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An Experimental Study on Waste Plastic Aggregate Based Concrete - An Initiative Towards Cleaner Environment

[1]T. Senthil Vadivel, [2]M. Doddurani and [3]K.S. Shobana

[1]Department of Civil Engineering, Dr. N.G.P. Institute of Technology,
Coimbatore – 641 048, Tamilnadu, India
[2]Assistant Engineer, PWD/WRO, Cauvery Basin, Salem – 636 007, Tamilnadu, India
[3]Department of Civil Engineering, Kongu Engineering College, Perundurai,
Erode – 638 052, Tamilnadu, India

Abstract: A substantial growth in the consumption of plastic is observed all over the world in recent years that has led to dumping of huge quantities of plastic related wastes in the environment. Recycling of plastic waste to produce construction material like concrete appears as one of the best solutions for the disposal of plastic waste. This paper involves a partial replacement of waste plastic as fine aggregates from 5% to 25% with 5% increment. The main objective of this study is to reduce the wastage of plastic and to improve the eco-friendly environment. Many investigations were taken for plastic so far, that has led to current research for using pulverized plastic which passes through 2.36 mm sieve and retained in 1.18 mm sieve in concreting material. The investigation was done and the mechanical properties of concrete were discussed in the present study. The experiment was done with M30 grade concrete for a curing of 7 days, 14 days and 28 days from which its compressive strength, tensile strength, flexural strength were taken and compared with the conventional concrete. The compressive strength has increased for 5%, 10 %, 15 % and gradual decrement is obtained for 20% and 25% of partial replacement. The tensile strength and flexural strength has been increased for all percentage of waste plastic replacements.

Key words: Recycling Pulverized Plastic · Compressive Strength · Tensile Strength and Flexural Strength

INTRODUCTION

In India approximately 40 million tones of plastic products are consumed every year. Nearly 15000 tones have been used per day out of which 95% has been wasted. Since waste plastic is a non decomposable material and dumping of waste plastic disturbs the environment and ecology. Hence lot of innovations in recycling of waste plastics has been practiced in many countries in order to avoid environment pollution. Due to the scarcity of river sand this current study motivated to substantiate river sand by using waste plastic as fine aggregate.

The application of powdered plastic in building material helps the search for alternative materials in a way to reduce costs and encourage the use of fine aggregates that are environmentally less aggressive. The plastics are characterized by high strength, low weight and as well as by their aesthetic appearances and smooth surface. Hence an attempt on the utilization of waste plastics as fine aggregate is done and its mechanical behaviour is investigated.

Resis *et al*. [1] made a study on partial replacement of aggregates mortar with non-biodegradable plastics. They identified that non – biodegradable plastic aggregate was made up of polyethylene terephalate (PET) from beverage containers are used as a partial replacement of aggregates mortar from about 5 to 20 % with an increment of 5%. A reduction of specific weight from 1810 Kg /m^3 to 1450 Kg / m^3 and improvement of flexural behavior was identified from the study. Yun Wang Choi *et al*. [2] investigated characteristics of mortar and concrete containing fine aggregate from recycled waste polyethylene terephthalate bottles. It also said that the development of lightweight aggregate concrete using fine aggregate from recycled

Corresponding Author: T. Senthil Vadivel, Department of Civil Engineering, Dr. N.G.P. Institute of Technology, Coimbatore - 641 048, Tamilnadu, India.

waste PET bottles. It also says that the WPLA is used in single grade (5-15mm) so that the density of WLPA is decreased by 47% compared with river sand. The addition of WLPA by 25%, 50% & 75% decreases the compressive strength by 6%, 16%, & 30% respectively. And it is also noted that the flow of WLPA mortar is increased proportionally to the proportion of WLPA in the mix and the slump of WLPA concrete increased proportionally.

Saikia and Brito [3], made a research by using plastic waste as fine aggregate in cement mortar and concrete preparation. In this paper the fine aggregate are replaced by various types of plastic by different shapes, when flaky shapes plastic is used, the slump of concrete decreases while the spherical shaped plastic increases it. The concrete containing plastic is more ductile than conventional concrete and it can arrest the cracks generated during mechanical failure of concrete. Concrete shrinkage is considerably increased due to the incorporation of various types of plastic aggregates (Farreiri *et al.*) [4]. Senthil Vadivel and Doddurani [5] utilized PET bottle strips as fiber in concrete with various percentages and concluded that the addition of fibers up to 3% were considerably increase the mechanical properties of concrete.

Material Investigation: An elaborative material study was carried out and is discussed below.

Cement: Cement is a basic requirement for any construction work and also provides a binding medium for the discrete ingredients. In the present study Ordinary Portland Cement of grade 53, confirming to IS: 12269–1987 was used for preparing the concrete. The specific gravity of cement was 3.14.

Fine Aggregate: Natural River sand passing through 4.75mm IS sieve is used for making concrete. As per IS: 383–1970 natural river sand was categorized under grading zone II. The specific gravity and fineness modulus of sand is found to be 2.63 and 2.03.

Coarse Aggregate: Coarse aggregate was passed through 20 mm sieve and retained on 12 mm sieve confirming IS: 383–1970 was used for concreting. The specific gravity and fineness modulus of coarse aggregate is found to be 2.61 and 7.42.

Water: Clean portable water free from suspended particles, chemical substances, biological elements etc., is used both for mixing of concrete and curing.

Plastic Aggregate: Finely grounded plastic waste ranges in size from very fine powder to sand-sized particles were used as fine aggregate which is shown in Fig. 1. Waste plastic materials are collected and are grinded for the use. The grading of plastic aggregates for IS: 383 – 1970 were compared with conventional fine and coarse aggregates. The plastic aggregates behaved quite similar to the normal aggregate which are shown in Fig. 2. Fineness modulus of plastic is 2.99.

Mix Design: The mix design for M30 grade concrete is calculated as per IS 456:2000, IS10262:1982 Table 1.

Specimen Casting: Cube mould of 150 x 150 x 150 mm size, cylindrical mould of 150 x 300 mm size and prism mould of 100 x 100 x 500 mm size were cast. The moulds were placed on an even surface and the materials were mixed in mixer machine. First coarse aggregate and fine aggregate were added and mixed thoroughly in a dry condition then cement and water added to get fresh concrete mix simultaneously powdered plastics were mixed properly. In this project, 5% to 25% of waste plastic has been replaced in the increment of 5% with fine aggregate by weigh batching. Compaction was done for all the specimens using vibrating table. The mould is striped after 24 hours. The test specimens were cured for 7 days, 14 days & 28 days in a curing tank.

Experimental Investigation: The casted specimen were demoulded for determining compressive strength, split tensile strength and flexural strength after a curing period of 7 days, 14 days and 28 days. The results were compared with the strength of conventional concrete. The test set up and failure specimen for compressive strength, split tensile strength and flexural strength test are shown in Fig. 3, 4 and 5.

Compressive Strength Test: Compression test is carried out to find out the compressive strengths of the conventional and WPAC cube specimens by using compression testing machine. The compression test results of the specimen at 7 days, 14 days, & 28 days are shown in Fig. 6.

Split Tensile Test: The split tensile test has been carried out and comparative results of conventional and WPAC are shown in Fig. 7.

Flexural Strength Test: The flexural strength test has been carried out and comparative results of conventional and PFRC are shown in Fig. 8.

Table 1: Quantity of Materials

Cement	Fine Aggregate	Coarse Aggregate	Water
490 kg	793 kg	1151 kg	186 kg

Fig. 1: Powdered Waste Plastic

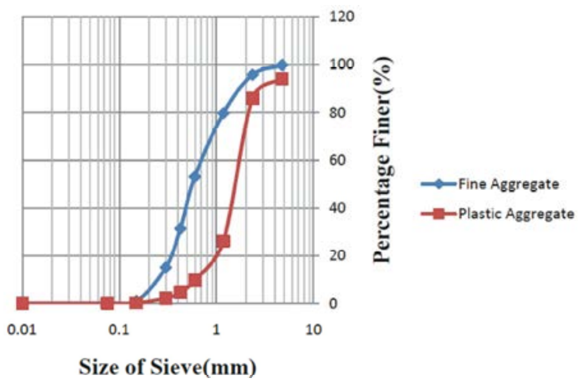

Fig. 2: Grading Aggregate

Fig. 3(a): Compressive Strength Test

Fig. 3(b): Compressive Strength Specimen after Testing

Fig. 4(a): Split Tensile Strength Test

Fig. 4(b): Split Tensile Strength Specimen after Testing

Fig. 5(a): Flexural Strength Test

Fig. 5(b): Flexural Strength Specimen after Testing

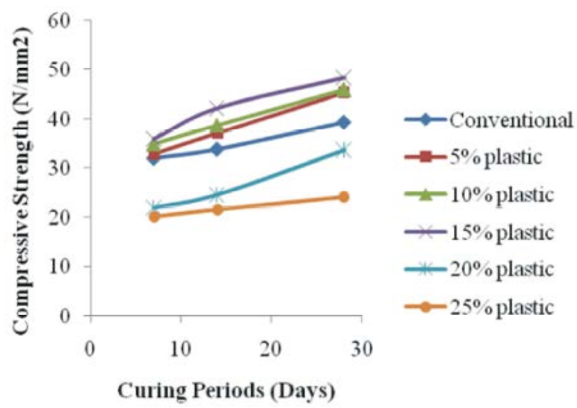

Fig. 6: Comparison of Compressive Strength

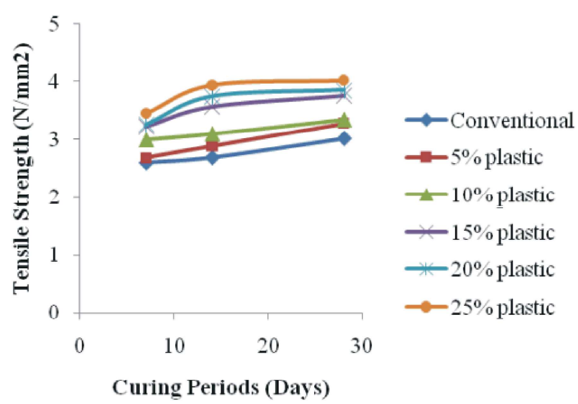

Fig. 7: Comparison of Split Tensile Strength

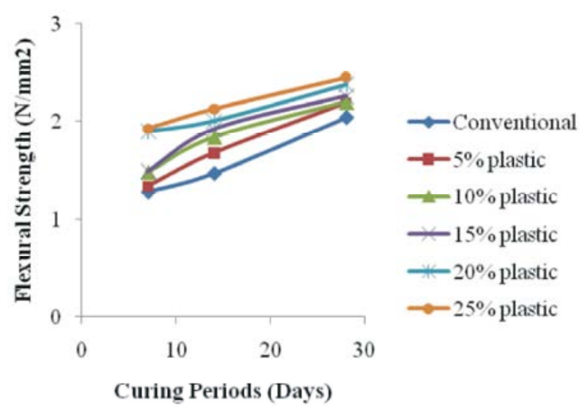

Fig. 8: Comparison of Flexural Strength

RESULTS AND DISCUSSIONS

The compressive strength of WPAC gradually increases up to 15% of waste plastic replacement, after it was found decreased in 20 and 25% (Fig. 6). The performance of 15% replacement of WPAC was highly appreciable than the conventional concrete which produces 19% higher compressive strength. The increment may be the evident of powderised waste plastic which was filled in the porous of concrete specimen, further decrement after 15% is the evidence of optimal usage of plastic in concrete.

According to Fig. 7, split tensile strength of WPAC performed exceptionally well compared to conventional concrete in all the percentages. The 25% replacement of waste plastic provides 24.87% higher split tensile strength than the conventional concrete.

Fig. 8 exhibits the flexural strength of WPAC which performed exceptionally well compared to conventional concrete in all the percentages. The 25% replacement of waste plastic provides 20% higher flexural strength than the conventional concrete.

CONCLUSION

The above said discussions made the authors to derive the following conclusion:

- The compressive strength of waste plastic aggregate concrete is optimal up to 15% after there was a slight reduction in strength was observed.
- All the replacement up to 25% of plastic aggregate performed better than conventional concrete in split tensile and flexural strength of concrete.
- The mechanical properties of waste plastic aggregate concrete increases marginally up to 15% replacement of waste plastic.
- Hence 15% replacement of powdered waste plastic is adequate and optimal solution. The authors suggested that the replacement of powdered plastic waste as fine aggregate is safer up to 15%.
- The utilization of powderised plastic waste will greatly reduce the environmental pollution which leads to the cleaner environment.

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