International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.(02), March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

Experimental Investigation On Mechanical Properties Of Concrete Incorporated With Waste Pvc And Copper Slag

S.Krishnaveni[1], D.Dhaarani[2]

[1,2]*Assistant Professor, Department of Civil Engineering,*
Dhaanish Ahmed college of Engineering, Chennai. (India)

ABSTRACT

The term "sustainable development" proposes a developing society, where people will live in a healthy environment with improved economic and social conditions. As civil engineers we have a part in sustainable development. The most important hindrance to sustainable development in civil engineering sector at present scenario is mining of natural fine aggregate (sand). In order to overcome this issue this research investigates upon the replacement of fine aggregate with cost effective and non-reusable waste materials that causes land filling tribulations too. On consideration of the essential parameters of fine aggregate an alternative considered are discarded polyvinylchloride (PVC) in shredded form and copper slag (a waste generated from copper production from Sterlite Industries)

Keywords — eco-friendly concrete, plastic, PVC, copper slag,

I. INTRODUCTION

In the last decades, due to the increasing cost of raw materials and the continuous reduction of natural resources, the recycling of industrial waste has become an interesting option for the building industry. Several industrial wastes, e.g. fly ash and demolition waste after adequate treatment, have shown to be suitable as construction materials and readily follow the design requirements. In particular, the large growth in the use of plastic materials has generated a growing interest worldwide in reusing the various types of recycled polymers. Many authors have already studied the suitability of plastic waste, such as PET and polystyrene in concrete manufacturing. In the last few decades, plastic consumption has increased, and will increase even more in coming years. Annual per capita consumption of plastics in India is about 8.8 kg, which results in about 11.76 million tons of plastics waste. The use of this type of waste in the construction field may represent an effective solution both to the problem of reducing the environmental impact of plastics and to the development of an increasingly sustainable building industry. Recent studies have reported the promising use of these materials in manufacturing of concrete, as part of the binder or as aggregate substitute. Polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET) and other materials are some of the polymers used in the building industry either in fiber or sand shape. The energy performance of a building is becoming increasingly important, because of environmental restrictions and rising costs of fuel and energy. These issues have led to the

development of appropriate solutions, creating a fast growing sector in modern construction. To obtain buildings with good thermal insulation performances, the use of new materials of suitable thermal insulation properties should be held into consideration. Another form of plastic waste is PVC, usage of PVC in concrete has not yet been taken into research and hence we have considered it as an alternative.

The Indian copper industry grew by nearly 50% in 2011. India has become a net exporter of copper after being a net importer during the last decade, even as the country is not a major producer of copper ore, but produces the refined forms of copper. About a decade ago, the Indian copper industry consisted of a single state-owned company and now the copper industry in India takes up about 3% of the global market for copper. Copper slag is an industrial by-product material produced from the process of manufacturing copper. For every ton of copper production, about 2.2 tonnes of copper slag is generated. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry (Gorai et al 2003). Although copper slag is widely used in the sand blasting industry and in the manufacturing of abrasive tools, the remainder is disposed of without any further reuse or reclamation. This waste is also considered as an effective replacement for fine aggregate.

II. MATERIAL INVESTIGATION

A. Cement

An OPC 53 Grade cement was used in this investigation. The quantity required for this work was assessed and the entire quantity was purchased and stored properly in casting yard. The following tests were conducted in accordance with IS codes and its results are as follows

TABLE I

PROPERTIES OF CEMENT

S.NO.	PROPERTIES	VALUES
1.	Specific Gravity	3.15
2.	Fineness	4.6 %
3.	Initial Setting Time	28 mins
4.	Final Setting Time	600 mins

B. Fine Aggregate

The fine aggregate used in this investigation was clean river sand and the following tests were carried out on sand as per IS: 2386- 1968 (III) and its results are as follows

TABLE II

PROPERTIES OF FINE AGGREGATE

S.NO.	PROPERTIES	VALUES
1.	Type	River Sand
2.	Specific Gravity	2.6585
3.	Fineness modulus	2.34
4.	Zone	II
5.	Uniformity Coefficient	3.33
6.	Coefficient of curvature	1.128

C. Coarse Aggregate

In the present investigation, locally available crushed blue granite stone aggregate of size 12.5 mm and down, was used and the various tests, carried out on the aggregates and its results are given below.

TABLE III

PROPERTIES OF COARSE AGGREGATE

S.NO.	PROPERTIES	VALUES
1.	Shape	Angular
2.	Size	12.5 mm
3.	Specific Gravity	2.738
4.	Fineness modulus	6.23

D. Water

Potable water was used throughout for this research.

E. Polyvinyl chloride

Abbreviated as PVC, it is more commonly used in pipes and fittings. The used and broken PVC pipes are collected for the study from Pondicherry and it is crushed into smaller pieces such that it can pass through 4.75mm sieve. The various tests conducted on PVC and its results given below.

TABLE IV

PROPERTIES OF PVC

S.NO.	PROPERTIES	VALUES

1.	Shape	Angular
2.	Colour	Blue
3.	Specific Gravity	1.613
4.	Fineness modulus	6.75

Fig. 1 Poly Vinyl Chloride used in this research

F. Copper Slag

Copper slag is a by-product material produced from the process of manufacturing copper. As the copper settles down in the smelter, it has a higher density, impurities stay in the top layer and then are transported to a water basin with a low temperature for solidification. The end product is a solid, hard material that goes to the crusher for further processing. Copper slag used in this work was bought from Sterlite industries (India) ltd, Tuticorin, Tamil Nadu, India. The various tests, carried out on copper slag and its results are given below.

TABLE V

PROPERTIES OF COPPER SLAG

S.NO.	PROPERTIES	VALUES
1.	Appearance	Glossy
2.	Colour	Black
3.	Specific Gravity	3.056
4.	Fineness modulus	3.949

Fig. 2 Copper Slag used in this research

III. MIX DESIGN AND SPECIMEN

A. Mix Design

The grade of concrete used in this investigation is M-40 grade. The mix design for M-40 is calculated as per IS 10262:2009 "Recommended Guidelines for concrete mix design" and the cement: fine aggregate : coarse aggregate ratio is obtained as 1: 1.786: 1.584 and the water to cement ratio is selected as 0.45.

B. Workability

The behavior of green or fresh concrete from mixing up to compaction depends mainly on the property called "workability of concrete". Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are slump cone and tamping rod. The slump value obtained for the above mix ratio is 85 mm of true slump. Thus the concrete has medium workability.

Fig. 3 Slump Cone Test

C. Specimen

For this research 14 batches of mixes are prepared and its details are as follows. For each batch 6 cubes and 6 cylinders are casted

TABLE VI
BATCHES OF SPECIMEN

ABBREVIATION	DETAILS
CM	Control Mix
P1	10 % PVC replacement
P2	20 % PVC replacement
P3	30 % PVC replacement

P4	40 % PVC replacement
P5	50 % PVC replacement
C1	10 % copper slag replacement
C2	20 % copper slag replacement
C3	30 % copper slag replacement
C4	40 % copper slag replacement
C5	50 % copper slag replacement
C3P1	10% PVC+30% copper slag
C3P2	20% PVC+30% copper slag
C3P3	30% PVC+30% copper slag

IV. EXPERIMENTAL SETUP AND TEST PROCEDURE

A. Compressive strength test

To determine the compressive strength of concrete, 100 mm × 100 mm × 100 mm size concrete cubes were casted and tested in accordance with IS: 516-1959. All strength tests were conducted using 2000kN compression testing machine. Cube moulds of size 100x100x100 mm were used. They were cleaned thoroughly using a waste cloth and then properly oiled along its faces. Concrete was then filled in mould and then compacted using a standard tamping rod of 60 cm length having a cross sectional area of 25mm^2.The mould is filled in three layers and the excess is trimmed off using a trowel. After 24 hours the specimen is removed from the mould and was placed in a curing tank. At the end of 7 days and 28 days , the cubes were taken out of the curing tank .The specimen was allowed to dry for 6 hours and then it was tested in the Compression Testing Machine (CTM). The critical load at the time of failure is noted down and the compressive strength are calculated using the formula,

$$Compressive\ strength = \frac{Load}{Surface\ Area}$$

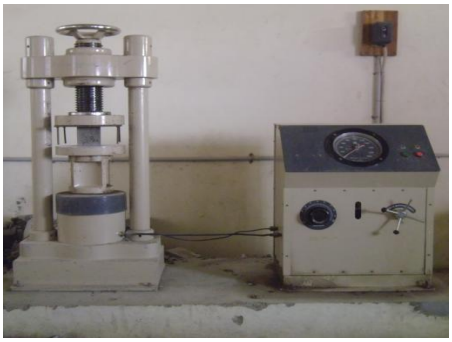

Fig. 4 Compression Testing Machine

B. Split tensile strength test

To determine the split tensile strength of concrete, 100 mm × 200 mm size concrete cylinders were casted and tested in accordance with IS: 516-1959. Cylindrical moulds of size 100mm x 200 mm were used. They were cleaned thoroughly using a waste cloth and then properly oiled along its faces. Concrete was then filled in mould and then compacted using a standard tamping rod of 60 cm length having a cross sectional area of 25mm^2.The mould is filled in three layers and the excess is trimmed off using a trowel. After 24 hours the specimen is removed from the mould and was placed in a curing tank. At the end of 28 days , the cylinders were taken out of the curing tank .The specimen was allowed to dry for 6 hours and then it was tested in the Universal Testing Machine (UTM). The critical load at the time of failure is noted down and the compressive strength are calculated.

$$Split\ tensile\ strength = \frac{2P}{\prod D L}$$

Where,

P - Load at the time of failure

D - Diameter of specimen

L - Length of specimen

V. RESULTS AND DISCUSSION

A. Compressive strength test results:

The 7-day compressive strength and 28 day compressive strength test results of various batches of specimens are tabulated below

TABLE VII

COMPRESSIVE STRENGTH TEST RESULTS

BATCH	COMPRESSIVE STRENGTH (N/mm^2)	
	7 DAY	28 DAY
CM	32.333	46
P1	34	48
P2	33.667	47
P3	32	45.667
P4	29.667	42.333
P5	28	39
C1	35.667	50
C2	38.333	54.333
C3	43	61
C4	40.667	57.667

C5	34.667	49.333
C3P1	38.667	55
C3P2	39.667	56.333
C3P3	31.333	44.667

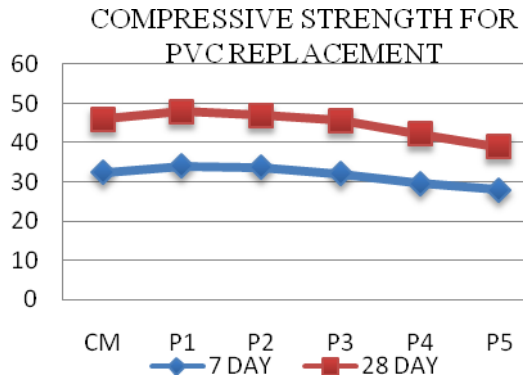

Fig. 5 Graph showing the 7 day and 28 day compressive strength of concrete using PVC

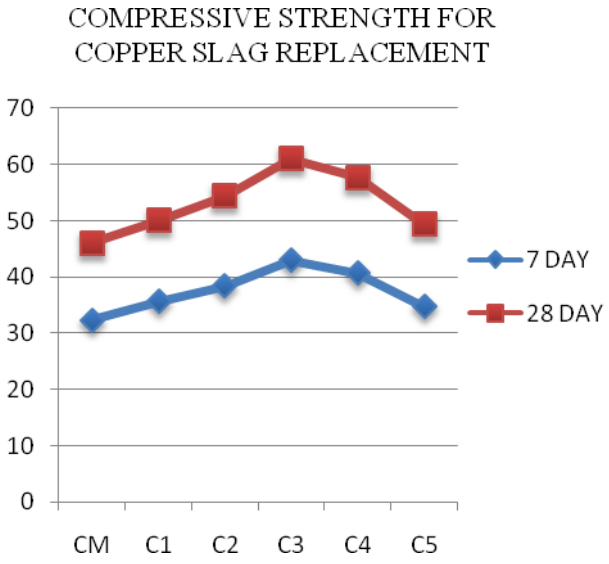

Fig. 6 Graph showing the 7 day and 28 day compressive strength of concrete using copper slag

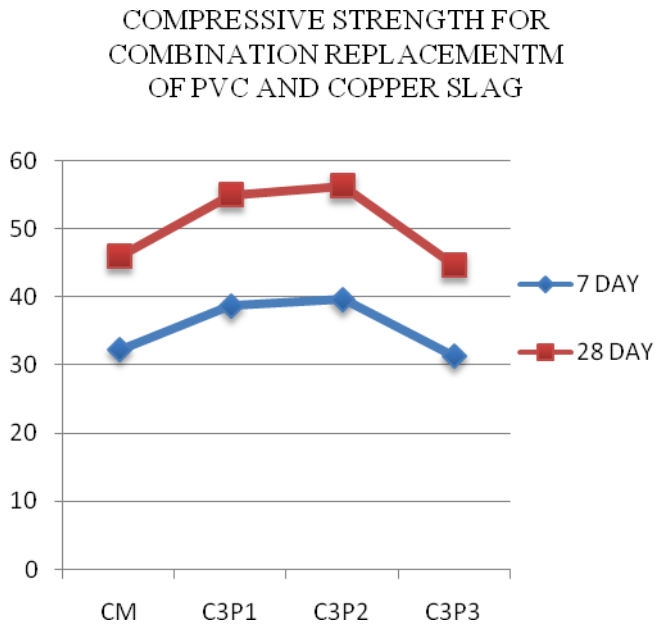

Fig. 7 Graph showing the 7 day and 28 day compressive strength of concrete using 30 % copper slag and different proportions of PVC.

B. Modulus of Elasticity

The modulus of elasticity of various batches of specimens are given below

TABLE VIII
MODULUS OF ELASTICITY RESULTS

BATCH	ELASTICITY MODULUS (N/mm^2)
CM	33911.65
P1	34641.02
P2	34278.27
P3	33788.68
P4	32531.91
P5	31224.99
C1	35355.34

C2	36855.46
C3	39051.25
C4	37969.4
C5	35118.73
C3P1	37080.99
C3P2	37527.66
C3P3	33416.69

C. Split Tensile Strength test

TABLE IX

SPLIT TENSILE STRENGTH

BATCH	SPLIT TENSILE STRENGTH (N/mm^2)
	28 DAY
CM	5.146
P1	5.73
P2	5.305
P3	5.09
P4	4.982
P5	4.783
C1	5.89
C2	6.12
C3	6.475
C4	6.324
C5	5.817
C3P1	6.222
C3P2	6.478
C3P3	5.106

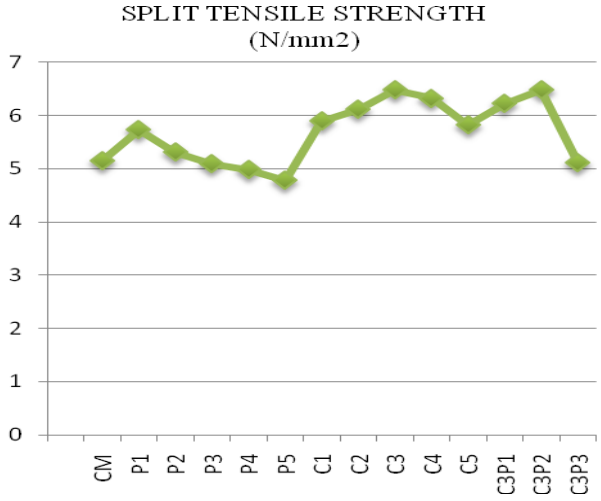

Fig. 8 Graph showing the 28 day split tensile strength of concrete using copper slag , PVC and combination of both.

D. Unit weight

The unit weight of all the specimen are tabulated as below. Unit weight is also a very important parameter that needs to be considered in replaemnent analysis of fine aggregate.

TABLE IX
UNIT WEIGHT

MIX	UNIT WEIGHT (KN/m^3)
CM	24.002
P1	23.25
P2	22.857
P3	22.645
P4	22.128
P5	21.719
C1	24.1
C2	24.976
C3	24.996
C4	25.045
C5	25.009
C3P1	24.309
C3P2	23.891
C3P3	23.194

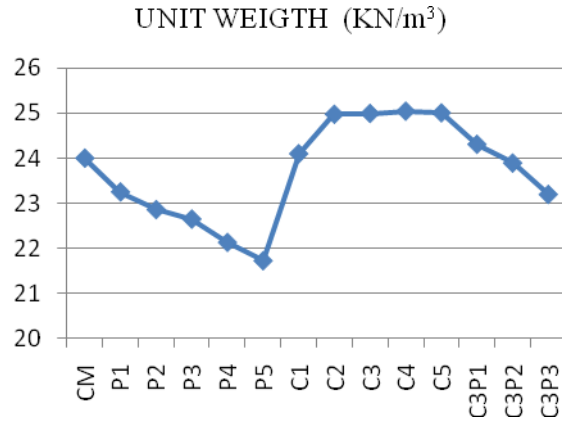

Fig. 9 Graph showing the unit weight of all batches of mix.

VI. RESULTS AND DISCUSSION

- In the case of replacing fine aggregate with PVC compressive strength increases by 5.16% and 4.13% and split tensile strength increases by 11.37% and 3.109% at 10% and 20% of replacement. After which the compressive strength as well as split tensile strength starts decreasing.
- When copper slag is considered as a replacement for fine aggregate in concrete the compressive strength and split tensile strength increases with an increase in the percentage of copper slag. The optimum is attained at 30 % replacement level with 33% increase in compressive strength and 25.83% increase in split tensile strength.
- The results of combination mix i.e. 30% of copper slag with different proportions of PVC shows that C3P2 has higher compressive and split tensile strength.
- The Elastic modulus of concrete incorporating PVC as fine aggregate replacement decreases and hence its ductility is more whereas in the case of copper slag it increases and hence its ductility decreases.
- The unit weight of PVC batches decreases with increases in percentage of replacement , but increases in the case of copper slag.

Thus we can conclude that PVC and copper slag can both used as a replacement of fine aggregate in concrete. This would lead to the reduction in construction cost and proves to be eco-friendly. These types of alternative would lead to reduction in land filling issues and aids in sustainable development also.

REFERENCES

[1]. F. Iucolano, B. Liguori , D. Caputo, F. Colangelo , R. Cioffi , “Recycled plastic aggregate in mortars composition: Effect on physical and mechanical properties” Materials and design ”, Science Direct, Jan 2012.

[2]. Al-Jabri, K. and Makoto Hisada. "Copper slag as sand replacement for high performance concrete", Cement & Concrete Composites, Vol. 31, pp. 483- 488, 2009.

[3]. Al-Jabri, K., Taha, R. and Al-Ghassani, M. "Use of copper slag and cement by-pass dust as cementitious materials" Cement, Concrete Aggregates, Vol. 24, No.1, pp. 7-12, 2005.

[4]. Al-Jabri, K.S., Abdullah, H., Al-Saidy and Ramzi Taha. "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete", Construction and Building Materials, Vol. 25, pp. 933-938, 2011.

[5]. Nabajyoti Saikia, Jorge de Brito "Use of plastic waste as aggregate in cement mortar and concrete preparation: A review", Building construction and materials, 2012 , pp 357