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USE OF TYRE WASTE IN CONCRETE: A REVIEW

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Abstract - *Waste Tyre rubber is one of the significant environmental problems world-wide. With the increase in the automobile production, huge amounts of waste tire (tyre) need to be disposed. Research had been in progress for long time to find alternatives to the waste tire (rubber) disposal. These alternatives are the recycling of waste-tire rubber. Discarded vehicle tires constitute one important part of solid waste which had historically been disposed of into landfills. An emerging use is the production of concrete, in which tyre rubber particles partially replace natural aggregates. This has the additional advantage of saving in natural aggregates used in the production of concrete which are becoming increasingly scarce. An emerging use is the production of concrete, in which tyre particles partially replace natural aggregates. This has the additional advantages of saving in natural aggregates used in the production of concrete which are becoming increasingly scarce. In this paper we will study about physical and mechanical properties of concrete containing recycled tyre or rubber material aggregates, to assess its suitability as a construction material.*

Key Words: **Rubber, Compressive Strength, Flexural Strength, Split Tensile Strength, Durability, and Mechanical Properties.**

1. INTRODUCTION

A large variety of waste materials are considered feasible and even much valuable additives for concrete. Some of these materials include cellulose, fly ash, silica fumes and wood particles. Rubber obtained from scrapped tyres is considered as the most recent waste materials that have been examined because of its vital use in the construction field. Worldwide, the production of rubber increases every year. Different countries of the world has different rate of producing rubber, for instance United States produces 3.6 million tons of rubber per year. Iran produces 100,000 tons of rubber per year similarly Malaysia produces 200,000 tons of rubber per year. These numbers increases with the increase in the production of vehicles. There are more than 1 billion scrap tires, approximately one tire per person, generated each year in the India. This creates a major problem for the earth and their livings. For this issue, the easiest and cheapest way of decomposing of the rubber is by burning it. This creates smoke pollution and other toxic emission and it create global warming. Currently 75-80% of scrap tyres are buried in landfills. Burying scrap tyres in landfills is not only wasteful, but also costly. Investigations have shown that scrapped rubber tyres contain materials that do not decompose under environmental conditions and cause serious problems. Based on these problems, tyres can be used as aggregates in concrete. India's waste tyres account for about 6-7% of the global total. With the local tyre industry growing at 12% per annum, waste volumes are rising. India has been recycling and reusing waste tyres for four decades, although it is estimated that 60% are disposed of through illegal dumping. Despite this, India is the second largest producer of reclaimed rubber after China. In 2011, India produced 90,000 metric tonnes of reclaimed rubber from waste tyres. By 2016, some100 000 kms of Indian roads had been laid with asphalt blended with recycled rubber, and over 500 000 tonnes of crumb rubber modified bitumen (CRMB) is used annually in road construction. New regulations introduced in 2016 allow for import of waste tyres for recycling.

The rubber tyre is classified into two classes according to the tyre of vehicles that use the tyre. The natural and synthetic rubber contents in car tyres are different from those in truck tyres. According to the use of tyre rubber in concrete preparation, it can be separated into three types:

- Shredded or chipped rubber is used to replace gravel. By shredding the rubber pieces, particles about 13 -76mm big are produced.

- Crumb rubber is used to replace sand with size range 0.425-4.75 mm and is manufactured by using special mills. The size of rubber particles depends on the type of mill used and the generated temperature.

- Ground rubber can be used as a filler material to replace cement. The tyres are subjected to two stages of magnetic separation and screening to produce this size of rubber particles. In micro-milling process, the rubber particles made are in the range of 0.075-0.475 mm.

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

abrasion, absorbing the shocks and vibrations, high ductility and brittleness and so on to the concrete.
Advantage of rubcrete concrete: -

- The rubcrete concrete is affordable and cost effective.
- It resists the high pressure, impact and temperature.
- They have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation.
- If we use magnesium oxychloride cement instead of Portland cement it gives more compressive and tensile strength.
- Also, if we react this rubcrete concrete with hot sulphur under temperature about 140oCit shows increase in strength of concrete.

Dis- Advantage of rubcrete concrete:-

- They are sometimes weak in compressive and tensile strength.

Application of rubcrete concrete:-

- In non-load bearing members as lightweight concrete walls.
- In highway constructions as a shock absorber.
- In sound barriers as a sound absorber.
- In buildings as an earthquake shock-wave absorber.
- It may also use in runways and taxiways in the airport, industrial floorings and even as structural member

Sulphur rubber concrete (SRC): - Sulphur rubber concrete (SRC) is an innovative idea. In sulphur rubber concrete, melted element sulphur, instead of Portland cement, act as a binder. This is why the concrete is called sulphur rubber concrete, because there is no Portland cement in it. Production of sulphur concrete is a hot mix procedure similar to the process for manufacturing of asphalt concrete. Sulphur concrete can be manufactured in a modified asphalt batch plant or a continuous mix facility. When rubber is used in the sulphur concrete to replace some of the natural aggregates, the hot mix process for the sulphur concrete makes the rubber aggregates undergo a vulcanization process and the strength of the sulphur rubber concrete is higher than the strength of the regular concrete with rubber aggregates

Fiber reinforced concrete: - A major reason for the growing interest in the performance of fibers in cement based materials is the desire to increase the toughness or tensile properties of the basic matrix. Fiber reinforced concrete was created to combine the tensile strength of rubber with the compressive strength of concrete. It was also intended to increase the toughness of concrete by including waste tires as fibers into the matrix. Waste tires possess high toughness and this property is hoped to be imparted to the concrete. Composites consist of one or more discontinuous phases embedded in a continuous. The discontinuous phase is usually harder and stronger than the continuous phase and is called the reinforcement or reinforcing material, whereas the continuous phase is called the matrix [United States, (US) Environmental Protection Agency, 1993].

Hazards of tyre waste:-

- These waste tyres are produces carbon by burning process.
- This amount of tyres is very large manner so it becomes dangerous as well as uncomfortable to placing, because of Land problems to our country.
- Potentially harmful substances were found exposed to highly acidic solutions.
- Aside from the persistent annoyance, mosquitoes have been shown to spread various dangerous diseases.
- Equally hazardous are tyre fires, which pollute the air with large quantities of carbon smoke, hydrocarbons and residue.
- Not only are these tyre mounds eyesores, they are also environmental and health hazards. The little pools of water retained by whole waste tyres create an ideal breeding ground for mosquitoes.
- These fires are virtually impossible to extinguish once started

2. Workability

S.NO.	Title	Author	Name of journal	Materials used	Test result
1.	Rubberized Portland cement concrete. [1]	Khatib, Z. K et.al.	Journal of Materials in civil engineering.	Ordinary Portland cement, Fine aggregate was replaced by waste materials of crumb rubber in 20%, 40%, 60%, 80%, and 100%. Cube- 100MM*100MM*100MM. Cylinder- 150MM diameter, 300MM height. Beam- 100MM*100MM*100MM.	The result show that by increasing the rubber content in concrete the slump as well as the unit weight decreases. But it still gave a workable mix despite of adding rubber to it when compared with ordinary concrete.
2.	Tyre rubber waste recycling in self-compacting concrete. [2]	M. Bignozzi et.al.	Cem Concr Res 36 (2006) 735–739.	Two different grain size distributions were chosen: Scrap (ST) and Crumb tyre (CT) with size range 0.5MM to 2 MM and 0.05MM to 0.7MM. W/C-0.53, W/Powder-0.34 for self-compacting concrete.	That the introduction of the rubber particles does not influence the workability in a significant way if the superplasticizer also increases.
3.	Deformation properties of concrete with rubber waste additives. [3]	G. Skripkiunas et.al.	Mat Sci 13 (2007) 219-223.	W/C with concrete without rubber waste-0.45. W/C without concrete with rubber waste-0.45. Portland cement is used with concrete specimens prisms 100MM*100MM*300MM.	Use of crumbed rubber to replace 23 kg of fine aggregates in concretes with 0.6% of a Policarboxile superplasticizer by cement mass obtaining the same workability of the reference Concrete.
4.	Experimental investigation of some fresh and hardened properties of rubberized self-compacting concrete.[4]	I. Topçu et.al.	Mater Design 30 (2009) 3056-3065.	Portland cement, Fly ash because it is an agent to carry the aggregates, Rubber, Admixture high plasticizer, Fine aggregate, Coarse aggregate.	The result shows that influence of rubber waste with a maximum dimension of 4mm in self-compacting concretes noticing that rubber replacing sand increase concrete workability which is due to the presence of viscosity agents even to a volume of 180kg/m3.
5.	Discarded tyre rubber as concrete aggregate: A possible outlet for used tyre. [5]	M. Marvrouli dou et.al.	Global NEST Journal.	Scrap tyre aggregate ranging from 1MM-20MM, Ordinary Portland cement, Coarse rubber aggregate- 10MM-19MM, Fine rubber aggregate- 4.75MM-10MM, Four different contents of rubber aggregate (by mass) were used to replace the mineral aggregate 10%, 20%, 30% and 40%.	With further increase in rubber content, for both the fine and coarse rubber specimens, the mix became stiffer and less workable, which was reflected in the significant decrease in slump values. The 40% coarse rubber tire mix in particular had too low slump values and was manually unworkable. The addition of fine aggregate rubber from 10% up to 40% rubber content maintained a linear decrease in slump values. This was not the case for the coarse aggregate rubber content which experienced a decrease of about 50% from a 10% rubber content to a 20%

					rubber content, a very small decrease in slump between 20% and 30% of rubber aggregate and then again a large decrease of about 33% between 30% and 40% of rubber aggregate. No particular trend was obvious as to whether the CRA or FRA mixes were more workable.
6.	Re-use of waste tire rubber pieces in the production of light weight concrete. [6]	K.Charan kumar et.al.	International Journal of Science and Research (IJSR).	Two concrete grade (M15, M25), 10%, 25%, and 50% of rubber aggregate with coarse aggregate.	The introduction of recycled rubber tires into concrete significantly increased the slump and workability. It was noted that the slump has increased as the percentage of rubber was increased.
7.	A technical and economical Assessment of replacement of coarse aggregate by waste tyre rubber in construction. [7]	Warudka r A.A et.al.	International Journal on Recent and Innovation Trends in Computing and Communicati on.	M20, Shredded rubber- 1%, 2%, 3%, 4% and 5% mixes. W/C-0.45, Ordinary Portland cement with 53 grades.	The light unit weight qualities of rubberized concrete may be suitable for architectural application stone baking ,interior construction ,in building as an earthquake shock wave absorber ,where vibration damping is required such as in foundation for machinery and railway station.

3. Tensile strength

S.NO	Title	Author	Name of journal	Materials used	Test result
1.	Use of recycled tires as partial replacement of coarse aggregate in the production of concrete.[8]	Michelle Danko et.al.	Purdue University Calumet.	Ordinary Portland cement, W/C-0.45, Coarse aggregate replacement 10%, 15%, 20% by volume with untreated shredded rubber with three concrete mixes 10%, 15%, 20% by volume with the surface modified shredded rubber tire particles.	Tensile strength of rubberized concrete is mostly affected by the size, shape, and textures of the aggregate and the strength of concretes decreases as the volume of rubber aggregate increases.
2.	Properties of crumb rubber concrete.[9]	Kaloush K.E et.al.	Arizona: Arizona State University.	No rubber concrete, 200LBS rubber per cubic yard, 300LBS rubber per cubic yard, 400LBS rubber per cubic yard, Crumb rubber use, Cylindrical specimens-3*6, Beam- 18*4*4, Cylindrical specimens- 3*6.	The tensile strength of rubberized conctere decreases but the strain at failure increases correspondingly. Higher tensile strain at failure is indicative of more energy absorbent mixes.
3.	A review on construction technologies that enable	Kumaran S.G et.al.	USA, Science Publication s, 2008.	Grade of cement-53 with combination of fine sand and coarse aggregate with 10MM and 20MM, Waste tyre rubber used in	Tests conducted on the behavior of rubberized concrete containing tyre chips and crumb rubber as a replacement of aggregates having

	environmental protection: rubberized concrete.[10]			the form of chips and fibres by partially replacing coarse aggregate by 0%, 5%, 10%, 20% and 25%. W/C-0.4, Waste tyre rubber chips with 6MM diameter holes, Fibre rubber of 75MM*7MM*7MM.	sizes 38, 24 and 19 mm showed reduction in tensile strength by almost 50% but also showed maximum energy absorption during tensile loading.
4.	Scrap-tyre-rubber replacement for aggregate and filler in concrete. [11]	E. Ganjian et.al.	Constr Build Mat 23 (2009) 1828-1836.	W/C-0.5, Superplasticiser -0.4% by weight of cement, 5%,7.5% and 10% weight of coarse aggregate were replaced by rubber chipped tyre, 5%,7.5% and 10% weight of coarse aggregate were replaced by rubber ground tyre rubber, 150MM cube, 100MM*100MM*150MM prism.	Tensile strength was reduced with increases the % of rubber replacement in concrete. In case of 5% to 10% aggregate replacement by chipped tyre rubber, the reduction in tensile strength was about 30% to 60%, In case of 5% to 10% aggregate replacement by powdered rubber, the reduction in tensile strength was about 15% to 30%.
5.	Discarded tyre rubber as concrete aggregate: A possible outlet for used tyre.[5]	M. Marvrouli dou et.al.	Global NEST Journal.	Scrap tyre aggregate ranging from 1MM-20MM, Ordinary Portland cement, Coarse rubber aggregate-10MM-19MM, Fine rubber aggregate- 4.75MM-10MM, Four different contents of rubber aggregate (by mass) were used to replace the mineral aggregate 10%, 20%, 30% and 40%.	Split tensile strength of the mixes which was also reduced with rubber aggregate content. It was observed that upon splitting, the rubber particles seemed to hold the two parts of the concrete specimen together although the specimen had technically failed.
6.	Recovery and modification of waste tire particles and their use as reinforcements of concrete.[12]	Eduardo Sadot Herrera Sosa et.al.	Hindawi Publishing Corporation International Journal of Polymer Science.	Waste tyre by % volume- 10%, 20%, 30%. Ordinary Portland cement, W/C-0.54, Cylindrical mould- 150MM diameter, 300MM height. Beam-150MM*150MM*600MM.	It can be seen that concrete with concentrations no greater than 10% of particles of 2.8mm and irradiated at 300 kGy show the highest values compared to those for the control concrete for compressive strength, tensile strength, and elastic modulus. Different behaviors were observed in terms of the particle sizes and the irradiationdoses. In general terms, higher values are obtained with addition of large particles and high irradiation dose. The gamma irradiation generates more homogeneous and smooth surfaces as well as some cracks on the tire particles. Smooth surfaces are related to a hard particle, and the cracks to a better bond between cement matrix and the tire particles; both characteristics can prevent earliest cracks and in consequence soon failures. Themorphological characteristics along with the geometrical arrangement of the tire particles into the concrete allow improvements on the mechanical

					properties.
7.	Re-use of waste tire rubber pieces in the production of light weight concrete. [6]	K.Charan kumar et.al.	International Journal of Science and Research (IJSR).	Two concrete grade (M15, M25), 10%, 25%, 50% of rubber aggregate with coarse aggregate.	Splitting tensile strength tests show that, there is a decrease in strength with increasing rubber aggregate content like the reduction observed in the compressive strength tests. However, there was a smaller reduction in splitting tensile strength as compared to the reduction in the compressive strength.
8.	Concrete made for energy conservation using recycled rubber aggregates.[13]	Moayyad Al-Nasra et.al.	International Journal of Engineering Science Invention.	Ordinary Portland cement, Sand aggregate, Rubber aggregate, 0%, 10%, 20% of rubber aggregate replacement of the mineral aggregate.	This study proved that there is a great potential for the used rubber tires to be used effectively in concrete. Even though, the addition of rubber aggregates decreases the concrete compressive and tensile strength, there are several properties that can be improved by adding rubber aggregate to the concrete.

4. Compressive strength

S. NO	Title	Author	Name of journal	Materials used	Test result
1.	Properties of crumb rubber concrete paving blocks with and without facing layer.[14]	Ling T.C. et.al.	Kuala lumpur.	CPB comprised of cement, Aggregate, Coarse sand , Fine sand, Waste tyre, The recycled waste tyre used with 1MM-3MM and 1MM-5MM crumb rubber, The internal dimension of 210MM length, 105MM width , 60MM depth.	The density of concrete greatly depends upon the amount of air entrained or air entrapped, water-cement ratio, which in turn depends upon the size of aggregates. The increase in rubber content in concrete increases the air content which decreases the density (unit weight) of concrete. At about 25% of the content of rubber in concrete, the density decreases to about 90% of the ordinary concrete. However this decrease is very less when rubber content is less than 10-15% of the total aggregate volume.
2.	The use of recycled polymers and rubbers in concrete.[15]	Felipe J.A et.al.	Florida, 2004.	Ordinary Portland cement, Fine aggregate was replaced by rubber with the weight % of rubber used was 5%, 10% with particle size of 0.25MM and 0.59MM, scrap rubber was used untreated with a solution of NaOh, W/C-0.53.	Strength reduction of 50% was celebrated for a mix with 14% replacement in their studies.
3.	Rubberized concrete, Colorado: Rocky	Carol Carder.	Construction, 2004.	Ordinary Portland cement, Fine aggregate, Coarse aggregate, Rubber and cement.	Achieved higher compressive strength in crumbrubber concrete by dropping trapped air in the mix.

	mountain. [16]				
4.	Scrap-tyre-rubber replacement for aggregate and filler in concrete. [11]	E. Ganjian et.al.	Constr Build Mat 23 (2009) 1828-1836.	W/C-0.5, Superplasticiser - 0.4% by weight of cement, 5%,7.5% and 10% weight of coarse aggregate were replaced by rubber chipped tyre, 5%,7.5% and 10% weight of coarse aggregate were replaced by rubber ground tyre rubber, 150MM cube, 100MM*100MM*150MM prism.	The decrease in compressive strength for increase rubber content. However, these authors obtained a slight increase in compressive strength when 5% of chipped rubber replaced the coarse aggregates probably due to a better grading of the mixture.
5.	Improving rubber concrete by waste organic sulfur compounds. [17]	L.Chou et.al.	Waste Manag Res 28 (2010) 29-35.	Sand which had composition SiO_2-96.83%, Fe_2O_3-0.086%, Al_2O_3-1.674%, SBR and natural rubber.	Suggest the pretreatment of crumb rubber with organic sulfur stating it can modify the rubber surface properties increasing the adhesion between the waste and the cement paste. Investigations about rubber waste concrete show a compressive strength loss with waste content increase.
6.	Rubberized portland cement concrete.[1]	Khatib Z. K. et.al.	ASCE Journal of materials in Civil Engineering .	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 rubber, Tyre chips were elongated particles that ranged in size from about 10 to 50mm.	Rubberized PCC mixes can be made and are workable to a certain degree with the tyre rubber content being as much as 57% of the total aggregate volume. However, strength results show that large reductions in strength would prohibit the use of such high rubber constant.
7.	Comparison of rubber as aggregate and rubber as filler in concrete.[18]	Mohammed Mustafa Al Bakari et.al.		Ordinary Portland cement, Coarse aggregate- gravels, Fine aggregate- river sand, Rubber waste (Shredded rubber tire), Type 1- Use in rubber filter in concrete, Type 2- Use in rubberized concrete, W/C-0.4,0.5,0.7.	The compressive strength was reduced in rubberized concrete for several reasons including the inclusion of the waste tyres rubber aggregate acted like voids in the matrix. This is because of the weak bond between the waste tyres rubber aggregate and concrete matrix. With the increase in void content of the concrete, there will be a corresponding decrease in strength. Portland cement concrete strength is dependent greatly on the coarse aggregate, density, size and hardness. Since the aggregates are partially replaced by the rubber, the reduction in strength is only natural.
8.	Effects of recycled tires rubber aggregates on the	Zeineddine Boudaoud et.al.	Open Journal of Civil Engineering .	Two mix is used, Ordinary Portland cement, Mix 1-Gravel/Sand-2.22 and W/C-0.51, Mix 2- Gravel/Sand- 2.45 and W/C-0.55.	Substitution of effects of coarse traditional aggregates by rubber aggregates resulting from worn tires decrease in the Mechanical characteristics of the tested concretes.

	characteristics of cement concrete. [19]				
9.	Studies on scrap tyre added concrete for rigid pavements. [20]	Eldhose C et.al.	International Journal of Engineering Research.	The fine scrap tyre aggregate is added as 2%, 4%, 6%, 10%, and 12% increment to replace the fine Aggregate; slab with dimensions 3.5 x 4.5 x0.24m, M35 mix is used.	That up to 8% of rubber aggregate can be added into concrete mixes without considerable reduction in strength.
10.	Investigations on replacement of coarse aggregates by waste tires for road construction. [21]	Reshma E.K et.al.	IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE).	For Crushing and Impact Test the aggregate size ranging from 12.5mm to 10mm, waste tires as replacement for coarse aggregates use in this test.	Replacement of coarse aggregates by tire leads to decrease of the aggregate impact value. By replacing the rubber content by 15 % it is difficult to conduct impact test due to the rebound effect.
11.	Use of crumb rubber to improve thermal and sound properties of pre-cast concrete panel. [22]	Piti Sukontasukkul.	Construction and Building Materials.	Portland cement, Gravel. Rubber sand, Water, Rubberized concrete with 15 volumes by % of coarse aggregate (gravel) was replaced by waste tire chips or fibres.	Strains of the concrete with the same compressive strength with rubber waste from used tires (3.2% from aggregate by mass) deformations are 56 % – 63 % higher after the static loading, while set deformations after the unloading is 219 % – 360 % higher than for the none rubberised concrete. Cyclic loading of 20 cycles have no influence on the prismatic compressive strength of both concrete with and without rubber waste (3.2% from aggregate by mass). And Ultimate strains on concrete failure load are 36 % – 47 % higher for concrete with tyre rubber waste additive.
12.	Performance and evaluation of rubber as concrete material.[23]	Nikhil Ramchandra Pardeshi et.al.	International Research Journal of Engineering and Technology (IRJET).	M30, 10% replacement of coarse aggregate, Fine aggregate by chipped rubber, Cube-150MM*150MM*150MM.	It can be concluded that the waste tyre rubber in the form of crumb and chipped rubber in replacement of coarse aggregate and fine aggregate but it is still not recommended for structural uses because of the low compressive strength comparing with the normal concrete containing natural rock aggregate.
13.	Studies on mechanical properties of tyre rubber Concrete.[24]	Sulagno Banerjee et.al.	SSRG International Journal of Civil Engineering (SSRG-IJCE).	Ordinary Portland cement of grade 43, Natural sand, Gravels. Truck tyre is used, M25 grade with 100MM*100MM*500MM.	The reduced compressive strength of rubberized concrete in comparison to conventional concrete, there is a potential large market for concrete products in which inclusion of rubber aggregates would be feasible which will utilize the discarded rubber tyres, the disposal of which is a big problem for environment pollution, Rubber can

					be used to produce lightweight concrete, Rubberized concrete strength may be improved by improving the bond properties of rubber aggregates.
14.	To study on waste tyre rubber as concrete.[25]	Swapnil Jain.	International Journal of Research in Engineering Technology and Management.	Sand, Aggregate, Tyre rubber, Portland cement and gypsum.	It can be concluded that despite the reduced compressive strength of rubberized concrete in comparison to conventional concrete there is a potential large market for concrete products in which inclusion of rubber aggregates would be feasible which will utilize the discarded rubber tyres the disposal of which is an environment pollution problem.
15.	Used of recycled tyre/rubber as course aggregate and stone dust as fine aggregate in cement concrete works.[26]	Mohd Kashif Khan et.al.	IOSR Journal of Mechanical and Civil Engineering.	Cement, 53 grade Ordinary Portland cement, Coarse sand/Stone dust (as replacement), Coarse aggregate(grit)/Tyre (as replacement), % of stone dust mix- 20,25,30,35,40. % of tyre mix- 2,5,10. Cubes-225M^2 (area of one face).	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 non-primary structural applications of medium to low strength requirements, benefiting from other features of this type of concrete. Even if 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 tyres.
16.	Recovery and modification of waste tire particles and their use as reinforcements of concrete.[12]	Eduardo Sadot Herrera-Sosa et.al.	Hindawi Publishing Corporation International Journal of Polymer Science.	Waste tyre by % volume- 10%, 20%, 30%. Ordinary Portland cement, W/C-0.54, Cylindrical mould- 150MM diameter, 300MM height. Beam-150MM*150MM*600MM.	It can be seen that concrete with concentrations no greater than 10% of particles of 2.8mm and irradiated at 300 kGy show the highest values compared to those for the control concrete for compressive strength, tensile strength, and elastic modulus. Different behaviors were observed in terms of the particle sizes andthe irradiationdoses. In general terms, higher values are obtained with addition of large particles and high irradiation dose. The gamma irradiation generates more homogeneous and smooth surfaces as well as some cracks on the tire particles. Smooth surfaces are related to a hard particle, and the cracks to a better bond between cement matrix and the tire particles; both characteristics can prevent earliest

					cracks and in consequence soon failures. Themorphological characteristics along with the geometrical arrangement of the tire particles into the concrete allow improvements on the mechanical properties.
17.	A technical and economical assessment of replacement of coarse aggregate by waste tyre rubber in construction.[27]	Warudkar A.A et.al.	International Journal on Recent and Innovation Trends in Computing and Communication.	M20, Shredded rubber- 1%, 2%, 3%, 4% and 5% mixes. W/C-0.45, Ordinary Portland cement with 53 grades.	We conclude that the reduced compressive strength of rubberized concrete in comparison to conventional concrete. But its strength is within acceptable limit. Rubberized concrete cost is less as compared to conventional concrete. The light unit weight qualities of rubberized concrete may be suitable for architectural application stone baking ,interior construction ,in building as an earthquake shock wave absorber ,where vibration damping is required such as in foundation for machinery and railway station.
18.	Concrete made for energy conservation using recycled rubber aggregates.[13]	Moayyad Al-Nasra et.al.	International Journal of Engineering Science Invention.	Ordinary Portland cement, Sand aggregate, Rubber aggregate, 0%, 10%, 20% of rubber aggregate replacement of the mineral aggregate.	This study proved that there is a great potential for the used rubber tires to be used effectively in concrete. Even though, the addition of rubber aggregates decreases the concrete compressive and tensile strength, there are several properties that can be improved by adding rubber aggregate to the concrete.
19.	Re-use of waste tire rubber pieces in the production of light weight concrete.[6]	K.Charan kumar et.al.	International Journal of Science and Research (IJSR).	Two concrete grade (M15, M25), 10%,25%,50% of rubber aggregate with coarse aggregate.	For rubberized concrete, the test results show that the addition of rubber aggregate resulted in a significant reduction in concrete compressive strength compared with the control concrete. This reduction increased with increasing percentage of rubber aggregate.
20.	Exploration on rubber fortification In concrete.[28]	K. C. Denesh et.al.	International Journal of Scientific Research in Civil Engineering .	M30 grade, concrete cubes of size 150 x 150 x 150 mm, Silica Fume (Admixture), Conplast 430 are used as super plasticizer, Cement ,Fine aggregate, Coarse aggregate , Rubber Tyre Fiber , Binding Wire Fiber.	The maximum compressive strength, occurs at 1.0 % fibers added to the concrete was 41.35Mpa at 28 days for M30 grade of concrete. The compressive strength is increased to 6.58 % on FRC compare to the conventional concrete.

5. Flexural strength

S.NO.	Title	Author	Name of journal	Materials used	Test result
1.	Compacted concrete using tire-rubber.[29]	Kang Jingfu et.al.	Additive, Tianjin, 2008.	Sand, Aggregate, Tyre rubber, Portland cement.	The flexural strength was increased by adding rubber in roller compacted concrete. By increasing the content of rubber into concrete the flexural strength and ultimate tension elongation increases when the compressive strebgth was kept constants for roller compacted concrete.
2.	Scrap-tyre-rubber replacement for aggregate and filler in concrete. [11]	E. Ganjian et.al.	Constr Build Mat 23 (2009) 1828-1836.	W/C-0.5, Superplasticiser - 0.4% by weight of cement, 5%,7.5% and 10% weight of coarse aggregate were replaced by rubber chipped tyre, 5%,7.5% and 10% weight of coarse aggregate were replaced by rubber ground tyre rubber, 150MM cube, 100MM*100MM*150MM prism.	The reduction was about 37% for coarse aggregate replacement and 29% for cement replacement.
3.	Studies on mechanical properties of tyre rubber concrete.[24]	Sulagno Banerjee et.al.	SSRG International Journal of Civil Engineering (SSRG-IJCE).	Ordinary Portland cement of grade 43, Natural sand, Gravels. Truck tyre is used, M25 grade with 100MM*100MM*500MM.	It is observed that when rubber replacement increases, the flexural strength decreases in concrete.
4.	Discarded tyre rubber as concrete aggregate: A possible outlet for used tyre.[5]	M. Marvrouli dou et.al.	Global NEST Journal.	Scrap tyre aggregate ranging from 1MM-20MM, Ordinary Portland cement, Coarse rubber aggregate- 10MM-19MM, Fine rubber aggregate-4.75MM-10MM, Four different contents of rubber aggregate (by mass) were used to replace the mineral aggregate 10%, 20%, 30% and 40%.	This test concerns strength in tension of a beam or slab and shows when cracking will develop upon bending. It is therefore relevant for structures such as highway and airfield pavements which are designed on the basis of flexural strength of concrete. FRA beams showed higher MoR than CRA beams. However the reduction is much smaller compared to other properties.
5.	Recovery and modification of waste tire particles and their use as reinforcements of concrete.[12]	Eduardo Sadot Herrera-Sosa et.al.	Hindawi Publishing Corporation International Journal of Polymer Science.	Waste tyre by % volume- 10%, 20%, 30%. Ordinary Portland cement, W/C-0.54, Cylindrical mould- 150MM diameter, 300MM height. Beam-150MM*150MM*600MM.	It can be seen that concrete with concentrations no greater than 10% of particles of 2.8mm and irradiated at 300 kGy show the highest values compared to those for the control concrete for compressive strength, tensile strength, and elastic modulus. Different behaviors were observed in terms of the particle sizes and the irradiation doses. In general terms, higher values are obtained with addition of large particles and high irradiation dose. The gamma irradiation generates more

					homogeneous and smooth surfaces as well as some cracks on the tire particles. Smooth surfaces are related to a hard particle, and the cracks to a better bond between cement matrix and the tire particles; both characteristics can prevent earliest cracks and in consequence soon failures. Themorphological characteristics along with the geometrical arrangement of the tire particles into the concrete allow improvements on the mechanical properties.

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