INTERNATIONAL JOURNAL OF ADVANCE RESEARCH AND DEVELOPMENT

(Volume3, Issue7)

Available online at: www.ijarnd.com

Study the effect of plastic waste on strength of concrete

Gopal Swarup Sangal

Student, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh

ABSTRACT

In this era of Global Warming, the increase in plastic waste has become a major concern in our society. The influence of plastic waste can be minimized by using them in the concrete. The plastic can lead to the increment in the strength of the mix. The objective of this research is to investigate the effectiveness of using waste plastic as the fine aggregate replacement in concrete mixtures. The compressive and tensile strengths of various concrete specimens were tested to determine how the replacement of fine aggregate by plastic waste would affect the development of strength in the mixes. For different plastics, the different methodology was taken into the consideration. For plastic bottle mix concrete, the size of the bottle had an impact on strength. Both the strength, i.e., compressive and tensile increased due to it. By using the plastic bag and seat, the compressive strength decreases while tensile strength increases while by using PVC in concrete, both the strength increases. The 10% replacement level only showed a 15% loss of compressive strength at 28 days compared to the control. Despite being much weaker in compression, the tensile strength test showed that 10%, 20%, and 30% replacements were stronger in tension compared to the control.

Keywords: *Compressive Strength, Concrete, Non-Biodegradable, Polyvinyl chloride (PVC), Pollution, Tensile Strength*

1. INTRODUCTION

Plastics have been with us for more than a century, and by now they're everywhere, for good and for ill. Plastics, a versatile material and a friend to common man become a problem to the environment after its use. Plastic pollution involves the accumulation of plastic products in the environment that adversely affects wildlife habitat, aquatic life, humans and unfavorably affects lands, waterways, and oceans. The threat of disposal of plastic will not solve until the practical steps are not initiated at the ground level. It is possible to improve the performance of concrete mixtures used in the building. Studies reported in the use of recycled plastic, mainly polyethylene, in the manufacture of blended indicated reduced permanent deformation in the form of rutting and reduced low - temperature cracking of the surface of the building. The field tests withstood the stress and proved that plastic wastes used after proper processing as an additive would enhance the life of the building and also solve environmental problems. Plastic is a very versatile material. Due to the industrial revolution, and its large-scale production plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, electronics, electrical, building construction, communication sectors has been virtually revolutionized by the applications of plastics. Plastic is a non-biodegradable material and researchers found that the material can remain on earth for 4500 years without degradation. Several studies have proven the health hazard caused by the improper disposal of plastic waste. The health hazard includes reproductive problems in human and animal, genital abnormalities etc. The municipal solid waste is either incinerated or landfilled. Both disposal methods are not the best ways to dispose of the waste and it causes both land and air pollution

2. SCOPE

Our Country, as well as whole World, produces the plastic in a very gigantic manner, so there is a very huge scope of using plastic waste in the construction of the building by mixing it in the concrete mix. Plastic is a non-biodegradable material and if we want to degrade it, it will take around 46oo years to get it to degrade, therefore using it in a building can reduce it and also can save the environment from getting polluted.

3. TYPES OF PLASTIC

i. Thermosets Plastics - Thermosets Plastics are those types of plastics which remain in a permanent state once it is hardened. Due to this, it can withstand high temperature without losing austerity.
ii. Elastomer plastics - Elastomer Plastics are those types of plastics which cannot melt and turn into a gaseous state.
iii. Thermoplastic Plastics - Thermoplastic Plastics are those types of plastics which can be re-melted and can change its shape on heating. Examples of thermoplastic polymers include polyethylene, PVC, and nylon.

4. USE OF PLASTIC IN A CONCRETE MIX

The Indian concrete industry is today consuming about 400 million tonnes of concrete every year and it is expected, that this may reach a billion tonnes in less than a decade. The plastic is one of the recent engineering materials which have appeared in the market all over the world.

It is estimated that on an average 25% of the total plastic production in the world is used by the building industry. The per capita consumption of plastics in the developed countries ranges from 500 to 1000N while in our country, it is only about 2N. There is, however, no increase in awareness regarding the utilization of plastic as a useful building material in our country.

Four types of plastic materials were selected to mix along with the concrete: (1) Polythene Sheet (2) Raw Plastics (3) Road Wastes (4) Plastic Straw to study their behavior in conjunction with concrete. The properties of the materials used in the present investigations were completely studied and the optimum mix of the above plastic materials was found based on their compressive, split tensile, flexural strengths. After finding the optimum mix percentages in compression, RC columns were cast and tested for its compressive strength. From the investigation, the road waste mixed concrete was found to take more loads in compression. Raw plastic mixed concrete, as well as plastic straw mixed concrete, were also found to give better strength than the reference RC column.

5. CHEMICAL DECOMPOSING

Chemical decomposing is a very effective solution to plastic pollution, as the non-biodegradable property of plastic is the main cause of plastic pollution. However, no technology has been developed yet to set up an economical and effective large-scale plastic decomposing facility. But chemical decomposing is still a field that has a great potential to develop in the future.
There are mainly two ways to decompose conventional plastics. Decomposing plastics by microorganisms is one of them. Another way to decompose plastics is by combustion. This is a relatively easy and inexpensive way compared to using microorganisms, however, odor and toxic gases produced during combustion is a big problem.

6. TEST ON CONCRETE

Table 1: Compressive strength of concrete at various ages

Age	Strength percent
1	16
3	40
7	65
14	90
28	99

The strength of concrete increases with age. The table shows the strength of concrete at different ages in comparison with the strength at 28 days after curing.

Table 2: Compressive strength of different grades of concrete at 7 and 28 Days

Grade of concrete	Minimum compressive strength (mpa) at 7 days	Specified characteristic compressive strength (mpa) at 28 days
M 15	10	15
M 20	13.5	20
M 25	17	25
M 30	20	30
M 35	23.5	35
M 40	27	40
M 45	30	45

Tensile Strength Test

Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied to load itself.
The tensile strength of concrete is very low as compared to the compressive strength of concrete. It is generally $1/10^{th}$ of compressive strength.

Due to difficulty in applying uniaxial tension to a concrete specimen, the tensile strength of the concrete is determined by indirect test methods, namely:

- **Split Cylinder Test:** It is a method used to determine the tensile strength of concrete. An indirect test for tensile strength of concrete established originally in Brazil, has recently come into rather general use and standardized (ASTM C496-62T). The specimen is kept in the conventional 100 mm × 200 mm, cylinder. The cylinder is loaded in compression along two axial lines which are diametrically opposite through bearing strips of plywood. The plywood cushion distributes the compressive load over a small width which is sufficient to avoid undue concentration of stress, and it compensates for surface irregularities. The compressive force produces a transverse tensile stress which is practically constant along the vertical diameter.
- **Flexural Test:** Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand a failure in bending. The results of the flexural test on concrete expressed as a modulus of rupture which denotes as in MPa or psi. The flexural test on concrete can be conducted using either a three-point load test (ASTM C78) or center point load test (ASTM C293). The configuration of each test is shown in Figure-2 and Figure-3, respectively. The test method described in this article is according to ASTM C78.

7. CONCLUSION

In my research work, a number of practicals were conducted on plastic mixed concrete and analyze of that take place. These practical consists of various plastics as discussed above and their effect on concrete were noted down according to the

replacement of sand (fine aggregate) by plastic in different ratio. Some plastics had lead to the increment in the compressive strength of the mix while some lead to the decrement in the tensile strength. The plastics out of the various types of plastics which exist in nature were used. These plastics were Plastic Bottles, Plastic Bags, Polyvinyl chloride pipes and the plastic seats, also known as Polypropylene fiber. The conclusion of the use of this different plastic on concrete is discussed below in a detailed manner.

Plastic Bottles: The use of plastic bottles in the concrete mix increased the strength as the size of bottles kept on increasing. It tends to increase the compressive as well as the tensile strength which means it makes the structure more flexible and also one can decrease the use of the reinforcement to a certain level which ultimately can reduce the budget of the construction cost.
From above analyze, one can observe that as the size of the bottle in a mix increases, the compressive strength increases which are shown below in the table below:

Table 3: The compressive strength of plastic bottle mixed concrete

Compressive strength (mpa)	Size of bottle (ml)
7.5	250
12.5	500
19.9	1000
21.1	1500
22.3	2000

The development of compressive strength of concrete containing all types of PET-aggregates is similar to conventional concrete, though this incorporation significantly lowers the compressive strength of the resulting concrete.

Apart from compressive strength, tensile strength also increases which leads to the flexibility in the structure. As we had seen in the practice that for 1000 ml bottle, the tensile strength at 28 days is 1.7 MPA. As the size will increase. The tensile strength will increase which finally helps in the work of the construction. The splitting tensile and flexural strength of concrete containing any type of PET-aggregate is proportional to its loss of compressive strength.

Table 4: Splitting Strengths of concrete mix with 1000 ml plastic bottle

Curing period (Days)	Splitting Strength (mpa)
3	0.55
7	0.82
28	1.7

Plastic Bags: The plastic bags were used as a sand replacement in the ratio of 1%,3%,5%,10%.The use of plastic bags in the concrete mix leads to the reduction in the compressive strength while it increases the tensile strength(both split tensile strength and flexural strength), which means that more strong concrete mix will be required if the plastic bag is used in the concrete mix and the flexibility will increases in the structure as the tensile strength is increased and it can withstand the effects of the earthquake.

Table 5: Compressive Strength of plastic bags mixed concrete

% of added plastic waste	FCU (mpa) at 7 days	FCU (mpa) at 28 days
1%	13.42	19.88
3%	13.22	19.47
5%	13.05	18.56
10%	12.33	16.46

Table 6: The Splitting tensile strength of plastic bags mixed concrete

% of added plastic waste	FCT (mpa) at 7 days	FCT (mpa) at 28 days
1%	1.38	1.989
3%	1.41	1.996
5%	1.47	2.002
10%	1.51	2.11

Polyvinyl Chloride pipes (PVC): The addition of PVC into the mix leads to the increase in the compressive strength as well as the tensile strength. The strength and durability characteristics of concrete mixtures have been computed in the present work by replacing 15%, 20%, 25% PVC with the sand. After adding PVC at various percentages in the mix, there is an increase in strength after 7and 28 days as compared to the normal mix. By adding 15%PVC, the compressive strength of concrete at 7 days increases by 27% and 59% at 28 days of testing, this indicates that compressive strength increases by the addition of polyvinyl chloride pipes. The compressive strength tends to increase with increasing percentages of PVC in the mix.

The split tensile also tends to increase with an increasing percentage of PVC in the mix. After adding PVC in the mix, there is an increase in strength than the normal concrete, After 7 and 28 days of testing. By adding 15% PVC, split tensile strength of concrete at 7 days increases by 8% and 18% at 28 days of testing, this indicates that compressive strength increases by the addition of polyvinyl chloride pipes. Both the tests are tabulated below in Table 7 and 8 respectively.

Table 7: The Compressive strength of PVC mixed concrete

% added plastic in the mix	FCU (MPA) at 7 days	FCU (MPA) at 28 days
15%	25.4	31.8
20%	26.2	32.2
25%	27.4	33.1

Table 8: Splitting Tensile strength of PVC mixed concrete

% of added plastic in the mix	FCT (MPA) at 7 days	FCT (MPA) at 28 days
15%	2.49	5.08
20%	2.36	4.75
25%	2.79	3.89

Plastic Seats: The addition of plastic seats in the concrete mix leads to in the compressive strength. Addition of the polypropylene fiber (Plastic seats) in the concrete mix has a little effect on its compressive strength. With increasing fiber content, the compressive strength of concrete decreased slightly. At 1.5% addition, it increases slightly and then decreases as it increases to 2 and 3%. At 1.5%, it is 14.5 and then it decreases gradually.

It was seen that the addition of the plastic seats in the concrete mix leads to the increase in the tensile properties of the concrete. The tensile splitting strength of concrete was found more than the normal (0% fiber) concrete with fiber addition up to about 0.25% above which the tensile strength was found lower than the control concrete.

The compressive strength and Tensile strength of Plastic seats mixed concrete are tabulated below in Table 9 and 10 respectively.

Table 9: The compressive strength of plastic seats mixed concrete

% of added plastic	FCU (MPA) at 7 days	FCU (MPA) at 28 days
1	14.41	22.31
3	13.47	19.4
5	11.21	18.2
10	9.8	16.6

Table 10: Splitting tensile strength of plastic seats mixed concrete

% of added plastic	FCT (MPA) at 7 days	FCT (MPA) at 28 days
1	1.441	2.00
3	1.347	1.74
5	1.12	1.58
10	1.05	1.37

8. REFERENCES

[1] Al-Manaseer, A. A., Dalal, T. R., Concrete containing plastic aggregates, Concrete International, 1997, 19(8), pp.47-52.
[2] ASTM C39 / C39M-14a, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens,
[3] ASTM International, West Conshohocken, PA, 2014.
[4] 3-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.
[5] Ismail, Z. Z., Al-Hashmi, E. A., Use of waste plastic in the concrete mixture as an aggregate replacement, Waste
[6] Management, 2008, 28, pp.2041-2047.
[7] 5-IS: 456 (2000), "Plain and Reinforced Concrete Code of Practice", Bureau of Indian Standards.
[8] IS 10262 (1982), "Recommended Guidelines for Concrete Mix Design", Bureau of Indian Standards.
[9] IS 383-1970, Specification for coarse and fine aggregate from natural sources for concrete (second revision), Bureau of Indian standards, New Delhi, India.
[10] Kayali O, 2008. Fly ash lightweight aggregate in high-performance concrete. Construction and building materials, 22:2393-2399.
[11] M.S. Shetty (2009), "Concrete Technology Theory and Practice" Published by S.Chand & Company.
[12] Parveen, Sharma, A., 2013. Structural behavior of fibrous concrete using polypropylene fibers. Int. J. Mod. Eng. Res. 3 (3), 1279–1282.
[13] Ramaraj A, Nagammal J (2014). Exploring the Current Practices of Post Consumer PET Bottles and the
[14] Innovative Applications as a Sustainable Building Material–A Way Ahead. 30th INTERNATIONAL PLEA CONFERENCE16-18 December 2014, CEPT University, Ahmedabad.
[15] Raut A, Patel MS, Jadhwar NB, Khan U, Dhengare SW (2015). Investigating the Application of Waste
[16] Plastic Bottle as a Construction Material- A Review. Journal of the International Association of Advanced Technology and Science, 16.
[17] Siddique R, Khatib J & Kaur I, 2008, 'Use of recycled plastic in concrete: a review' *Waste Manage, vol.* 28, pp. 1835–1852.
[18] Sikalidis CA, Zabaniotou AA & Famellos SP, 2002, 'Utilization of municipal solid wastes for mortar production, *Resour, Conserv Recycl*, vol. 36, no. 2, pp.155–167.

