"EXPERIMENTAL INVESTIGATION ON DURABILITY ENHANCEMENT OF CONCRETE BY USING WASTE RUBBER TYRES"

T.EZHAVENDAN
Student, PRIST Deemed University, Vallam, thanjavur

Mr. B. JOSE RAVINDRA RAJ ,M.E.,(Ph.D)
Associate Professor, PRIST Deemed University, Vallam, thanjavur

ABSTRACT

Concrete is a synthetic construction material made by mixing of cement, fine aggregates, coarse aggregate and water in the proper proportions. Recycled waste tyre rubber is a promising material in the construction industry due to its lightweight, elasticity, energy absorption, sound and heat insulating properties. One such application that could use old rubber tires is rubberized concrete. Concrete can be made cheaper by replacing some of its fine aggregate with granulated rubber crumbs from used rubber tires.

The main objective of the project is to increase the compressive strength of concrete by adding waste materials. Develop test information that may aid in the eventual goal of drafting a practical rubber in concrete specification for non-structural / low loading usage. Evaluate possible advantages of using crumb rubber in concrete including: resistance against cracking, reduction of thermal expansion and contraction, and lightweight concrete.

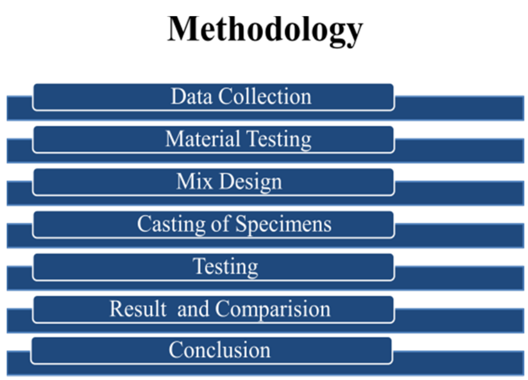
Light weight masonry of this type of concrete has a positive economic effect on total cost of the construction, it reduces the dead weight loading, giving smaller supporting sections and foundations as well as saving in transport and construction costs. Compressive strength decreases when the percentage of replacement of crumb rubber increases. The 7-days and 28 days compressive strength of the specimens decreased by addition of silica fume to concrete containing crumb rubber.

1. INTRODUCTION

Concrete is a synthetic construction material made by mixing of cement, fine aggregates, coarse aggregate and water in the proper proportions. recycled waste tyre rubber is a promising material in the construction industry due to its lightweight, elasticity, energy absorption, sound and heat insulating properties. One such application that could use old rubber tires is rubberized concrete. Concrete can be made cheaper by replacing some of its fine aggregate with granulated rubber crumbs from used rubber tires. These granulated rubber crumbs are achieved through a process called continuous shredding, which is necessary to create crumbs small enough to replace an aggregate as fine as sand. Such kind of concrete is used in manufacture of reinforced pavement and bridge structures have better resistance to frost and ice thawing salts.

The offshoot of this pragmatic revolution gave rise to new dimensions of problems in the form of rubber garbage. Tyre rubber wastes represent a major environmental problem of increasing significance. Investigations show that used tires are composed of materials which do not decompose under environmental conditions and cause serious contaminations. Several crumb rubber in concrete test sections were built throughout the state of Arizona and are being monitored for performance. Laboratory tests were conducted at ASU and industry associations to support the knowledge learned in the field. This paper summarizes findings to date and knowledge learned in the field.

2. METHODOLOGY



3. LITERATURE REVIEW

Gintautas et al described deformation properties of concrete with rubber waste additives. The aim of investigation was to study the deformation properties of Portland cement concrete with rubber waste additive. Rubber waste additives reduced both static and dynamic modulus of elasticity. Ultimate strains on concrete failure load are 36 - 47 % higher for concrete with tire rubber waste additives. Big amounts of used rubber tyres cumulate in the world each year – 275 million in the United States and about 180 million in European Union. The decrease of compressive strength of concrete after modification with rubber waste is explained by the more elastic and softer rubber particles compared to the sand particles].The second reason for concrete compressive strength reduction is significantly lower compressive strength of the crumbed rubber particles comparing to the strength of concrete aggregates. The objective of the work was to analyze the effect of fine composition of the elastic aggregate made from rubber waste on the elastic properties of concrete under the static and dynamic load.

Kotresh K.M et al described Study on waste tire rubber as concrete aggregates. From that the compressive strength of concrete is decreased by using rubberized concrete compared with conventional concrete. The light unit weight qualities of rubberized concrete may be suitable for architectural application, false facades, stone baking, interior construction, in building as an earthquake shock wave absorber. Rubberized concrete strength may be improved by improving the bond properties of rubber aggregates.

In India, out of 36 tyre manufacturers the tyre recyclers are around 20, the major contribution is only by four or five.. Among these, M/S Gujarat Reclaim has an annual turnover of over Rs.15 Crore from its Haridwar (Uttarakhand, India) tyre recycling plants, with a production of 20 tons of reclaim rubber per day. The tyre recycling factories should supply quality rubber aggregates in 20-10mm, 10-4.75mm and 4.75mm down sizes to be used as cement concrete aggregate. the effects in different percentage replacements other than those made in this research needs to be investigated.

Mohammad Rez sohrabi et al described An Experimental study on compressive Strength of concrete containing crumb rubber. Added various percentages of 5-20 mm crumb rubber to the concrete. By substituting 100 vol% of coarse aggregate by rubber. In this paper, the 7- day and 28-day compressive strength of concretes containing crumb rubber; silica fume and crumb rubber; Nano silica and crumb rubber; and Nano silica, silica fume and crumb rubber is investigated. This results in the improvement of such mechanical and dynamical properties as energy adsorption, ductility, and resistance to cracking. However, this may cause a decrease in compressive strength of the concrete which will be compensated by adding Nano silica to rubber- containing concrete. The maximum 7- day compressive strength of rubber- containing concrete was achieved by CRSFC10-10 specimen which contained 10% silica fume and 10% crumb rubber. In this case, the strength was increased by 17% compared with plain concrete. On the other hand, maximum of 27% increase in 28- day compressive strength was achieved by CRSFC5-15 specimen.

The reason is that the nano silica helps filling the nanometric voids in cement paste, and so producing a denser structure. This results in the increment of concrete compressive strength. However, nano silica has no considerable effect on concretes containing 10 and 15% crumb rubber. The slump decrease in concrete mixes containing nano silica was higher than those containing silica fumes.

Addition of rubber to concrete resulted in a more ductile failure. This behavior indicates that these types of concretes have higher strength and better energy adsorption capability

Akinwonmi et al were described mechanical Strength Of Concrete With Crumb And Shredded Tire As Aggregate Replacement. The objective of this research is to assess the mechanical strength of concrete with crump tyre and shredded tyre replacement as aggregates if could be used as replacement of aggregates in concrete production in order to help reduce the cost of concrete production arising from the increasing cost of cement, and reduce the volume of waste generated from unused tyres. The results of the compressive test show that by replacing the aggregate by 2.5 % shredded tyre, the compressive strength increased by about 8.5% but at 5% replacement and beyond, the compressive strength decreased. For the Crumb tyre aggregates, the compressive strength decreased generally as the percentage replacement increased. Thus, crumb tyre is not advisable to be used as aggregate replacement due to its weak compressive strength. The analysis of the experimental results showed that replacing 2.5% of coarse aggregate by shredded tyre slightly increased the compressive strength of the concrete but replacing more than 2.5%, reduces the concrete strength. Crumb tyre is not advisable to be used as aggregate replacement due to its weak compressive strength.

4. MATERIALS USED

The basic materials for mixing concrete are required such as,

- Cement
- Coarse aggregate
- Fine aggregate
- Tyre rubber
- Silica fume

PORTLAND POZZOLANA CEMENT

Portland Pozzolana cement is a kind of blended cement which is produced by either intergrinding of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker gypsum and pozzolanic materials separately and thoroughly blending them in certain proportions. The chemical and physical properties of cement are presented in Table

Table. Physical Properties of Cement

Sl.No	Properties	Observed Values
1.	Specific Gravity	2.95
2.	Fineness	0.002%
3.	Initial Setting Time	40 minutes
4.	Final Setting Time	600 minutes

COARSE AGGREGATE

Coarse aggregate is chemically stable material in concrete. Presence of coarse aggregate reduces the drying shrinkage and other dimensional changes occurring an account of movement of moisture.

Coarse aggregate contributes to impermeability of concrete, provide that is properly graded and the mix is suitably designed. Coarse aggregate is conventional concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement mix and aggregate surface in conventional concrete. By restricting the maximum size of aggregate and cement becomes more homogeneous and there is a marked enhancement in the strength properties as well as durability characteristics of concrete.

Table Properties of Coarse Aggregate

Sl.NO	**Test for coarse aggregate**	**Observed value**
1.	Specific Gravity	2.6
2.	Sieve analysis	FM-2.8

FINE AGGREGATE

Locally available free of debris and nearly riverbed sand is used as fine aggregate. Among various characteristics, the most important one is its grading coarse may be preferred as fine aggregate, increase the water demand of concrete and very fine sand may not be essential as it usually has larger content of thin particles in the form of cement. The sand particles should also pack to give minimum void ratio, higher voids content lead to requirement of more mixing water. Properties such void ratio, gradation specific surface and bulk density have to be assessed with optimum cement content and reduced mixing water.

Fineness modulus of fine aggregate $= (\sum C)/100$

$= 326.85/100$

$= 3.2$

Table Properties of Fine Aggregate

Sl.No	**Test for fine aggregate**	**Observed values**
1.	Fineness Modulus	3.2(Zone III)
2.	Specific Gravity	2.7

WATER

Water to be used for mixing and curing should be free from impurities. Mixing water quality is required in accordance with the quality standards of drinking water.

SHREDDED TYRES

Tyre shreds or chips involve primary and secondary shredding. The size of the tyre shreds produced in the primary shredding process can vary from as large as 300 to 460 mm long by 100 to 230 mm wide, down to as small as 100 to 150 mm in length, depending on the manufacturer's model and condition of the cutting edges. Production of tyre chips, normally sized from 76 mm to 13 mm, requires both primary and secondary shredding to achieve adequate size reduction.

Figure Shredded Tyres

CRUMB RUBBER

It is the processing of the tyre into fine granular or powdered particles using mechanical or cryogenic processes. And it was obtained from S.S Traders, Pudukkottai The steel and fabric component of the tyres are also removed during this process. Crumb rubber consists of particles ranging in size from 4.75 mm to less than 0.075 mm. Generally, these methods are used to convert scrap tyres into crumb rubber. These methods are (i) cracker mill process, (ii) granular process, and (iii) micro mill

The cracker mill process tears apart or reduces the size of tyre rubber by passing the material 1 between rotating corrugated steel drums. By this process an irregularly shaped torn particles having large surface area are produced. The sizes of these particles vary from 5 mm to 0.5 mm and are commonly known as ground crumb rubber. Granular process shears apart the rubber with revolving steel plates, producing granulated crumb rubber particles, ranging in size from 9.5 mm to 0.5 mm.

Figure Crumb rubber.

S. No.	Property	Crumb Rubber
1	Specific gravity	1.16
2	Unit weight (Kg/m^3)	1150
3	Elongation at break (%)	800
4	Water absorption	Small

Table 3.6.1 Properties of Crumb Rubber

SILICA FUME

Silica fume is highly reactive pozzolanic material and is a byproduct from the production of silicon or ferro- silicon metal. It is composed from the flue gases from electric arc furnaces. Silica fume is very fine powder, with particles about 100th times minor than average cement grain. It is available in a water slurry form. It is used at 5% to 12% by mass of supplementary cementitious materials for concrete structures that requires high strength.

Figure Silica Fume

5. MIX DESIGN

Mix design for M30 grade concrete by Indian Standard recommended method of concrete mix design as per design code IS: 10262-2009

PROPORTION:

a) STIPULATIONS FOR PROPORTATIONING

a) Grade designation
:M30
b) Type of cement
:PPC
c) Maximum nominal size of aggregate
:20mm
d) Minimum cement content
:320kg/m^3
e) Workability
:100 mm (slump)
f) Exposure condition
:mild (for reinforced concrete)
g) Degree of supervision
:good
h) Type of aggregate
:crushed angular aggregate

i) Maximum cement content :$450 kg/m^3$

b) TEST DATA FOR MATERIAL

a) Cement used : PPC

b) Specific gravity of cement : 2.95

c) Specific gravity of Coarse aggregate : 2.6

d) Specific gravity of Fine aggregate : 2.7

e) Water absorption for Coarse aggregate : Nil

f) Water absorption for Fine aggregate : Nil

g) Free (surface) moisture for Coarse aggregate : Nil

h) Free (surface) moisture for Fine aggregate : Nil

i) Sieve analysis Fine aggregate : Conforming to Zone II of table 4 of IS 383

c) TARGET STRENGTH FOR MIX PROPORTATION

$$f'_{ck} = f_{ck} + 1.65s$$
$$= 30 + 1.65 * 5$$
$$= 38.25\ N/mm^2$$

Where

f'_{ck} = Target average compressive strength at 28 days

f_{ck} = Characteristic compressive strength at 28 days

s = Standard deviation

d) SELECTION OF WATER-CEMENT RATIO

From Table 5 of IS 456, maximum water-cement ratio = 0.45

As per durability property, adopt water-cement ratio as 0.4

e) SELECTION OF WATER CONTENT

From Table 2, maximum water content for 20 mm aggregate = 186 litre (25 to 50 mm slump range)

Estimated water content for 55 mm slump = 186+6/100x186

=197.16litre

f) CALUCATION OF CEMENT CONTENT

Water cement ratio = 0.4

Cement content $= \frac{197}{0.4} = 492.5 kg/m^3$

g) PROPORTATION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From Table-3, Volume of course aggregate corresponding to 20mm size aggregate and fine aggregate (Zone-II) for water cement ratio 0.50 = 0.62

Present water cement radio =0.45

Therefore difference is 0.50-0.45 = 0.05

The proportion of volume of coarse aggregate is increased by 0.01 (At the rate of -/+ 0.01 for +0.05 change in W/C ratio)

= 0.6+0.02

= 0.62

Volume of fine aggregate content = 1.00 - 0.62

= 0.38

gravity of fine aggregate x 1000

= 0.637* 0.38 * 2.7 * 1000

= 653.562kg

PROPERTIES OF FRESH CONCRETE

The properties of fresh concrete are

- Compatibility
- Mobility
- Stability
- Consistency
- Segregation
- Bleeding
- Curing
- Workability

WORKABILITY

Workability is defined as the ease to placement with resistance to segregation. According to ACI:116R-90 workability is defined as the property of freshly mixed concrete or mortar which determines the case and homogeneity with which it can be mixed, placed, consolidated and finished. According to ASTM: C125 workability is the property of determining the effort required to manipulate a fresh mixed quantity of concrete with minimum loss of homogeneity. Therefore, the workability of concrete is associated with terms such as flow ability, mobility, stability, resistance to segregation, and palpability. Workability is necessary to compact concrete to the maximum possible density.

FACTORS AFFECTING WORKABILITY

Workable concrete is the one which exhibits very little internal friction between particle and particle or which overcomes the frictional resistance offered by the formwork surface or reinforcement contained in the concrete with just the amount of compacting efforts forthcoming.

Some of the factors affecting workability are

- Water content
- Mix proportions
- Size of aggregates
- Shape of aggregates
- Surface texture of aggregate
- Grading of aggregate
- Use of admixtures

SLUMP TEST

Slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and placed, compacted and finished.

6. RESULT

Type of collapse: shear slump

Slump value: 100 mm from top.

COMPACTION FACTOR TEST

It gives an idea of degree of compaction and can be defined as the ratio of the density actually achieved in the test to the density of fully compacted concrete. The degree of compaction in this test is medium.

RESULT

Compaction factor: 0.85

Workability : Medium

HARDERNED CONCRETE

COMPRESSIVE STRENGTH OF CUBE

The concrete mix proportions of M30 (1:1.81:3.85) with the water cement ratio of 0.4 was used. The concrete mix design was proposed to achieve the compressive strength of 35Mpa after 7days and 28days curing, in case of cubes. The concrete cubes (150mmX150mmX150mm). Each layer was compacted with 25 blows using 16mm dia rod.

$$\text{Compressive strength} = \frac{\text{Maximum load on failure}}{\text{Area of the load faces}}$$

SPLIT TENSILE STRENGTH ON CONCRETE

The test consists of applying a compressive line load along the opposite generators of concrete cylinder placed with its axis horizontal between the compressive platens. Due to the compression loading a fairly uniform tensile stress is developed over nearly 2/3 of the loaded diameter as obtained from an elastic analysis. The magnitude of this tensile stress σ_{sp} is given by the formula ,

$$\sigma_{sp} = 2p/\pi dl$$

Where p is the applied load, d and l are the diameter and the length of the specimen respectively. Due to the tensile stress, the specimen fails by splitting vertically into two halves; this test is also called the split test. For the routine testing, the specimens shall be cylinders 150mm diameter and 300mm in length. The apparatus used are Cylinder mould, compression testing machine

FLEXURAL STRENGTH OF CONCRETE

In the symmetrical two point loading, the critical crack may appear at any section, not strong enough to resist the stress within the middle third, where the bending moment is maximum. It can be expected that the two point loading will yield a lower value of modulus of rupture than the centre point loading.

Flexural strength, $F = Pl/bh^2$

Where,

P = load in Newton shown in dial gauge

L = length of rectangular prism in mm i.e. 700 mm

B = breadth of rectangular prism i.e. 150 mm

H = height of rectangular prism i.e. 150 mm

EXPERIMENTAL STUDY

HARDENED CONCRETE TEST

A time schedule for testing of specimens is maintained to ensure their proper testing on the due date and time. The cast specimens are tested as per standard testing procedures, immediately after they are removed from curing pond and wiped off the surface water, as per IS 516:1959. The test results are tabulated carefully.

The various tests carried out for Normal & High Density Concrete are

1. Compression strength test
2. Split Tensile test
3. Flexural test

COMPRESSIVE STRENGTH TEST

Totally 18 concrete cubes were casted and it is allowed for 7 days and 28 days curing. After drying, cubes were tested in Compression Testing Machine (CTM) to determine the ultimate load**.**

Figure Compressive strength test

7. CONCLUSION

1. Compressive strength decreases when the percentage of replacement of crumb rubber increases.

2. The 7- days and 28- days compressive strength of the specimens decreased by addition of silica fume to concrete containing crumb rubber.

3. The analysis of the experimental results showed that replacing 5% of fine aggregate by crumb tyre slightly increased the compressive strength of the concrete but replacing more than 5%, reduces the concrete strength.

4. Finally by replacing fine aggregate by crumb rubber we can save our environment and natural sources.

5. Experimental investigation of Tensile strength and flexural strength will be done in phase II

8. REFERENCES

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