elasticity of scrap tyre replaced concrete

4. CONCLUSIONS

From the limited experimental study the following conclusions are seem to be valid:

1. The compressive strength of scrap tyre replaced concrete decreases when increases scrap tyre percentage. When compared to conventional concrete, the scrap tyre concrete lost 40% compressive strength at 20% replacement.
2. The density of fresh concrete slightly decreased with increasing quantity of scrap tyre compared to nominal mix.
3. This slump results shows that the scrap tyre replaced concrete reduces the workability by increasing the scrap tyre percentage.
4. The modulus of elasticity decreased continuously with increase in percentage of scrap tyre i.e., from 0 to 20% replacement.
5. So that it may be recommended construction of light weight concrete and non-loading structural elements by replacing more the 25% of scrap tyre
6. Due to continuous usage of naturally available aggregate within short length of time these natural resources get depleted i.e scarcity of aggregates can be reduced.
7. Based on the experimental investigations it is concluded that scrap tyre as artificial fine aggregate produced from automobile industrial by-product is in no way inferior to naturally available fine aggregate, more over which may be used in construction purpose its scrap tyre percentage may be reduces so, environmentally safe.

RECOMMENDATIONS FOR FUTURE WORK:

1. Effect of different curing periods of scrap tyre as fine aggregate can be studied.
2. Different replacements With different natural lightweight aggregates like scoria, rice husk, sawdust with and without steel fibres can be studied.
3. The present investigations were made for M20 grade, but it can be recommended to researcher for higher strength concrete to check it.
4. In addition to above with above materials with different mineral admixtures can be carried out.
5. Non destructive tests like rebound hammer; pulse velocity methods can be applied to know the quality of the concrete mixes.
6. Durability studies can be carried out with different percentages of Chloride and Sulphate and acids
7. X-ray diffraction (XRD), SEM, TEM analysis, electrolyte analysis can be studied for future work and also modelling can be done.

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