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"PARTIAL REPLACEMENT OF FINE AGGREGATE BY WASTE TYRE CRUMB RUBBER IN CONCRETE"

A PROJECT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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by

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to

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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"USE PARTIAL REPLACEMENT OF FINE AGGREGATE BY WASTE TYRE CRUMB RUBBER IN CONCRETE"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by Prajwal Gupta (Enrolment no. 141629) during a period from July 2018 to December 2018 under the supervision of Dr Ashok Kumar Gupta, Professor & Head of Department, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

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CONTENTS

List of Figures

List of Tables

List of Charts

ABBREVIATIONS

Abbreviations	Word(s)
ASTM	American Standard for Testing and Material
OPC	Ordinary Portland cement
Fc	Target mean strength of mix design
V	Absolute volume of fresh concrete
W	Mass of water per m^3 of concrete
KN	kilo Newton
Mm	Millimeter
cm	Centimeter
KJ	Kilo joule

CHAPTER 1

INTRODUCTION

GENERAL

The disposal of waste material is one of the key issues all around the world. The dumping of the waste tyre is a major matter because this material is not easily biodegradable even after a long time. Waste rubber is also used as raw material for rubber products. Concrete is made by the composition of cement, fine aggregate and coarse aggregate. Out of all kind of construction materials concrete is most commonly used material. Due to which there is decrease in the natural aggregates. There are several techniques which were proposed for the consumption of waste tire, one of them is the use of waste tire crumbs in the concrete as a partial of full replacement of fine aggregates or coarse aggregates but only limited researches were done till now on the use of waste rubber tire in concrete.

Rubber treated cement mixture might be reasonable for basic and nonstructural purposes, for example, lightweight concrete dividers, building exteriors and compositional units. The utilization of crumb rubber in lightweight concrete is viewed as a conceivably critical road. Due to above said qualities, the crumb rubber with concrete will discover new ranges of use in interstate development as a safeguard, in sound walls as a sound absorber, and furthermore in structures as a seismic tremor stun wave absorber.

Dangerous waste materials are being produced and aggregated in huge amounts making an expanding risk to the earth. Risky materials can be named synthetic, lethal or non-rotting material amassing with time. The amassing of elastic and plastic can be considered non-rotting materials that exasperate the encompassing condition. Be that as it may, a positive technique for discarding this non-rotting material, for example, reuse in cement blends, would have a useful effect4. One of the major ecological difficulties confronting regions around the globe is the transfer of exhausted vehicle tires. Most disposed of tires are covered in the landfills5. Just less are utilized as fuel or as crude materials for the fabricate of elastic products. Covering scrap tires in landfills is both inefficient and expensive. Transfer of entire tires has been restricted in the most landfills since they are cumbersome and will in general stream to the surface with time, so tires are frequently shredded6-8. On the off chance that tires are reused as a development material as opposed to being singed, the interesting properties of tires can by and by be misused in a valuable way. In this specific situation, the utilization of tire contributes lightweight cement is viewed as a possibly critical road. Accordingly, the utilization of scrap tires in solid assembling is a need than a longing. The utilization of scrap tires in cement is an idea connected widely over the world9. The utilization of scrap tires elastic in ordinary quality cement is another measurement in solid blend plan and whenever connected on a huge scale would reform the development business, by conserving the development cost and expanding the well used out tire disposal10-12. It is with this intension, an exploratory examination was directed by utilizing scrap elastic as sand in bond concrete in various extents.

The historical backdrop of the establishing is as old as the historical backdrop of building development. Concrete is a standout amongst the most broadly utilized development material today. Over 90% of the structures extending from building, spans, streets, dams, holding dividers and so forth use the solid for their development. The flexibility and shape capacity of this material, its high compressive quality and revelation of fortifying and prestressing system has picked up its broad utilize. This is the well known development material where quality solidness, impermeability, imperviousness to fire and scraped area opposition are required. Quality toughness and functionality might be considered as primary properties of cement. What's more, great cement ought to have the capacity to oppose wear and erosion and it ought to be water – tight, and prudent. The solid must be sufficiently able to withstand without damage all the forced worries with the required factor of wellbeing. At the point when the solid blend has been structured based on most extreme admissible water-concrete proportion, keeping in view the prerequisites of solidness, it will build up the required quality if legitimately put in position and restored. Subsequent to putting, cement ought to be permitted to dry quickly on the grounds that dampness is especially fundamental for the improvement for its high quality. To build up a given quality , longer time of sodden restoring is required at lower temperatures than is important while relieving is done at high temperature.

Concrete is homogenous blend of folio (bond) , fine totals, coarse totals and water in some predetermined extent. The properties of cement in plastic state or solidified state are subject to the properties and the sort of fixings utilized. So with the end goal to get the required kind of solid quality it is important to control the properties of the fixing materials. An exhaustive learning of cooperation of different information of association of different elements of cement is required to be known to make a solid with stipulated qualities. Concrete is great in pressure however powerless in strain. Cement can be made tough by utilizing great nature of materials that is bond totals and water, by diminishing the degree of voids by reasonable evaluating and proportionate the materials, by utilizing sufficient amount of concrete and low – water concrete proportion accordingly guaranteeing cement of expanded impermeability .moreover, careful blending wanted setting, satisfactory compaction and relieving of the solid is similarly critical to have sturdy cement.

Alterations of development materials have a vital bearing on the building division . A few endeavors along these lines made in the building material industry to put to utilize squander material items ,e.g exhausted tires into valuable and financially savvy things . Accomplishment in such manner will add to decrease of waste material dumping issues by using the waste materials as the crude materials for different items . The waste issue considered as a standout amongst the most vital issues confronting the world as a wellspring of the ecological contamination . It is contributing as an immediate shape in contamination that incorporates the negative consequences for the wellbeing by expanding the sicknesses , illnesses vector level of mortality and bringing down the way of life . The waste typically characterized as all remaining parts if things came about because of generation , exchange and uses forms and when all is said in done every single transmitted thing and assets that the proprietor or the makers need to arrange or should arrange to keep the hazard on the soundness of the people and spare the earth by and large.

1.1 CONCRETE

Concrete is the most commonly known construction material. It is made by the mixing of aggregates and cement. Concrete is suitable for any kind of building construction in the recent researches some new type of construction materials are used, these are like metals, plastics and fabrics. In the inner walls new materials like waterproof tar based materials and other types of coatings are used in the recent years. The main construction materials are cement, bricks and tiles. The evolution of new construction materials is due the increase in demand for the construction materials. But many of these new construction materials are not good for the environment.

1.1.1 Durability of Concrete

The term durability is basically the resistance to the damage in the different weathering conditions, chemical attacks and also the abrasion. It is the time period up to which no repair work is needed for the structure. The durability requirement depends upon the environmental conditions and properties of concrete. The durability properties of concrete can be enhanced if :

- Dense cement paste, low value of permeability.
- In case of freeze-thaw cycle, there should be air entrained in it.
- Proper grading in the aggregates.
- There should be minimum impurities in all the ingredients of concrete.

1.1.1.1 Factors affecting durability of concrete

Cement content

The concrete mixture must be prepared in such a way that there must be no segregation and bleeding, and cohesion should also be ensured. If the cement content is reduced or increased then it will lead to the poor compaction due to the loss in workability, and in case the w/c ratio is increased then there is increase in the permeability. This results to the loss of durability.

Compaction

Poor compaction of concrete leads to the formation of voids in concrete. Compaction is governed by the different compaction equipments from work.

Curing

The main reason behind the curing is the proper hydration, this result to the full development of strength.

Permeability

Permeability is considered as the important factor which affects the durability. Permeability is higher if the porosity of the structure is higher. The factor which should be considered for better permeability, properties of sufficient curing, proper cement content, good compaction and proper concrete cover.

1.1.1.2 Different methods for the enhancement in durability

- By the use of chemicals: The chemical substances which can be utilized to enhance the durability take a shot at the procedure of giving appropriate covering of the compound on the surface of cement. A portion of these chemical compounds are epoxy covering, siloxane sealer etc. These chemicals work by giving decreasing in the contact of steel with and steel in the concrete.
- By use of physical methods: The physical methods involve the use of pozzolonic materials like fly ash. These materials help in enhancing the properties of concrete

like permeability. They also help in improving the resistance to sulphate which leads to the better durability.

- By the addition of bacteria and concrete: Utilization of bacteria in concrete aides in the upgrade of concrete properties by the calcite precipitation, this calcite helps in diving the pores of concrete structure, which improve the penetrability of cement and this prompts the better toughness of cement.

WASTE TYRE:-

PHYSICAL PROPERTIES

According to the American society of testing and materials (ASTM) [1997c], a "waste tire" is defined as a tire, which is no longer capable of being used for its original purpose, but which has been disposed of in such a manner that it cannot be used for any other purpose. 'Tire shreds' are pieces of scrap tyres that have a basic geometrical shape and are generally between 50mm (2 in.) and 300 (12 in.). The reduction in tire size is commonly accomplished by mechanical processing device called a 'shredder'. Tires retain their basic chemical properties and physical shape even when shredded into smaller pieces.

A scrap tires can be managed as a whole tire, a slit tyre, a shredded or chipped tyre, as ground rubber or a crumb rubber product.

Whole tires

A typical scrapped automobile tyre weighs 9.1 kg (20Ib). Roughly 5.4 kg (12Ib) to 5.9 kg (13Ib) consists of recoverable rubber composed of 35% of natural rubber and 65% synthetic rubber. Steel belted radial tyres are the predominant type of tyre currently produced in the United States. A typical truck tire weighs 18.2 kg (40Ib) and also contains from 60-70% recoverable rubber. Truck tires typically contain 65% natural rubber and 35% synthetic rubber.

Although a majority of truck tires are steel belted radials, there are still a number of bias ply truck tyres, which contain either nylon or polyester belt material.

Slit tires

Slit tires are produced in tire cutting machines. These cutting machines can slit the tire into two halves or can separate the side walls from the tread of the tire.

Crumb rubber

Crumb rubber usually consists of particles ranging in size from 4.75 MM (NO.4 sieve) to less than 0.075mm (NO. 200 sieve). Most processes that incorporate crumb rubber as an asphalt modifier use particles ranging in size from 0.6mm to 0.15mm (No. 30 to No. 100 sieve). Three methods are currently used to convert scrap tires to crumb rubber. The cracker mill process is the most commonly used method. The cracker mill process tears apart or reduces the size of tire. Rubber by passing the material between rotating corrugated steel drums. This process creates an irregularly shaped torn particle with a large surface area. These particles range in size from approximately 5mm to 0.5mm (No. 4 to No. 40 sieve) and are commonly referred to as ground crumb rubber. The second method is the granulator process, which shears apart the rubber with revolving steel plates that pass at close tolerance, producing granulated crumb rubber particles, ranging in size from 9.5mm (3/8 inch) to 0.5mm (No. 40 sieve). The third process is the micro mill process, which produces a very fine ground crumb rubber in the size ranging from 0.5mm(No. 40 sieve) to as small as 0.075mm(No. 200 sieve). In some cases, cryogenic techniques are also used for size reduction.

1.2 Manufacturing of crumb rubber

Crumb rubber is made by combination or application of several size reduction technologies. These technologies divided into two major processing categories, mechanical grinding and cryogenic reduction.

Mechanical grinding:-

Mechanical grinding is the most most utilized process. The method comprises of mechanically separating the elastic into little particles utilizing an assortment of pounding methods, for example, saltine factories, granulators, and so on. The steel segments are evacuated by an attractive separator. The fiber parts are isolated via air classifiers or other separation equipment..

Cryogenics:-

The cryogenic process consists of freezing the shredded rubber at an extremely low temperature. The frozen rubber compound is then easily shattered into small particles. The fiber and steel are removed in the same fashion as in mechanical grinding. The advantage of the system are cleaner and faster operation resulting in the production of fine mesh size. The most significant disadvantage is the slightly higher cost due to the added cost of cooling (liquid nitrogen, etc.) (Blumenthal 1998).

Shredded or Chipped tires:-

In most cases the production of tyre shreds or tire chips involves primary and secondary shredding. A tire shredder is a machine with a series of oscillating or reciprocating cutting edges, moving back and forth in opposite directions to create a shearing motion, that effectively cuts or shreds tires as they are fed into the machine. The size of the tire shreds produced in the primary shredding process can vary from as large as 300 to 460mm (12 to 18 in.) long by 100 to 230 mm (4 to 9 in.) as wide, down to as small to 100 to 150mm in length, depending on the manufacturer, model and condition of the cutting edges.

Ground rubber:-

Ground rubber might be measured from particles as vast as 19mm (3/4 in) to as fine as 0.15mm (No. 100 sifter) contingent upon the sort of size decrease gear and the planned application. The generation of ground rubber is accomplished by granulators, pound plants or fine crushing machines. Granulators normally deliver particles that are frequently molded and cubical with a similarly low surface area.The steel belt fragments are removed by a magnetic separator.

Fiber glass or fibers are separated from the fine rubber particles, usually by an air separator. Ground rubber particles are subjected to a dual cycle of magnetic separation, then screened and recovered in various size fractions.

1.3 CHEMICAL PROPERTIES

Crumb rubber is not reactive under normal environmental conditions. The principal chemical component of tires is a blend of natural and synthetic rubber, but additional components include carbon black, sulfur, polymers, oil, paraffin's, pigments, fabrics, and bead or belt materials.

1.4 MECHANICAL PROPERTIES

Limited data are available on the shear strength of crumb rubber. The small size of crumb rubber makes it difficult, is not virtually impossible, to find a large enough apparatus to perform a meaningful shear test. Although the shear strength characteristics of tire chips vary according to the size and shape of the chips, internal friction angles were found. Crumb rubber has a permeability coefficient ranging from 1.5 to 15cm/sec.

1.5 OTHER PROPERTIES

Scrap tires have a heating value ranging from 28000kl/kg to 35000kl/kg. As a result given appropriate conditions, scrap tire combustion is possible and must be considered in any application. Crumb rubber can also be expected to exhibit high insulating properties. If crumb rubber is used as a fill material in subgrade applications, reduced depth of frost penetration compared with that of granular soil can be expected.

Gradation

Tires shreds are generally, relatively, uniformly graded. The whole tyres are cut by shredder knives. The required size is achieved by adjusting the screen size on a slow rotating shredder screen.

Typically, multiple passes through the shredder are required for tyre shred sizes of less than 12 inches (305mm). The gradation of tyre shreds is evaluated in accordance with ASTM 422 [ASTM, 1997b]. The sample size should be large enough to contain a representative selection of particle sizes (Note, that since the specific gravity of tyre shreds is usually less than half the values obtained from common earthen materials usually tested by this method, it is permissible to use a minimum weight of test sample
that is half of the specified value [Humphrey, 1996b]).

Compressibility

The compressibility of tyre shreds is applicable in evaluating landfills air space. Tyre shreds less than 3-in.(75-mm) in size indicate that vertical strains of up to approximately may occur in the tyre shreds under low vertical stress up to approximately 40% may occur under high vertical stress of up to 60 Ibf /in2 (48kpa) and that vertical strains of up to approximately 40% may occur under high vertical stress of up to 60 Ibf/in2 (414 kpa).

Shear strength

Tire shreds placed as distinctive layers with in a municipal solid waste (MSW) landfill could influence the internal stability of the landfill. The shear strengths of tire shreds and tire shred/concrete mixtures are variable. However, it appears that they have shear strength properties' such that no detrimental effect on landfill stability should occur.

1.6 ENGINEERING PROPERTIES OF CRUMB RUBBER

Specific gravity

The specific gravity of tyre shreds is the ratio of unit weight of solids of the shreds divided by the unit weight of water (material, whose unit weight of solids equals the unit weight of water, has a specific gravity of 1.0). The specific gravity is evaluated in accordance with ASTM 127 [ASTM, 1997a]. (Note, the specific gravity of tyre shreds usually less than half the values obtained from common earthen materials usually tested by this method, so it is permissible to use a minimum weight of test sample that is half of the specified value [Humphrey,1996b]). The apparent specific gravities of tyre shreds depends on the amount of glass belting or steel wire in the tyre, and range from 1.02 to 1.27 meaning that tyre shreds are heavier than water and will sink in water. (The high end of the range generally has a greater proportion of steel belted shreds.) For comparison, the specific gravity for soil typically ranges between 2.6 to 2.8, which are more than twice as heavy as tyre shreds [Humphrey, 1996b].

Water absorption

Absorption capacity is the amount of water absorbed on to the surface of the crumb rubber and is expressed as the percent (%) water (based on the dry weight of the crumb rubber.) Water absorption capacity of crumb rubber generally ranges from 2% to 4.3 %.

Other uses

The following are also some examples on using scrap tyres:

- Playground surface material.
- Gravel substitute.
- Drainage around building foundations and building foundation insulation.
- Erosion control /rain water runoff barriers (whole tires).
- Wetlands/ marsh establishment (whole tires).
- Crash barriers around race tracks (whole tires).
- Boat bumpers at marinas (whole tires).
- Artificial reefs (whole tires).

1.7Classification of Scrap Tires

Generally, there are two classes of particle sizes "ground rubber" (passing No. 10 sieve) and "coarse rubber" (larger than No. 10 sieve, with a minimum size of 1/size one-half inch). (EPA 2012). Other groupings have also been made by some researchers to further classify scrap tires. From these groupings, it is observed that scrap tires are being managed as slit tires, shredded or chopped tires, and crumb rubber tire and as a ground rubber tyre. (Siddique and Naik 2004). Slit tires are mainly those cut using tire cutting machines.

Shredded or chipped tires are sized in two stages: the primary process (300 to 460mm long by 100 to 230mm wide to as small as 100 to 150mm in length) and the secondary process (normal size 76mm to 13mm) (Heitzman 1992; Siddique and Naik 2004).

Ground rubber employs use the double cycle separation (magnetic), afterwards, there is screening then the various sizes can be retrieved. Particle sizes range from 19mm to 0.15mm (Heitzman 1992; Siddique and Naik 2004).

Crumb rubber has particle sizes ranging from 4.75mm (No. 4 sieve) to less than 0.075mm (No. 200 sieve). Cracker mill, granular and micro mill processes are amongst those use to produce crumb rubber from scrap tyres (Heitzman 1992; Siddique and Naik 2004).

1.8 Mechanical properties

Compressive strength:-

Behavior of ordinary concrete and under pressure is surely knew, as far as the stress – strain curve and the inception and engendering of splits inside the matrix. In any case, this isn't on account of rubber cement. Concrete has been examined as for ground tire elastic cement by many researcherss. It is seen from results that different variables impact compressive quality of cement with rubber and these range from size of rubber particles utilized, treatment of elastic particles, extents of elastic particles utilized, measure of air in blend and the kind of bond utilized in blends. (Kaloush et al. 2005) found that the compressive quality of piece elastic cement (1mm molecule sizes) diminished as rubber substance was expanded. (El-Gammal et al. 2010) further seen that in as much as compressive quality was lessened, chipped elastic gave a lower compressive quality has contrasted with piece rubber (finer particles). (Li et al.1998) inferred that rubber treated cement has bring down compressive quality than ordinary cement; notwithstanding, barrel shaped compressive quality of 29 MPa can be accomplished by covering rubber particles with concrete paste.

Toughness:-

Mechanical tests demonstrate that crumb rubber concrete stay unblemished at disappointment (don't break into pieces) indicating strength (Kaloush et al. 2005) (Li et al. 1998) likewise inferred that rubber treated concrete has a fantastic adaptability and malleability when contrasted with ordinary concrete.(Eldin and Senouci 1993) saw that under pressure stacking, examples of rubber concrete displayed a steady disappointment rather than fragile mode in traditional concrete. They contended that when miniaturized scale splits quickly spread in the concrete glue, they experience an elastic total which in light of their capacity to with stand huge tensile deformations,will go about as minor springs.v

(Goulias and Ali 1997) discovered that dynamic modulus of elasticity and rigidity decreased with an increase in the rubber content, demonstrating a material with reduced stiffness and brittleness. They further reported that damping capacity of concrete (a measure of the ability of the material to decrease the amplitude of free vibrations in its body) seem to decrease with an increase in rubber content.

Unit weight:-

Addition of rubber has been observed to lower the unit weight of the concrete, due to rubber having a low specific gravity than the other typical solid components (Kaloush et al. 2005) observed that the unit weight of crumb rubber concrete (1mm particle size) decreased approximately 6pcf for every 50ibs per cubic yard of crumb rubber added.

(Khatib and Bayomy 1999) also concluded the change in unit weight is negligible when rubber content is lower than 10 to 20 % of total aggregate volume. Due to the low specific gravity of rubber, the unit weight of rubberized mixtures decreases as the percentage of rubber increases. In addition, the increase in rubber content increases the air content, which in turn further reduces the unit weight (Fedroff 1995). However, the decrease is almost negligible for rubber contents lower than 10 to 20% of the total aggregate volume.

Slump :-

Khatib and Bayomy (1999) examined the workability of rubber treated mixtures. They observed the reduction in slump with increased rubber substance by total aggregate volume. Their outcomes demonstrate that at rubber content of 40% by aggregate total volume, the slump was almost 0 and the solid was not workable by hand. Such mixtures must be compacted utilizing a mechanical vibrator. Mixtures containing fine crumb rubber were, anyway more workable than mixtures containing either coarse tire chips or a mix of morsel elastic and tire chips. In another examination directed by Raghavan et al. (1998), it was discovered that mortars containing rubber shreds accomplished functionality practically identical to or superior to anything a control mortar without rubber particles. It isn't clear, anyway whether the impact of rubber particles on the functionality of cement is a tribute to a decrease in the thickness of cement or to genuine changes in the yield esteem and plastic consistency of the blend. Rheological estimations utilizing major methods (e.g., rheometers) as opposed to the profoundly experimental slump test are in this way expected to illuminate the impact of the elastic total substance and molecule measure conveyance on the rheology of fresh concrete.

Workability and Air content :-

It has been accounted for that by expansion of rubber particles, the workability of concrete is lessened (Fedroff et al. 1996; KhatibandBayomy 1999). Further outcomes from (Rangaraju and Gadkar) presumed that despite the fact that compressive quality diminished altogether with expanding rubber content, the normal qualities of rubber cement was shut to that of expanding rubber content, the average strength of rubber concrete was shut to that of air – entrained concrete.

The possibility of pre-treating the rubber particles has been effectively appeared by the researchers, to enhance its bonding with the concrete paste. This has included washing rubber particles with water, corrosive drawing, plasma pretreatment, and covering with cellulose ethers arrangement (Eldin and Senouci 1993; Li et al. 1998; Rostami; Tantala et al.1996). These measures are relied upon to evacuate contaminants , increment the surface unpleasantness of the elastic and enhance the interior holding. The compressive qualities got after the pre treatment of elastic, were higher than those situations where the regular rubber particles were utilized.

Thermal properties:-

(Kaloush et al.2005; Lingannagari et al. 2003) achieved an end from tests that piece rubber cement (1mm rubber molecule sizes) indicated more resistance to thermal changes. This examination demonstrated that rubber cement has good coefficient of warm development (CTE) values, with lessened warm impacts of warming and cooling on the concrete. For concrete pavements, the CTE is considered as a critical factor in the structure of joints, computing stresses, joint sealant plan, and choosing sealant materials (USDOT 2012).

(Huynh et al. 1996) in their examination on rubber particles from reuse tires in cementitious composite materials found that specimens containing 0, 5, 10 and 15 % rubber strands broke, while those containing polypropylene fibers did not break in the initial three hours. It was additionally seen that consideration of fibrous rubber kept the crack from proceeding and despite of the powerless holding of rubber, it could give adequate restriction to keep break from advancing. It was seen that the beginning of splitting was postponed by the addition of fibrous rubber: the mortar without fibers cracked inside 30 minutes, while the example with 5% and FR 4.75 (rubber fibers that went through 4.75mm sieve and were retained on 2.36mm sieve) cracked following 60 minutes.

Plastic shrinkage:-

Preliminary results of an examination directed by Raghavan et al. (1998) recommend that the expansion of rubber shreds to mortar diminished plastic shrinkage cracking contrasted with a control mortar. The utilization of rubber shreds in mortar enabled various cracking to happen over the width of mortar examples contrasted with a solitary crack in a mortar example without rubber shreds. Regardless of the various cracking, the aggregate crack zone if there should be an occurrence of the rubber filled mortar diminished with an expansion in the rubber mass division. In spite of their obviously weak bonding to the cement paste, the rubber shreds gave adequate restriction to keep prevent micro cracks from propagating.

Freezing and Thawing resistance:-

(Fedroff et al. 1996) carried out investigation to study the freezing and thawing (ASTM C 666, procedure A) durability rubber concrete. Various mixtures were made by incorporating 10, 15, 20 and 30% ground rubber by weight of cement to the control mixture. Based on their study they concluded that:

(i) Rubber concrete mixtures with 10 and 15% ground rubber exhibited durability factors higher than 60% after 300 freezing and thawing cycles, but mixtures with 20 and 30% of ground rubber by weight of cement could not meet the ASTM standards.

(ii) Air entrainment did not provide significant improvements in freezing –thawing durability for concrete mixtures with 10, 20, and 30% ground tyre rubber.

(iii) Increase in scaling (as measured by the reduction in weight) increased with the increase in freezing and thawing cycles.

Scanning Electron Microscope (SEM)

(Rangaraju and Gadkar 2012), reported from SEM analysis of concrete samples with 24% rubber replacement of fine aggregate that, there was the presence of air voids around rubber particles. In their analysis, their 24% rubber concrete samples were of three categories, that is, samples containing number 8 rubber sizes, those containing no. 50 and no. 100 rubber sizes. However it was noticed that there was better bonding between rubber aggregates and cement paste for finer rubber aggregates.

1.9 CIVIL ENGINEERING APPLICATIONS OF RECYCLED RUBBER FROM SCRAP TYRE:-

Scrap tire chips and their granular partner, crumb rubber, have been effectively utilized in various structural designing applications. Tire chips comprise of tire pieces that are generally destroyed into 2.5 to 30 cm lengths. crumb rubber is a finely ground tire rubber from which the texture and steel belts have been removed. It has a granular texture and ranges in size from fine powder to sand sized particles. Crumb rubber has been effectively utilized as an elective total source in both asphalt concrete and PCC.

Subgrade insulation for roads:-

Excess water is discharged when subgrade soils defrost in the spring. placing a 15 to 30 cm thick tire shred layer under the road cab keeps the subgrade soils from freezing in the first place. Furthermore, the high permeability of tire shreds enables water to deplete from beneath the roads preventing damage to road surfaces (ASTM D6270-98)

Subgrade fill and embankments:-

Tire shreds can be utilized to construct embankments on weak, compressible foundations soils. Tire shreds are feasible in this application because of their light weight. For most projects, utilizing tire shreds as a light weight fill material is fundamentally a less expensive option.

Backfill for walls and bridge abutments :-

Tire shreds can be useful as backfill for walls and bridge abutments . The weight of tire shreds decreases even weights and takes into account construction of more slender, more affordable walls. Tire shreds can likewise lessen issues with water and ice development behind walls since tire shreds are free depleting and give great thermal insulation..

Landfills:-

Landfill construction and operation is a developing business sector application for tire shreds. Scrap tire shreds can replace other construction materials that would need to be obtained. Scrap tire might be utilized as a light weight inlay in gas venting frameworks, in leachate gathering frameworks, and in operational liners. They may likewise be utilized in landfill topping and terminations, an as a material for day by day cover.

CHAPTER 2

OBJECTIVE

- The objective of this study is to test the properties of concrete when crumb rubber is used as aggregate by partial replacement of natural fine aggregates.

- Study the feasibility of incorporating Crumb rubber as fine aggregate in concrete mixes and determine the adjustment in the properties after the incorporation of the rubber into the concrete mix.

- The aim of this study is to introduce an environmental friendly technology, which can benefit the society and the nation.

- We need to test the flexural, compressive and tensile strength using the waste tire Crumb rubber in concrete and comparing the results with the conventional concrete.

CHAPTER 3

NEED

In the developmental procedures a lot of waste is being produced in which ,there lies two categories degradable and non degradable while the rubber tyres falls in the non degradable category thus they cannot be decomposed easily. People however try to decompose this material by dumping them in the ground but this method works only for a limited duration as after sometime they come out of the landfills and get on the top of the surface of land while some people try to decompose them by burning which is even worst as they emit a lot of carbon while burning which results in the increased air pollution. So it is better to put them for the reuse, one of the best way to reuse them is by using them in construction industries as a building material .They can be mixed with concrete to build various structures which will make the disposal of rubber tyres easy as well as productive. The structures made by this composite are good in resisting the ultrasonic waves which highly reduces the damage factor as the rubber particles of the composite act as absorbers. Globally 15 million tonnes of waste is being generated every year , out of which India contribute a million tonnes ,that's why there is huge need of proper management of these wasted tires and reusing is the best possible option we have got. Reusing it in the construction companies is the best way to mange this non degradable stuff and brings some benefits out of the waste, which is a good sign for mother earth as well.

CHAPTER 4

SCOPE

With the increase in urbanization of countries like INDIA & ETHIOPIA, the number of vehicles and the amount of used tire is going to increase significantly in the future. Hence, no environmental nature of these wastes is going to be a potential threat. This study can show an alternative way of recycling tires by use them into concrete construction.

In the developmental procedures a lot of waste is being produced in which ,there lies two categories degradable and non degradable while the rubber tyres falls in the non degradable category thus they cannot be decomposed easily. People however try to decompose this material by dumping them in the ground but this method works only for a limited duration as after sometime they come out of the landfills and get on the top of the surface of land while some people try to decompose them by burning which is even worst as they emit a lot of carbon while burning which results in the increased air pollution. So it is better to put them for the reuse, one of the best way to reuse them is by using them in construction industries as a building material .They can be mixed with concrete to build various structures which will make the disposal of rubber tyres easy as well as productive. The structures made by this composite are good in resisting the ultrasonic waves which highly reduces the damage factor as the rubber particles of the composite act as absorbers. Globally 15 million tonnes of waste is being generated every year , out of which India contribute a million tonnes ,that's why there is huge need of proper management of these wasted tyres and reusing is the best possible option we have got. Reusing it in the construction companies is the best way to mange this non degradable stuff and bring some benefits out of the waste ,which is a good sign for mother earth as well.

The process requires a broad laboratory for studying the proportion of crumb rubber in the preparation of rubberized concrete .The motive of the study was to know the strength behavior that is change in compressive , flexural strength and Split tensile strength of rubberized concrete with different percentage of crumb rubber along with the use silica fume as a mineral admixture

Parameters varied in Investigation as shown below:

- Firstly, 5% replacement of fine aggregate is done in the concrete.
- Then, 10% replacement of fine aggregate is done in the concrete.
- And, At last, 15% of the fine aggregate is replaced with crumb rubber in the concrete.

The main aim of this study is to know the effects on the varying volume of crumb rubber on

1. Compressive Strength.
2. Split Tensile Strength.
3. Flexural Strength.

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CHAPTER 5

LITERATURE REVIEW

Eldin and Senouci (1993), on the premise of experimental outcomes, demonstrated that there was around 85% reduction in compressive strength and half reduction in rigidity when the total coarse was completely replaced by coarse rubber chips. In any case, examples lost up to 65% of their compressive strength and up to half of their rubberity. He likewise demonstrated that when stacked in pressure examples carrying rubber did not show fragile disappointment. The continuous disappointment was watched, both of a part (coarse tire chips) or a shear mode (fine morsel rubber). It was contended that since the bond glue is significantly weaker in strain than in pressure the rubber treated example containing coarse tire chips would begin flopping in strain before it achieves its pressure confine The produced pliable anxiety focuses at the top and base of the rubber totals result in numerous pliable small scale breaks that frame along the tried example. These smaller scale splits will quickly proliferate in the concrete glue. Until they experience an rubber total. On account of their capacity to withstand expansive pliable distortions, the rubber particles will go about as springs deferring the broadening of splits and anticipating whole crumbling of the concrete mass. The constant utilization of compressive load will cause an era of more splits and in addition augmenting of existing ones. Amid this procedure, the coming up short example is equipped for engrossing noteworthy plastic vitality and withstanding expansive miss happenings without full breaking down. This procedure will proceed until the burdens beat the bond between the concrete glue and the rubber totals6.

Neil N. Eldin (1993) 2, broke down the after effects of compressive and part rigid qualities in rubber treated cement following 7 and 28 days curing and watched that there was slightest change in the compressive and rubber qualities between the 7th and 28th day, when the coarse total were supplanted by rubber chips with an expansive volume that is for the examples carrying 75% and 100% tire chips. The decrease of up to 85% of compressive and half of rubberity has been observed when the coarse total was supplanted by rubber. A little decrease was observed when sand was supplanted with piece rubber. The examples showed high limit with regards to retaining plastic vitality under both pressure and strain loadings 13-14.

Topcu (1995) 3, investigated the consequences of pressure tests led on normal and rubber treated concrete. He also observed that the compressive strength of standard cement gotten from 3D shape tests is higher than that acquired from barrel tests. In any case, the outcomes regarding rubber treated cements out of the blue demonstrated the turn around15. This shows the mechanical strength of rubber treated mixture is extraordinarily influenced with the size, extent, surface of rubber particles and the sort of concrete utilized as a part of such mixture.

Goulias and Ali (1997) 9,on premise of test outcomes utilizing diverse parameters, it was discovered that dynamic moduli of flexibility and inflexibility diminished with an expansion of the rubber substance, demonstrating that a less concrete and less fragile material was acquired. The damping limit of cement (a measure of the capacity of the material to diminish the adequacy of free vibrations in its body) appeared to diminish with an expansion of the rubber substance16.

On the other hand, Topcu and Avcular (1997a) and Fatuhi and Clark (1996) suggested utilizing rubber treated cements in conditions where vibration damping is required, for example, in structures as a tremor stun wave safeguard, in establishment cushions for apparatus, and in railroad stations. Aftereffects of Poisson's proportion estimations showed that barrels with 20% rubber had a bigger proportion of horizontal strain to the comparing pivotal strain than that of 30% rubber concrete chambers (Goulias and Ali 1997a). It was additionally discovered (Goulias and Ali 1997) that the higher the rubber substance, the higher the proportion of dynamic modulus of flexibility to the static modulus of versatility.

The dynamic modulus was then found with compressive strength, giving a high level of relationship between's the two parameters. This recommends nondestructive estimations of the dynamic modulus of versatility might be utilized for evaluating the compressive strength of rubber treated18-19. A decent relationship between's compressive strength and the damping coefficient figured from transverse recurrence was additionally discovered, demonstrating that the damping coefficient of rubber treated may moreover be utilized for anticipating the compressive strength20. Consequently more research is required before such suggestions can be made.

Topcu and Ozcelikors (1991) demonstrate that 10% rubber chips expansion expanded the strength of cement by 23%.

They likewise researched the workability of rubber treated mixture21-22. They watched a reduction in droop with expanded rubber substance by aggregate total volume. Their outcomes demonstrated that at rubber substances of 40% by aggregate total volume, the droop was close to 0 and the concrete was not workable by hand. Such type of mixture must be compacted utilizing a mechanical vibrator. Mixture containing fine piece rubber was, in any case, more workable than mixture containing either coarse tire chips or morsel rubber or a mix of them.

A.K Sahu et al. (2003) explored "the fundamental properties of ordinary concrete and concrete made utilizing quarry dust have thought about. They have studied M20 and M30 concrete. Proportional blends are gotten by supplanting stone residue somewhat/completely. Test outcomes demonstrates the powerful utilization of stone residue with same compressive quality, practically identical elasticity and modulus of break. Functionality of 40percentage supplanting of stone residue with 2percentage Super plasticizer is equivalent to the workability of regular cement. Usefulness is expanded by the expansion of per plasticizer as replaced materials to regular sand has turned out to be useful and common in the world. Stone dust is fabricated by pulverizing larger stones of quarry to specific size of sand. Its chemical and physical properties, for example, color,size and shape, surface up particles depend on sorts of stone and its source .Use of crushed sand has turned into a decent substitute for normal sand and it has turned out to be fundamental keeping in perspective of specialized, business and ecological prerequisites. Legitimate quality control while utilizing pulverized sand/made sand can result in better outcomes. Diverse analysts have done research to examine the impact of utilization of smashed sand on properties of mortar".

Mohammed Mustafa Al Bakari. A. Syed NuzulFazl S.A, Abu BakarM."Comparison of rubber as aggregate and rubber as filler in solid" this examination will endeavor to utilize rubber waste substitution of coarse aggregates to deliver early age concrete. It do two distinctive sort of solid which are rubberized concrete and rubber filler in cement. In rubberized solid, rubbers were utilized to supplant coarse aggregates and sand as fine aggregate. Coarse aggregate normally rock or pulverized stone and destroyed rubber as filler in cement. The compressive quality was diminished in rubberized concrete for a few reasons including the consideration of the waste tires rubber aggregate acted like voids in the matrix. This is a direct result of the feeble bond between the waste tires rubber aggregate and solid matrix. With the expansion in void substance of the concrete, there will be a comparing diminish in quality. Portland bond solid quality is needy significantly on the coarse aggregate, thickness, size and hardness. Since the aggregates are incompletely supplanted by the rubber, the decrease in quality is just characteristic.

Ganjian et al. 2008,investigated the execution of solid blend joining 5percentage, 7.5percentage and 10percentage tire rubber by weight as a substitution of aggregate and concrete. Two arrangement of solid blend were made. In the main set chipped rubber supplanted the coarse aggregate and in the second set scrap tire powder supplanted bond. The

toughness and mechanical test were performed. The outcome demonstrated that up to 5percentage replacement in the two sets no real changes happened in concrete characteristic.

Hadassa Baum and AmnonKatzl,studied" the percentage of fines in crushed sand and its effects on the concrete mixes. They pointed out that the addition of fine filler (mesh 0.075mm) has apositive potential on the properties of the mortar. But, at the same time, the fraction of less than 5 microns of the fine filler used for plastering may have a bad effect on the concrete. They also studied the effect of the composition of water reducing agent on mixes containing crushed sand that exhibited the lowest properties. They noted that Compressive strength improved, chlorides permeability and the shrinkage reduced".

Humphrey (1999), rubberized concrete and supplanted the coarse aggregate in ordinary concrete with ground and crushed scrap tire in different volume proportions. Ground rubber powder and the crushed chips particles go in size from around 15 to 4 mm were utilized. The impact of rubber tyre and rubber dispute strength, modulus of elasticity were tested and considered. The pressure – strain hysteresis circles were acquired by stacking, emptying and reloading of examples. Fragility file esteems were determined by hysteresis circles. Studies demonstrated that compressive quality and modulus of versatility of pounded rubberized concrete were lower than the ground rubberized concrete

Mavroulido.M and Figueiredo.J (2010), "Discarded tyre rubber as concrete aggregate: a possible outlet for used tyres" it can be concluded that despite the observed lower values of the

mechanical properties of concrete there is a potential large market for concrete products in which inclusion of rubber aggregate would be feasible. These can also include nonprime structural applications of the medium to low strength requirements, benefiting from other features of this type of concrete. Even if the rubber tyre aggregate was used at
relatively low percentages in concrete, the amount of waste tyre rubber could be greatly reduced due to the very large market for concrete products worldwide. Therefore the use of discarded tyre rubber aggregates in concrete shows promise for developing an additional route for used.

Nagraj T.S et.al (1996),"reported that rock dust which have higher surface area consumes more cement in with respect to sand which increases workability. He studied to effect of rock dust and pebble as aggregate in cement and concrete and found that crushed stone dust could be used to replace the natural sand in concrete".

Shukla et al. (1998),"investigated the behavior of concrete made by partial or full replacement of sand by crushed stone dust as fine aggregate and reported that 40 percent sand can be replaced by crushed stone dust without effecting the strength of concrete".

Toutanji,H.A (1996), "The use of rubber tyre particles in concrete to replace mineral aggregates. Cement concrete investigated the effect of replacement of mineral coarse aggregate by rubber tyre aggregate. Shredded rubber tyres used had a maximum size of 12.7mm and a specific gravity of about 0.61. The incorporation of these rubber tyre chips in concrete exhibited a reduction in compressive and flexural strength. The specimens which contained rubber tyre aggregate exhibited ductile failure and underwent significant displacement before fracture. The toughness of flexural specimens was evaluated for plain and rubber tyre concrete specimens. The test revealed that high toughness was displayed by specimens containing rubber tyre chips as compared to control specimens".

Venugopal (1999) et al., "examined the effect of rock dust as fine aggregate in cement and concrete mixes. They have suggested a method to proportion the concrete using rock dust as fine aggregate".

Divakar et al. (2012)," have experimented on the behavior of M20 grade concrete with the use of granite fines as a partial replacement for sand in 5percentage, 15percentage, 25percentage, 35percentage and 50percentage; and based on the results obtained for compressive, split-tensile and flexural tests, it was recommended that 35percentage of sand can be replaced by granite fines". **Khatib Z.K and Bayon F.M (1999),** has developed "Rubberized Portland cement concrete to conduct experimental program in which two types of rubber fine Crumb Rubber and coarse tyre chips were used in Portland cement concrete (PCC) mixtures. Rubberized PCC mixes were developed by partially replacing the aggregate with rubberand tested for compressive and flexural strength in accordance to ASTM standards. Tyre chips were elongated particles that ranged in sizefrom about 10 to 50mm. Results show that rubberized PCC mixes can be made and are workable to a certain degree with the tyre rubber content being as much as 57percentage of the total aggregate volume. However, strength results show that large reductions in strength would prohibit the use of such high rubber constant. It is suggested that rubber contents should not exceed 20percentage of the total aggregate volume".

Amirkhanian et al (1994), has tested the use of crumb rubber asphalt concrete in road pavement at several areas to determine the economicand engineering feasibilities of these materials. They concluded that the roadsection paved using wet process has been performing satisfactorily to thispoint. The test result coring that it indicates the asphalt rubber mixture isproducing higher wet indirect tensile strength and tensile strength ratios thancontrol mixture.

Larson (2003),found that crumb rubber in concrete couldreduce thermal expansion, contraction, drying shrinkage, ride noise, freezethawdamage, brittleness and weight in road pavements.

Eldin and Senouci (1993)," reported a reduction in density of, up to25% when ordinary aggregate was replaced by coarse rubber aggregate".

Li et al (1998), found that" the density of TRAC was reduced by around 10%when sand was replaced by crumb rubber to the amount of 33% by volume".

Ali et al. (1993), reported that when rubber aggregate was added tothe concrete, the air content increased considerably (up to 14%).

Topcu (1995), investigated" the effect of particle size and content oftyre rubbers on the mechanical properties of concrete. The researcher foundthat, although the strength was reduced, the plastic capacity was enhancedsignificantly".

Chou et al (2007), investigatedRubber traded concrete for variousapplications and has demonstrated promising outcomes. The expansion of rubber particlesleads to the debasement of physical properties, especially, the compressivestrength of the concrete.

Chung et al (1999), introduced "rubber concrete usingwaste rubber using the dry process. The compressive strength of rubberconcrete was about 89 MPa and the Poisson's ratio, which is the ratio ofcompressive-to-tensile strength, was 5.5".

CHAPTER 6

RESEARCH GAP

The existing review of literature has been reviewed thoroughly in which the present researcher found that fine aggregate has been replaced by waste tire Crumb rubber as the waste rubber contains elastic properties. In this connection the present researcher would try to focus on the effectiveness of Crumb rubber on the partial replacement of fine aggregate on the concrete strength and to evaluate the quantum of natural resources that can be saved annually in India and abroad after implementing partial replacement of fine aggregate by Crumb rubber by trying to gradually increase its quantity in concrete mixtures along with the use of silica as mineral admixture in order to improve the adhesive and bonding properties of concrete keeping in mind all the properties of concrete which can get affected by doing so to make it more economical eco friendly as well as efficient.

CHAPTER 7

EXPERIMENTAL PROGRAM

This thesis aims at using waste tire crumb rubber as a constituent in concrete mixes and its products as a partial replacement of natural and artificial fine aggregate components

7.1 Work Procedure

The following represents the methodology by which thestudy for the effect of utilization of waste tire crumb rubber in concrete mixes was done:

No. of cubes = 9

No. of cylinders = 9

No. of beams =9

7.1.1 Materials

The materials used in this thesis were locally available materials. The crushed coarse aggregate and fine aggregate were obtained from Waknaghat, and the waste tire crumb rubber was obtained from ATG RUBBER PVT LTD Chandigarh.

The basic ingredients of rubberized concrete and its products, which were used in this research work, are:

1- OPC-53 grade ultra tech cement.
2- Natural Coarse aggregate (sedimentary rock source).
3- Natural Fine Aggregate (sand).
4- Water.
5- Fine crumb rubber (sieve size < 4.75mm)

7.1.2 Raw material tests

The materials used in this research work were tested for the purpose of identification of basic physical properties using the following tests:

Sieve analysis of Fine and Coarse Aggregate

Specific Gravity of Fine and Coarse Aggregate

Water Absorption and MoistureContent

Tests results of the raw materials used will be presented in the following chapter of this thesis.

7.2 EXPERIMENTAL PROGRAM RELATED TO CONCRETE

7.2.1 Materials used in concrete

7.2.1.1 Ordinary Portland cement (53 grade)

OPC 53 grade cement was used in the concrete and it was tested as per Indian Specifications IS: 12269- 1997. The chemical properties of OPC 53 grade is shown in table 7.1.

Table 7.1 Chemical properties of OPC 53 GRADE

Chemical	**Constituent**
SiO_2	21.08%
Al_2O_3	5.04%
Fe_2O_3	3.22%
CaO	62.18%
MgO	2.48%
$K_2O + Na_2O$	1.06%
SO_3	3.16%

7.2.1.2 Fine aggregates

Natural sand with 4.75 mm maximum size of particles was used as fine aggregate. Sand was tested as per Indian Standard Specifications IS: 383-1970. Weight of sample taken for test was 20 kg. The results of sieve analysis are shown in table 7.2.

Table 7.2: Sieve analysis of fine aggregates

I.S Sieve	Weight retained (gm)	%age Weight retained	Cumulative %age Weight retained
4.75mm	114	5.7	5.7
2.36mm	203	10.15	15.85
1.18mm	157	7.85	23.70
600µm	566	28.3	52.00
300µm	732	36.6	88.60
150µm	194	9.7	98.30
Pan	34	1.7	100

7.2.1.3 Coarse aggregates

The coarse aggregate used was crushed stone with maximum 20 mm size. Weight of sample taken for test was 5.0 kg. The results of sieve analysis are shown in table below, respectively.

Table 7.3: Showing sieve analysis results

I.S. Sieve	Weight retained (gm)	%age weight retained (gm)	Cumulative %age weight
20mm	58	1.16	1.16
12.5mm	4898	97.96	99.12
10mm	24	0.48	99.60
6.3mm	10	0.20	99.80
4.75mm	0	0	99.80
Pan	10	0.20	100

7.2.2 Design of concrete mix

The compressive strength of concrete is fundamentally considered as the strength and nature of cement. So the mix configuration is set up for a specific compressive strength with required workability so the fresh concrete can b legitimately mixed,, put and compacted. The mix configuration was made by the BIS: 10262-2009

The mix design of concrete consist three steps

1. Selection of materials, other cementing materials, aggregates and water.
2. Determination of quantities of materials for required strength and durability.
3. Careful quality control on every stage of process of concrete making.

In this study Mix design for M30 grade of concrete is made according to the BIS: 10262-2009.

Characteristic strength at 28 days =28.66 N/mm2

Maximum size of the aggregates = Less than 20mm

The ingredients of M30 Concrete mix are shown in table 7.4.

Table 7.4: Mix proportion of M30 grade

Units of batch	Water (liters)	Cement (kg)	Fine aggregates (kg)	Coarse aggregates (kg)	Mineral Admixture (kg)
Cubic meter	170	434.8	843.42	1074.008	3.319
Ratio	0.31	1	1.94	2.47	0.0076

Mix composition

The mix design was prepared with constant quantities of cement, aggregate and water.

Controlled mix design was prepared as per IS: 10262-2009 to have 28days compressive strength of 28.66 N/mm^2. After that the fine aggregate was replaced with 5%, 10% and 15% crumb rubber by weight of fine aggregates. The detailed description is in the table 7.5.

Table 7.5: Mix composition for different percentages of crumb rubber

Content	M-1(0%CR)	M-2(5%CR)	M-3(10%CR)	M-4(15%CR)
Cement(kg/m^3)	434.8	434.8	434.8	434.8
Fine aggregate (kg/m^3)	843.42	801.25	749.078	716.907
Coarse aggregate (kg/m^3)	1074.008	1074.008	1074.008	1074.008
Water (kg/m^3)	170	170	170	170
W/C ratio	0.31	0.31	0.31	0.31
Mineral admixture(kg/mm^3)	3.319	3.319	3.319	3.319
Slump (mm)	75	80	85	87

M: denotes design mix

The mixing procedure adopted was as follows:

1. Cement and crumb rubber were dry mixed in a tray for 15 minutes until it obtains a uniform color.
2. Then coarse and fine aggregates were mixed in dry state.
3. Water was then added.
4. The moulds were properly oiled before stating the casting. The casting followed mixing, after the tests for fresh properties the top surface of the specimen was specimen was scraped to achieve a smooth finish. After 24 hours moulds were removed and cured in the water till testing

After the required period of curing i.e. 7 and 28 days, the specimens were taken out from the tank and their surfaces were wiped off.

7.2.3 Preparation of test specimen

The concrete cubes, cylinders and beams were made with three different ratios of crumb rubber that is 5%, 10% and 15% and controlled samples were casted without addition of crumb rubber.

7.2 Testing procedure for concrete

Strength properties of concrete were investigated by performing the following tests.

Compressive strength (IS: 516-1959)

Split tensile strength (IS: 5816-1999)

Flexural strength (IS:516-1959)

The concrete properties were determined at the age of 7 and 28 days

7.3.1 Compressive strength

Compressive strength can b defined as the capacity as a material to withstand the effect of axially pushing forces. When the material reached the compressive strength limit, the material is crushed. In the present study, crumb rubber with 0%, 5%, 10%and 15% replacement with fine aggregates. Then the best result of rubberized concrete and controlled concrete were compared. Cubes were casted and compacted in a vibration machine. After the de-molding all the specimens were kept for curing and the test were conducted at 7 and 28 days. Controlled specimens were likewise arranged similarly. Compressive strength is measuredon a universal testing machine. The measurement of the compressive strength is influenced by the test technique and state of the measurement. At the point when the concrete specimen is stacked in a way that it expands then it is intention and in the event that material is compressed, it is in compression. cube specimen of size 150mm was gave a role according to Indian Standard Specification IS: 516-1959. After the completing, the examples were secured with sheets limit the loss of moisture. The specimens were de-formed following 24 hours and after that kept in water for curing. The compressive strength test was done following 7 and 28 days.

Calculations

The formula used for calculation of the compressive strength was:

$\sum\sigma = P/A$

Where, $\sum\sigma$ = Compressive strength (N/mm^2)

P = Maximum load (N)

A = Cross section area of cube (mm^2)

7.3.2 Split tensile strength

Split tensile strength can be defined as the ability of a material to resist a force which tends to pull it apart. It is expressed as the maximum tensile stress required for splitting the material apart. In the present study, crumb rubber with 0%, 5%, 10%,and 15% replacement with fine aggregates is used and the best results of rubberized concrete and controlled concrete were compared. Cylinders were casted and compacted in a vibration machine. After the de-molding all the specimens were kept for curing and test were conducted after 7 and 28 days. Cylinders specimens of size 150 mm diameters and 300mm length were casted as per the Indian standard specifications IS: 5816-1999. According to IS specifications diameter of cylinder should be 150mm and length should be 300mm. Split tensile strength can b measured on any compression machine having sufficient capacity for the test and also capable of applying the load.

Calculations

The formula used for the calculation of split tensile strength was

$F_{ct} = 2P/\pi lD$

Where,

P = maximum load in Newton applied

l = length of the specimen (in mm)

D = cross sectional dimensions of the specimen

7.2.3 Flexural strength

Flexural strength is defined as the ability of a material to resist the deformation under load. Flexural strength is also known as bend strength, fracture strength and modulus of rupture. In the present study, crumb rubber with 0%, 5%, 10% and 15% replacement with fine aggregates is used and the best results of rubberized concrete and controlled concrete were compared. Beams were casted and compacted in a vibration machine. After the de-molding all the specimens were kept for curing and the test were conducted after 7 and 28 days. Controlled specimens were also prepared in the same way. Beam specimens of size 10*10*50cm were casted as per the Indian standard specification IS: 516-1959

Calculations

The flexural strength of the specimen is expressed as the modulus of rupture fb, in which, if 'a' equals the distance between the line of fracture and the nearer support.

$$fb = \frac{p.l}{b.d^2}$$

when 'a' is greater than 20.0 cm for 15.0 cm of specimen, or greater than 13.3cm for a 10.0 cm specimen, or

$$fb = \frac{3.p.a}{b.d^2}$$

When 'a' is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3cm but greater than 11.0 cm for a 10.0 cm specimen.

Where:

b = measured width in cm of the specimen,

d = measured depth in cm of the specimen at the point of failure,

l = length in cm of the span on which the specimen was supported, and

p = maximum load in kg applied to the specimen

if 'a' is less than 17.0 cm for a 15.0 cm specimen, or less than 11.0 cm for a 10.0 cm specimen, the results of the tests shall be discarded.

CHAPTER 8

RESULTS AND DISCUSSIONS

8.1 General

The main objective of this research work is to highlight the effect of crumb rubber on the strength properties of concrete.

For the concrete containing crumb rubber, the test results shows that with the addition of crumb rubber there is decline in the value of compressive strength, flexural strength and split tensile strength.

8.2 RESULTS OF CONTROLLED CONCRETE SAMPLE

Table 8.1: Strength properties of controlled concrete sample (M30)

Property	**7 Days**	**28 Days**
Compressive strength(N/mm^2)	**27.98**	**28.66**
Split tensile strength (N/mm^2)	**7.87**	**9.22**
Flexural strength(N/mm^2)	**10.12**	**11.9**

8.3 RESULTS OF CONCRETE SAMPLES CONTAINING CRUMB RUBBER

Table 8.2: Strength properties of concrete samples containing different percentages of crumb rubber

Property	Mix	7 Days	28 Days
Compressive strength (N/mm^2)	5% CR	26.22	28.01
	10% CR	24.01	26.55
	15% CR	18.35	20.68
Split tensile strength(N/mm^2)	5% CR	6.08	7.33
	10% CR	5.68	6.44
	15% CR	5.35	6.01
Flexural strength(N/mm^2)	5% CR	9.70	10.03
	10% CR	8.91	9.83
	15% CR	7.03	8.49

8.4 Charts showing the comparison between the Compressive, Split tensile and Flexural strength of different concrete mix samples having different percentages of Crumb rubber

CHART 8.4.1: 28 days Compressive strength comparison of different mixtures of concrete having different percentages of crumb rubber.

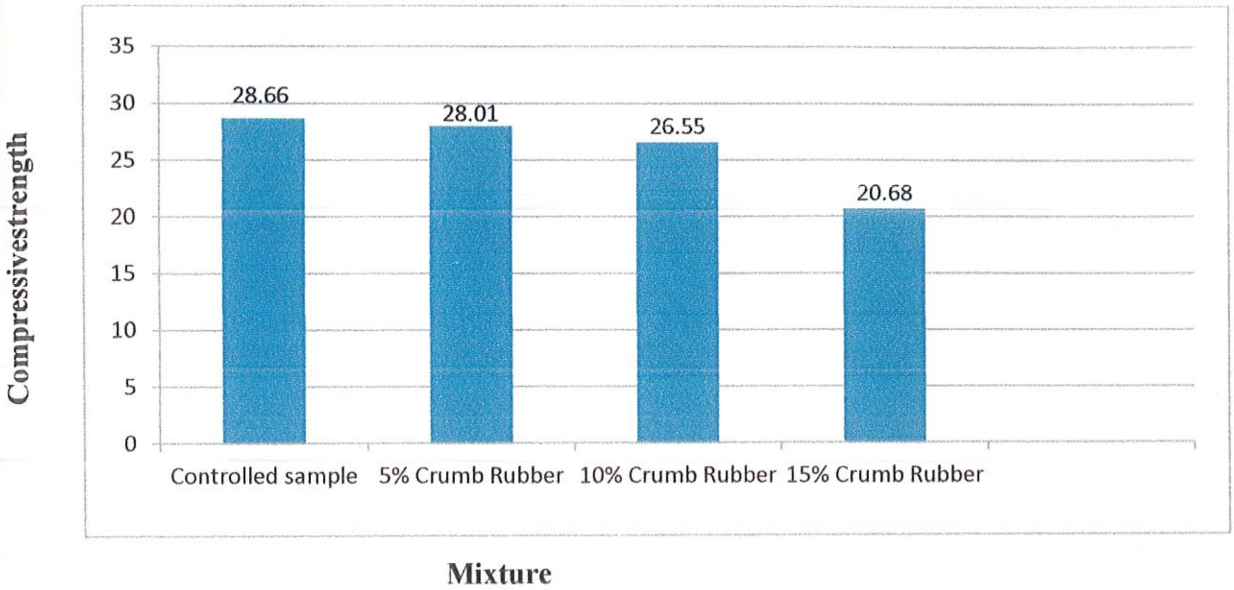


CHART 8.4.2: 28 days Split tensile strength comparison of different mixtures of concrete having different percentages of crumb rubber.

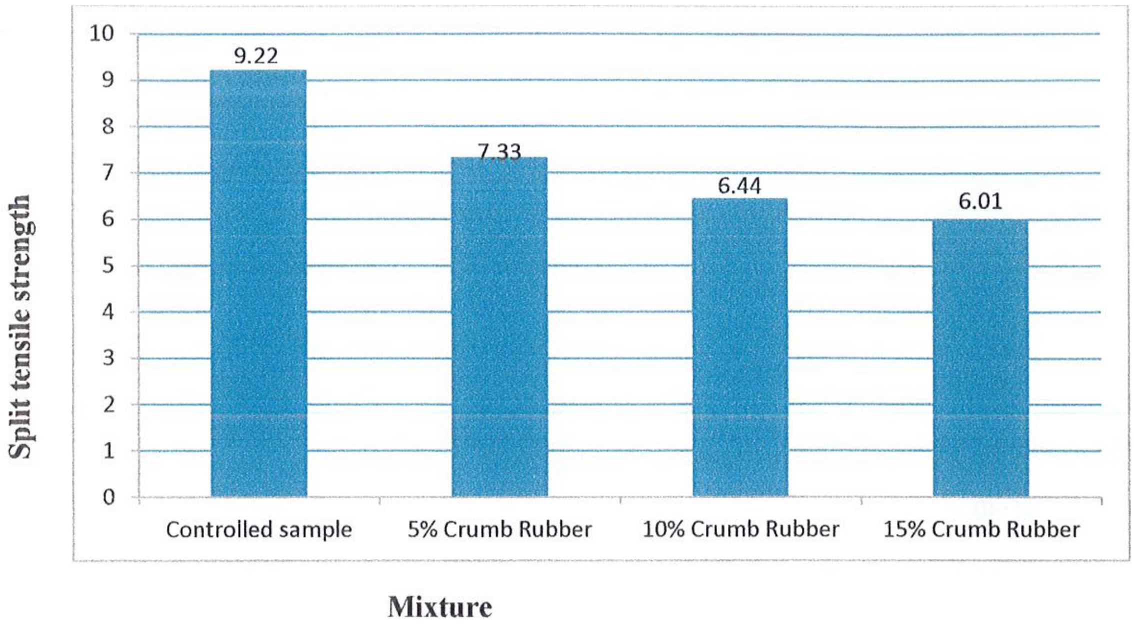
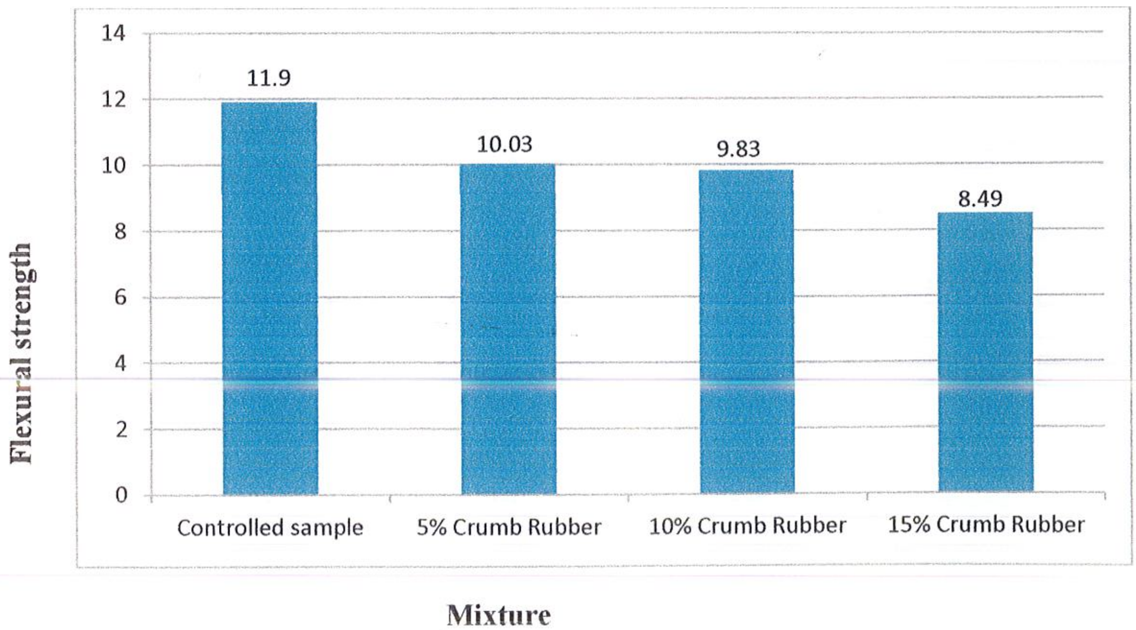


CHART 8.4.3: 28 days Flexural strength comparison of different mixtures of concrete having different percentages of crumb rubber.



CHAPTER 9

CONCLUSION

9.1 GENERAL

The present work investigated the effect of waste tire crumb rubber on the strength properties of concrete. The properties studied were on M30 grade of concrete. On the basis of the test results of the present study, following conclusions are made.

9.2 WORK PROCEDURE

The mixes were designed with constant cement and aggregates. The concrete mixtures were designed as per IS: 10262-2009 for 28 days compressive strength of 28.66 N/mm^2. The fine aggregate was partially replaced with 0, 5%, 10% and 15% crumb rubber in the presence of silica used as mineral admixture.

9.3 PROPERTIES OF CONCRETE

According to the experimental investigation, the utilization of rubber tire as partial replacement of fine aggregates has been used in three different proportions 5%, 10% and 15% with silica fumes as mineral admixture. Based on the results, following conclusions are drawn:

1. As the percentage of crumb rubber is increased, the workability of the concrete also increases.

2. In comparison to the previously done experimental investigations with crumb rubber in the absence of silica fumes, this research has shown comparatively better adhesive and bonding properties and hence comparatively better values for compressive, tensile and flexural strength.

3. The increase in the workability also shows decrease in the voids due to the betterment in the compaction but due to the decrease in the other properties it is not significant.

4. For larger percentage of rubber in concrete, the decline rate of compressive strength is higher than normal concrete.

5. Better results were obtained when 5% of rubber is used for substituting the natural aggregate in the rubberized concrete.

9.4 FUTURE SCOPE

1. Two different types of fibers such as steel fiber along with crumb rubber may tend to provide better performance.

2. Silica can be tried and tested with varying quantity in the rubberized concrete which can show some positive results in terms of adhesive and bonding properties and in turn also can give higher strengths.

3. Fire performance of rubberized concrete can be investigated for its limits and the extent to which it can be put into use in terms of fire safety.

CHAPTER 10

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