EXPERIMENTAL INVESTIGATION ON THE PROPERTIES OF CONCRETE REPLACING WASTE PLASTIC AS AGGREGATES FOR SOLVING WASTE MANAGEMENT PROBLEM

Author: Mr. Zubair Ahmad Khan[1] Mr. V. S. Sagu[2]

[1] M. Tech Scholar Student, Department of Civil Engineering, PPIMT, Hisar, Haryana, India

[2] Assistant Professor, Department of Civil Engineering, PPIMT, Hisar, Haryana, India

ABSTRACT

Solid waste management is one of the growing problems of every country. As part of this on-going programme to consider the growing waste management, pollution problem and prevention framework in India, the Ministry for the Environment has suggested various approaches and ways through which we can either recycle or use the most polluting materials like plastic. The present study covers one of the way through which the recycled and one of the polluting plastics as the replacement of coarse aggregates in concrete and concrete related projects. The focus of this experimental study is to investigate the change in the behavior of mechanical properties of bulk concrete with the inclusion of plastics in the percentage replacements of 0%, 4%, 8%, 10% and 16% with the natural aggregate. In addition, a fixed percentage of plastic fibers of 01% for every mix for making the concrete samples .The type of cement used in the current experimentation is OPC 53-grade.

The use of plastic aggregates is found to have contributed and resulted in the formation of lightweight concrete .Cubes and cylinders are casted and tested for compression strength and tensile strength. In addition to compressive strength, the tensile strengths of concrete have also reduced at higher percentages with the introduction of plastic aggregate. The change that is very worth to mention is that within 4% to 8% of proportion by aggregates, the concrete gives very good results. It can act both as an ideal replacement to be used in

structural concrete and generation of a light weighted concrete. Therefore, it can be said that the plastics after recycling can act as a lightweight concrete making.

Key Words: plastic, waste management, lightweight aggregate, workability, compressive strength and tensile strength

1. INTRODUCTION

As construction industry is one of the top most and largest industry in India. It is fifth largest industry in the globe. Demand for new construction is increasing day by day with the rise in population. As the materials used in construction are non-renewable like cement, sand, aggregates etc. The non-renewable aggregate supply has therefore emerged as a concern in India. With the shortage as seen today, the future seems to be darker for the construction sector. Seeking and making aggregates available for construction, new materials have been used and checked in the field to see whether they act as a replacement or not. If yes, then how much and in how much quantity. These are some of the questions that need to be kept in mind. Similarly, an approach needs to develop, to focus on awareness of environment and safeguarding the natural resources. Now waste materials also have been used in the building industry. In India, the quantity of solid waste is rapidly increasing due to the growing population. Among the total solid-waste materials, plastics represent 8 to 10% by weight of the total solid wastes. Ultimately, these non-biodegradable plastic materials will end up as either as landfills or thrown into water bodies

For solving the disposal problem of these materials into earth, it can act as aggregates and reused. The reuse of plastics is one of the feasible applications to reduce deposition. Plastics as aggregates will not be damaged as natural aggregates since plastics belong to polymers of long string molecules of carbon atoms that are bonded

with other atoms such as hydrogen, nitrogen, oxygen, fluorine. They develop crystalline structures, which are considered as more resistant to various chemicals so they are hard and strong too. It would be a boon for the building and construction industry if plastics and plastic-like materials to be used in construction industry.

The present work is aimed at studying the strength of concrete under partial replacement of natural aggregates by plastic aggregates.

1.1 Plastic Waste

Plastics may be defined as the materials that contain one or more high molecular weight polymers. Looking and learning about the global problems of post-consumer plastic waste environmental pollution perspectives, research efforts are been made to consume this waste on a large scale in an environmental responsible manner. Researchers intended to transform plastic waste into concrete as the ingredient, is said to be the second most material consumed by humans after water. The continuous and planned use of plastic waste into concrete in this manner will not only act as a safe disposal method but it may also

enhance the concrete properties like tensile strength, drying shrinkage, chemical-resistance and creep on short and long-term basis. It will also act as an bulk ingredient of aggregates which may solve future scarcity of aggregates

1.2 Why we should use plastics necessarily.

Polymers have a number of important properties, that can be used alone or in mixture make significant, notable and expanding contributions towards constructional needs

- It is economical and has longer life.
- Durable and corrosion resistant.
- Act as an insulator for heat and sound.
- Requires less maintenance.
- Easy to install and process.
- Very light weight.

2 OBJECTIVE OF THE STUDY

The properties of concrete after adding plastics into it to check the following properties:

(a) Compressive Strength after 7 days, 14 days and 28 days of curing.

(b) Tensile strength after 7 days, 14 days and 28 days of curing.

(c) Workability by slump test.

(d) Dry unit Weight Reduction

Apart from the above tests, some of the other properties of concrete will also be taken into consideration such as water-cement ratio, compaction, segregation and bleeding.

3 LITERATURE REVIEW

R.N.Nibuldey, P. B. Nagarnaik et al. (2013) have learned about the strength and fracture properties of M30 concrete by adding waste plastic fibers into it as reinforcement. Various concrete mixes of percentage proportions (0 percent to 3 percent) of waste plastic fibers of two aspect ratios were casted into desired size and shape as per requirements of the test. After 28 days of curing, the workability (slump and compaction factor) decreased when the fiber percentage increased (max. slump for 0% fiber was observed 67mm and 32mm (AR350, 22mm (AR50) respectively. The compressive strength of control (AR35 and AR50) at 1% fiber and then reduced to 31.70 MPa for (AR 35) and 33.19 MPa at (AR 50). The impact on the flexural strength was that the strength of control concrete was 4.99 MPa and it first increased to 5.71 Mega Pascal (AR-35) and 6 Mega Pascal (AR -50) at 1 % fiber content and further reduced to 3.89 Mega Pascal (AR35) and 4.17 Mega Pascal (AR-50).

Mohd Mustafa Al Bakri Abdullah, Mohammad Tamizi Selimin et al. (2011) made an endeavor to use domestic plastic wastes like big trash plastic wastes (HDPE) for the preparation of plastic concrete (PC) . On adding the polymer into concrete, the characteristics of polymer into the concrete were studied. Five different compositions of coarse aggregates with different crushed(pulverized) stone HDPE waste volumetric ratios used were 0:100, 15:85, 30:70, 45:55 and 60:40 .On comparison, the workability and strength properties showed that both

compression and flexural strength decreased as the proportion of plastic waste increased. The concrete containing 60:40 ratio of plastic waste gave the highest strength results.

A. Ashok Kumar and Elango A. in 2018 executed experiments on concrete with plastic-fine aggregates. They used OPC 53 -grade, crushed aggregates and River sand. They used plastic instead of fine aggregates, in proportion of 10perecent, 20percent and 30percent. They checked and tested mechanical properties and durability properties on their concrete perespective samples. The results showed the concrete of lower strength. However, it is found that the concrete shows good results against acid attacks and increase in elasticity. Therefore, they come to an end that the plastic as aggregate concrete can be used as a replacement where we need less strength in compression but more durability

Lhakpa Wangmo ThinghTamang et al. in 2017 performed experiments on Plastics into Concrete as Coarse Aggregate. They performed the tests to check the mechanical properties of concrete containing Plastic aggregates. Aggregates in proportions of 10percent, 15percent, and 20percent were used in their experiment, found marginal reduction in strength, and suggested the optimum result as 15% replacement.

Zainab Z. Ismail, Enas A. Al-Hashmi (2008) conducted various tests of 86 experiments and 254 tests, involving the waste plastic into the concrete mixture. During their whole experiment, thirty kilograms (30Kgs) of waste plastic of fabriform shapes (any shapes or size, may even irregular) was used as a partial replacement instead for sand 0%, 10%, 15% and 20% with eight hundred kilograms of concrete new mixtures. The study and experimentation shows that reusing the unusable plastic as a sand substitution aggregate to the concrete gives a good and improved approach to reduce the material cost and can solve the waste related growing problems.

4 VARIOUS TESTS PERFORMED

- Workability.
- Compressive strength.
- Split tensile strength
- Dry unit weight reduction

5 TEST RESULTS AND DICUSSIONS

Mix Design

Solid mix design of M20 grade controlled concrete as shown table 1, is performed as per IS: 10262- 2009 to obtain M20 grade mix at 0.5 water-cement ratio. For making the mix with plastic aggregate, the amount of plastic is calculated by using the same volume of plastic in place of natural coarse aggregates at different percentages of 0%, 4%, 8%, 12%, and 16% respectively and adding a constant percentage of plastic fibers (1% of wt. of cement) for every mix. The resultant mix proportions of M20 grade concrete and different replacement percentages of plastic wastes are mixed in such a way that equal replacement of volumes should maintain. The control mix is designed as according to the Indian standard code guidelines. The resultant mix proportions of mixes are shown in table 2 as below.

	Water	Cement	Fine Aggregate	Coarse Aggregate
By Weight (Kg)	186	373	682.32	1153.47
By Volume	0.5	1	1.82	3.09

Table 1 Mix design M20

Mix Type	Cement	Fine aggregate	Normal Coarse Aggregate	Plastic Coarse Aggregate	Plastic Fiber	Mix. Ratio Proportions
Control Mix	100% 373	100% 682.32	100% 1153.47	0% 0	0%	1:1.82:3.09:0
Mix-01	100% 373	100% 682.32	100% 1153.47	0% 0	0%	1:1.82:3.09:0
Mix-02	100% 373	100% 682.32	96% 1107.33	4% 46.138	1.0%	1:1.82:2.847:0.12
Mix-03	100% 373	100% 682.32	92% 1061.19	8% 92.2776	1.0%	1:1.82:2.845:0.247
Mix-04	100% 373	100% 682.32	88% 1015.06	12% 138.41	1.0%	1:1.82:2.72:0.371
Mix-05	100% 373	100% 682.32	84% 968.92	16% 184.552	1.0%	1:1.82:2.59:0.494

Table 2 Different Mix Designs

5.1WORKABILTY

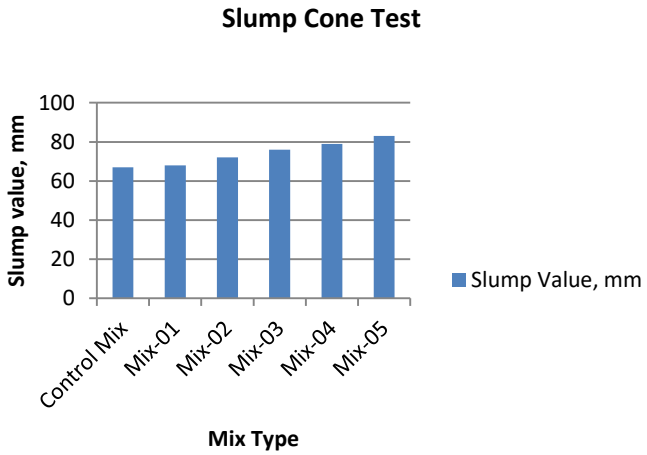
With the use of plastic added aggregates in place of normal available aggregates, the fresh concretes have shown the effects on the slump value. The slump value of the concrete increases with the increase in plastic content in concrete. Hence, the workability enhances. This is due to the face that the plastic aggregates absorb less water as compared to the natural aggregates. This is shown in the fig.1.The results obtained of different mixes and its variations are shown in table 3 and graph 1 respectively as shown below

Fig .1 Slump testing by Slump cone apparatus with different percentages of plastic

S. No.	W/C Ratio	Mix Design	Slump Value(mm)
1	0.5	Control mix	67
2	0.5	Mix-01	68
3	0.5	Mix-02	72
4	0.5	Mix-03	76
5	0.5	Mix-04	79
6	0.5	Mix-05	83

Table 3 Slump test results

The workability of different concrete mixes as shown above in table 3 and graph 1, increases as we increase the percentage of plastics into the concrete mix.



Graph 1 shows variations in slump with different plastic content

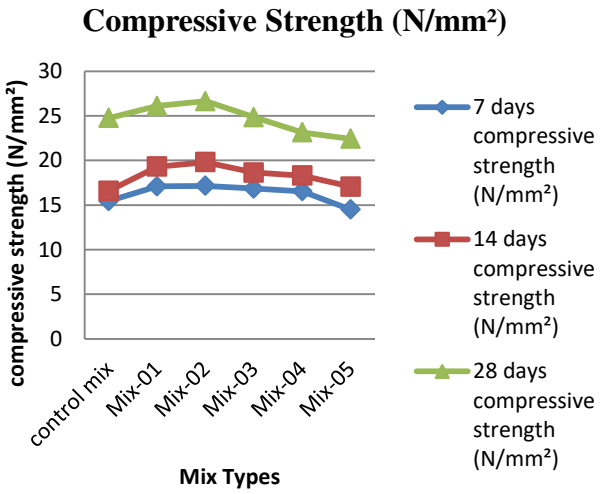
5.2 COMPRESSIVE STRENGTH

Cube moulds of sizes 150mm casted were checked for compressive strength produced by replacing the natural available aggregates by (self-made) plastic aggregates up to 16% after 7 days, 14 days and 28 days gave the following results as stated in table 4.

The compressive strength test results of different mixes are shown in table 4.As we can see from the table that as we tend to increase the percentage of plastic aggregates the compressive strength first increases a little, but as we go on increasing the quantity (percentage) of plastics, the compressive strength decreases. The compressive strength variations are shown in graph .2

S. No.	Mix	Compressive Strength(N/mm^2)		
		7 days	14days	28days
1	Control mix	15.45	16.60	24.75
2	Mix-01	17.10	19.30	26.10
3	Mix-02	17.15	19.80	26.65
4	Mix-03	16.85	18.65	24.84
5	Mix-04	16.55	18.30	23.15
6	Mix-05	14.50	17.06	22.43

Table 4 Compressive strength test results after 7 days, 14 days and 28days



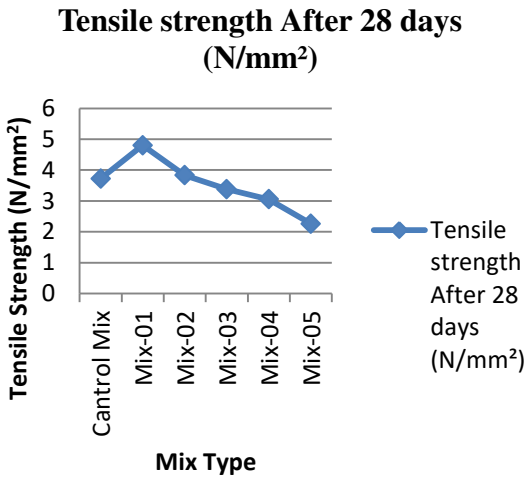
Graph.2 showing variations in compressive strength after 7 days, 14 days and 28 days

5.3 SPLIT TENSILE STRENGTH

The calculation procedure of split tensile strength test is very much similar to the compressive strength test. The proportioning of materials for the split tensile test was made similar to the compression test. To conduct this test, cylindrical molded specimens of size 150mm diameter × 300 mm height were casted. The current test was conducted at the end of 28 days of curing. The different test results are enlisted in table 5 and its variations as per proportions are shown in graph 3 below

S. No.	Mix type	Tensile strength after 28days(N/mm^2)
1	Control mix	3.72
2	Mix-01	4.08
3	Mix-02	3.83
4	Mix-03	3.38
5	Mix-04	3.05
6	Mix-05	2.26

Table 5 tensile strength test results



Graph 3 Showing variations of tensile strength after 28 days

As per the above graph, it is evident that the tensile strength of cylinder first increases and as we go on increasing the percentage of plastics into the concrete, the tensile strength noticeably decreases From this experimental investigation, we can say that though the concrete properties does not enhance, yet within certain limit we can use plastics into the concrete which may help in reducing the problems of solid waste management and thereby will solve the problems of environmental pollution

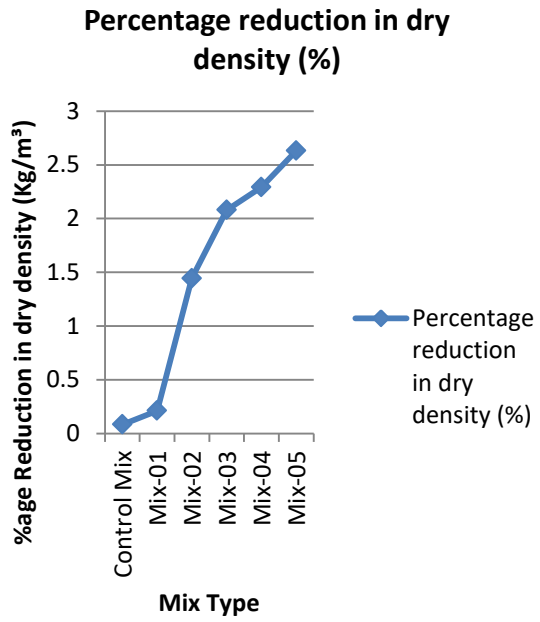
5.4 DRY DENSITY

From the tests conducted on the different cubes taken after proper curing, just before the compressive strength test. The values of dry density obtained from the control mixes and the partially replaced plastic concrete as shown in the figure 4 for 0.5 water-cement ratio. It is found that the unit weight of them gets considerably decreased as compared to the control mix concrete cubes. The water-cement ratio does not affect the unit weight that much, but we have seen that as we increase the quantity of plastic as aggregate, the unit weight gets reduced considerably. From the tests, it is found that the plastics as the replacement reduces the unit weight and concrete can act as the lightweight concrete. For the accuracy of the results, three samples of the control mix concretes and three samples of plastic replaced concretes were casted and then

tested. The average of the three was taken as the result. The results of the unit weight of control and plastic replaced concretes are shown in table 6. In order to compare the effect of plastic with normal aggregate, the percentage reduction in the unit weight of concretes obtained by using plastics as aggregates is found. It can be examined from the table that with the usage of plastic, the dry density reduced in all percentage mixes, at all water-cement ratio. The density reduced was nearly 35% in all mixes. The whole reduction in density is all due to the lower density of plastic aggregates.

Dry density of concrete(kg/m3)		Percentage reduction in dry density (%)
Control mix	Plastic used concrete	
2356	2352	0.084
2356	2350	0.212
2356	2322	1.443
2356	2307	2.079
2356	2302	2.292
2356	2294	2.631

Table 6 Dry density of control concrete and plastic added concrete



Graph 4 Between dry density reduction % and plastic %(mix type)

6 CONCLUSIONS AND FUTURE SCOPE

Conclusions

Below mentioned conclusions are obtained based on the current research

- Plastic has the ability to be used in the concrete as an aggregate. This will result in the reduction of unit weight of the concrete which has a great application in making light weight concrete like light weight concrete frames, wall elements, concrete panels in walls and frame facades
- With the given and selected water-cement ratio, the introduction of plastics in the concrete mix results decreasing the compressive strength, density and tensile strength of concrete. Showing good results at 4% to 8% of replacement
- The selected water-cement ratio impact on the strength development is not prominent in case of plastic concrete. The failure of concrete will be due to the failure of bond between cement paste and plastic aggregates
- The addition of recycled waste plastic in the concrete buildings under investigation has shown an advantage from the thermal resistance viewpoint. The effective use of plastic aggregates may help the interior environment of buildings cooler as compared to the normal concrete.
- With the use of plastics in concrete in effective manner, there are increasing chances of concrete to show early
- signs before failure. This characteristic of the plastic concrete makes the concrete very useful in circumstances where it is subjected to severe and harsh weather such as freezing, thawing, contraction and compaction.
- Based on the research results, it can be deduced that the plastics in concrete is not a good material as the strength perspective as it decreases both compressive as well as.

Future Scope

- Effect of plastic in the concrete decreases the compressive strength; various materials combined with plastics needs to be studied so that it will not impact on the strength criterion.
- Effects on durability and overall bulk of the concrete needs to be studied
- Study must go on other wastes as well so that the problem of waste disposal on land and water can reduce.

REFRENCES

1) R.N.Nibuldey, P.B. Nagarnaik, D.K.Parbat, A.M.Pande, "Strength and Fracture properties of Post Consumed Waste Plastic Fiber Reinforced Concrete" International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD),ISSN 2249-6866.Vol.3,Issue 2,June 2013,9-16

2) Mohd Mustafa Al Bakri Abdullah, Norazian Mohamed Noor, Che Mohd Ruzaidi, H. Kamarudin "Effects of HDPE Plastic Waste Aggregate on the Properties of Concrete" http://www.researchgate.net/publication/202057106, Conference Paper, January 2008.

3) Elango A and Ashok Kumar A " Study on Partial Replacement of plastic waste as fine aggregate in concrete" International Journal of Current Engineering And Scientific Research, Volume 5, Issue 5, 2018, ISSN (Print):2393-8374, ISSN (Online): 2394-0697

4) Lhakpa Wangmo ThinghTamang, Tshering Wangmo, Karma TsheringDarjay, Karma Sangay Phuntsho, Phuntsho Namgyal, Ugyen Wangchuk "Use of Plastics in Concrete as Coarse Aggregate" International Journal of Education and Applied Research, Volume 7, Issue 5, 2017, ISSN (Print) 2249-4944, ISSN(Online) 2348-0033.

5) Boutemeur R., Taibi M., Ouhib, N., Bali, A., 2004, "Investigation of the use of waste plastic as aggregate for concrete" In: International Conference, Sustainable Waste Management and Recycling: Challenges and Opportunities, 14–15. Thomas Telford Publishing, Thomas Telford Ltd., London, ISBN 0727732854.

6) Praveen Mathew, Shibi Varghase, Thomas Paul ,Eldho Varghase, " Recycled Plastic as coarse aggregates for structural concrete", International Journal for Innovative Research in Science, Engineering and Technology, Volume 2, Issue 3, 2013, ISSN 2319-8753

7) Raghatate Atul M., "Use of plastic in concrete to improve its properties", International Journal of Advanced Engineering Research and Studies, Volume 1, Issue 3, 2012, ISSN 2249-8947

8) S. Vanitha, V. Natrajan and M Praba" utilization of waste plastic as a partial replacement of coarse aggregates in concrete Blocks" Indian Journal of Science and Technology, Volume 8, Issue 12, 2015, ISSN (Print) 0974-6846, ISSN (Online) 0974-5645

9) Dr M. Vijaya Sekhar Reddy, D. Mrudula, M. Seshalalitha, Strength and Density Characteristics of Light Weight Concrete by Using HDPE Plastic Waste, International Journal for Research in Applied Science & Engineering Technology (IJRASET), ISSN: 2321-9653, Vol. 3, Special Issue-1, May 2015, pp. 149-152

10) Daniel Yaw Osei, " Experimental investigation on recycled plastics as aggregate in concrete", International Journal of Structural and Civil Engineering Research, Volume 3, Issue 2, 2014, ISSN 2319-6009

11) Subramani and V K Pugal, " Experimental study on Plastic waste as a coarse aggregate for structural concrete", International Journal of Application or Innovation in Engineering & Management, Volume 4, Issue 5, 2015, ISSN 2319-4847

12) Manhal A Jibreal and Farah Peter, "Strength and Behavior of concrete contains waste plastic", Journal of Ecosystem and Ecography, Volume 6, Issue 2, 2016, ISSN 2157-7625

13) IS: 2386 (Part 1) - 1963 (Reaffirmed 1997), Indian Standard code of practice- methods of test for aggregates for concrete, Bureau of Indian Standards, New Delhi, India.