Influence of Waste Tyre Chips (WTC) As Partial Replacement In Coarse Aggregate on The Strength of Silica Fume And Flyash Blended Concrete

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Abstract- *Concrete is a combination of cement, water, fine aggregate and coarse aggregate. The coarse aggregate occupies most of the volume of the concrete and it plays a major role in the strength of concrete. The size, shape and type of aggregate more influence the characteristics of concrete like workability, durability, strength, weight and shrinkage. There is lot of difficulties in the disposal of unused or already used tyres which involves generation of pollution in the environment. Waste Tyre Chips (WTC) of size equal to conventional coarse aggregate which have produced from the unused tyres of auto-mobiles can be used for the construction purpose which gives a good results in the construction as well as solution to the waste management. This research will attempt to use Waste Tyre Chips (WTC) in partial replacement to the course aggregate with various proportions (0 %, 15%, 30% & 45%) for the M20 grade of flyash silica fume based concrete which consider from research paper of Toronto University. The optimum mix binder of the considered paper is 64% of Cement + 30% of Flyash + 6% of Silica fume. In this entire research fine aggregate is constant but major concentration is on effect of WTC as a replacement to the coarse aggregate on the fresh concrete properties by conducting the workability test (Slump cone) and strength properties of hardened concrete by conducting compression strength using CTM on the standard cube.*

Keywords- Silica Fume, Flyash, Waste Tyre rubber Chips, Workability & Compressive Strength.

I. INTRODUCTION

Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementations materials such as fly ash and slag cement, aggregate (generally a coarse aggregate made of crushed rocks such as limestone, or granite, plus a fine aggregate such as sand), water, and chemical admixtures. The word concrete comes from the Latin word "concretus" (meaning compact or condensed), the past participle of "concresco", from "com-" (together) and "cresco" (to grow). The paste fills the voids in the aggregate and after the concrete is placed and vibrated it hardens to form a solid structural member. Concrete has high compressive strength and low tensile strength. Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material.

Structural Properties of Concrete:

Compressive strength

The compressive strength of concrete is one of the most important and useful properties of concrete. Strength is a measure of amount of stress acquired to fail a material. Concrete is strong in compression but weak in tension and the working stress theory for the concrete design also consider the concrete as a mostly suitable for bearing the compressive load ; that is why the compressive strength of the material is specified .Since the strength of concrete is a function of cement hydration process, which is relatively slow , traditionally the specification and the test for concrete strength are based on specimens cured under standard temperature humidity conditions for a period of 28 days.

Tensile strength

It is attributed to the heterogeneous and complex structure of concrete it is mentioned that tensile strength of concrete is in the order of 10-15% of the compressive strength. The reason for such large difference between tensile and compressive strength is attributed to the heterogeneous and complex structure of the concrete. In the methods of design described in the code of practice CP114, it is assumed that concrete does not resistant to tension .Since cracks are caused by shrinkage; concrete cannot can be relied upon resist tension during flexure, but at the same time concrete does possess a tensile strength, but may vary from 8-20% depending up on its age, the type and quality of the cement and aggregate.

Shear strength

It is engineering is a term used to describe the strength of a material or component against the type of yield or structural failure where the material or component fails in shear. For shear stress τ applies.

$$(\sigma1 - \sigma2) / 2$$

Where

σ 1 is major principal stress
σ 2 is minor principal stress
Shear stress exists between 2parts of bodies in contact when the 2 equal opposite and opposite forces exert on each laterally Q=P/A

Shear modulus (G) =shear strain / shear stress

Although pure shear is not encountered in concrete structures, an element may be subjected to the simultaneous action of compressive, tensile and shearing stress. Therefore the failure analysis under multi axial stress is carried out from a phenomenological rather than a material standpoint .Although the Coulomb-Mohr theory is not exactly applicable to concrete, the Mohr rupture diagram offers a way of representing the failure under combined stress state from which estimate shear strength can be obtained.

Bond strength

Compatibility of two materials act together to resist the external load is called bond strength. In fact, the strength of concrete is really derived from the bond between paste and aggregates. In view of the micro cracks formed in the body of the paste measurement of bond strength between the pastes, the measurement of the bond strength between paste and aggregate becomes difficult. However attempts have been made to find out the bond strength between gel and aggregate. The bond strength depends upon the surface texture of the aggregate, mineralogical nature of the aggregate and the specific surface of the gel.

Impact strength

Impact strength is of importance when concrete is subjected to repeated falling object, as pile driving, or a single impact of a large mass at a high velocity. The principal criteria are the ability of the specimen to with stand the high blows. It is interesting to point out that impact strength of concrete increases greatly with the rate at which impact stress is applied. It is generally assumed that the impact strength is directly related to compressive strength, since both are adversely affected by the micro cracks and voids. This assumption is not completely correct; it is found for the same compressive strength increased substantially with angularity and surface roughness of coarse aggregate. In general the impact strength of concrete increases with compressive strength, but the higher the static compressive strength of concrete the lower the energy, energy absorbed per blow before cracking.

II. LITERATURE REVIEW

1. Eldin et al., conducted on rubberized Concrete behaviour, using tire chips and crumb rubber as aggregate substitute of sizes 38,25mm and 19mm exhibited reduction in compressive strength by 85% and tensile splitting strength by 50% but showed the ability to absorb a large amount of plastic energy under tensile and compressive loads.

2. In Biel and Lee have used recycled tire rubber in concrete mixes made with magnesium oxychloride cement, where the aggregate was replaced by fine crumb rubber up to 25% by volume. The results of compressive and tensile strength tests indicated that there is better bonding when magnesium oxychloride cement is used. The researchers discovered that structural applications could be possible if the rubber content is limited to 17% by volume of the aggregate.

3. Schimizzedeveloped two rubberized concrete mixes using fine rubber granulars in one mix and coarse rubber granulars in the second. While these two mixes were not optimized and their design parameters were selected arbitrarily, their results indicate a reduction in compressive strength of about 50% with respect to the control mixture. The elastic modulus of the mix containing coarse rubber granular was reduced to about 72% of that of the control mixture, whereas the mix containing the fine rubber granular showed a reduction in the elastic modulus to about 47% of that of the control mixture. The reduction in elastic modulus indicates higher flexibility, which may be viewed as a positive gain in rubberized PCC (RPCC) mixtures used as stabilized base layers in flexible pavements.

4.I.B. TopÇuin investigated the effect of particle size and content of tire rubbers on the mechanical properties of concrete. The researcher found that, although the strength was reduced, the plastic capacity was enhanced significantly.

5. Zaher*et al* concluded that RPCC mixtures can be made using ground tire in partial replacement by volume of CA and FA. Based on the workability, an upper level of 50% of the total aggregate volume may be used. Strength data developed in their investigation (compressive and flexural) indicates asystematic reduction in the strength with the increase of rubber content. From a practical viewpoint, rubber content should not exceed 20% of the aggregate volume due to severe reduction in strength. Once the aggregate matrix contains nontraditional components such as polymer additives, fibers, iron slag, and other waste materials, special provisions would be required to design and produce these modified mixes. At present, there are no such guidelines on how to include scrap tire particles in PCC mixtures.

6. Hernandez-olivares*et al* used crumbed waste tire fibres (average length 12.5 mm) and short polypropylene (pp) fibres (length from 12-10 mm) to modify concrete.

7. Gregory Garrick , shows the analysis of waste tire modified concrete used 15% by volume of coarse aggregate when replaced by waste tire as a two phase material as tire fiber and chips dispersed in concrete mix. The result is that there is an increase in toughness, plastic deformation, impact resistance and cracking resistance. But the strength and stiffness of the rubberized sample were reduced. The control concrete disintegrated when peak load was reached while the rubberized concrete had considerable deformation without disintegration due to the bridging caused by the tires. The stress concentration in the rubber fiber modified concrete is smaller than that in the rubber chip modified concrete. This means the rubber fiber Modified concrete can bear a higher load than the rubber chip modified concrete before the concrete matrix breaks.

8. Kamil*et al*, analyzed the properties of Crumb Rubber Concrete, The unit weight of the CRC mix decreased approximately 6 pcf for every 50 lbs of crumb rubber added. The compressive strength decreased as the rubber content increased. Part of the strength reduction was contributed to the entrapped air, which increased with the rubber content. Investigative efforts showed that the strength reduction could be substantially reduced by adding a de-airing agent into the mixing truck just prior to the placement of the concrete.

9. Guoqiang Li, conducted investigation on chips and fibers. The tire surfaces are treated by saturated NaOH solution and physical anchorage by drilling holeat the centre of the chips were also investigated and they concluded that fibers perform better than chips: NaOH surface treatment does not work for larger sized tire chips: using physical anchorage has some effect. Further efforts will be geared toward the enlarging the hole size and insuring that the hole be through the chip thickness entirely. Fibre length restricted to less than 50mm to avoid entangle: steel belt wires provided positive effect on increasing the strength of concrete. From the above literature review it is seen that waste tire rubber modified concrete is characterized as having high toughness and low strength and stiffness. Various methods have been tried to improve the strength and stiffness of waste tire modified concrete. However preparing waste tire powders and thin tire fibres is time, effort and money consuming. Sometimes, the cost may be so high that it cannot be justified by its gain in performance. Because larger sized chips or fibres are very easy to produce, it is expected that the cost of larger sized chips or fibre modified concrete will be very low. However, it is not clear if larger sized fibres or NAOH treated chips work or not. Further experimental analyses are needed.

10. Eldin and Senouci (1993) reported that Rubberized concrete showed good aesthetic qualities. The appearance of the finished surfaces was similar to that of ordinary concrete and surface finishing was not problematic. However, the authors reported that mixes containing a high percentage of larger sized rubber aggregate required more work to smooth the finished surface. They also found that the color of rubberized concrete did not differ noticeably from that of ordinary concrete.

III. METHODOLOGY

Materials Used and Their Properties:

1) Cement:

A 53 Grade Ordinary Portland Cement (OPC), (IS: 12269-1987) was bought from Market.

Table 3.1: Properties of Cement

S.No	Name of Property		Value
1	Sp. Gravity Value		3.2
2	Fineness		3.40%
3	Normal Consistency		33%
4	Setting Time	Initial	38
		Final	360
5	Compressive Strength	3 Days	34.6
		7 Days	51.8
		28 Days	56.4

2) Fine Aggregate:

The Fine Aggregate i.e. Sand has been brought from the Godavari River from Rajahmundry.

Table 3.2: Properties of Fine Aggregate

S.No	Name of Property	Value
1	Sp. Gravity Value	2.61
2	Fineness Modulus	2.67
3	Bulking of Sand	0.9

3) Coarse Aggregate:

For the present study, the coarse aggregate has been brought from Prathipadu Village.

Table 3.3: Properties of Coarse Aggregate

S.No	Name of Property	Value
1	Sp. Gravity Value	2.75
2	Bulking of Sand	1.21

4) Flyash:

For the present study the Flyash was brought from Dr. Narla Tata Rao Thermal Power Plant, Vijayawada and Andhra Pradesh, India.

Table 3.4: Chemicals Present in Flyash

S.No.	Chemical	Composition
1	SiO_2	61.85
2	Al_2O_3	28.03
3	Fe_2O_3	5.03
4	CaO	1.06
5	MgO	1.05
6	SO_3	0.07
7	Na_2O	0.21
8	K_2O	1.34
9	Cl	0.001
10	LOI	0.95

5) Silica Fume:

It was bought from Bahubali Chemical Industries, Vadodara, Gujarat, India

Table 3.5: Chemicals Present in Silica Fume

S.No.	Chemical	Composition
1	SiO_2	87.13
2	Al_2O_3	1.96
3	Fe_2O_3	1.13
4	CaO	7.16
5	MgO	0.33
6	SO_3	0.12
7	Na_2O	0.09
8	K_2O	0.33
9	Cl	0
10	LOI	1.52

6) List of Laboratory Tests:

- Specific Gravity,
- Fineness of Cement,
- Normal Consistency of Cement,
- Setting time of Cement,
- Compressive Strength of Cement,
- Bulking of Sand,
- Waster Absorption of Coarse Aggregate,
- Sieve analysis for aggregates,
- Workability for fresh concrete,

7)* Different variables Studied*:

S.No.	Material	Variables Studied
1.	WTC	0%, 15%, 30% & 45%

IV. RESULTS & DISCUSSION

Effect of Waste Tyre Rubber Chips on Workability:

Table 4.1, Fig 4.1 shows the variation of workability test (Slump cone Test) on fresh concrete with various percentages of Waste Tyre Rubber Chips (WTC) as a replacement to the coarse aggregate. Fig 4.1 shows the variation of slump for M20 grade concrete with various % replacement of WTC for coarse aggregate from 0% to 45% with an increment of 15%. From fig 4.1 we can observe that the slump was getting decrease with increase in WTC content from 0% to 45%. Compared to conventional concrete slump decreased by 54% at 45% of WTS as a replacement to the coarse aggregate.

Table 4.1: Slump Results for Various Mix

S. No.	Mix Proportion	M20
1	Control Mix	44
2	0 % WTC	40
3	15 % WTC	35
4	30 % WTC	28
5	45 % WTC	20

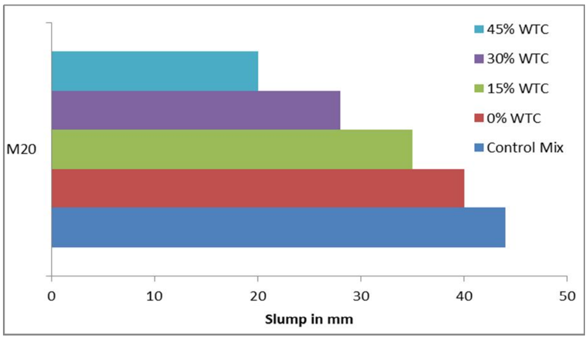

Fig 4.1: Variation of Slump for M20 Grade with different WTC Mixes

Effect of Waste Tyre Rubber Chips on Compressive Strength:

Table 4.2& Fig 4.2 to 4.5 show the variation of compressive strength of various grades of concrete with different variations in Waste Tyre Rubber Chips (WTC) as a replacement to the coarse aggregate. The compressive strength of the concrete which replacing the coarse aggregate by using WTC was improved up to 30% and the compressive strength was decreased for 45% replacement of WTC

Table 4.2: Compressive Strength in N/mm^2

% WTS	Load Taken by Cube		
	7 Days	14 Days	28 Days
Control Mix	17.18	20.02	26.82
0% WTC Mix	18.47	21.53	28.84
15% WTC Mix	19.58	22.6	30.28
30% WTC Mix	21.08	24.76	33.16
45% WTC Mix	19.8	23.68	31.72

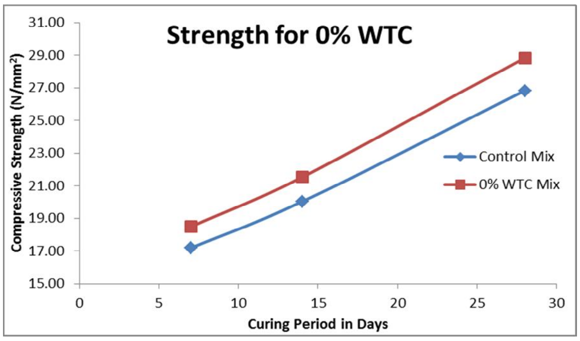

Fig 4.2: Compressive Strength for 0% WTC

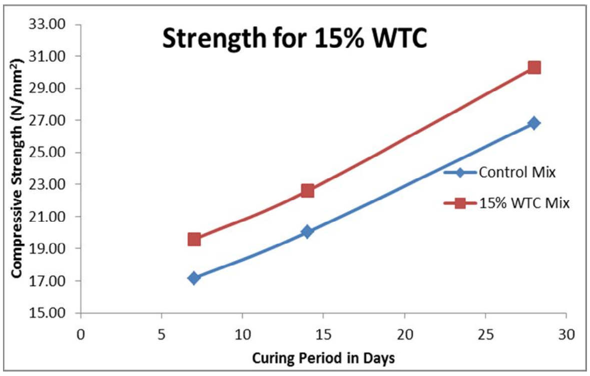

Fig 4.3: Compressive Strength for 15% WTC

Figure 4.2 shows the compressive strength comparison between the concrete prepared by control mix and concrete with 0% Waste Tyre rubber Chips. 0% WTC mix is nothing but the mix with proposed binder by using flyash, silica fume & cement. The compressive strength of 0% WTC mix is higher than control mix at any curing period. It indicates that the industrial waste materials flyash & silica fume shows impact on compressive strength of concrete.

Figure 4.3 shows the compressive strength comparison between the concrete prepared by control mix and concrete with 15% Waste Tyre rubber Chips. The compressive strength of 15% WTC mix was more than the control mix at any curing period. The strength was improved by 13% when compared with control mix of 28 days curing.

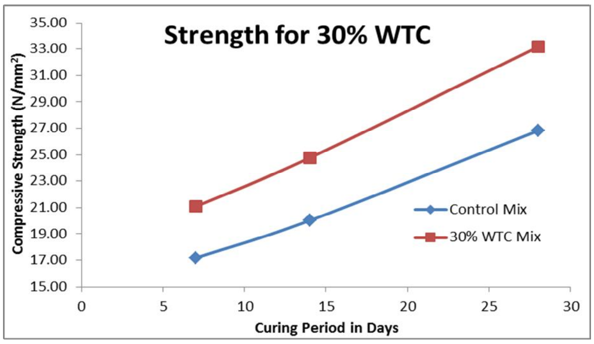

Fig 4.4: Compressive Strength for 30% WTC

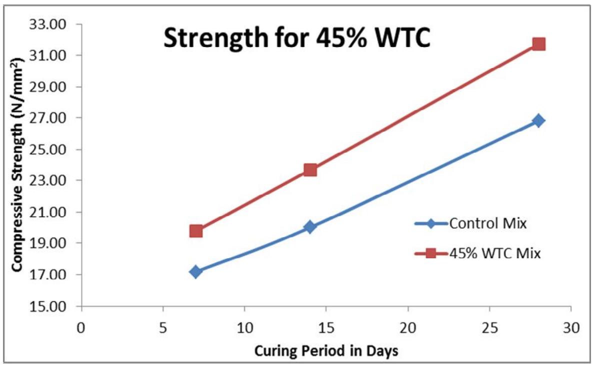

Fig 4.5: Compressive Strength for 45% WTC

Figure 4.4 shows the compressive strength comparison between the concrete prepared by control mix and concrete with 30% Waste Tyre rubber Chips. The compressive strength of 30% WTC mix was more than the control mix at any curing period. The strength was improved by 23% when compared with control mix of 28 days curing.

Figure 4.5 shows the compressive strength comparison between the concrete prepared by control mix and concrete with 45% Waste Tyre rubber Chips. The compressive strength of 45% WTC mix was more than the control mix at any curing period, but the compressive strength of 45% WTC was lower than the compressive strength of 30% WTC mix. The strength was reduced by 4% when compared with 30% WTC mix.

Figure 4.6 shows the compressive strength of all mix variations for M20 grade concrete in a bar chart. From the figure we can say that the strength was improved up to 30% replacement of WTC to the coarse aggregate, where for the 45% replacement of WTC for coarse aggregate the strength get decrease at any curing period.

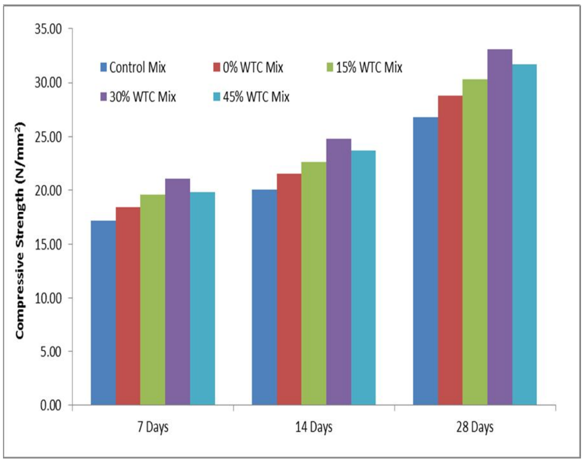

Fig 4.6: Variation of Compressive strength for different proportions of WTC replacement to the coarse aggregate.

V. CONCLUSIONS

The following are the conclusions made from the laboratory experimentation and the discussion made in the previous chapter.

- The strength of ternary blended concrete was more at any curing period, compared with conventional concrete.
- The present optimum mix of triple blended concrete was considered from a paper on ternary blended concrete from Toronto University, USA.
- The workability of concrete with various % of Waste Tyre Chips (WTC) as a replacement to the coarse aggregate was observed to be decrease with increase in content of WTC.
- Optimum % of WTC for M20 30% as a replacement in coarse aggregate.
- Concrete production by using this industrial waste was leads to decrease in pollution in our environment also it gives better strength for concrete than the conventional concrete.

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