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"MITIGATION FOR FIRE-INDUCED SPALLING IN CONCRETE BY REUSED TYRE POLYMER FIBRES"

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ABSTRACT*: Traditional concrete is primarily made up of four fundamental ingredients, i.e. coarse aggregate, fine aggregate (i.e. sand), cement and water. Nowadays, large quantities of scrap tires are generated each year globally. With the increased incidents of major fires in buildings; assessment, repairs and rehabilitation of fire damaged structures has become a topical interest. In the last 20 years, a lot of work by using these waste materials has been done in various civil engineering projects. By using waste tire rubber as a coarse aggregate as well as fine aggregate in concrete the natural resources can be saved and environmental pollution can be minimize. Partially replacing the coarse or fine aggregate of concrete with some quantity of small waste tire cubes 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. It has been observed that the use of waste tire as aggregate replacement improves the toughness and sound insulation properties of concrete. Rubberized concrete is specially recommended for concrete structures located in areas of severe earthquakes risk and also for applications submitted to severe dynamic actions like railway sleepers. The rubberized concrete is reasonable, cost effective and withstand for more pressure, impact and temperature when compare it with conventional concrete. It is observed that the Rubber Modified Concrete (RMC) is very weak in compressive and tensile strength. But they have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation. Rubberized Concrete improves the mechanical and dynamic properties such as energy absorption, ductility and resistance. This thesis, generally, aims to explore the potential utilization of waste crumb tires in various Portland cement Concrete categories for the production of Portland cement concrete to study the structural behavior of concrete, and to help partially solving environmental problem produced from disposing waste tires. Coarse and fine aggregates are replaced using volumetric method by waste crumb tires replacements for the various PCC categories of model. This topic also gives a Comprehensive knowledge on the overall strategy for the return of fire damaged buildings and also presents a critical appraisal of the assessment procedures by different non destructive techniques, specifications and execution of repair techniques. The experimentation has been done to find out the impact of the fire on concrete by heating. The heated samples are cooled under standard room temperatures for 24 hours. The changes in the mechanical properties are studied using universal testing machine (UTM), CTM, and two point flexural test.*

Keywords*: Portland cement concrete, waste crumb tire, universal testing machine (UTM), CTM, two point flexural test, Rubber Modified Concrete (RMC).*

1. INTRODUCTION

1.1 Background

Modifications of construction materials have an important bearing on the building sector. Several attempts have been therefore made in the building material industry to put to use waste material products, e.g., worn-out tires, into useful and cost effective items. Success in this regard will contribute to the reduction of waste material dumping problems by utilizing the waste materials as raw material for other products. The waste problem considered as one of the most crucial problems facing the world as a source of the environmental pollution. It is contributing as a direct form in pollution that includes the negative effects on the health by increasing the diseases, diseases vector, percentage of mortality and lowering the standard of living. The waste usually defined as the all remains things resulted from production, transfer and uses processes, and in general all transmitted things and resources that the owner or the producer wants to dispose. During last recent years, many improvements in India have occurred in all parts of life such as social, industrial, economical etc. Like all countries in the world, this will lead to generate new ways of living and increase the human requirements, and will also increase types and quantities of the waste in the India, without any active processes to provide solution to this problem. One of the important types of remains is waste tires which have been classified as a part of municipal solid waste (MSW), resulted from the increase of vehicle ownership and traffic volume within the Palestinian territories. Natural coarse aggregate are extracted from quarries and a result this quarries will soon be depleted in few decade if the rate of their uses continuous at this pace .As a result there was a need of permanent solution to this long-lasting problem. Keeping this view the feasibility of use of waste tires as replacement of coarse aggregate construction has been experimentally assessed in this project. Basic mechanical and physical test have been carried out on aggregates. This eventually will increase consumption of tires over time. Current practices show that residents throw it randomly in different places such as valleys, road sides, open areas, and waste dumpsites in improper ways taking the means of open fire, and without consideration of risk on human health and environment. Figures 1.1 and 1.2 show some of the forms of dumping and wrong practices for waste tires.

Figure 1.1: Used Tires Waste in an Open Area

Figure 1.2: Waste Tire Dump on Fire

1.2 Problem Statement

In presenting the properties of tires, it can be seen that tire is a rubber article with a complex structure, in which rubber represents approximately (85%) of the weight of car or truck tires. The average tire life is 50,000 km, after which it must be replaced. In the assessment of the size of this environmental problem, the weights of scrap tires generating in the India is given in Table 1.1. This is the point why i choose tires as a replace material?

Table 1.1: Weights of scrap tires for different classes of vehicles

Type of Vehicles	Weight of tires (Ton/Year)
Private car	2500
Light truck up to 10 ton	2000
Heavy trucks and buses	2300
Agriculture and heavy equipment	700
Other vehicles	500
Total	8000

Waste rubber tires cause serious environmental problems all over the world. One of the potential means of utilizing the waste tires is to process this waste material for the protection of the environment and society. It is suggested to use this waste tires as an additive in Portland cement concrete (PCC) mixes for non-structural applications, which would partially help in solving this problem.

1.3 Goals and Objectives

This study is conducted to accomplish some predefined objectives. These objectives are:

(A) To determine the most suitable concrete mix by replacement of tire rubber as an aggregate that produces the highest strength of concrete grade M25.

(B) To evaluate the mechanical properties of concrete mix which includes:-

a) Workability test
b) Heating effect test in term of :-
1) Compressive strength,
2) Tensile strength of structure and
3) Flexural strength test

The objective of this research is to investigate the utilization of rubber tires in the form of shredded tires (crumbs) in PCC for non-structural concrete through investigating its impact on the mechanical characteristics of PCC as compressive strength, workability, water absorption (porosity), noise insulation, thermal insulation, and abrasion. Detailed review of different studies and researches about utilizing waste tires in several applications is presented in Chapter Two. This chapter includes background about waste tire as an environmental problem, civil engineering application of recycled rubber from scrap tires, properties of concrete containing scrap tires, tires manufacturing, typical chemical composition and crumb manufacturing. The methodology of utilizing rubber waste tires by using this waste as a constituent of the PCC mixes by partial or full replacement of coarse aggregate (10mm), and the experimental tests used in this paper to identify the materials and the tests on the concrete mixes.

1.4 Significant of the Study

Concrete is one of the most widely used construction materials in the world. Many modifications and developments have been made to place industrial waste such as waste tires on building construction. Utilization of waste materials for construction shall not only solve waste problems, but also provide a new source for construction purposes. The introduction of waste tires as coarse aggregates replacement materials in concrete seems to be successful recently. The use of waste tires as a substitute for fine aggregates in concrete mix is one option that can improve tire disposal problem. Research and development to convert waste tires to useful application such as a construction material will provide more alternatives for the engineer to select the most suitable concrete replacement material for different environments. In this case, studies are needed to study the performance of concrete using waste tires as an aggregate as replacement materials. In addition, the use of waste tires as aggregates replacement materials in concrete is not common in the Indian construction sector. This study will be able to enhance the understanding on the suitability of waste tires as aggregates replacement material.

1.5 Challenges and Scope of Waste Tires

The use of waste tires in concrete is relatively rare. There are three main reasons for that:

1. Overall economics – direct costs can also be UN favorable.
2. Situation of steady supply of suitable aggregates - aggregate producers do not want to build up large stock of waste tires for concrete since there is no market.
3. Other end users are far more tolerant than concrete of the inevitable contaminants in waste tires.

Concrete strength is greatly influenced by the properties of its constituents and the mixture design parameters. Therefore, an appropriate mix design is required to optimize the tire content in the concrete mix. To find the most appropriate mixing design, different amounts of rubber-tire particles with sizes varying from 0.475 mm to 10 mm were used in these studies. The results indicated that increasing the weight fraction of waste tire rubber particles generally leads to a reduction in the compressive strength of waste tire rubber-filled concrete. Therefore, to control the compressive strength of rubber-filled concrete, there should be a limit for the maximum amount of waste tire rubber particles. They showed that this maximum limit is a function of the waste rubber particle size and the nominal compressive strength of the concrete. Although the concrete is not designed to resist tension, the knowledge of tensile strength of concrete is of value in assessing the load at which crack will start appearing in concrete.

2. CRITICAL LITERATURE REVIEW

The previous studies have shown that the inclusion of rubber aggregate in concrete as a full or partial replacement for natural aggregates reduces the compressive strength of the concrete. These studies also indicate that the mechanical strength of TRAC is greatly affected by the size, proportion and surface texture of the rubber aggregate and the type of cement used. This strength reduction can be expected primarily because rubber aggregate is much softer (elastically deformable) than the surrounding cement paste. Secondly, the bonding between the rubber aggregate and the cement paste is likely to be weak, so that soft rubber aggregate may be viewed as voids in the concrete mix. It has also been recognized that, the strength of concrete greatly depends upon the density, size and hardness of the aggregates. In addition, the previous studies have shown that the workability of concrete containing rubber aggregate is reduced. This could affect the method of preparation of concrete samples and products and requires further study during the present investigation. A critical review of literature presented above indicated that the proportion of rubber aggregate in the concrete should be restricted to prevent great loss in mechanical properties. Further there is no specific literature found to analyze the flexural performance, deflection and ductility behavior of Reinforced Cement Concrete beams made of TRAC. In addition an attempt is also made to make use of rubber strips as rebar in tensile zone. As such, the research focus on waste tire rubber as material itself is in infant stage. In general, Concrete has relatively high compressive strength, but significantly lowers tensile strength. Concrete is employed in a wide variety of application, ranging from piles to multistory buildings and from railroad ties to dams. It is also used in foundations, pavements, walkways, storage tanks, and many other structures. In fact, it is hard to find a structural application in which concrete is not put to use in one form or another. It is one of the most economical materials of construction, being very versatile by nature and flexible in application.

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3.1 METHODOLOGY

It is the method followed to perform the experiment. In this section we have made step wise procedure to perform experiment which is briefly described as follows:

1) Mix design
2) Batching
3) Experimental programmed of casting
4) Mixing
5) Compaction
6) Curing
7) Testing

Table 3.1: Mix combinations model

Model taxonomy	Model detailed
NC-100	Control Mix
PF-10-90	10% waste rubber tire replacement of fine aggregates (90% Natural fine aggregates + 10% waste rubber tire)
PF-20-80	20% waste rubber tire replacement of natural fine aggregate (80% fine aggregate + 20 % waste rubber tire)
PF-30-70	30% waste rubber tire replacement of natural fine aggregate (70% fine aggregate + 30 % waste rubber tire)
PC-10-90	10% rubber tire replacement of Natural coarse aggregates (90% Natural coarse aggregates + 10% waste rubber tire)
PC-20-80	20% rubber tire replacement of Natural coarse aggregates (80% Natural coarse aggregates + 20 % waste rubber tire)
PC-30-70	30% rubber tire replacement of Natural coarse aggregates (70% Natural coarse aggregates+ 30 % waste rubber tire)

4. RESULT AND CONCLUSION

4.1 Slump Test

Table 4.1: Slump Test Results of Mixed Concrete and Graphically Representation

Sr. No.	Specimen identification	Slump (mm)
1	NC-100	86
2	PF-10-90	79
3	PF-20-80	76
4	PF-30-70	74
5	PC-10-90	73
6	PC-20-80	67
7	PC-30-70	63

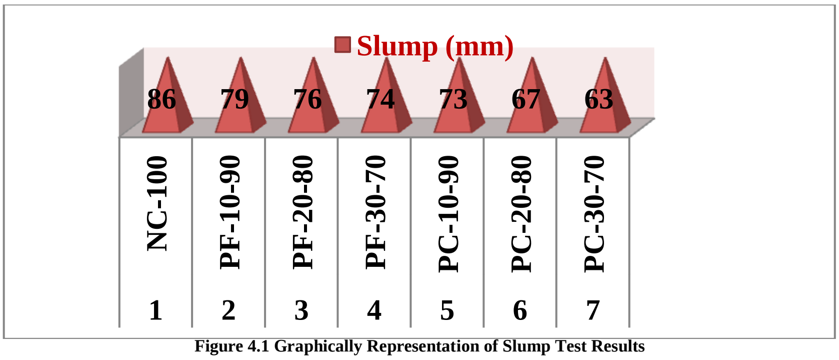

Figure 4.1 Graphically Representation of Slump Test Results

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4.1.2: Compressive Strength Test

Table 4.2: Day's Compressive Strength Test Reading

Specimen identification	Compressive strength (MPa)		Compressive strength (MPa)		Compressive strength (MPa)	
	7 Days	Average	14 Days	Average	28 Days	Average
NC-100	25.28 26.79 25.57	25.87	29.07 30.27 29.66	29.67	35.13 34.24 33.14	34.17
PF-10-90	22.76 20.88 19.28	20.97	26.17 24.01 21.79	23.99	35.13 33.52 37.38	35.34
PF-20-80	21.23 18.41 20.28	20.11	24.84 20.80 23.31	22.99	32.92 31.44 30.00	31.53
PF-30-70	21.84 17.45 20.25	19.85	24.67 20.94 24	23.23	32.47 30.52 29.92	30.96
PC-10-90	17.45 17.39 17.93	17.54	19.36 20.86 20.61	20.28	31.30 27.35 29.68	29.44
PC-20-80	15.85 17.11 17.02	16.66	17.75 20.18 20.25	19.42	27.74 30.64 25.26	27.88
PC-30-70	12.73 13.33 13.53	13.20	15.19 16.13 15.70	15.67	18.24 18.75 17.89	18.29

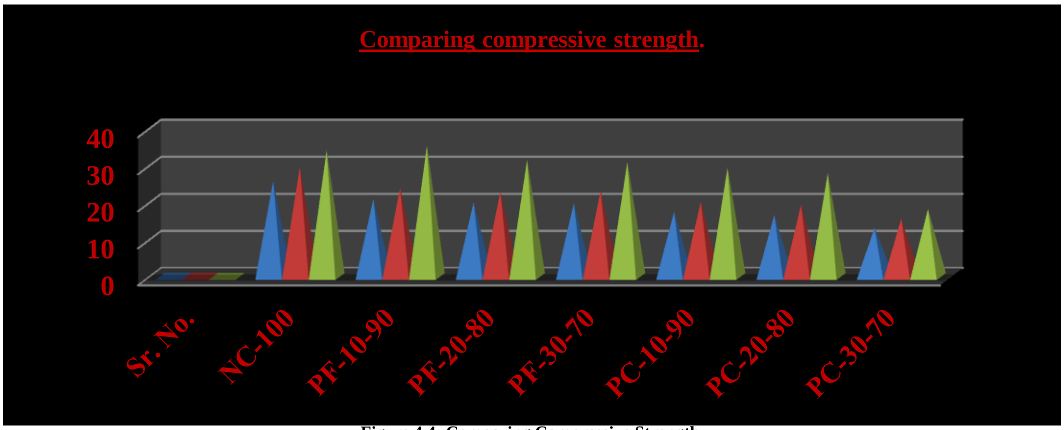

Figure 4.4: Comparing Compressive Strength

The dry process which was developed in the late 1960's in Sweden under the trade name Rubit was patented for use in the United States in 1978 under the trade name Plus Ride. It differs from the wet process in that the crumb rubber is used as a portion of the aggregate and is directly mixed with the aggregate. Specimens of cubes are used to measure compressive strength, the specimens cured in water 28 days date of testing. As we know that concrete is design for compressive strength and concrete is week in flexural and tensile strength. So fire mitigation and spelling test are done only for cube specimen not in beams and cylinders. The specimens subjected to temperatures of 200^0 and 800^0C. The all 42 numbers of cubes are placed in an oven shown in Figure for 5 hours. Also to study the effect of high temperature, specimens are subjected to a temperature of 800 ° C by an oven shown in Figure for two hours. The concrete specimens are then taken away from the oven and left at the room temperature to cool for 24 hours and then tested in compressive strength.

Table 4.2: Fire Mitigation Test on Compressive Strength Test Reading

Specimen identification	Compressive strength at 24^0C- 28^0C	Compressive strength at 200^0C	Compressive strength at 800^0C
NC-100	34.17	32.14	14.11

PF-10-90	35.34	37.33	17.12
PF-20-80	31.53	33.28	17.00
PF-30-70	30.96	30.00	15.75
PC-10-90	29.44	31.58	11.25
PC-20-80	27.88	34.75	18.37
PC-30-70	18.29	38.89	21.74

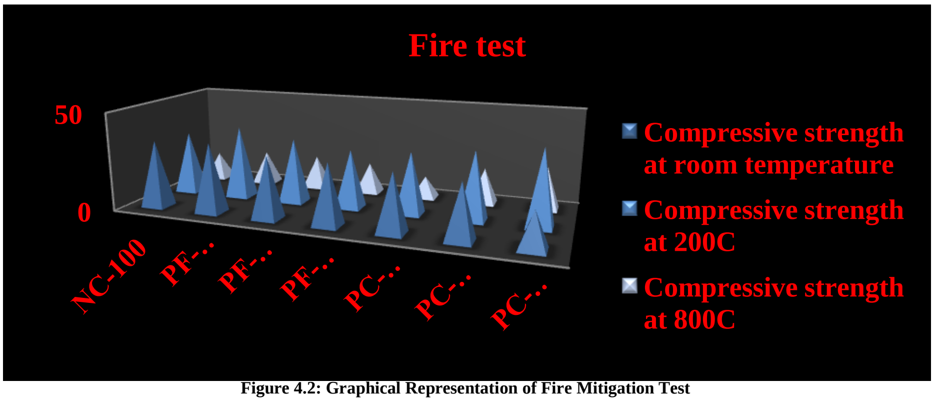

Figure 4.2: Graphical Representation of Fire Mitigation Test

4.1.3: Split Tensile Test

Table 4.7: 28 Days Tensile Strength Test Reading of Tire Mixed Concrete

Sr. No.	Specimen identification	Tensile strength (MPa)	
		28 days	Average
1	NC-100	3.53 3.34 3.28	3.4
2	PF-10-90	3.19 3.1 3.1	3.2
3	PF-20-80	2.96 2.84 2.8	2.9
4	PF-30-70	3.22 3.00 3.18	3.2
5	PC-10-90	2.97 3.03 3.20	3.1
6	PC-20-80	3.33 3.1 3.00	3.2
7	PC-30-70	2.19 1.793 2.13	2.2

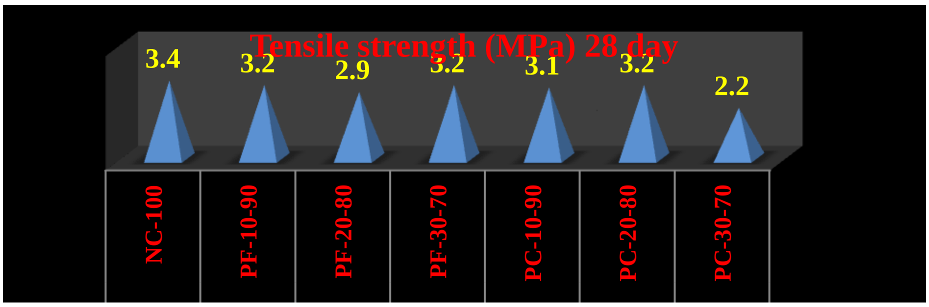

Figure 4.3: Graphical Arrangement of Tensile Strength

Sr. No.	Specimen identification	Flexure strength (MPa)	
		28 days	Average
1	NC-100	4.22 4.3 4.8	4.45
2	PF-10-90	4.76 3.02 4.17	3.99
3	PF-20-80	3.64 4.22 3.35	3.74
4	PF-30-70	7.18 7.49 7.08	7.21
5	PC-10-90	5.69 3.77 5.46	4.97
6	PC-20-80	3.2 4.5 5.07	4.25
7	PC-30-70	2.95 3.39 2.86	3.07

4.1.4: Flexure Test of Beam

CONCLUSION

The reuse of recycled materials derived from tire industries and waste rubber mill is growing all over the world. One of the most environmentally responsible ways of meeting the challenges of sustainability in construction is the use of tire rubber in new construction. The main objective of the study is to investigate the effect of tire rubber in concrete in terms of Compressive strength, flexural strength and tensile strength with and without temperature effect.

On the basis of the present experimental study **"PARTIAL REPLACEMENT OF AGGREGATE BY WASTE TYRE RUBBER IN CONCRETE UNDER TEMPREATURE EFFECT"**, following conclusions is drawn:

1. Workability of the concrete decreases on addition of tire rubber. Lower values of slump were observed in the case of the study (waste tire rubber). PF-10-90, gives second higher value among them. So, we can say small amount of both aggregate reduce very less workability of concrete.

2. The compressive strength of the waste tire rubber mixed concrete is increased when it is used as fine aggregate in larger quantity as compared to plain concrete.

3 The compressive strength of the waste tire rubber mixed concrete is increased when it is used as coarse aggregate in smaller and larger quantity respectably.

4. The tensile strength of the waste tire rubber mixed concrete was increased when it is used as fine aggregate and coarse aggregate in larger quantity as compared to plain concrete.

5. PF-15-85 and PC-30-70 gives maximum value and cement mixed with 10% of waste tire rubber gives minimum value of tensile strength.

6. The flexure strength of waste tire rubber concrete was increased when it used as fine aggregate as compared to plain concrete.

7. Maximum value of flexure strength was observed in PF-20-80 and minimum value in PC-10-90.

8. Waste and recycling management plans should be developed for any waste tire rubber mill work in order to sustain environmental, economic, and social development principles.

9. Due to lack of accurate equipment the temperature up to 200^0C the fire effect increases the concrete compressive strength in all models but coarse aggregate replacement decrease the strength.

Specimen identification	Compressive strength at 200^0C	Fire effect at 200^0C	Compressive strength at 800^0C	Fire effect at 800^0C
NC-100	32.14	Good	14.11	Bad effect
PF-10-90	37.33	Good	17.12	Bad effect
PF-20-80	33.28	Good	17.00	Bad effect
PF-30-70	30.00	Good	15.75	Bad effect
PC-10-90	31.58	Good	11.25	Bad effect
PC-20-80	34.75	Good	18.37	Bad effect
PC-30-70	38.89	Good	21.74	Bad effect

10. Beyond the 200^0C to 800^0C the all strength of concrete decreases the value of compressive strength.

11. Thermal properties (conductivity, heat capacity, diffusivity and effusively) of concrete increases with increase in density (unit weight) and temperature (reversely thermal properties decreases with reduction in density and temperature) with exception of thermal resistivity which is the inverse of thermal conductivity.

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