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Experimental Investigation on Strength of Concrete using waste rubber tyres as Partial Replacement of Coarse Aggregate

Sunil Sammani[1], Anusuri. Uma Maheswari[2]

[1]M. Tech Student, Department of Civil Engineering, Chaitanya Engineering College, Kommadi, A,P, India
[2]Assistant Professor & HOD, Department of Civil Engineering, Chaitanya Engineering College, Kommadi, A,P, India

ABSTRACT

The use of scrap tyre rubber in the preparation of concrete has been thought as an alternative disposal of such waste to protect the environment. In this study an attempt has been made to identify the various properties necessary for the design of concrete mix with the coarse tyre rubber chips as aggregate in a systematic manner. In the present experimental investigation, the M50 grade concrete has been chosen as the reference concrete specimen. Scrap tyre rubber chips, has been used as coarse aggregate with the replacement of conventional coarse aggregate Concrete is one of the most popular building materials. The construction industry is always increasing its uses and applications. Therefore, it is required to find alternative materials to reduce the cost of concrete. On the other hand, non-biodegradable waste i.e. water bottles,disposable glasses, shredded or crumbed rubber etc., is creating a lot of problems in the environment and its disposal becoming a great difficulty. The objective of this paper is to investigate the use of rubber pieces as coarse aggregate in the concrete. Concrete tested with varying percentages of rubber from 0 to 20% of normal aggregate. Strength tests and Slump cone test on concrete is carried out and comparative analysis is made.

Keywords: Compressive Strength, Crumb rubber,Flexural Strength, Rubberized Concrete, Split Tensile Strength.

INTRODUCTION

Waste-Tire rubber is one of the significant environmental problems worldwide. With the increase in the automobile production, huge amounts of waste tire need to be disposed. Due to the rapid depletion of available sites for waste disposal, many countries banned the disposal of waste tire rubber in landfills. It is recommended to use rubcrete in the production of curbs, roads, concrete blocks, and non-bearing concrete wall. Recycled waste tire 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 tire rubber has been investigated. Recycled waste tire rubber has been used in this study to replace the coarse aggregate by weight using different percentages. Extensive investigations on wastage recycling are being implemented to minimize the environmental damages. Investigation shows that used tyre do not decompose under environmental condition, so burning is the only the choice for their decomposition, which causes harmful pollution. On the basis of experiments, we can use these crumb rubber tyres in concrete as coarse aggregate. However, this may decrease the compressive strength of concrete which will be compensated by adding nano-silica to the rubber containing concrete.

LITERATURE REVIEW

A. Y. Kamala Raju, N. Harish Kumar (2019), "Strength Performance of Crumb Rubber Concrete":
Compressive strength of M40 grade of concrete with 0.4 water to cement ratio was investigated; in which, crumb rubber shall be used at varying percentages 0%, 10%, 20%, 30% as a partial replacement to sand in concrete in order to find out the optimum percentage of crumb rubber. The concrete mix of M40 prepared was tested at 7, 14 & 28 days. The use of crumb rubber overcome pollution problem in the environment and it helps in the durability of concrete. On the basis of experimental investigation and the test results, following conclusions are drawn, the compressive strength increases up to 10% and then gradually decreases and workability of rubberized concrete decreases with increase in rubber content which could be compensated by increasing the dosage of chemical admixtures.

B. Mazyad Al-Fadhli (2017), "Advantages of Concrete Mixing with Tyre Rubber":
This paper examines the properties of rubber aggregates mixed in concrete where sand and coarse aggregate are replaced by rubber chips. Test results indicate that while the tensile strength is increased, compressive strength is reduced when proportion of rubber aggregates is increased beyond 50%. There findings indicate that it is not advisable to use rubber aggregates in concrete mixes for high strength and load bearing applications. Using rubber aggregates in such applications can help to prevent pollution and overcome the problem of storing used tyres.

C. Bhavik Bhatt, Parth Khandla and Tausif Kauswala (2017), "Experimental Study of Crumb Rubber in Concrete":
In this research an innovative use of the crumb rubber in concrete formulations as a sand replacement in range of 0%, 2.5%,5%,7.5% and 10 % by weight for M-25 grade cement (OPC). From the results of the experimental study, the following conclusions were observed. The compressive strength for M 25 grade for all proportions comes within 25 N/mm^2. So we can replace the crumb rubber upto 10 %. The Flexural strength comes optimum when 5% of Crumb rubber is replaced by fine aggregate. The water Absorption increases with the increase in proportion of the crumb rubber.

D. S.Selvakumar, R.Venkatakrishnaiah (2015), "Strength Properties of Concrete Using Crumb Rubber with Partial Replacement of Fine Aggregate":
The compressive strength of crumb rubber concrete with 5% replacement is 38.66 N/mm^2.It is higher than the strength of normal concrete (36.73N/mm^2) on 28th day. The compressive strength of crumb rubber concrete with 10% replacement, it gives acceptable strength of 3.47 N/mm^2 at 7days. In splitting tensile strength the strength of crumb rubber concrete is lower than the strength of normal concrete. In the flexural strength test conducted on crumb rubber concrete it shows a decrease in strength when compared to the strength of normal concrete. From the test results, it is found that the crumb rubber posses less bonding ability which has affected on the strength of the concrete.

EXPERIMENTAL PROGRAM

This paper aims at utilizing rubber waste tyres as a constituent in concrete mixes and its products as a partialreplacement of natural coarse aggregate components.In this study six different types of mixes or combination is being considered and designed as per Indian Standard Specification IS: 10262(2009).

- Water cement ratio- The water cement ratio must be optimum according to the grade of concrete chosen and mix design has to be done

- Quality aggregates – The quality of aggregates must be high.

- The other five concrete mixes were made by replacing the coarse aggregates with 5%, 10%, 15%, 20%, 25% and 30% of discarded tyre rubber by weight.

MATERIALS

A. Cement
Cement is a binding material use in construction to bind other materials like coarse and fine aggregate. Cement confirming to IS 8112-1989 OPC of grade 53 was used in this experiment. The cement used for casting the specimen is ZUARI 53 grade ordinary Portland cement. The required quantity is procured as single batch, stored in airtight bags are used for the experimental programme.

B. Fine Aggregate
Fine Aggregates (Sand). It is divided in four gradations Zone-I, Zone-II, Zone-III & Zone IV. Generally, the size of the aggregate lesser than 4.75 mm is considered as Fine Aggregate. The physical properties of aggregate were considered according IS: 2386(1963). Aggregate most of which pass through 4.75 mm IS sieve is known as fine aggregate. Fine Aggregate belongs to Zone II is used.

C. Coarse Aggregate
The aggregate that retains on 4.75mm sieve, it is called coarse aggregate. It reduces shrinkage and occupies the 70-80% volume of concrete. Crushed stone and natural gravel are the common material used as coarse aggregate for concrete. Coarse aggregate is obtained by crushing various types of granites, schist, crystalline and lime stone and good quality sand stones. Testing is done as per Indian Standard Specification IS: 383-1970.

D. Water
Water is a key ingredient in the manufacturer of concrete.Water is used for mixing,curing purpose should be clan and portable, fresh and free from any bacteria and desire matter confirming to IS 3025-1964 is used for mixing.

E. Waste Rubber Tyre

Waste Tyre Rubber obtained from Scrap Market. Waste Tyre Rubber is an ideal material for recycling. The use of Waste Tyre Rubber saves lot of energy and the increasing awareness of Waste Tyre Rubber, recycling speeds up focus on the use of Waste Tyre Rubber with different forms in various fields.

TESTS CONDUCTED ON MATERIALS

A. Cement

On Cement Normal Consistency, Setting Time, Fineness, Soundness and Compressive Strength tests were carried out and the various properties of cement were determined.

Table1: Properties of OPC53 Grade Cement

S.NO.	PropertyofCement	ValuesObtained	StandardValues (AsPerIs:12269-1987)
1.	StandardConsistency(%)	32%	28%
2.	InitialSettingTime(mins)	60mins	≥30mins
3.	FinalSettingTime(mins)	380mins	≤600mins
4.	Fineness(%)retainedonIS90µSieve	3%	≤10%
5.	Soundness(byLeChatelier)	4mm	≤10mm
6.	SpecificGravity	3.15	----------
7.	CompressiveStrength(N/mm^2)	$39N/mm^2$	$\geq 37N/mm^2$
		$57.66\ N/mm^2$	$\geq 53N/mm^2$

B. Fine Aggregate

On Fine Aggregate Sieve Analysis, Water Absorption, Specific Gravity and Bulking tests were performed and the results were tabulated below.

Table2: Properties of Fine Aggregate

S.NO.	PropertyofFineAggregate	ValuesObtained
1.	SpecificGravity	2.74
2.	Water Absorption(%)	3.20%
3.	GradingZone	II
4.	FinenessModulus	2.91
5.	Bulking of Sand	36%

C. Coarse Aggregate

On Coarse Aggregate Sieve Analysis, Water Absorption, Specific Gravity and Bulking tests were performed and the results were tabulated below.

Table3: Properties of Coarse Aggregate

S.NO.	PropertyofCoarseAggregate	ValuesObtained
1.	ParticleShape	Angular
2.	SpecificGravity	2.74
3.	WaterAbsorption(%)	0.27%
4.	FinenessModulus	4.07

RESULTS & DISCUSSIONS

A. Compressive Strength Results

Table4: CompressiveStrength ofConcreteCubes for Varying Percentages of Rubber Tyre

Rubber Content (%)	Average3 DaysCompressive Strength (N/mm^2)	Average7 DaysCompressive Strength	Average28 DaysCompressive Strength

		(N/mm^2)	(N/mm^2)
0%	21.86	34.34	53.56
5%	22.79	35.56	54.74
10%	23.81	36.68	55.79
15%	22.09	34.37	53.62
20%	20.19	33.20	52.66

B. Split Tensile Strength Results

Table5: Split TensileStrength ofConcreteCylinders for Varying Percentages of Rubber Tyre

Rubber Content (%)	Average7 DaysSplit Tensile Strength (N/mm^2)	Average28 DaysSplit Tensile Strength (N/mm^2)
0%	3.69	4.84
5%	3.76	5.15
10%	3.87	5.35
15%	3.71	5.03
20%	3.61	4.79

C. Flexural Strength Results

Table6: Split TensileStrength ofConcretePrisms for Varying Percentages of Rubber Tyre

Rubber Content (%)	Average7 DaysSplit Tensile Strength (N/mm^2)	Average28 DaysSplit Tensile Strength (N/mm^2)
0%	5.44	6.08
5%	5.59	6.20
10%	5.98	6.70
15%	5.50	6.10
20%	5.41	6.00

D. Slump Cone Test Results

Table7: Slump ofConcretefor Varying Percentages of Rubber Tyre

Rubber Content (%)	Slump Value (mm)
0%	50

5%	52
10%	53
15%	48
20%	40

CHART 1: Compressive Strength of Concrete Cubes for Varying Percentages of Rubber Tyre

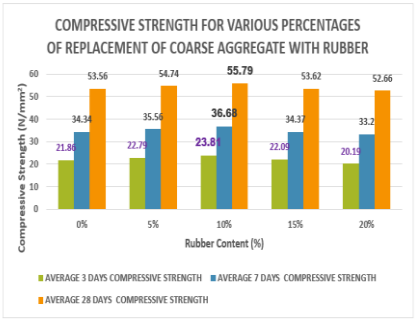


CHART 2: Split Tensile Strength of Concrete Cylindrical Specimens for Varying Percentages of Rubber Tyre

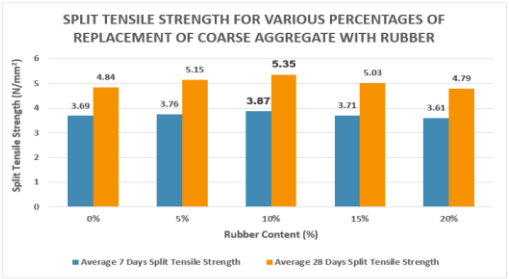


CHART 3: Flexural Strength of Concrete Prism Specimens for Varying Percentages of Rubber Tyre

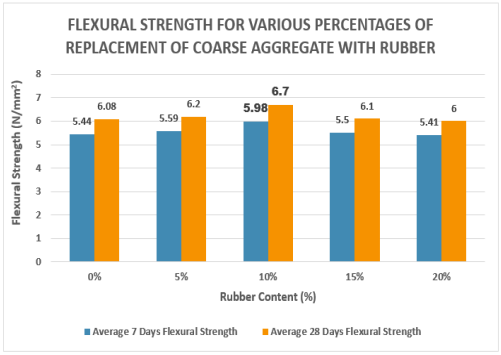
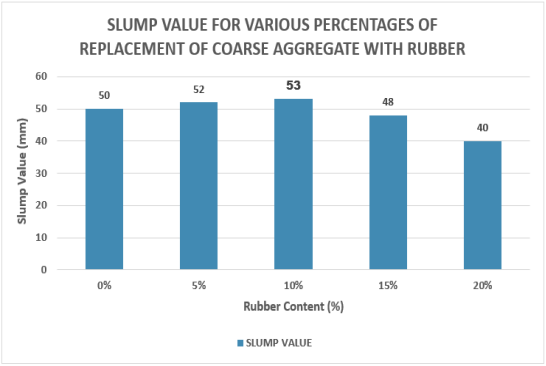


CHART 4: Slump Value of Concrete for Varying Percentages of Rubber Tyre



CONCLUSIONS

The test results of this study indicate that there is great potential for the utilization of waste tyres in concrete mixes in several percentages, ranging from 5% to 20%. Based on present study, for different grade proportion, the strength of rubberized concrete may vary when compared with the conventional concrete. So, it is preferable and economical when the places required rubber as partial replacement on concrete. From our experiment we can conclude that rubber replaced concrete for coarse aggregate can be used for domestic purposes like wall panels, road construction, etc., the rubberized concrete not only reduces the cost and environmental impacts of concrete, but also it eliminates the waste tyre stockpiles and its potential threats to the environment.

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	Anusuri Uma Maheswari, working as an Assistant Professor & HOD in Chaitanya Engineering College, kommadi. Obtained B.Tech and M.Tech Degree from G.V.P. College of Engineering