PERFORMANCE STUDY ON VARIOUS INDUSTRIAL WASTE UTILIZATION IN CONCRETE

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Abstract - *With the rapid growth in population, it becomes difficult to control the huge amount of residual materials generates from enormous industrial activities does not have useful disposal till now it leads to generate a pollution. Concrete is most widely used building material in world, and about 12.6 billion tons of natural resources are used to make the concrete. Hence to control environmental pollution waste materials are replaced in concrete. This project evolves on experimentally investigation of waste materials with following percentages. The tire waste crumbled and it's immersed in epoxy resin were partially replaced to the place of coarse aggregates by 4% and 6%. Steel slag is replaced partially as fine aggregates by 15% and 30%.Copper slag is replaced partially in place of fine aggregate by 40% and Tio_2 is replaced as cement by 10%. M_{30} grade of concrete was designed and tested. The strength of concrete with partial replacement of waste materials at various percentages had been investigated and compared with ordinary conventional concrete. Experimental investigations like workability, Compressive strength test, Split tensile strength test, Flexural strength test for different concrete mixes with different percentages of copper slag, steel slag, tire waste, and Titanium oxide after 7, 14 and 28 days curing period has done.*

Keyword: Copper slag1, Steel slag2, Tire waste3, Titanium oxide4, compressive strength5, flexural strength6, split tensile strength7.

1. INTRODUCTION

1.1 General

In our world, the environmental pollution is one of the major problems in nowadays mainly the pollution such as land pollution due to waste are dumped in the land, air pollution due to the burning of waste, water pollution due to without any treatment the waste to dispose of in water. Recent year's population is much more so vehicle level will increase in our country.

1.1.1 Tire

Nearly 200 million tires produced in India per year. Only 60% of the tire could be replaced in the tire industry also and the remaining 40% of the tire doesn't know how it can be disposed of these tires have to utilize in concrete. When rubber was used instead of aggregate in concrete it shows less compressive strength (Nouman Khattak, 2015) and with added tire percent increase the compressive strength of concrete decreases (Partha sika, 2016).

1.1.2 Copper Slag

The Tuticorin plant of Sterlite has a capacity of 4 million tons per annum for every tone of copper metal produced, around 1.8-2.2 tons of slag is generated. The molten temperature of copper slag is above 1573k. The raw materials of copper concentrate which mainly consists of iron in copper slag are 30-45%, and sulfur. During the operation, iron is removed as iron silicate, which is commonly known as copper slag (Ferro sand). The disposal of copper slag is a major issue in recent years so that it can be used as fine aggregates in concrete.

Copper slag is also used as a building industry for use in a filling material, it possess little threat to the environment. The utilization of copper slag as a partial replacement of sand, it can be applied for all construction activities (Prachi Gupta 2012). In a review (Lakshmi Narayani P 2014) the ultrasonic pulse velocity test indicates the excellent quantity of concrete at a 40% replacement level of fine aggregates.

1.1.3 Steel Slag

Steel Slag is the glass-like by-product left over after the desired metal has been separated from its raw ore. There are many grades of steel that can be produced, and each grade of steel slag the properties can change. The steel slag consists of many impurities such as carbon as gaseous carbon monoxide, and environment during disposal of slag. So it can be used as a fine aggregate.

It has been observed that 36%replacement of fine aggregates with steel slag to be good in compression as well as tension (G. Maheswaran 2015). Due to this replacement, can reduce the extraction of river sand and manufactured sand also. The optimum percentage of steel slag is the replacement of fine aggregates is 40% and for coarse aggregates is 30% beyond which the compressive strength decreases on further replacement (V. Subathra Devi 2014).

1.1.4 Titanium

In this research work, titanium is used to replace cement by a certain percentage. Titanium is a light meta composed of 60% iron, 4.5g/cc. Recently, titanium is being used as many good, such as building materials, medical applications, and accessories. This amount to about 30% of domestic consumption. In 2017, world titanium metal production was a mere 170,000 tons (according to the US geological survey).

1.2 OBJECTIVES

1. To study the feasibility on usage of waste materials in concrete.
2. To preserve the natural properties.
3. By using waste materials in concrete, it an reduce the pollution such as land, water and air and minimize the environmental degradation in our country.
4. To study experimentally the compressive strength, flexural test and split tensile strength of concrete elements with tire, copper slag, steel slag, titanium.

1.3 SCOPE AND SIGNIFICANCE

In order to decrease the cost of construction and make a building free from environmental effluence, the waste materials are to be used in the construction. The materials are added with concrete to attain a required strength.

1. Durable and corrosion resistant.
2. Good isolation for cold, heat and sound saving energy and reducing noise pollution.
3. It is efficient and has a longer life.
4. Keep free 5. Hygienic and fresh.

1.4 METHODOLOGY

Being the major component of structure, many researchers have been done on concrete to improve its properties in every possible manner to develop a sustainable concrete mass. The concrete can be strengthened only by the replacements of its ingredients by better ones. Waste materials used in concrete which gives environment friendly at the same time more suitable to construction. In this aspect lot of researches have been done on using the tire, copper slag and steel slag as aggregates in concrete and finding the strength by using compressive testing machine and universal testing machine then compared the strength in control mixes.

2. MATERIALS PROPERTIES AND MIX DESIGN

2.1 Cement

The emission of CO_2 is reduced through using blended cement is estimated to be at least 5% of total CO_2 emission form of cement making. Portland pozzolana cement (PPC) confirming to IS 1489-1 (1991) was used for the project work. The properties of cement are given in the table as 2.1.

Table 2.1 Chemical properties of PPC

Chemical composition	Percentage
Silica (SiO_2)	29.07
Alumina(Al_2O_3)	13.89
Iron oxide(Fe_2O_3)	3.10
Magnesium Oxide (MgO)	1.11
Potassium Oxide(K_2O)	0.46

2.3 M sand

Due to the scarcity of river sand, the manufactured sand is used as fine aggregates in concrete. The maximum size is 4.75mm and it was confirmed to Zone II as per IS383-1987. The specific gravity and water absorption of M sand are. The unit weight of M sand was 1580 Kg/m^3. Sieve analysis was described as a table 2.2

Fig 2.1 M Sand

2.4 Coarse aggregate

Crushed granite aggregate with a maximum nominal size of 20mm and it was confirming to IS 3831987 was used as coarse aggregate in concrete. The specific gravity, fineness modulus and water absorption of coarse aggregate are referred to the table as. The bulk density of crushed granite is 1755kg/m^3

2.5 Copper Slag

Copper slag is partially replaced as fine aggregates used in concrete mixes. It was collected from Sterlite industry at Tuticorin. It is the byproduct of copper extraction by smelting. The chemical composition of the slag varies with the type of treatment process. A typical copper slag composition from the smelter.

Fig 2.2 Copper Slags

2.6 Steel Slag

Steel slag collected from the local steel industry and it was crushed into small pieces for replacement of fine aggregates in concrete mixes. The physical and chemical properties are in the following tables 2.4

Fig 2.3 Steel Slag

2.7 Tire

Tire waste was collected from Selvam tire industry near locally available. A tire typically consists of four different kinds of rubber, natural rubber, styrene, butadiene rubber, polybutadiene rubber.

The chemical properties of tire include zinc oxide as 37.8%, while 22.3% of ash consisted of silica, lime was 5.7%, the ferric oxide was 7.4%, sulfate ions were 7% of tire ash After collecting the rubber it was cut into a piece of 12mm size by using a knife or wooden cutter. The crumble tire was used in both with and without treatment of epoxy resin. The crumble waste tire is dipped in epoxy resin for 24 hours after it replaces as coarse aggregate in research work.

Fig 2.4 Crumbled Tire

Fig 2.5 Crumbled Tire with Epoxy

Table 2.2 Sieve analysis of M sand

Sieve size (mm)	Weight retained % in gm	Weight of passing %	Cumulative % By weight retained
4.75	0	0	0
2.36	0	0	0
600	24.6	25.4	50.85
300	17.2	8.2	16.4
150	6.2	2.0	4
Grading	Zone II	IS383-1970 (Table 4)	

2.8 Titanium

It is also known as a transition metal on the periodic table of elements denotes by symbol Ti. Titanium occurs below the earth surface now 12 countries are manufacture in recent years It is lightweight, Silver gray material. It can be replaced as PPC cement. Since titanium has good corrosion resistance. The Specific gravity is 4.5

Fig 2.6 Titanium

3. MIX PROPORTION

Various replaceable waste materials and different mix percentage are used to be prepared as concrete with water-cement of 0.4. The specimen is casting by using M30 grade of concrete. The cement content of this mix is 480kg/m^3. The cement, fine aggregates, and coarse aggregates are in the ratio of 1:1.44:2.39 as per IS 383-1970 and IS 4562000 specifications. The various test program is conducted for this research work. The mixture proportions of concrete with specimen were tire, copper slag, steel slag, titanium are mixed.

4. EXPERIMENTAL PROCEDURE

In this project, the concrete mixes are prepared by using various materials. The cube specimen is prepared by 150X150X150 mm. The cylinder molds are prepared by using 150X300 mm. Before molding the specimen the workability is to be checked by using the slump cone test in the value of 15mm. Some mix is in SS and CS as fine aggregates and tire are added without treatment and with the treatment of epoxy resin as replace of coarse aggregates. After molding the specimen, these are curing temperature of 20+2ºC which is the specific period of 7, 14, 28 days. Curing has been done the molds are removed and take the dry weight after these specimens are tested by using compression testing and universal testing machine which has a capacity of 2000 KN. In this test results are compared with ordinary conventional concrete.

4.1 TESTING ON FRESH CONCRETE

4.1.1 Slump Test

The concrete slump test is an empirical test that measure the workability of fresh concrete. More specifically, it is also used to determined consistency of between individual batches. The test is popular due to the simplicity of apparatus used and simple unfortunately, the simplicity of the test often allows a wide variability in the manner that the test is performed. The slump measured should be recorded in mm of subsidence of the specimen during the test. The slump concrete takes various shapes, and according to the profile of slumped concrete the slump is termed as true slump shear slump or collapse slump. If a shear or collapse slump is achieved a fresh sample should be taken and the test procedure. Unfortunately, the simplicity of the test often allows a wide variability in the manner that the test is performed.

The slump measured should be recorded in mm of subsidence of the specimen during the test. The slump concrete takes various shapes, and according to the profile of slumped concrete the slump is termed as true slump shear repeated. A collapse slump is an indication of too wet a mix. Only a true slump is of any use in the test. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriates. Very dry mixes; having slump 0-25 mm are used making low workability mixes; having slump 10-40 mm are used for foundations with light reinforced medium workability mixes;50-90 for normal reinforced concrete placed with vibrated high workability concrete >100mm.

4.1.2 Compaction Factor Test

The compacting factor test is designed primarily for use in the laboratory but it can also be used in the field. It is more precious and sensitive then the slump test. The compaction factor test gives the behavior of fresh concrete under the action of external force. In this test the

L=length in mm

compaction achieved through a free fall of concrete determines its workability. It is more accurate than slump test for concrete mixes and value of compaction factor of 0.75 to 0.8 is suggested as per IS 456- 2000. It is not suitable for concrete of very low workability of 0.7 or below.

The concrete sample is placed in the upper hopper. Then the hopper is opened. The sample drops into lower hopper filling it to over flowing. The trap door of the lower hopper is then opened and the sample falls into the cylinder. The surplus concrete is removed from the top of the cylinder with the help of a trowel. The outside surface of the cylinder is wiped and cleaned. The cylinder is then weighed and it is recorded as weight of partially compacted concrete. The cylinder is again filled with concrete in layers not exceeding 50mm in thickness. Each layer is fully compacted with tamping rod. The cylinder is again weighed and it recorded as a weight of fully compacted concrete.

Compaction factor =Wp/Wf

Table 4.1 Fresh concrete test

No of Sets	Mix of materials	Fresh Concrete Test	
		Slump Flow	**Compaction Factor**
Mix A	Conventional concrete	Shear	0.83
Mix B	Cement + [FA+**SS(15%)**] +[CA+**T(6%)**]	Collapse	0.82
Mix C	Cement + [FA+**SS(15%)** + **CS(40%)**] + [CA+**T (4%)**]	Shear	0.86
Mix D	Cement + [FA+**SS(30**%) + **CS(40**%)] +[CA+ **TE(4%)**]	Shear	0.85
Mix E	[Cement+**TiO_2(10%)**] + [FA+**CS(40**%)] + [CA+ **TE (4%)**]	Shear	0.875

4.2 TESTING OF HARDENED CONCRTE

Concrete specimens of cube, cylinder, prism is casted for conventional and modifier mix in various percentages of by the weight to the sand, coarse aggregate and cement with the optimum percentage of concrete specimens. The various tests are listed in below tables

4.2.1 Compressive Strength Test

Compressive test is the most common test conducted on hardened concrete; partly it is easy test to perform because of most desirable characteristic properties of concrete and qualitatively related to its compressive strength. The compression test is carried out on specimen cubical or cylindrical in shape. Prism is also sometimes used, but it is not common.

Compressive strength = (P/A) (N/mm^2)

Where,

P=Applied load (N)
A=Area of the specimen (mm^2)
D=diameter in mm
L=length in mm

Fig 4.1 Compressive test machine

4.2.2 Split Tensile Strength

The split tensile strength of concrete cylinder was determined as per IS 5816-1999. The load shall be applied nominal rate within the range 1.2N/mm2/min to 2.4N/mm2/min.

Split tensile strength is = 2P/ 3.14DL (N/mm2)

Where,
P=load in N
L=length in mm
D=diameter in mm

The tensile strength of concrete is one of the basic and important properties. Split tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension.

Fig 4.2 Split Tensile test machine

4.2.3 Flexural Strength

This test method is used to determine the modulus of rupture of specimens prepared and cured. The strength determined will vary where there are differences in specimen size, preparation, moisture condition or curing. This test method covers the determination of the flexural strength of concrete specimens by the use of the sample beam with center-point loading.

Fig 4.3 Flexural Test machine

Flexural Strength = PL/bd2

Where,
P=load in N
L=length in mm
D=diameter in mm

5. RESULTS AND DISCUSSIONS

5.1 Compressive Strength Analysis

The compressive strength tested on cube for different materials and percentage for M30 concrete for 7days, 14days and 28days having better result achieved.

Table 5.1 Compressive Strength of Cube

No. of Sets	Mix of materials	Compressive strength (N/mm2)		
		7days	14days	28days
Mix A	Conventional concrete	21.66	31.66	33.33
Mix B	Cement+[FA+**SS(15**)] + [CA+**T (6%**)]	19.64	28.71	30.22
Mix C	Cement+[FA+**SS(15%)**+**CS (40%)**]+[CA+**T(4%)**]	21.57	31.52	33.18
Mix D	Cement + [FA+**SS(30%)** **CS(40%)**]+[CA+**TE(4%)**]	20.22	29.55	31.11
Mix E	[Cement+**TiO2(10%)**] +[FA+**CS(40%)**]+[CA+**TE (4%)**]	35.34	45.94	47.77

5.2 SPLIT TENSILE STRENGTH ANALYSIS

The split tensile strength tested on cylinders for different percentage of Copper Slag, Steel Slag, Tire and Titanium for M30 concrete for 7days, 14days and 28days having better result achieved. The below tables shows the split tensile strength of cylinders at different percentage of material mixes.

No. of Sets	Mix of materials	Split tensile strength		
		7days	14dayS	28dayS
Mix A	Conventional concrete	2.57	3.76	3.96
Mix B	Cement+ [FA+**SS(15%)**] + [CA+**T (6%)**]	2.23	3.22	3.39
Mix C	Cement+ [FA+**SS (15%)**+ **CS (40%)**] +[CA+**T (4%)**]	2.27	3.33	3.5
Mix D	Cement+ [FA+**SS (30%)** +**CS (40%)**] +[CA+ **TE (4%)**]	2.28	3.33	3.5

Table 5.2 Split Tensile Strength of Cylinder

5.3 Flexural strength

In this method to find the flexural value of prism and taking the results of 7, 14, 28 days after curing the specimen.

Table 5.3 Flexural Strength Of Prism

NUMBR OF SETS	MIX OF MATERIALS	FLEXURAL STRENGTH AT 28 DAYS(N/mm2)
Mix A	Conventional concrete	3
Mix B	Cement+ [FA+**SS (15%)**] + [CA+**T (6%)**]	2.4
Mix C	Cement+ [FA+**SS (15%)** + **CS (40%)**] + [CA+**T (4%)**]	2.9

DISCUSSION

Compressive Strength Comparison between Various Mixes At 7 Days, 14 Days & 28 Days

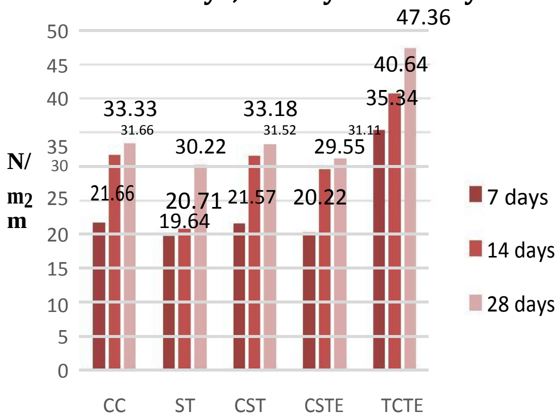

Fig 5.1 Compressive Strength Analysis

5.2 Split Tensile Strength comparison Between Various Mixes At 7 Days, 14 Days &28 Days

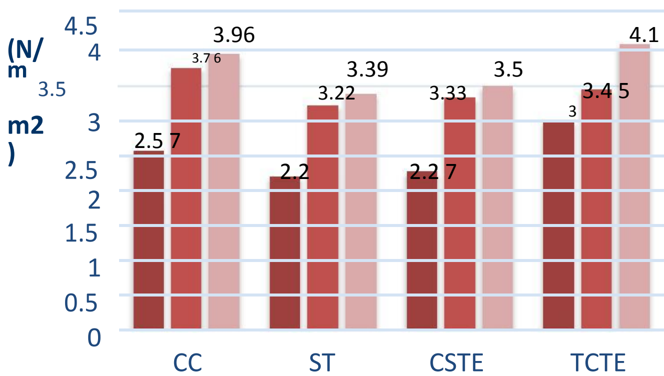

Fig 5.2 Split Tensile Analysis

5.3 Flexural Strength Comparison between Various Mixes At 7 Days, 14 Days & 28 Days

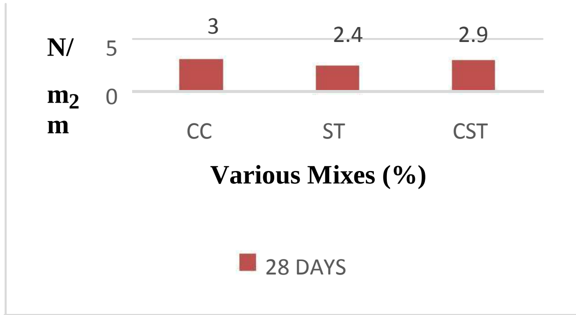

Fig 5.3 Flexural Strength Analysis

6 SUMMARIES AND CONCLUSION

6.1 General

The basic objectives of the study is to prepare a concrete much more stable and durable than the conventional by replacing aggregates both coarse and fine. Mix designs for all the replacements of material have done. The specimens are prepared and tested in the aspect strength calculation and also comparisons done.

6.2 Conclusion

The following conclusion is made based on the experimental investigation on compressive strength, Split tensile strength and flexural strength considering the environment aspects also:

In Mix E, the titanium as 10% replacement of cement, 40% of copper slag, Tire as 4% with epoxy resin dipped for 24 hours in these proportion the compressive strength and split tensile strength are greater when compared to conventional plain cement concrete.

When percentage of tire increases, the strength of concrete decreases gradually so tire can adopt 4% and 6% of coarse aggregate. Copper slag as 40% and steel slag as 15% replace in fine aggregates to attain good compressive strength in concrete

The split tensile strength of result as conventional in same as the Mix C so it various waste materials are suitable in construction purposes.

The cost is optimum and it's economical in all different proportion of concrete mixes when compared to ordinary cement concrete.

In all mixes of specimen should be more or slightly less equal to the controlled specimen. It must be preserve the degradation of environment .Industrial waste can be effectively used in concrete and thus provide a solution for the disposal problem of the copper slag, steel slag, and tire. It will used to protect the environment and maintains a green country.

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