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AN EXPERIMENTAL INVESTIGATION OF USAGE OF SCRAP RUBBER TYRES AS PARTIAL REPLACEMENT OF FINE AGGREGATE

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ABSTRACT

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. While coming to fine aggregate; due to continuous usage of naturally available fine aggregate, with in the short span of time natural resources get depleted and it will be left nothing for future generations. Hence there is a necessity for utilization of artificially available materials in- stead of natural resources in the construction industry. 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. Moreover due to continuous usage of naturally available aggregates like fine and coarse aggregates are get depleted and it will be left nothing for future generations. Hence there is a necessity for finding alternate materials for preparing cement concrete making use of waste materials produced suchas municipal wastes, agricultural wastes and industrial wastes.

From the earlier studies it appears that much less attention has been made towards study of using scrap tyres as fine aggregate. Landfills all over the world are filled with tremendous amounts of scrap tyres. The disposal of used tyres in landfills is becoming unacceptable because of the rapid depletion of available sites for waste disposal. For example, there are two billion scrap tyres in the U.S. landfills with over 250 million tyres added every year. These stockpiles are dangerous not only due to potential environmental threat, but also from fire hazards and provide breeding grounds for rats, mice and mosquitoes.

Scrap tyres present both a challenge and an opportunity. The challenge is in how to dispose them in a safe and sustainable manner, while the opportunity is to turn a waste stream into a resource. The disposal of waste tyres is a serious environmental concern. The chemistry of rubber in these disposed tyres plays a major role is associated environmental pollution.In order to prevent the environmental problem from growing, recycling tyre is an innovative idea or way in this case. Disposed tyres have been recycled or used in various ways for several decades. The need to discover more ways to utilize disposed tyres is more important than ever because of the growing number of used tyre stockpiles in the US.

Key Words: flyash, pondash, Meta koalin, Blast furnace and Silica fume.

1. 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. While coming to fine aggregate; due to continuous usage of naturally available fine aggregate, with in the short span of time natural resources get depleted and it will be left nothing for future generations. Hence there is a necessity for utilization of artificially available materials in-stead of natural resources in the construction industry.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.

Fig.1. Scrap tyre collecting processes

Mix design M20 grade of concrete was used to study the different hardens properties of concrete. Scrap tyre has higher water absorption and usually no pozzolanic effect. Therefore, it is dumped in land fill sites or discharged in mass quantity and is easily available with free of cost. A previous in literature survey has indicated that, scrap tyre would be a potential fine aggregate in concrete. According to Indian scenario it is observed that at very few places good quality of sand may be available in plenty. All metro and mega cities in India are facing acute shortages of good quality of sand. At some places sand available is coarser than Zone I sand and hence not suitable for construction work. In contrast to the sand, scrap tyre is available in huge quantity due to more and more automobile industries in India. Scrap tyres can be granulated to produce Crumb Rubber, which has a granular texture and ranges in size from very fine powder to coarse sand-sized particles. Due to its low specific gravity, Crumb Rubber can be considered a lightweight aggregate. This Crumb Rubber can then replace sand in flowable fill to produce a lightweight material.

2. LITERATURE REVIEW

The performance of any concrete mixture is affected by the constituents that are combined to make up the final product. Rubberized concrete has been tested with the typical components used in traditional concrete mixtures, but with portions of the coarse and fine aggregates substituted with recycled waste tyre particles of various sizes. Replacement quantities by weight and particle sizes (passing a #40/retained on #60 sieve to cut strips of tyre 76mm long have been used to replace the natural aggregates normally used in concrete [Pierce, et al., 2002; Guoqiang, et al., 2004].

Fig.2. Scrap tyre collecting processes

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Recycled waste tyre rubber is a promising material in the construction industry due to its lightweight, elasticity, energy absorption, sound and heat insulating properties. In this paper the compressive strength of concrete utilizing waster tyre rubber has been investigated. Recycled waste tire rubber has been used in this study to replace the fine aggregate in different percentages.

Bakri et al.(2007) suggested that the reduction in strength due to increase in air content. And also observed that the scrap rubber increases the compressive strength decreases.Based upon above literature review it could be concluded that all researchers gave their findings with concrete up to 0-10%replacement of fine aggregate with scrap tyrein which compressive and tensile strength is increased up to 20% whereas not much change occurs in modulus of elasticity. Also workability is decreases with the increase of scrap tyre content because of high air voids.

3. OBJECTIVE & SCOPE OF INVESTIGATION

3.1. Structural modified concretes are considered as alternatives to concretes made with dense natural aggregate because of the relatively high strength to unit weight ratio that can be achieved. Due to continuous usage of naturally available aggregate within short length of time these natural resources get depleted and it will be left nothing for future generations. Hence there is a necessity for choosing alternate aggregate making use of waste materials from agricultural produce and industrial wastes

3.2. OBJECTIVES

The objective of this study was to determine the maximum amount of sand replacement with Scrap tyre in concrete mixtures without compromising the structural integrity of the concrete. This research will provide the necessary information to determine the beneficial use of recycled tyres in concrete construction. The specific objectives of the present investigations are as listed below.

3.3. APPLICATION OF SCRAP TYRES

If recycled waste tyre particles are found to provide a viable material substitution in the concrete

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matrix, The civil engineering market encompasses a wide range of uses for scrap tyres. In almost all applications, scrap tyre material replaces some other material currently used in construction such as lightweight fill materials like expanded shale or polystyrene insulation blocks, drainage aggregate, or even soil or clean fill.

A considerable amount of tyre shreds for civil engineering applications come from stockpile abatement projects. Tyres that are reclaimed from stockpiles are usually dirtier than other sources of scrap tyres and are typically rough shredded. Rough tire shreds can be used as embankment fill and in landfill projects.

Fig.3. Road embankment constructed with shredded tyres in El Paso, Texas.

3.4. LAND FILLS

Landfill construction and operation is a growing market application for tyre shreds. Scrap tyre shreds can replace other construction materials that would have to be purchased. Scrap tyres may be used as a lightweight backfill in gas venting systems, in leachate collection systems, and in operational liners. They may also be used in landfill capping and closures, and as a material for daily cover.

4. STANDARD TEST METHODS

The experimental study is done to the effect of scrap tyre in cement concrete. The percentage of scrap tyre is replaced with natural fine aggregate. The scrap tyre is used in this study was procured from Bangalore Tyre Recycling Company, Bangalore. This rubber is manufactured by special mills where big rubber change into smaller particles. The scrap tyre is mixed with the locally available natural fine aggregate, which is being used for making the cement concrete.

Fig.4. Cement bags for concrete.

Grade 53 Zuari cement was used for casting cubes and cylinders for all concrete mixes. The cement was of uniform colour i.e. grey with a light greenish shade and was free from any hard lumps. Summary of the various tests conducted on cement are as under given below.

Fig.5. Natural Sand

In this project research Sand has been procured from local swarnamukhi River in srikalahasthi. used as fine aggregate and passing through 4.75mm IS sieve is used. Various tests have been conducted as per the procedure given in IS 383 (1970) and from them it is found that.

4.1. COARSE AGGREGATE

Coarse aggregate makes solid and hard mass of concrete with cement and sand. It increases the crushing strength of concrete .It reduces the cost of concrete, since it occupies major volume.

Fig.6. Coarse Aggregate

4.2. SCRAP TYRE

In the present study the old rubber from heavy vehicles. Such as truck tyre 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.

Fig.7.Scrap Tyre

4.3. GROUND GRANULATED BLAST FURNACE SLAGE Admixture is defined as a material, other cement, water and aggregates that is used as ingredients of concrete and is added to the batch immediately before or during mixing. Additive is a material which is added at the time of grinding cement clinker at the cement factory. Admixtures are chemicals which are added to concrete at the mixing stage to modify some of the properties of the mix. Admixture should never be regarded as substitute for good mix design, good workmanship, are use of good materials.

Fig.8.GGBS

Although Portland blast furnace slag cement, Which is made by inter grinding the granulated slag with Portland cement clinker(blended), has been used for more than 60 years. The use of separately ground slag combined with Portland cement at the mixer as a mineral admixture did start until the late T97T's.

4.4. SETTING TIME FOR CEMENT

To determine the initial and final setting time of cement:

Weight about 400gms of cement.Measuring 85 times of percentage of water as determine in consistency test.

Mix the paste well and fill it to the mould.Attach a square needle of cross sectional area 1*1mm to the moving rod of vicat apparatus.

Quickly released the vicat rod and allow the needle to penetrate the cement paste in the beginning.

The needle is penetrate completely it is taken out and set fresh plan.

The procedure is repeated at regular intervals until the penetration is 5mm from the bottom of the mould. The time taken to achieve should not be more than 30 min is called initial setting time.

The time after which the needle falls to make an impression on the surface is the final setting time.

Initial Setting Time of Cement = 91 minutes

Final Setting Time of Cement = 240 minutes

Fig.9.Vicat Apparatus

4.5. NATURAL FINE AGGREGATE

Take empty pycnometer weight as W1.

In this test the fine aggregate was free from all the physical impurities.

Then ¾ TH of volume of pycnometer was filled with fine aggregate.

Then the weight of pycnometer and fine aggregate weight is taken as W2. And at the same time the water is filled with pycnometer up to the top and then the weight is taken as W3.

Then only the weight of container plus water is taken as W4.

By using these W1,W2,W3,and W4 the specific gravity of fine aggregate is calculated as following formulae ie,

Specific gravity =[(w2 –w1)]/ [(w2 – w1) –(w3 – w4)]

Fig.10.PYCNOMETER

4.6. Sieve Analysis

The given sample of aggregates were dried by keeping it oven a temperature of 100 to 110ºC for a period of 24 hours.

The weight of air dried samples was taken. The weight of sampled aggregates was kept in the top most sieve of the set with largest size at top and lower size at bottom. Care should be taken to ensure that the sieves were cleaned before use. Each sieve should be shaken separately over a clean tray for a period of not less than 2 minutes. The shaking was done with a varied motion backwards and forwards, left and right, clock wise and anti clock wise so that the material was kept moving over the surface in frequently changing directions. The weight retained aggregates was found on each sieve taken in order.

4.7. Scrap yre

Take empty pycnometer weight as W1.

In this test the Scrap tyre was free from all the physical impurities.

Then ¾ th of volume of pycnometer was filled with scrap tyre.

Then the weight of pycnometer and Scrap tyre weight is taken as W2. And at the same time the water is filled with pycnometer up to the top and then the weight is taken as W3.

Then only the weight of container plus water is taken as W4.

By using these W1,W2,W3,and W4 the specific gravity of fine aggregate is calculated as following formulae i.e, Specific gravity of Scrap tyre = [(w2 – w1)]/ [(w2 – w1) – (w3 – w4)] .

3. Results

Specific gravity of scrap tyre = (w2 –w1)/ (w2 – w1) – (w3 – w4) = 1.05

% of Water Absorption = (w6 – w5) / w5 * 100= 2.0% The entire sample procedure for second sample was repeated.

Specific gravity of scrap tyre = 1.05 Water absorption of scrap tyre = 2%

Table -1: SIEVE ANALYSIS OF FINE AGGREGATE

Sl. No	I.S.Sieve Size in	Weight Retain	Cumulative Weight	Cumulative Percen	Cumulative Percen
1	10.00	0.00	0.00	0.00	100.00
2	4.75	0.00	0.00	0.00	100.00
3	2.36	22.00	22.00	2.20	97.80
4	1.18	158.00	180.00	18.00	82.00
5	0.60	162.00	342.00	34.20	65.80
6	0.30	581.00	923.00	92.30	7.70
7	0.15	52.50	975.50	97.55	2.45
8	Pan	24.50	1000	0	
	Total	1000		244.25	

Percentage fineness modulus of the fine aggregate =

$$\frac{\text{cumulative percentage weight retained}}{100} = \frac{244.25}{100}$$

2.44%

5. EXPERIMENTAL PROGRAM

Table -2: MIX PROPORTIONS

S.I.N.O	WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
1	191.6	383	664.048	1090.74
2	0.5	1	1.734	2.85

5.1. MIXTURE PROPORTIONS

The tests carried out on water-cement ratio of 0.50. The control mix (M20) is designed with the Indian Standard Code guidelines. For making the mixes containing cement, scrap tyre, fine aggregate, Coarse aggregate, and water. The resultant mix proportions of all the mixes are tabulated in following Table.5.1.

Table -3: MIX PROPORTIONS

PARAMETERS	PERCENTAGE OF PARTIAL REPLACEMENT OF SAND BY SCRAP				
	CONTROL	MIX 1 (5	MIX 2	MIX 3	MIX 4
W/C	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	664.048	630.85	597.64	564.44	531.24
Coarse aggregates	1090.74	1090.74	1090.74	1090.74	1090.74
Scrap tyre	0	33.20	66.40	99.61	132.81
Mix proporti (C:FA:CA	1:1.73 2.85:0	1:1.6 2.85: 0.5	1:1.5 2.85: 0.1	1:1.4 2.85: 0.15	1:1.3 2.85: 0.2

Table -4: DESIGNATION OF DIFFERENT MIXES

SI.NO	Name of the mix	Percentage by weight of natural fine aggregate (FA) and scrap tire (ST)		No of specimens curing period	
		Natural fine aggregate	Scrap tire (ST)	7	28
1	ST-0	100	0	3	3
2	ST-5	95	5	3	3
3	ST-10	90	10	3	3
4	ST-15	85	15	3	3
5	ST-20	80	20	3	3

5.2. **SLUMP CONE TEST**

Slump cone test apparatus was made according to IS:7320-1974 and usedfor determination of the workability of concrete where the nominal maximum size of aggregate did note exceed 25mm.The apparatus used for doing slump test are Slump cone and tamping rod. Slump cone was filled with fresh concrete mix in four equal layers, and each layer was tamped for 25 times with a tamping rod in a uniform manner over the cross section. Finally the top of the cone was stroked off, so that, the slump was exactly filled. After that metal cone was removed by raising slowly and carefully in a vertical direction.

Fig.11.Slump Cone

5.3. CASTING & CURING TEST

For casting, all the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage out of slurry. Careful procedure was adopted in the batching, mixing and casting operations.The coarse aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams.

After de-moulding the specimen by loosening the screws of the steel moulds, the cubes were allowed to dry for one day before placing them in the temperature controlled curing tank for a period of 7 and 28 days . That means the strengths are calculated at 7 and 28 days respectively

5.4. COMPRESSIVE STRENGTH TESTING MACHINE

Compressive strength testing machine is important to determine the compressive strength of the cube. All the concrete specimens were tested in a 3000KN capacity automatic compression testing machine with 0.5kN/sec rate of loading until the specimens are crushed. Testing is conducted immediately after the specimens are removed from the curing process which is by air dry and using wet sack. Compression test is the most common test conducted on hardened concrete, partly because it is easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength.

Fig.12.Before placing the cube

The cube specimen of sides 150mm*150mm 150mm was casted to test various concrete mixtures for compressive strength. The cubes after remoulding were stored in curing tanks and on removal of cubes from water at 7days and 28days the compressive strength was conducted. The water and grit on the cubes were removed before testing the cubes.

Fig.13.Compressive strength After placing the cube

The compressive strength of the specimen is affected by the specimen size. Increasing the specimen size will reduce the strength,because there is a greater probability of weak elements where failure starts in large specimens than in small specimens.

6. RESULTS & DISCUSSIONS

The test data and results obtained from the tests conducted in the present investigations 30 concrete cubes have been presented in tables and discussed in this chapter in the test carried out, importance has been given to ultimate compressive strength, cracking and durability. The results of normal strength concrete are compared with 20% replacement of fine aggregate. Qualities such as slump value, compressive strength have been observed and recorded. Graphs of compressive strength vs. Replacement of aggregates in concrete have been represented in this project.

In this test investigation different type of concrete mixes were conducted, each one of the type have denoted by an identification mark. They are A, B, C, Dand E.

A= Conventional concrete

B = 5% Replacement of scrap tyre in fine aggregate

C = 10 % Replacement of scrap tyre in fine aggregate D = 15% Replacement of scrap tyre infine aggregate E = 20% Replacement of scrap tyre in fine aggregate.

6.1. Slump Cone Test Results

B = The slump value is 2.3 cm C = The slump value is 2.2 cm D =The slump value is 2.1 cm E = The slump value is 1.9 cm F = The slump value is 1.8 cm

The obtained slumps were considered under true slumps. The slumps were 2.4cm, 2.3cm, 2.2cm, 2.1cm and 1.9cm so; the degree of workability is high up to 20% replacement of scrap tyre. This type of slumps requires manually compaction. It is used for road construction works and mass concrete foundation.

Table -5: SLUMP RESULTS BY INCREASE IN SCRAP TYRE

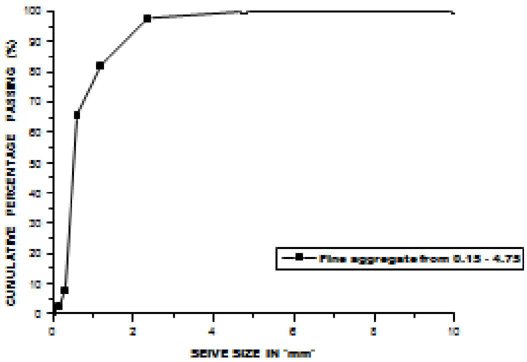
S.NO	% of scrap replacement	Slump in cm
1	0	2.4
2	5	2.3
3	10	2.2
4	15	1.9
5	20	1.8

6.2. COMPRESSIVE STRENGTH TEST

The compressive strength for same water cement ratios of scrap tyre added concrete and conventional concrete were tested at the end of 7 days and 28 days using compressive testing machine as shown in Fig 5.5. The water cement ratios were taken as 0.50. Three cubes are casted and the average of three test results is taken for the accuracy of the results. The concrete cubes were cured at room temperature. The compressive strength is clear from the Graph.6.2. In this test results the scrap tyre content increases the Compressive strength decreases. And the scrap increases the workability increases 0% to 20%.

Table -6: Youngǯs Modulus Results as per I.S.Code

S.I.NO	Name of the mix	Percentage by volume of natural ineaggregate(FA)an		Youngǯs Modulus (E)in N/mm2		Percentage decrease in youngǯs w.r.t. ST-0	
	Natural Fine Aggregate	Scrap tyre	7 Days Curing	28 Days Curin g	7 Days Curin g	28 Days Curin g	28 Day s Curing
1	ST-0	100	0	20629	25276	0	0
2	ST-05	95	5	18708	22901	-9.31	9.4
3	ST-10	90	10	18317	22435	-11.21	11.2
4	ST-15	85	15	18196	22311	-11.79	11.7
5	ST-20	80	20	16099	19720	-13.95	13.8



Graph 1.Grading curve of fine aggregate

6. CONCLUSIONS

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

1. The compressive strength decreases when increases scrap tyre percentage, when compared to conventional concrete.
2. The density of fresh concrete slightly decreased with increasing quantity of scrap tyre compared to nominal mix.
3. This results shows that the scrap increases the workability increases 5 to 20%.
4. The modulus of elasticity decreased continuously with increase in percentage of scrap tyre i.e., from 0 to 20% replacement.
5. So, it is not used for large constructions, and it can be used where only in light weights are necessary. So it can be used as light weight aggregate.
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.

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