RESEARCH ARTICLE OPEN ACCESS

Experimental Study on Concrete made by partially replacing Coarse Aggregate with scrap tire rubber

Vineeta Nirmal[1], Mrs. Shraddha Sharma[2]

1Student, Dept of Civil Engineering,
Bhilai Institute of Technology
Durg, CSVTU Bhilai,(C.G),India

2Assistant Professor Dept of Civil Engineering,
Bhilai Institute of Technology
Durg, CSVTU Bhilai,(C.G),India

Abstract:

Production of rubber tires are increasing on large scale due to increased automobile demand. One of the major environmental challenges around the world is the disposal of worn out tires. Scrap tires are non- biodegradable in nature therefore, it create major problem in environment. Civil Engineers around the world are in search of new alternative materials, which are required for cost effective solution as well as for saving natural resources like sand, aggregates etc. Using rubber tire as replacement to natural aggregate has advantage of saving in natural constituent which is used in the production of concrete. In this experimental study M20 grade concrete is used as reference point. In this study the effect of using scrap tire rubber as a partial replacement of coarse aggregate (4%,8% and 12% replacement)on various properties of concrete like strength and workability has been observed. The use of waste tire rubber in making concrete is the best disposal method to protect our environment.

***Keywords* — Automobile, Scrap tire, Strength, Workability etc.**

1. INTRODUCTION

Concrete is one of the basic materials which is used in construction industry, because of its properties such as high compressive strength, good durability properties, versatility and availability, cost effectiveness, as well as the ability to produce complex geometrical shapes to fit different requirements. Many types of concrete are used for different purposes. For example, self-compacting concrete is favourable for the situation where vibration is not able to apply as it can flow and compact by its own gravity. Recycled aggregate concrete is a kind of concrete which uses recycled materials, such as aggregate from demolished buildings, used for replacing natural aggregate for cost effectiveness and environment sustainability. High Early strength concrete, is suitable for emergent repairs, especially in cold condition, as it has a relative high strength in the early age after casting. Corrosion resistant concrete is generally used in marine environment where a lot of chloride ions and sulphate ions exist. Extensive research has been undertaken from the last 20 years of using recycled rubber as an aggregate replacement of concrete. As we all know, concrete has high compressive strength but weak in tensile strength. Therefore, the addition of rubber aggregate helps in improving the poor ductility, tensile and dynamic properties but it reduces the strength of concrete. Rubber concrete is often used for various applications such as highway crash barriers and other impact loading scenarios. However, practical projects to date which have been carried out for a specific use are still scarce.

1.1RECYCLED AGGREGATE

Concrete is the second most widely used material in the world because of its favourable properties. Natural aggregates are an important ingredient in concrete and is greatly used. This is disappointing for sustainable development because sand and gravels are non-renewable materials. Meanwhile, with the development of society ,year by year, more and more new buildings have been constructed, especially in developing counties. Correspondingly, many old buildings will be demolished, which causes a large amount of construction wastes generated. A variety of recycling methods for construction and demolition wastes have been explored and well developed in the last few decades. Recycled aggregates can be treated into different size to replace fine or coarse aggregate respectively. Many conclusions and recommendations have been drawn.

Figure.1.1: Waste Rubber Tyres

However, the study of using recycled aggregate in concrete with scrap tyre rubber together has not been researched. Therefore, this will be studied in the present research. recyclable, such as fine aggregate, coarse aggregate, and additions. The use of such materials would not only reduce the initial costs, but also create a far more sustainable approach to the construction, which is a clear selling point to a lot of investors. By cutting and grinding the tyres down into small particles, they can effectively be used in several concrete applications.

Figure.1.2: Environmental pollution due to burning of Tyres

1.2 RUBCRETE CONCRETE

The concrete mixed with waste rubber added in different volume proportions is called rubcrete concrete. Partially replacing the coarse or fine aggregate of concrete with some quantity of small waste tire in the form of crumb and chipped can improve qualities such as low unit weight, high resistance to abrasion, absorbing the shocks and vibrations, high ductility and brittleness etc to the concrete.

1.3 OBJECTIVES

1.Design of a standard concrete mix.
2.Replacement of coarse aggregate of standard concrete mix with different weight ratios of scrap tire rubber as (0%, 4%, 8%, and 12%) respectively.
3.To check the mechanical properties (workability, compressive strength etc) for both standard and modification concrete mix and comparing the properties of normal and modified concrete
4.To find which one of additive has excellent properties for civil construction applications

1.4ADVANTAGES OF RUBBER MODIFIED CONCRETE

1.The rubber modified concrete is affordable and cost effective.
2.It can resists the high pressure, impact and temperature.
3.The concrete have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation.
4.It provides flexibility when used in pavements.
5. Using magnesium oxychloride cement instead of Portland cement gives more compressive and tensile strength.

1.5 DISADVANTAGES OF RUBBER MODIFIED CONCRETE

1.Rubber modified concrete is weak in compressive and tensile strength.

1.6APPLICATION OF RUBBER MODIFIED CONCRETE

Rubberized concrete can find its successful application in non-structural components such as crash barriers, pavement blocks, sidewalks, culverts in road construction, precast roofs for green buildings and roofing tiles with lighter weight. It can be used in highway constructions as a shock absorber. It is used in sound barriers as a sound absorber. In can be used in buildings as an earthquake shock-wave absorber.

Figure 1.3: Rubber modified pavement blocks

2. LITERATURE REVIEW

1.IlkerBekirTopcu(1995) on their thesis 'the properties of rubberized concretes', they explained that the concrete was modified by mixing with crumb rubber in coarse aggregate in the ratio of 15%, 30% and 45%. The changes in the properties of rubberized concrete were investigated in terms of both size and amount of rubber chips added. In this investigation the physical and mechanical properties were determined from the stress strain diagram were developed from the toughness value and the plastic and elastic energy capacities were determined.[1]

2.Kamil E. Kaloush et al. 2004 in their study they tested various properties of concrete and compared them to concrete with rubber aggregates. From the study they observed that as the rubber content increased, the tensile strength decreased, but the strain at failure increased. Higher tensile strain at failure is indicative of more ductile mixes. He also established that Crumb Rubber Concrete is more resistant to thermal changes.[2]

3.**Grinys A, Sivilevi H, Daukšys M. (2012)** found some increase in the splitting tensile strength and attributed that to the adhesion between the cement paste and the crumb rubber. Although the compressive strength is lower than the conventional concrete, the absorption of the plastic energy is higher. They observed that as the percentage of the rubber tyres aggregates increase, the weight of the concrete decreases. Furthermore, the compressive strength decreases, if the rubber tyres aggregates are used to partially replace the normal ballast. Hence, the use of rubber tyres has not been recommended in the structures where high compressive strength is needed. Grinys et al. (2012) and Neil and Senouci (1994) used the rubber tyres as fine aggregates in concrete with different added percentages, and showed that strength and the weight were decreasing.[3]

4.**Nadim A. Emira and Nasser S. Bajaba (2012),** studied the viability of addition of waste rubber tyres aggregate as a replacement for natural aggregates in concrete, moreover, effect of curing time on the engineering properties were studied. Different concrete groups were prepared using plain Portland cement, crumb rubber as replacement for fine aggregates (0%, 10%, 20 % and 30%) by volume. Different sizes of crumb rubber were used which has been divided into three groups namely; (0.01-0.5) mm, (0.5-2) mm, and (2-3) mm. The specimens of all the different groups were investigated after different curing time namely; 7, 14, 21 and 28 days. The grade for normal concrete used in the study was M25. [4]

5.**Parveen, Sachin Dass, Ankit Sharma**,(2013) The aim of their study is the use of rubber waste as partial replacement of fine aggregate to produce rubberized concrete in M30 mix. Different partial replacements of crumb rubber (0, 5, 10, 15 and 20%) by volume of fine aggregate are cast and test for compressive strength, flexural strength, split tensile strength and stress-strain behavior. From the study they concluded that there is a reduction in all type of strength for crumb rubber mixture, but slump values increase as the crumb rubber content increase from 0% to 20%. Crumb rubber mixture is more workable compare to normal concrete and also useful in making light weight concrete. It is recommended to use the rubberized concrete for non structural applications.[5]

6.**Shanmugapriya M** (2015) investigated the feasibility on the use of rubber modified concrete in light weight structures. Ordinary Portland cement of 53 grade and rubber tyre aggregates with their size ranging from 12 to 20 mm was used. The aggregates are replaced with tyre aggregates with 3, 6, 9 and 12% (by weight).M25 grade concrete was used in this investigation. The mechanical properties, such as, compressive strength, tensile strength and toughness index were examined, stress strain response was also studied .they concluded that compressive strength of concrete reduces with increase in % replacement of aggregates.[6]

7.Mr. Chothe Onkar K.1, Mr. V.S.Kadam2, (2016) In this experimental study M20 grade concrete used as reference point. Tyre rubber waste used as a course aggregate in 5% , 10%, 15% replacement for conventional aggregate. As per this percentage cost benefit and strength ratio also identified.[7]

8.Nikhil Ramchandra Pardeshi1, Digvijay P. Singh2, Sakshi Ramesh Patil3, Pravin J. Gorde4 (2017) In this experimental study Two types of waste tyres are used as replacement of coarse aggregate and fine aggregate (crumb rubber and chipped rubber) by percentage of (0%, 10%, 15%, and 20%) in concrete. Hence this project have aimed to study the use of rubcrete concrete in structural and non-structural members and show how it is suitable for the concrete, its uses, barriers and benefits and way to future study. And To determine the characteristics of concrete containing tyre materials. From some results they concluded that there is a decrease in compressive strength of the concrete in other hand an increase in their toughness with good approach properties and also solve a serious problem posed by waste tires. And also Based on the results of some tests, concrete containing shredded tire particles as aggregates is still not recommended for structural uses because of the low compressive strength comparing with the normal concrete containing natural rock aggregates.[8]

9.S. D. Jamdar1, U.S Ansari2(2018) in their study, the specimens were prepared with replacements of the fine aggregate by 5, 10 and 15 percentage of crumb rubber aggregate and compared it with normal concrete with no replacement of aggregate. They also added 5% Fly Ash by weight of cement into normal concrete and crumb rubber mix concrete. In this evaluation, tests are performed as workability by slump cone test, unit weight, compressive strength, flexural strength, split tensile strength at 7th and 28th days on various concrete mixes. From this study they concluded that the compressive strength, split tensile strength unit weight of cube specimens and slump value of concrete is reduced as we increase the percentage of rubber in concrete. But, at 5% replacement of rubber the compressive strength increases with comparison of normal concrete.[9]

10.Shanvendra Singh, Manish Dubey,(2018) in their experimental study the Mix design of concrete grade M-15 and M-20. different percentages of course aggregate replaced by tyre rubber presence, In each mixes starting from 0% as normal concrete, and further 8%, 16%, and 24%, and water reducing admixture. From the study they observed that the strength differential between the specimens having no rubber aggregate and after adding rubber aggregate and concrete specimens became more distinct after at 28 days. It has been seen during study that as the percentage of tyre rubber aggregate increases the compressive strength increases initially, on further increase in its percenta reduces its compressive strength.[10]

3. MATERIALS AND METHODOLOGY

3.1Cement **:** Ordinary Portland cement of grade 53 is used. It should be fresh and without any lumps. Some properties of cement are as follows: Specific gravity- 3.15,Initial setting time-30 minutes, Final setting time -600 minutes

3.2 Fine aggregate: River Sand conforming to zone II as per IS 383-1970, is used as fine aggregate. Sand particles are sieved through 4.75mm sieve to remove the particles coarser than 4.75mm before used in concrete. Fine aggregate shall consists of natural sand, crushed stone sand, crushed gravel sand stone dust or arable dust, fly ash and broken brick (burnt clay). It shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc.

3.3 Coarse Aggregate: Coarse aggregate conforming to IS 383-1970 of maximum size 20mm is used. Specific gravity- 2.8,Bulk density 1383kg/m3. The coarse aggregate serves as reinforcement to add strength to the overall composite material

3.4 Scrap Tyre Rubber: Scrap tyre rubber in shredded form with particle size ranging from4.75mm to not more than 20mm is used as a partial replacement of coarse aggregate.

Figure 3.1 : Scrap Tyre Rubber

3.5 Water cement ratio: Water cement ratio is used as per IS456:2000 and IS 10262:2009. Mixing water should be fresh, clean and potable. Water should be free from impurities like clay, loam, soluble salts which lead to deterioration in the properties of concrete. Potable water is fit for mixing or curing of concrete.

MIX PROPORTIONS FOR TRIAL NUMBER 1 IN KG (for 1m^3 concrete and weight batching)

Cement	Water	Fine aggregate	Coarse aggregate	Rubber tyre	W/C ratio
403.2	181.44	588	1302	0	0.45

MIX PROPORTIONS FOR TRIAL NUMBER 2 (4% replacement of coarse aggregate by shredded tyre) IN KG (for 1m^3 concrete and weight batching)

Cement	Water	Fine aggregate	Coarse aggregate	Rubber tyre	W/C ratio
403.2	181.44	588	1249.92	52.08	0.45

MIX PROPORTIONS FOR TRIAL NUMBER 3 (8% replacement of coarse aggregate by shredded tyre) IN KG (for 1m^3 concrete and weight batching.

Cement	Water	Fine aggregate	Coarse aggregate	Rubber tyre	W/C ratio
403.2	181.44	588	1197.84	104.16	0.45

MIX PROPORTIONS FOR TRIAL NUMBER 4 (12% replacement of coarse aggregate by shredded tyre) IN KG (for 1m^3 concrete and weight batching)

Cement	Water	Fine aggregate	Coarse aggregate	Rubber tyre	W/C ratio
403.2	181.44	588	1145.76	156.24	0.45

4. Laboratory Tests

a. Fineness test of Cement:- The cement of good quality should have less than 10% of wt of cement particles larger than 90 µm. (micron).

b. Particle Size Distribution of Fine Aggregates : Test Sieves conforming to IS : 460-1962 Specification of 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron, Balance, Gauging Trowel, Stop Watch, etc is used.

c. Specific Gravity of Fine aggregate.

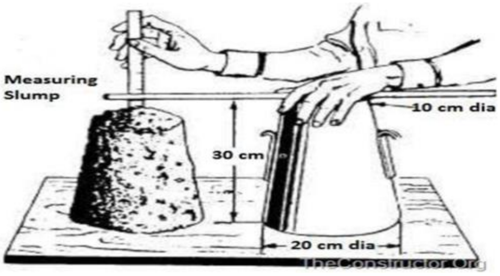
d. Fineness Modulus of Coarse aggregate.

e. Specific gravity and water absorption of coarse aggregate

f. Compressive strength test

g. Fineness Modulus of Rubber tire

g. Slump Test



5 RESULT

Table 5.1: Value of cumulative % retained of Coarse aggregate

IS sieve	Weight retained on sieve(Kg)	% of weight retained	% of weight passing	Cumulative % retained
80mm	0	0	100	0
40mm	0	0	100	0
20mm	1.359	27.18	72.82	27.18
10mm	3.187	63.74	36.26	90.92
4.75mm	0.353	7.06	92.94	97.98
2.36mm	0.065	1.3	97.98	99.28
1.18mm	0.036	0.72	100	100
600micron	0	0	100	100
300micron	0	0	100	100
150 micron	0	0	100	100
Total				**715.26**

Fineness modulus of Coarse aggregate is found to be = sum of cumulative % retained/100

= 7.15

Table 5.2: Unit weight of M20 Concrete

% Replacement	Unit weight(Kg)	% Reduction
0	8.432	0
4	8.12	3.7
8	7.94	5.84
12	7.46	11.53

Table 5.4: Value of Slump for M20 grade Concrete

Specimen	% Replacement	Slump Value (mm)
S0	Normal (0% replacement)	84
S4	4%	76
S8	8%	63.5
S12	12%	54.3

Table 5.3: Compressive Strength for M20 grade concrete

Specimen	Replacement in %	Actual Compressive Strength (MPa)		Avg. Compressive Strength(MPa)	
		7 days	28 days	7 days	28 days
S0	0	16.71	25.24	16.787	26.002
		16.865	26.764		
S4	4	16.03	23.23	15.96	23.605
		15.89	23.98		
S8	8	15.65	20.47	15.305	20.025
		14.96	19.58		
S12	12	14.34	18.69	13.835	18.46
		13.33	18.23		

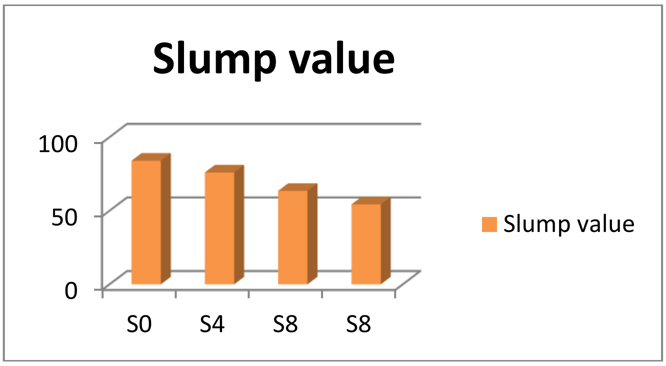


Chart1:Graph showing variation of slump with % replacement with rubber tyre

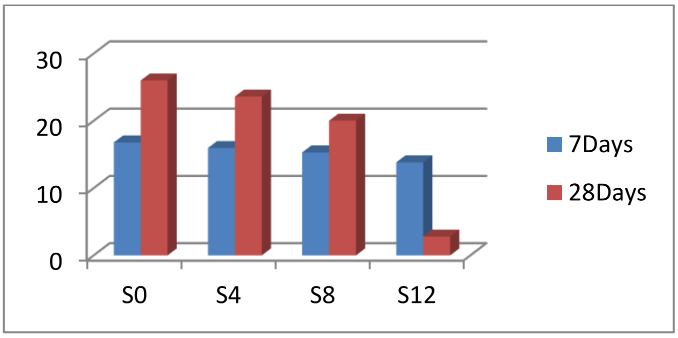


Chart2:Graph showing the variation of tyre rubber versus compressive strength in N/mm2 of M20 grade of concrete

Table 5.10: Value of cumulative % retained of rubber tir

Fineness modulus of Rubber tire is found to be =   sum of

IS sieve	Weight retained on sieve(Kg)	% of weight retained	% of weight passing	Cumulative % retained
80mm	0	0	100	0
40mm	0	0	100	0
20mm	0.927	18.54	81.46	18.54
10mm	3.843	76.86	23.14	95.4
4.75mm	0.230	4.6	95.4	100
2.36mm	0	0	100	100
1.18mm	0	0	100	100
600micron	0	0	100	100
300micron	0	0	100	100
150 micron	0	0	100	100
Total				**713.94**

cumulative % retained/100 =7.14

6. CONCLUSION

Based on the experiments done for the research following conclusions are observed:

1. From the study it is observed that as the percentage of rubber content increased, the compressive strength decreased, but the strain at failure increased. Hence, the use of rubber tyres has not been recommended in the structures where high compressive strength is required
2. With increase in percentage of rubber tyre, slump value of concrete decreases. Hence workability decreases with increase in fraction of rubber tyre.
3. The use of rubber in concrete is an excellent choice for feasibility, a cleaner environment, and a reduction in insulation cost and non structural element.
4. Workability and unit weight of concrete also decreases as we increase % of replacement of coarse aggregate.

7. SCOPE FOR FUTURE WORK

1. Rubber tire based concrete shows a better performance than ordinary concrete, so it has a future scope in various types of construction works where high strength is not required.
2. In this study, the work can be carried out by using higher percentage of tire rubber concrete.
3. In this experimental study, material other than TYRE rubber aggregate, fly ash can be used to increase the strength of concrete
4. In this investigation tire rubber of about 4 ,8 and 12 % of the total replacement content have been done. Further study can be carried out by using different percentage of replacement.
5. Workability of concrete decreases on increasing the % of rubber tire. For maintaining the workability, super plasticizer have to add.
6. In this study, silica fume can be used to increase the strength of rubberized concrete.

8. REFERENCES

[1]. Ilker Bekir Topcu (1995) “The properties of rubberized concrete”, Cement and Concrete Research, Vol. 25, No.2, pp. 304- 310, 1995. [2]. Kamil E. Kaloush, George B. Way, Han Zhu, “Properties of Crumb Rubber Concrete” 2004.

[3].Grinys A, Sivilevi H, Daukšys M (2012). Tyre Rubber Additive Effect on Concrete Mixture Strength. J. CIVIL ENG. MANAGE. Ten.doi:10.3846/13923730.2012.693536

[4]. Nadim A. Emira and Nasser S. Bajaba (2012) “Utilization of Waste Crumbed Rubber Tire As Fine Concrete Aggregate”, Yanbu Journal Of Engineering and Science, Vol.4,april 2012 (1433H), 2012.

[5].Parveen, Sachin Dass, and Ankit Sharma. "Rubberized Concrete: Needs of Good Environment (Overview)." International Journal of Emerging Technology and Advanced Engineering (2013).

[6] Shanmugapriya M, “Effects of Concrete By Using Waste tyre Rubber (Solid Waste)”, International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 5 (2015) pp. 13221-13230, 2015.

[7]. Mr. Chothe Onkar K.1, Mr. V.S.Kadam2, Patil Vikram3, Patil Pravin4,EFFECT OF REPLACEMENT OF COURSE AGGREGATE BY SCRAP TYRE RUBBER : EXPERIMENTAL STUDY, Volume: 03 Issue: 05 | May-2016 www.irjet.nete-ISSN:2395 -0056, p-ISSN: 2395-0072.

[8] Nikhil Ramchandra Pardeshi1, Digvijay P. Singh2, Sakshi Ramesh Patil3, Pravin J. Gorde4 ,Prachity P.Janrao5, Performance and Evaluation Of Rubber As Concrete Material, Volume: 04 Issue: 01 | Jan -2017, www.irjet.net, e-ISSN: 2395 -0056 p-ISSN: 2395-0072

[9]. S. D. Jamdar1, U.S Ansari2 “Experimental Study of Rubberized concrete”, International Journal of Engineering and Techniques - Volume 4 Issue 1, Jan – Feb 2018.

[10]. Shanvendra Singh, Manish Dubey “ An Experimental Study on Strength of concrete using Tyre Rubber & Replacing Aggregates of Different Percentage with Tyre Rubber”, International Journal of Research and Technology (IJRT) ISSN No. 2394-9007 Vol. V, No. III, June 2018

[11]. IS456:2000

[12]. IS 10262:2009