Munish Thakur et al. International Journal of Recent Research Aspects ISSN: 2349-7688, Vol. 3, Issue 2, June 2016, pp. 79-91

Innovative Application of Waste Tyre in Concrete Mixes

Munish Thakur[1], Bhupinder Singh[2],
[1]M.Tech Student Indo Global Group Colleges.
[2]Assistant Professor at Indo Global Group of Colleges.

Abstract- Global movement in worldwide Scenario is going to be carbon reduction and energy saving. Maximum application of resources, efficient construction, economical construction and quality improvements costs have become urgent issues, which promotes overall economic development, strives to improve living standards and solves the problems of shortages in resources. Recycling is accepted to be one of the important bases of sustainability. Now days we are trying to utilize all kind of product, whether they are metal, concrete, plastic, wood, or even glass, will eventually turn into wastes that must be disposed. The best possible way to deal with such kind of wastes is to recycling, recovery and reuse them as raw materials or modifiers. This will reduce the drain on the natural resources of the raw materials, and it will reduce the spaces used as landfills. Among all these wastes rubber, this is worldwide used in our daily life by direct or indirect manners. However, the disposal of rubber is not an easy matter. Rubber tires are a non-biodegradable and ductile material that can exist for a long time without any degradation. The issue is growing amount of waste rubber tires has resulted in an environmental big problem. Most of the countries, open burning and using as a fuel are considered the easiest way to get rid of the waste rubber tires, even though these processes may lead to a very serious health hazard. Since the waste rubber tires cannot be biodegradable even after a long period of landfill treatment, material and energy recoveries are viable alternative to the disposal of this solid waste. Several investigations were carried out on the use of scrap tire particles in cement concrete. In this study rubber tires (waste) were used to replace natural aggregate depending on the fineness of particles. Concrete has become the most widely accepted and used construction material in civil engineering industry, the incorporation of waste rubber tire particles in concrete would be a very good and promising way to utilize the large quantities of waste rubber. Waste rubber tire used as particles in concrete would not only make a use of such waste materials but also help to improve some concrete properties. The concrete containing rubber reflects excellent flexibility, ductility and energy absorbency as compared with conventional or controlled concrete. Tire rubber is preferable for use in self-consolidating concrete since it effectively interacts with cement matrix to produce high flow ability along with good cohesiveness. This work studies the effects of worn rubber tire as aggregate and filler as a partial replacement of coarse and fine aggregate in the cement concrete. The primary aim of this study was to evaluate the strength and durability property of rubberized concrete. This Study has shown that replacing some percentage of natural aggregates by waste rubber causes significant change in properties of concrete. The properties studied are 7days, 28days compressive strengths, flexural strength, Modulus of rupture and expensive properties etc.

Keywords- Waste tyre, compressive strength, flexural strength, Expansive properties and split tensile strength.

I. INTRODUCTION

Currently humanity may be living in an unsustainable manner with respect to its usage of natural resources. Although the supply of natural resources is measurable, the demand for raw materials has increased greatly during the years. The growing demand for natural resources may cause the causalities such as technological improvements that have made more products available to society, rising affluence levels in the developing world and the overall increase in the overall global population. Another concern about the use of natural resources is the potential generation of CO_2 emissions and their harmful effect on the globe. These concerns have led to a re-evaluation of how natural resources are used and call for the implementation of more sustainable practices that preserve resources and allow them to endure for the future. In response to these concerns, the engineering community has begun to develop programs and standards that address sustainable construction practices. The U.S. Green Building Council has developed the Leadership in Energy and Environmental Design (LEED) and many more agencies program that provides guidelines to certify that proposed construction projects use resources that meet metrics for more sustainable construction (U S Green Building Council2011).The International Standards Organization has developed a number of standards to be used in environmental assessment methods (ISO 2012). Recently the Portland Cement Association (PCA 2009) has proposed several amendments to the International Building Code (International Code Council 2009) that consider sustainability. The amendments differentiate between a high performance building that uses sustainable construction practices and code requirements based upon minimum standards.

Solid waste management has gained a lot of attention to the engineering community. As concerned solid waste, accumulated waste tyres, has become a problem of interest because of its non- biodegradable nature [Malladi, 2004]. Most of the waste tyre rubbers are used as a fuel in many of the industries such as thermal power plant, cement kilns and brick kilns etc. unfortunately, this kind of usage is not environment friendly and requires high cost. Thus, the use of scrap tyre rubber in the preparation of concrete has been thought as an alternative disposal of such waste to protect the environment. Rubberized concrete may be used in places where desired deformability or toughness is more important than strength like the road foundations and bridge barriers. Apart from these the rubberized concrete having the reversible elasticity properties may also be used as a material with tolerable damping properties to reduce or to minimize the structural vibration under impact effects [Siddique *et al.* 2004].

Zheng et al. 2008 worked on rubberized concrete and replaced the coarse aggregate in normal concrete with ground and crushed scrap tyre in various ratios. Ground rubber powder and the crushed tyre chips particles range in size from about 15 to 4 mm were used. The effect of rubber type and rubber content on strength, modulus of elasticity were tested and studied. *Taha et al. 2008* used chipped tyre rubber and crumb tyre rubber to replace the coarse and fine aggregate respectively in the concrete at replacement levels of 25%, 50%, 75%, and 100% by volume. The tyre rubber was chipped in two groups of size 5 to 10 mm and 10 to 20 mm. the crumb tyre rubber of size 1 to 5 mm was used. *Khallo et al. 2008* determined the hardened properties of concrete using different types of tyre rubber particle as a replacement of aggregate in concrete. The different types of rubber particles used were tyre chips, crumb rubber and combination of tyre chips and crumb rubber. These particles were used to replace 12.5%, 25%, 37.5%, and 50% of the total mineral aggregate by volume. Result showed large reduction in strength and modulus of elasticity in concrete when combination of tyre rubber chips and crumb rubber were used as compared to that when these were used individually. It was found that the brittle behavior of concrete was decreased with increased rubber content. The maximum toughness index indicated the post failure strength of concrete with 25% rubber content.

Ganjian et al. 2008 investigated the performance of concrete mixture incorporating 5%, 7.5% and 10% tyre rubber by weight as a replacement of aggregate and cement. Two set of concrete mix were made. In the first set chipped rubber replaced the coarse aggregate and in the second set scrap tyre powder replaced cement. The durability and mechanical test were performed. The result showed that up to 5% replacement in both sets no major changes occurred in concrete characteristic. Bakri *et al.* 2007 replaced the coarse aggregate by waste tyre rubber to produce early age concrete. Two different concrete mixes viz. rubberized concrete and rubber filler in concrete were used. In rubberized concrete they replaced the coarse aggregate with the rubber. It was suggested that the compressive strength and density of concrete depend on the amount of rubber added in the concrete. In the rubberized concrete containing little amount of added rubber, the density and compressive strength were reduced to nearly 80%, as compared to ordinary concrete. Huang *et al.* 2004 prepared a rubberized Portland cement concrete with a portion of aggregate replaced by tyre rubber particles. Preliminary experiment was conducted to determine the mechanical properties of concrete. A parametric analysis was conducted using finite element analysis. It was found that rubberized concrete had very high toughness. However its strength decreased when the rubber content increased. The rubberized concrete was treated as a multiphase particulate filled composite material.

Savas, et al. (1996) carried out investigations to study the freezing and thawing (ASTM C 666, Procedure A) durability of 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 studied they concluded that (i) rubcrete 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% ground rubber by weight of cement could not meet the ASTM standards, (ii) Air-entrainment did not provide significant improvements in freezing the thawing durability for concrete mixtures with 10, 20, and 30% ground tire rubber, and (iii) increase in scaling (as measured by the reduction in weight) increased with the increase in freezing and thawing cycles.

Present scope of this investigation is the study of rubber waste generated from the discarded tyres and possibility of using waste tyre rubber as partial replacement of coarse aggregate in order to produce rubberized concrete. The purpose of the investigation is to see the effect on properties of concrete with different proportions of scrap tyre rubber chips. The methodology is to replace different proportions of the coarse aggregate with coarse rubber chips and test the properties of fresh and hardened concrete.

II. MATERIALS AND PROPERTIES

Scrap tire rubber powder can be obtained from tires through two principal processes: (a) ambient, which is a method in which scrap tire rubber is ground or processed at or above ordinary room temperature and (b) cryogenic, a process that uses liquid nitrogen to freeze the scrap tire rubber until it becomes brittle and then uses a hammer mill to shatter the frozen rubber into smooth particles. For this study, the rubber was produced from three used automobile tires by mechanical shredding at ambient temperature. Steel was removed by magnetic separation and one part of textile fiber was removed by density.

Properties	**Rubber powder(M. Bekhiti,et al, 2014)**	**Federal Highway Administration (U.S Deptt. of transportation)**			
		Shredded tyre	**Tyre Chips**	**Ground Rubber**	**Crumb Rubber**
Density (kg/m^3)	0.83 (Loose)	535-390(Loose)	490-320 (Loose)	--------	--------
	--------	840-650 (Compacted)	730-570 (Compacted)	--------	--------
Size	80 µm – 1.6 mm	(460-25)mm	(76-13)mm	(9.5-0.8)mm	Less than 4.75mm
Elongation (%)	420	--------	--------	--------	--------
Specific gravity	0.94	--------	--------	--------	--------
Unit weight g/cm^3	0.69	--------	--------	--------	--------
Absorption %	1.8	--------	2.0-3.8	--------	--------

Typical physical properties of waste rubber tyre (U.S Deptt. of transportation)

Material/element	**Mass percentage**
Rubber	54%
Carbon black	29%
Textile	2%
Oxidize zinc	1%
Sulfur	1%.
Additives	13%

Typical chemical composition (M. Bekhiti, et al, 2014)

III. EXPERIMENTAL INVESTIGATION:

Objective:

The main objective of this study was to utilize the waste rubber as aggregate in the concrete mixture and identify the properties of the mixture, its durability, expansion and also it's fresh and hardened concrete properties. The study started by replacing the percentage of the volume of natural aggregates, normally used in the manufacture of concrete in worldwide with waste rubber in increments of 3% by the natural aggregates were replaced by waste rubber.

➢ CEMENT PROPERTIES

    - Cement Brand : Ultratech Cement
    - Cement Type : Ordinary Portland Cement
    - Specific Gravity of Cement: G = 3.13
- Standard Consistency of cement:
    - Quantity of Cement: W1=400gms
    - Quantity of Water: W2= 33%= 132ml
- Penetration of Plunger from Top = 33 mm (Desirable is 33 to 35 mm)
    - Initial Setting Time: Quantity of Cement: W1=400gms
- Weight of Water as per Standard Consistency: P = 33 % = 132 ml
- Initial Setting Time of the Cement :28mins.
- Final Setting Time of the Cement : 560 mins.
- Fineness of Cement:W = 225m^2/kg
- Compressive strength of Cement

3days : 23
7days : 37

28days : 43

➢ SAND (Fine Aggregate)

The sand used for the work was locally procured and conformed to Indian Standard Specifications IS: 383-1970. The sand was sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. The various other tests conducted are specific density, bulk density, fineness modulus, water absorption and sieve analysis. The results are given below in Table (a) and (b). The fine aggregated belonged to grading zone II. This Aggregate has absorption of 1.23%. The Bulk Specific Gravity of the fine aggregate was 2.60 while its SSD Specific Gravity was 2.63.

Table (a): Physical Properties of fine aggregates

Characteristics	**Value**
Specific gravity	2.63
Bulk density	2.60
Fineness modulus	2.63
Water absorption	1.23%

Table (b) :Sieve analysis of fine aggregate

Aggregate Size: Fine **Type: Sand (Zone II)**

Sieve size (mm)	Material retained in gms	% retained	%passing	Cumulative % retained
4.75	14.5	1.45	98.55	1.45
2.36	37	3.70	94.85	5.15
1.18	246.5	24.65	70.20	29.80
600	205.5	20.55	49.65	50.35
300	287.5	28.75	20.90	79.10
150	177	17.70	3.20	96.80
Pan	32	3.20		
Sum	**100**		**Sum**	**262.65**

F.M= 2.63

- **AGGREGATE (COARSE AGGREGATE)**

The material which is retained on IS sieve no. 4.75 is termed as a coarse aggregate. The crushed stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970. The results of various tests conducted on coarse aggregate are given in Table ©,(d) and (e).

Table (c): Physical Properties of coarse aggregates

Characteristics	Value
Type	Crushed
Specific Gravity	2.884
Total Water Absorption	0.97%
Fineness Modulus	6.96

Table (d): Sieve Analysis of Coarse Aggregates (20mm)

Aggregate Size: 20mm **Type: Crushed (Coarse)**

Sieve size (mm)	Material retained in gms	% retained	% passing	Cumulative % retained
80	0	0.00	100.00	0.00
40	0	0.00	100.00	0.00
20	68.5	2.28	97.72	2.28
10	2776.5	92.55	5.17	94.83
4.75	113.5	3.78	1.38	98.62
2.36	0	0.00	0.00	100
1.18	0	0.00	0.00	100
0.600	0	0.00	0.00	100
0.300	0	0.00	0.00	100
0.150	0	0.00	0.00	100
Pan	0	0.00	0.00	100
Sum	**3000**		**Sum**	**695.73**

F.M= 6.96

Table (e) : Mechanical Properties of Aggregate

Property	Value
Elongation Index	13 % (should not be more than 15 %)
Flakiness Index	12 % (should not be more than 15 %)
Specific Gravity of Aggregate Slag Aggregate	G = 2.98
Aggregate impact value	4.5 % (should not be more than 30 %)
Crushing value	19.11 % (should not be more than 45 %)
Dry Loose Bulk Density	1.52 Kg/lt
Water Absorption	1.0 % (should not be more than 2 %)
Abrasion Value	14 % (should not be more than 30 %)

➢ **DESGIN MIX**

- Mass of Cement in kg/m^3 - 400
- Mass of Water in kg/m^3 - 160
- Mass of Fine Aggregate in kg/m^3 - 704
- Mass of Coarse Aggregate in kg/m^3 - 1271
  - Mass of 20 mm in kg/m^3 - 915
  - Mass of 10 mm in kg/m^3 - 356
- Mass of Admixture in kg/m^3 - 2.00
- Water Cement Ratio - 0.40

➢ **TESTING PROGRAME**

Test	Protocols and Methods	No. of Tests specimen
	Aggregates	
Gradations	IS: 383-1997	12 samples
	Fresh Concrete Properties	
Workability	IS: 1199-1959	5 Samples
Unit Weight	IS: 1199-1959	5 Samples
	Hardened Concrete Properties	
Compressive Strength	IS: 516-1959, (150X 150 X150) mm cube	3 samples at 7 & 28 days, total of 6
Splitting tensile Strength	IS: 5816-1999, (150X300) mm cylinder	3 samples at 7 & 28 days total of 6
Flexural Strength	IS: 516-1959, (150X150X700) mm beams	3 samples at 7 & 28 days total of 6
	Expansive Properties	
Length Change	IS: 1199-1959 , (150X 300) mm beam	4 samples at 7, 28 & 56 days total of 8
	Durability	
Sulphate resistance	ASTM C1012, (150X 150 X150) mm cube	3 samples at 28 days, total of 6

IV. RESULTS AND DISSCUSSION

Firstly, we will discuss the Fresh Concrete properties and then the Hardened Concrete properties.

Gradations

The sieve analysis of the material was a combination of both fine aggregates and coarse aggregates. Figure 1.1shows the results of sieve analysis of Waste rubber (Heavy vehicle tire) obtained from Local market when compared with fine aggregates and coarse aggregates. The waste rubber aggregates fractions lies between the fine aggregates and coarse aggregates.

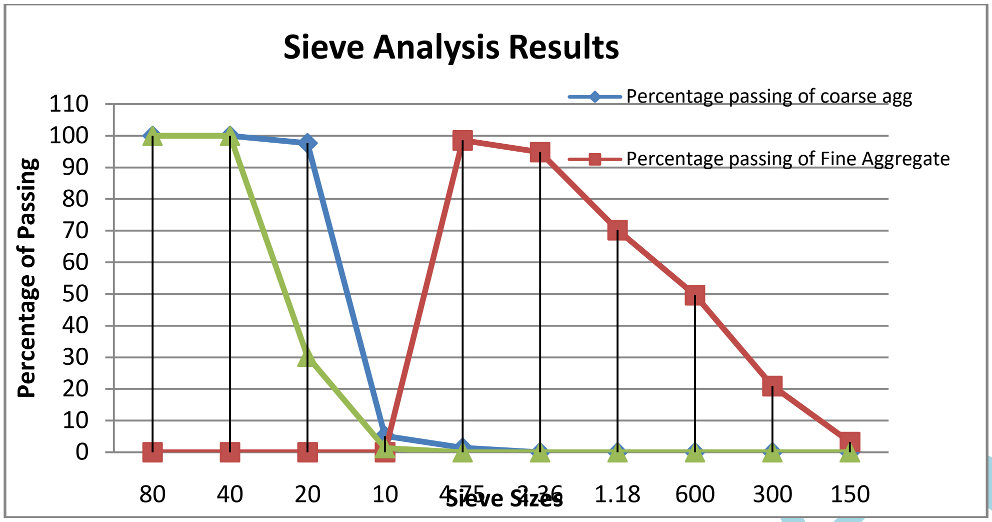

FIGURE 1.1: Sieve analysis results of Waste rubber tyre compared with fine and coarse aggregates.

Slump Test

Slump test of various concrete mix specimens are shown in table (f).

Table (f): Measured values of Slump

Specimen	Mixture	Measured slump (mm)	Average Measured Slump (mm)
Rubberized Concrete	MX 0%	58	**44.5**
	MXR 3%	54	
	MXR 6%	46	
	MXR 9%	49	
	MXR 12%	40	
	MXR 15%	36	
	MXR 18%	29	

It is observed from slump test (workability), workability of concrete increases with the increase in the waste rubber tyre with replacement by natural aggregates. But upto 9% limit after which there is decrement of slump is there not too much.

Unit Weight

Unit weight or density of the fresh concrete can be determined by weighing a known volume of concrete. The sample is generally weighed immediately before the air content is determined. The presence of entrained air affects the unit weight, since air contributes volume, but not weight. The unit weight also gives an approximate indication of air content for concrete made with different materials. As can be seen in Figure 1.2and table (g) the measured unit weight was approximately equal in every instance than the desired design unit weight. Unit weight normally indicates the consistency in all phases of concreting operations. Both the designed unit weight and measured unit weight are reasonably close. Unit weight is a function of initial ingredients of concrete, mix proportions, initial and final water content, air content, volume changes, and degree of consolidation. Therefore with the change in the mixture proportions, there is a slight variation in the designed unit weight and measured unit weight. The unit weight test is the best tool to quickly find the uniformity of sample and possible significant changes in the mixture.

TABLE (g): Designed unit weight and measured unit weight for different mixtures.

Specimen	Replacement of Steel Slag	Designed Unit Wt. kg/m^3	Measured Unit Wt. kg/m^3
Rubberized Concrete	MX 0%	2250	2300
	MXR 3%	2060	2060
	MXR 6%	1860	1890
	MXR 9%	1680	1650
	MXR 12%	1440	1465
	MXR 15%	1320	1363
	MXR 18%	1120	1230

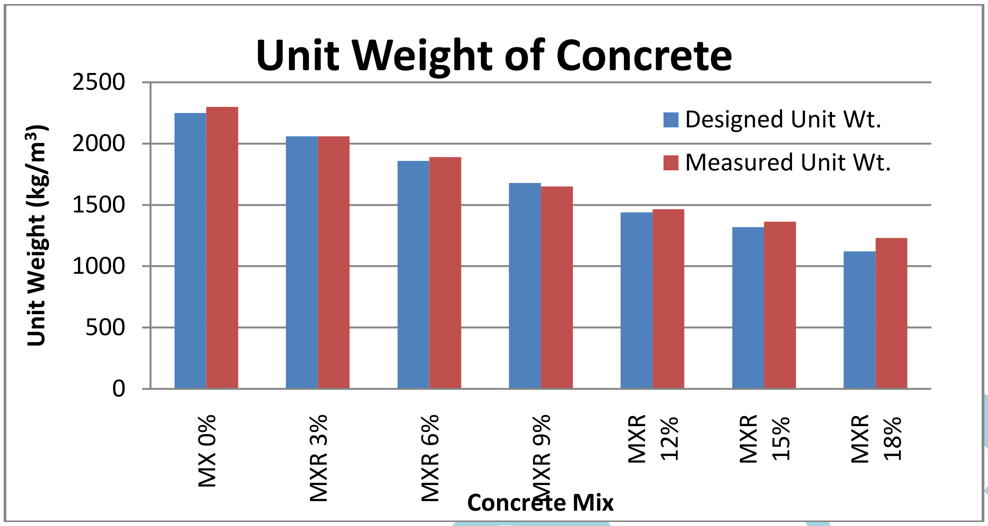

FIGURE 1.2: Graph showing Unit weight of aggregates replaced by Waste Rubber Tyre.

Compressive Strength for concrete specimens and Flexure beams

Cylinders were molded with a diameter of 150 mm and a length of 300 mm to determine the compressive strength of the concrete mixtures. The cylinders were tested at 7 and 28 days as per IS 516-1959. Table (h) provides the compressive strength of concrete for 7 and 28 days. All the concrete mixtures do not exceed the compressive strength requirements. Figure 1.3 shows that at the end of 28 days all the specimens have a compressive strength less than 39MPa. The compressive strength of concrete can also be determined by cube specimens having dimensions 150 X 150 X 150 mm also demonstrated a compressive strength at the end of 7 and 28 days.

Table (h): 7 days average compressive strength of concrete cube specimens (150 X 150 X 150 mm)

Specimen	7 days Compressive Strength (Mpa)			
	Mean weight (kg)	**Mean load at failure (kN)**	**Compressive Strength (MPa)**	**Reduction in Strength (%)**
MX 0%	8.236	610.35	27.12	
MXR 3%	7.968	592.32	26.32	2.94
MXR 6%	7.723	557.69	24.78	8.60
MXR 9%	7.614	505.33	22.45	17.21
MXR 12%	7.503	470.62	20.92	22.86
MXR 15%	7.446	425.12	18.89	30.35
MXR 18%	7.133	402.30	17.88	34.07

Specimen	28 days Compressive Strength (Mpa)			
	Mean weight (kg)	**Mean load at failure (kN)**	**Compressive Strength (MPa)**	**Reduction in Strength (%)**
MX 0%	8.428	868.31	38.59	
MXR 3%	8.133	882.31	39.21	
MXR 6%	7.877	780.72	34.70	10.08
MXR 9%	7.732	740.92	32.93	14.67

MXR 12%	7.654	718.33	31.92	17.28
MXR 15%	7.54	692.93	30.80	20.19
MXR 18%	7.233	640.43	28.46	26.25

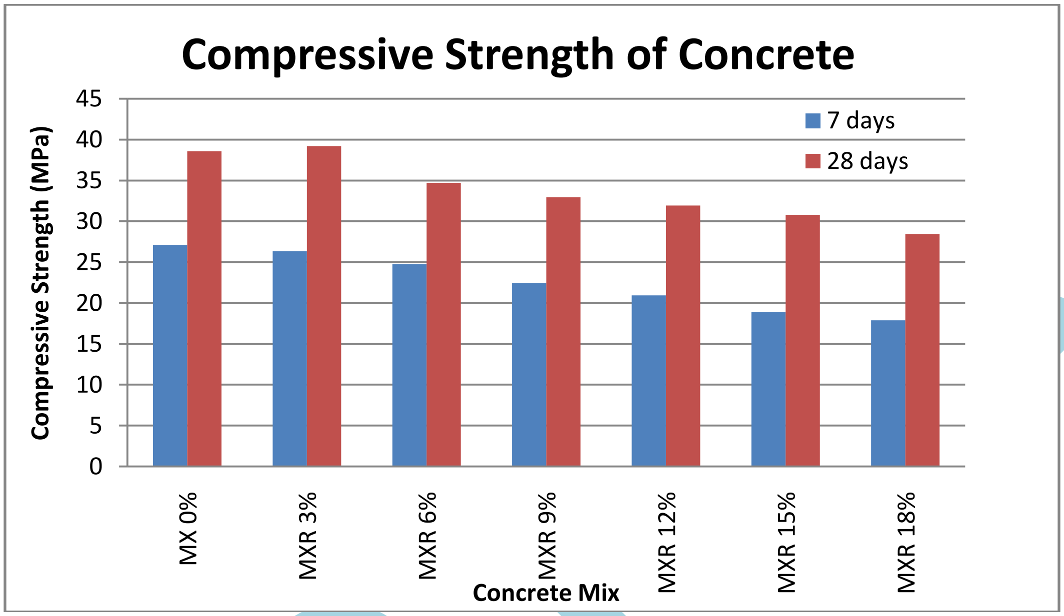

FIGURE 1.3: Graph showing the 7 &28 days Compressive Strength of concrete

FLEXURAL STRENGTH OF CONCRETE

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having a rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. Beam specimens were prepared having a cross section of 150 x 150 x 700 mm (if nominal size of aggregate exceeds 38mm) to determine the modulus of rupture. The modulus of rupture was also found at the end of 7 days and 28 (Table (i)) days by following IS 516-1959 using a third point loading on a hydraulic testing machine. Figure 1.4 shows the results for the modulus of rupture for concrete mixture. All specimens have modulus of rupture for 28 days above 2.12MPa.

TABLE (i): Flexural Strength of Concrete Prisms.

Percentage Replacement	7 days Flexural Strength (Mpa)	28 days Flexural Strength (Mpa)
MX 0%	3.68	5.4
MXR 3%	3.32	5.5
MXR 6%	3.46	5.7
MXR 9%	3	5.4
MXR 12%	2.78	4.37
MXR 15%	2.47	3.12
MXR 18%	2.02	2.12

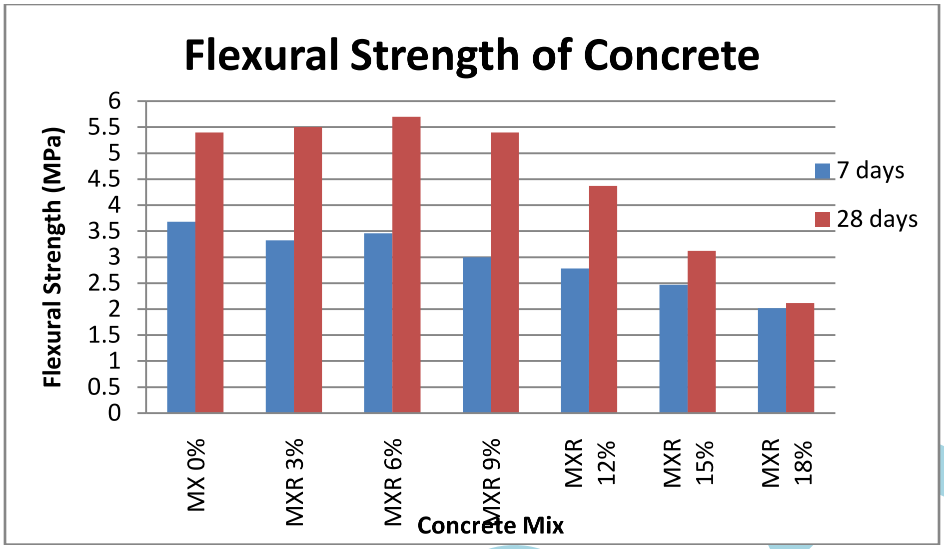

FIGURE 1.4: Graph showing the Modulus of rupture for concrete beams at 7 days and at 28.

SPLIT TENSILE STRENGTH OF CONCRETE

The splitting tensile strength of the concrete specimens was determined at 7 and 28 days following IS 5816-1999. The specimens were molded at the same time as the compressive strength specimens. Cylinders were molded with a diameter of 150 mm and a length of 300 mm. Figure 1.5 displays the average splitting tensile strength of the samples at 7 and 28 days. Table (j) shows the7 &28 days splitting tensile strength on concrete specimens. The splitting tensile strength of concrete specimens at the end of 28 days was approximately about 2.4MPa. The measured split tensile strength f_{ct} of the specimen shall be calculated to the nearest value 0.05 N/mm^2.

TABLE (j): 7 days Splitting Tensile Strength on Concrete Specimens.

Specimen	7 days Splitting Tensile Strength (Mpa) for Length of cylinder =300mm, diameter = 150mm			
	Mean weight (kg)	Mean load at failure (kN)	Split Tensile Strength (MPa)	Reduction in Strength (%)
MX 0%	12.90	140	2.10	
MXR 3%	12.42	120	2.01	4.28
MXR 6%	12.211	113	1.80	14.28
MXR 9%	12.012	115	1.68	20
MXR 12%	11.987	102	1.527	27.28
MXR 15%	11.723	90	1.473	29.86
MXR 18%	11.511	82	1.373	34.61

Specimen	28 days Splitting Tensile Strength (Mpa) for Length of cylinder =300mm, diameter = 150mm			
	Mean weight (kg)	Mean load at failure (kN)	Split Tensile Strength (MPa)	Reduction in Strength (%)
MX 0%	13.1	220	2.89	
MXR 3%	12.572	198	2.81	2.769
MXR 6%	12.341	190	2.69	6.92
MXR 9%	12.212	178	2.52	12.80
MXR 12%	11.987	168	1.987	31.25
MXR 15%	11.823	156	1.68	41.86
MXR 18%	11.671	147	1.44	50.18

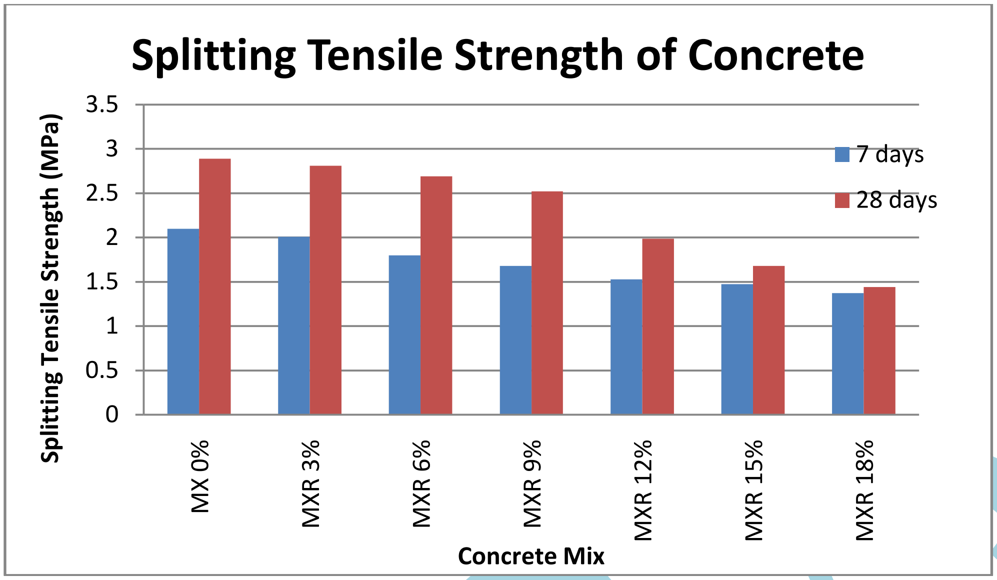

FIGURE 5.5: Graph showing the 7 &28 days Splitting Tensile Strength of concrete.

Resistance to Sulphate attack of concrete

This test was conducted on 150 x 150 x 150mm cube specimens. The cubes were casted and cured in water for 28 days. Sodium sulphate solution of 50g/l is used to evaluate sulphate resistance of concrete. Cubes are immersed in solution after 28 days curing, and are tested for compressive strength at 7, 28 and 56 days. Test results are given below in table (k) and figure as shown in 1.6. When this compressive strength is compare with the compressive strength of specimen cured in water at same ages, there is decrease after 7, 28 and 56 days respectively. When the replacement of waste rubber increase in the mix, the strength of specimen tends to decrease as compare to the compressive strength cured in water at same ages.

Table (k): Compressive strength of concrete mixes after immersion in $NaSo_4$ solution.

MIX	7 Days Compressive strength (Mpa)		28 Days Compressive strength (Mpa)	
	Control (28 Days)	Immersed	Control (28 Days)	Immersed
MX 0%	38.59	30.33	38.59	37.52
MXR 3%	39.21	31.32	39.21	34.96
MXR 6%	34.70	28.73	34.70	32.89
MXR 9%	32.93	27.43	32.93	30.05
MXR 12%	31.92	26.49	31.92	28.92
MXR 15%	30.80	22.21	30.80	24.45
MXR 18%	28.46	17.97	28.46	20.18

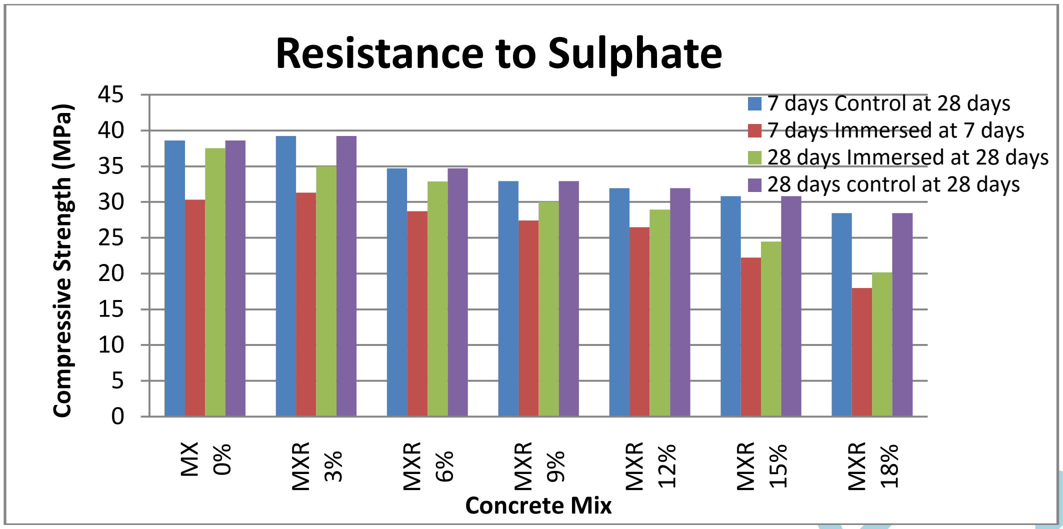

FIGURE 1.6: Graph showing the 7 &28 days Resistance to Sulphate attack of concrete

Change in length of concrete specimens

Table (l) shows the change of length of the concrete specimens and is compared to the initial length at the start of the test procedure. All the specimens were kept at the normal room temperature in the water basin. The result shows that the change in length of concrete specimens was negligible at the end of 90 days. The control specimens showed a sign of expansion but there was slight contraction in length in the specimens with 18% waste rubber tyre. Figure 1.7 shows the change in length of concrete specimen at 7 & 28 days.

Initial CRD of concrete Specimen is 1m								
Mixture	**CRD 7 Days**	**Length Change (%)**	**CRD 28 Days**	**Length Change (%)**	**CRD 56 Days**	**Length Change (%)**	**CRD 90 Days**	**Length Change (%)**
MX 0%	1	0	1.001	0.1	1.001	0.1	1.002	0.2
MXR 3%	1.02	2	1.04	4	1.05	5	1.08	8
MXR 6%	1.03	4	1.05	5	1.07	7	1.09	9
MXR 9%	1.05	5	1.07	7	1.09	9	1.11	11
MXR 12%	1.07	7	1.10	10	1.12	12	1.14	14
MXR 15%	1.02	2	1.03	3	1.06	6	1.09	9
MXR 18%	1.02	2	1.04	4	1.07	7	1.10	10

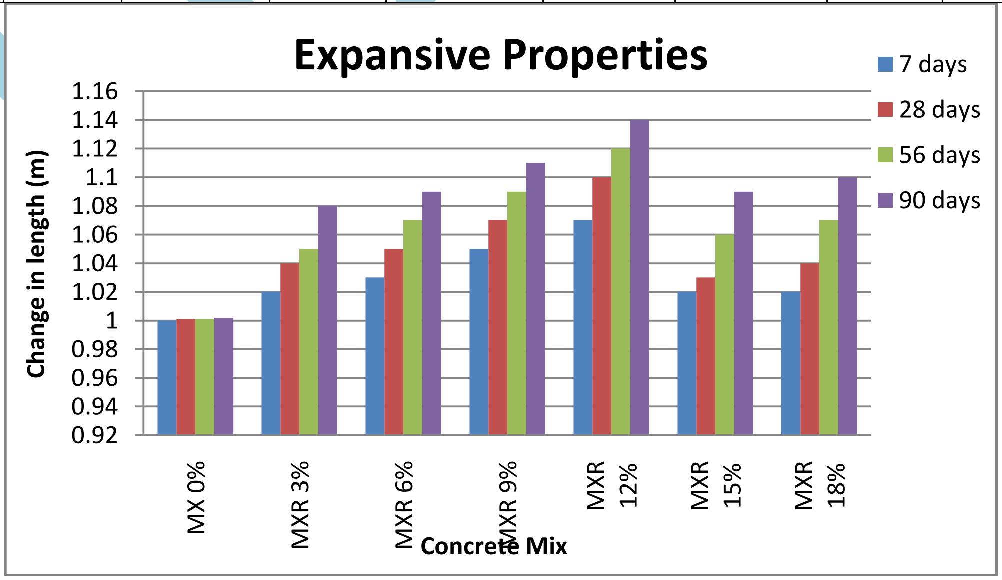

FIGURE 1.7: Graph showing the 7, 28, 56 & 90 days expansive properties of concrete.

V. REFERENCES

[1]. ASTM C 33. (2003).Standard Specification for Concrete Aggregates. ASTM International.

[2]. ASTM C 39/C 39M. (2003). Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.. ASTM International.

[3]. ASTM C 78. (2002). Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).. ASTM International.

[4]. ASTM C 138/C 138M. (2001). Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.. ASTM International.

[5]. ASTM C 143/C 143M. (2005). Standard Test Method for Slump of Hydraulic-Cement Concrete.. ASTM International.

[6]. ASTM C 150. (2005).Standard Specification for Portland Cement.. ASTM International.

[7]. ASTM C 157/C 157 M. (2004).Standard Test Method for Length Change of Hardened Hydraulic-Cement, Mortar, and Concrete.. ASTM International.

[8]. ASTM C 173. 2004. .Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.. ASTM International.

[9]. ASTM C 192/C 192M. 2002. .Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.. ASTM International.

[10]. ASTM C 215. (1997). Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens.. ASTM International.134

[11]. ASTM C 231. 2004. Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.. ASTM International.

[12]. ASTM C 260. (2001). Standard Specification for Air, Entraining Admixtures for Concrete.. ASTM International.

[13]. ASTM C 494/C 494 M. (2005). .Standard Specification for Chemical Admixtures for Concrete.. ASTM International.

[14]. ASTM C 496. 1996. Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.. ASTM International.

[15]. ASTM C 1012. (1997). Standard Test Method for length change of hydraulic cement mortars exposed to a Sulphate solution. ASTM International.

[16]. ASTM D 4792 (2006) .Potential Expansion of Aggregates from Hydration reaction. ASTM International

[17]. ASTM D 702 (2006) .Practice for reducing samples of aggregates to testing size. ASTM International

[18]. Ahmed N. Bdour 1) and Yahia A. Al-Khalayleh (2010).Innovative Application of Scrap-tire Steel Cords in Concrete Mixes.Jordan Journal of Civil Engineering, Volume 4, No. 1.

[19]. Ali I. Tayeh," Effect of Replacement of Sand by Waste Fine Crumb Rubber on Concrete Beam Subject to Impact Load: Experiment and Simulation"- Civil and Environmental Research ISSN 2224-5790 (Paper) ISSN 2225-0514 (Online)

[20]. Khalid BattalNajim, (JUNE 2007) “Mechanical Properties Of Fiber Waste Tire Concrete"-IJCE-8th ISSUE.

[21]. Khalil Nabil Dalloul, (2013)" Study of the Effect of Crushed Waste Glass as Coarse Sand and Filler in the Asphalt Binder Course" Master’s thesis.

[22]. Mohammad Reza sohrabi1, Mohammad karbalaie2, (2011)"An experimental study on Compressive strength of concrete containing crumb tyre. IJCEE-IJENS Vol: 11 No: 03.

[23]. Raja Muhammad UsmanRafique- (Dec-2013) "Life Cycle Assessment of Waste Car Tyres at Scandinavian Enviro Systems".

[24]. H.Beshr, A.A.Almusallam, M.Maslehuddin-,(2003) "Effect of Coarse Aggregates Quality on the Mechanical Properties of High Strength Concrete" - Construction and Building Materials 2003.

[25]. K. C. PANDA et al.(2012) . Scrap-Tyre-Rubber Replacement for Aggregate in Cement Concrete: Experimental Study. IJESE,ISSN 0974-5904, Volume 05, No. 06 (01)

[26]. IS 10262:2009- Concrete Mix Design - Guidelines, Bureau of Indian Standards,(BIS), New Delhi India

[27]. IS 383 (1997) — Specification for course and fine aggregates from Natural Sources for Concrete

[28]. IS-516 (1959) — Methods of Tests for Strength of Concrete.

[29]. IS-1199 (1959) – Method of Sampling and analysis of Concrete.

[30]. IS-5816 (1999) — Splitting tensile strength of concrete- Method of test.

[31]. J.P,Patel (2006), Broder use of steel slag aggregate in concrete.

[32]. Juan M Manso, Javier J Gonzalez and Juan A Polanco, (2004)"-Electric Arc Furnace Slag in Concrete". Journal of Materials in Civil Engineering ASCE Nov 2004.

[33]. Juan M Manso, Juan A Polanco, Milagros Losanez and Javier J Gonzalez, (2006) "Durability of Concrete made with EAF Slag as Aggregates "Cement and Concrete Composite 2006.

[34]. M Maslehuddin, M Shameem and N U Khan, (1999) "Performance of Steel SlagAggregates Concrete", Exploiting Wastes in Concrete --Proceedings of the International Seminar held at the University of Dundee, Scotland, UK Sept 1999.

[35]. M.Maslehuddin, Alfarabi M Sharif, M.Shameem, M.Ibrahim and M.S.Barry, (2003)"Comparison of Properties of Steel Slag and Crushed Limestone Aggregates Concrete", Construction and Building materials 2003.

[36]. National Slag Association, (2003) "Iron and Steel making Slag Environmentally Responsible Construction Aggregates".-- NSA Technical Bulletin may 2003. http://www.nationalslag.org/steelslag.htm

[37]. National Slag Association, MF186-1 .Steel slag utilization in asphalt mixes by John Emery VP, Trow Ltd. consulting engineers. Taken from Canadian Technical Asphalt Association Proceedings, 1984

[38]. Paul Bosela, Delatte, Obratil, Ashish. Fresh and Hardened Properties of Paving Concrete with steel slag aggregates. (2007) Cleveland State University, submitted a paper at TRB 87th Annual Meeting of Transportation Research Board Annual Meeting at Washington D.C and also presented at ICCP 9th annual conference at San Francisco CA (2008)

[39]. P. Kumar Mehta, (1999) "Advancements in Concrete Technology..Concrete International June 1999.

[40]. P.S. Pajgade1and N.B.Thakur (2013), Utilisation of Waste Product of Steel Industry.

[41]. Rustu S Kalyoncu, (2001) "Slag iron and Steel." US Geological Survey Minerals Yearbook 2001.

[42]. State of Pennsylvania (1995), PA Test method No. 130, .Method of Test for Evaluation of Potential Expansion of steel slags..

[43]. Sidney Mindess, J Francis Young and David Darwin (2003) .Concrete. second edition.

[44]. Van Oss, H.G., Iron and Steel Slag, Mineral Commodity Summaries, U.S. Geological Survey, January 2008.

[45]. Wagaman, T and W.J.Stanley (2005), "Slag: The Ultimate Renewable Resource." Pit and Quarry, May 24 2007.