Journal of Civil Engineering and Environmental Technology
Print ISSN : 2349-8404; Online ISSN : 2349-879X; Volume 2, Number 9; April – June, 2015 pp 63-67
Krishi Sanskriti Publications
http://www.krishisanskriti.org/jceet.html

Experimental investigation of crumb rubber concrete confined by FRP sheets

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Abstract: *This paper, through experimental study and literary sources investigates the utilization of rubber waste in developing Green Concrete (GC). The natural aggregate (sand) of Conventional Concrete (CC) is replaced as 5%,10%, 15% fine rubber aggregate. The samples were tested in laboratory after a specific time on various aspects including compression strength and results were compared with each other and also with Conventional Concrete Mix (CCM)..Due to the known loss of compressive strength experienced by crumb rubber concrete (CRC) compared with conventional concrete, there have been few applications explored to date for the structural use of these materials. This paper describes experimental work conducted to explore the possible future use of CRC for structural columns by evaluating the use of fibre reinforced polymer (FRP) confinement as a means of overcoming the material deficiencies (decreased compressive strength). The results indicated that the use of FRP to confine rubberized concrete effectively negates the decrease in strength, and retains the advantages of increased ductility that arise from rubberized concrete. This indicates promising potential for structural column applications, particularly in seismic zones. The key objective of this research is to find out an efficient solution for utilizing rubber waste for better environment and construction industries.*

1. INTRODUCTION

Concrete strength is greatly affected by the properties of its constituents and the mix designparameters. Because aggregates represent the major constituent of the bulk of a concretemixture, its properties affect the properties of the final product. An aggregate has beencustomarily treated as an inert filler in concrete. However, due to the increasing awareness ofthe role played by aggregates in determining many important properties of concrete, thetraditional view of the aggregate as an inert filler is being seriously questioned. Aggregatewas originally viewed as a material dispersed throughout the cement paste largely foreconomic reasons. It is possible, however, to take an opposite view and to look on aggregateas a building material connected into a cohesive whole by means of the cement paste, in amanner similar to masonry construction. In fact aggregate is not truly inert and its physical,thermal, and sometimes chemical properties influence the performance of concrete.

Kumaran S.G. et al stated that the increasing piles of waste tires will create the accumulationof used tires at landfill sites and presents the threat of uncontrolled fires, producing a complexmixture of chemicals harming the environment and contaminating soil and vegetation

Material	passenger car	Truck car
Natural rubber	14 %	27 %
Synthetic rubber	27 %	14 %
Carbon black	28 %	28 %
Steel	14-15 %	14-15 %
Fabric, fillers, accelerators, antiozonants, etc.	16-17 %	16-17 %

Table 1.Percentage composition of materials for a passanger and a truck car

SCOPE OF THE STUDY: To achieve adequate strength, higher energy dissipation, higher damping ratio, and higher ductility for bridge column.The FRP acts as a stay-in-place structural formwork, and provides shear reinforcement, and confining reinforcement..This segmental column is able to resist lateral forces without experiencing significant or sudden loss of strength.To increase the axial capacity and ductility

METHODOLOGY: In this experiment the performance of concrete mixes incorporating 0%,5%,10%,15% of crumbed scrap tyre rubber particle as a partial replacement of fine aggregate is investigated..FRP sheets are confined to the steel cylinders(150X300).The FRP fabric has a width of 300mm,thickness of 0.13mm,and is cut to the required length to wrap the each cylinder.The epoxy was prepared using brush and a roller, the fabric sheets were fully saturated with epoxy,and then wrapped around the cylinder..Thefibres are oriented in the hoop direction..Concrete was poured into the prepared cylinders,and is cured in a water bath at normal temperature.7 days and 28 days compressive strength,stress-strain behaviour,poissons ratio and modulus of elasticity is evaluated after 28 days of curing.

2. EXPERIMENTAL PROGRAM

In this research the performance of concrete mixes incorporating 0%, 5%, 10%, and 20% of crumbed scrap tyre rubber as a partial volume replacement of fine aggregates was experimentally investigated. The effects of rubber content, rubber pre-treatment, and silica fume (SF) additives on concrete workability, compressive strength, tensile strength, modulus of elasticity, and Poisson's ratio were examined by testing 101 standard concrete cylinders

2.1 Materials used for the study

The materials used for the study Cement, Fineaggregate. Coarse, aggregate. Water, Silica, sand. Rubberaggragate, Fibre ,reinforced polymer(FRP)Chemical admixture.

2.2 Fine aggregate

Fine aggregate / sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles, but is distinct from clays which contain organic materials. For the present study Manufactured sand (M-sand) was used. Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing. The size of manufactured sand (M-Sand) is less than 4.75mm.

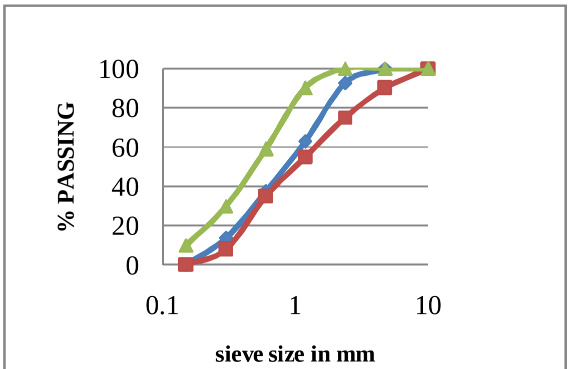


Fig 1.Gradation of fine aggregate (manufactured sand)

2.3 Coarse aggregate

Coarse aggregate are the crushed stone is used for making concrete. The commercial stone is quarried, crushed, and graded. Much of the crushed stone used is granite, limestone, and trap rock. The last is a term used to designate basalt, gabbro, diorite, and other dark colored, fine-grained igneous rocks. Graded crushed stone usually consists of only one kind of rock and is broken with sharp edges. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), although lager sizes may be used for massive concrete aggregate. Machine chorused granite broken stone angular in shape is as use as aggregate

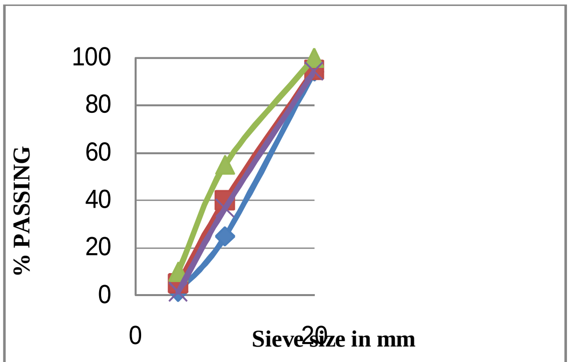


Fig.2 Gradation of coarse aggregate…

2.4 Rubber aggregates:

Some of the other civil engineering applications include road and landfill construction, septic tank construction etc. Remaining tires are disposed of into the landfills. The tire derived fuels i.e. TDF are accounted for 40.3%, ground rubber applications are accounted for about 26.2% and 5.5% accounted for various civil engineering applications of the total generation of scrap tires in the year 2009 [Rubber Manufacturer's Association]. However, at the end of 2010, about 112 million scrap tires still remained in the stock piles and this number is increasing every year. The statistics brings out the importance of the more widespread and durable application program for the reuse of the scrap tires.
The ground rubber also called as crumb rubber is produced by reducing scrap tires to smaller sizes by grinding.

Properties of rubber aggregates	**Values**
Specific gravity	0.73
Water Absorption %	0%
Bulk density (g/cc)	0.5283

Table2 Physical properties of rubberized concrete

2.5 Compressive Strength of Cubes

The target mean strength for M30 concrete is 38.25 N/mm^2. Concrete cubes of size 150 mm×150mm×150mm were cast and tested under compression testing machine. The compressive strength was determined at the age of 7 days. After 7 days, the beams as well as cubes casted along with the beams was removed from curing.

The maximum load at failure reading was taken and the compressive strength is calculated by using the equation:
Compressive strength (N/mm^2) = Ultimate load in N

Area of cross section (mm^2)

Testing of cubes under compression testingmachine

2.6 Fibre Reinforced Polymer Composites (FRP): Fibre reinforced polymer (FRP) composites consist of high strength fibres embedded in a matrix of polymer resin.Thesefibres are all linear elastic up to failure, with no significant yielding compared to steel. The primary functions of the matrix in a composite are to transfer stress between the fibres, to provide a barrier against the environment and to protect the surface of the fibres from mechanical abrasion.

Fig4Carbonfibre reinforced polymer

Epoxies provide high bond strength with high temperature resistance, whereas acrylics provide moderate temperature resistance with good strength and rapid curing. Several considerations are involved in applying adhesives effectively.
The present study of retrofitting of beams was carried out by using carbon fiber reinforced polymer which was bought from BASF, Bangalore

Technical data of fiber	400 gsm
Modulus of elasticity	230 kN/mm^2
Tensile strength	4900 N/mm^2
Total weight of sheet	400 g/m^2
Density	1.8 g/cm^2
Thickness for static design	0.25 mm

Table 3 Properties of FRP used for the present study

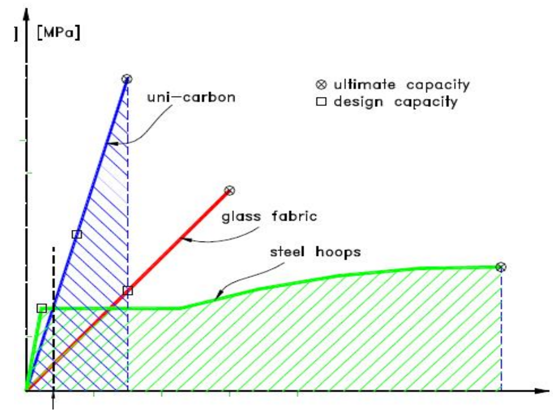


Fig 5 Graph showing the capacity of carbon fibers compared to other fibers

3. PROPERTIES AND TEST ARRANGEMENTS
3.1Tensile Strength:

The tensile strength of rubber containing concrete is affected by the size, shape, and surface textures of the aggregate along with the volume being used indicating that the strength of concretes decreases as the volume of rubber aggregate increases . As the rubber content increased, the tensile strength decreased, but the strain at failure also increased. Higher tensile strain at failure is indicative of more energy absorbent mixes . Tests conducted on
rubberized concrete behavior, using tire chips and crumb rubber as aggregate substitute of sizes 38, 25 and 19 mm exhibited reduction in splitting tensile strength by 50% but showed the ability to absorb a large amount of plastic energy under tensile loads.

3.2 TOUGHNESS
Concrete composites containing tyre rubber waste are known for their high toughness having a high energy absorption capacity. The ASTMC1018-97 defines several toughness indexes as the area under load-deflection curve of a flexural specimen for different times of deflection after crack initiation related to area under the same curve up to the crack initiation. Some authors report a 63.2% increase in the damping ratio

(self capacity to decrease the amplitudeof free vibrations) for concrete containing 20% rubber particles. Other authors confirmed the high damping potential of rubber waste concrete. These means that tyrewaste concrete maybe specially recommended for concrete structures located in areas of severe earthquake risk and also for the production of railway sleepers.

3.3 MODULUS OF ELASTICITY

Since the concrete with rubber waste has low compressive strength and a correlation exists between compressive strength and the modulus of elasticity it is expected they also possess lower modulus of elasticity. However, Skripkiunas et al.compared concretes with similar compressive strength (a reference one and another with 3.3% of crumb rubber) obtaining different

static modulus of elasticity, 29.6 GPa versus 33.2GPa for the reference concrete just 11% higher. The explanation for this behaviour is related to the low modulus of elasticity of rubber waste .

4.TESTING ARRANGEMENT

In this study, a total of 16 cylinders consisting of concrete grades C30were produced with partial replacements of the fine aggregate by 10, 5 and 20 % of the rubber aggregate. Moreover, a control mix with no replacement of the coarse aggregate was produced to make a comparative analysis. The mix design process adopted was the Department of Environment (DOE) method.

4.1 Methodology Adopted for Wrapping: The composite fibers were wrapped to the cylinders in tension zone by using epoxy resin. The following procedure was carried out.

4.2 Surface Preparation The surface to be prepared is typical aborted to smooth out irregularities, remove the sharp corners. This can be done by sand blasting, sand papers, water jets or grinders.

4.3 Application ofPrimer and Epoxy Saturant:M-Brace Primer is a 100% solid epoxy resin based primer for use on porous mineral substrate. Low viscosity enables effective penetration and sealing of porous substrate

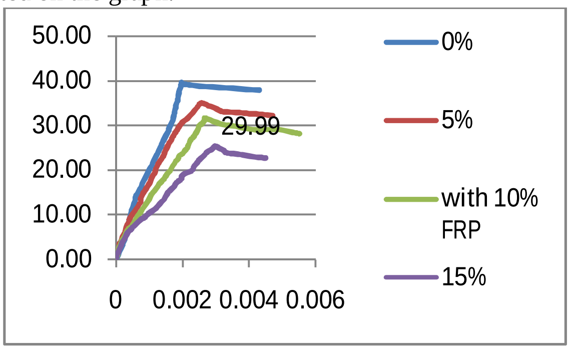
M-Brace Saturant is a 100% solid, blue pigmented, epoxy resin for saturation of M- BraceFiber Sheet to form in-situ FRP Composite. Mixing ratio,by weight(B:H) : 100:52. Apply first coat of fully mixed M-Brace Saturant to primed concrete substrate using roller or brus**h**.

Fig 6.Affter appllying FRP sheets and After curing

5 RESULTS AND DISCUSSIONS

5.1 Stress strain behaviour

In this experiment stress strain behaviour of crumb rubber concrete confined by FRP and without FRP are disscussed.Here fall of strain due to the crumb rubber is plotted on the graph.



STRAIN

Fig 7..Stress strain behaviour of crumb rubber concrete confined by FRP

Here as the percentage of the crumb rubber increases strenth of conrete cylinders decreases but strain increases due to energy absorption of rubber particles.Graph clearly shows that after the failure also cylinders will take load.

5.2 Indirect (splitting) tensile strength:

The tensile strength of the concrete mixes at 28 days was only determined for the L group mixes using the indirect tensile (splitting) test and the results are shown. As expected, the pattern of the concrete tensile strength was similar to that of the corresponding compressive strength. In addition, the tensile strength of each mix was about 8.7% of the corresponding compressive strength. This indicates that the tensile behaviour of CRC is similar to that of conventional

Concrete

Fig 8. Specimen after applying tensile load

% variation of rubber particles	Without FRP(KN)	With FRP(KN)
0	158	220
5	140	208
10	128	190
15	115	160

Table 4 Load taken by the cylinders at the time of testing splitting tensile strength

6. CONCLUSION

increased its ductility, especially at higher levels of confinement. Therefore, the use of confined CRC in structures subject to seismic loads, where ductility demands are more critical than strength, looks promising.

The Confined CRC displayed similar volumetric behaviour to the confined conventional concrete. However, the rate of volume expansion for CRC mixes was less than that of conventional concrete. At a given axial stress and confinement thickness, the volumetric strain of CRC is higher than that of conventional concrete. This also confirms the higher ductility of CRC compared to conventional concrete.

The confined CRC can be used as a promising alternative to the confined conventional concrete in a CFFT segmental column.The CRC can enrich the structure ductility, damping ratio, and the energy dissipation which are the most important parameters in structures resisting earthquakes.

REFERENCES

[1] .Batayneh M. K., Marie I. and Asi A., Promoting the use of crumb rubber concrete in developing countries, Science Direct, Waste Management (2008) .

[2] Zaher, K. K. and Bayomy, F. M., Rubberized Portland cement concrete, Journal of Materials in Civil Engineering.

[3] Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates, ASTM International, (2006).

[4] Youssf O, ElGawady, M. A. An overview of sustainable concrete made with scrap rubber.

[5] ACMSM 22, Sydney, NSW, Australia 11–14 December, 2012

[6] Torgal FP, Ding Y, Jalali S. Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): anoverview; 2012.

[7] Naik T. SS. Utilization of Discarded Tyres as Construction Materials for Transportation Facilities. Report No CBU-1991-02, UWM Centre for byproducts.utilization, University of Wiscosin

[8] Segre N, Joekes I. Use of tire rubber particles as addition to cement paste. CemConcr