STRENGTH AND DURABILITY PROPERTIES OF CONCRETE INCORPORATING PLASTIC WASTE: A REVIEW

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Abstract :A major concern these days is the disposal of plastic wastes. These wastes are non-biodegradable in nature bringing about ecological infirmity and cleanliness problems. The reason for this review study was to resolvethe solid wasteissuescreated by plastics. This review paper present the plastic waste utilization in concrete for making concrete more economical and light weight on the other hand it is viewed as the best ecological option for taking care of the issue of waste disposal. This review paper shows a detailed review about utilization of plastic waste in concrete and mortar. The influence of plastic on varied strength and durability properties (impact resistance, acid attack and carbonation depth) of concrete and mortar is discussed in this paper.

***Keywords* - plastic waste, compressive strength, impact resistance, acid attack, carbonation depth, sustainable environment**.

1. INTRODUCTION

Numerous waste generated today will stay in nature for hundreds and may be a large number of years. Plastic, a standout amongst the hugest developments of twentieth century, plastic is a worldwide material. Plastic waste isdiscovereverywhere on the globein recent years. A colossal progress within the consumption of plastic is found all over the arena in contemporary years, which additionally raises the creation of plastic-associated waste. The generation of waste plastics is expanding very rapidly [1]. Consumption of plastics in India can growfifteen million tonnes by 2015[2] and is set to be the third biggest shopper of plastics on the planet. The plastic waste is nowa heavyenvironmental threat to modern civilisation. Plastic is composed of a number of poisonous chemical compounds, and for this reason plastic contaminates environment. Plastic is a non-biodegradable fabric and researchers determined that the material can stay on this planet for 4500 years without degradation. Land-filling using plastic would mean keeping the unsafe fabric forever [3-4].Plastics don't decay normally thus elective techniques should be executed [5]. On the other side cement concrete is prime material in construction industry but in the meantime it is an ecological concern, as it generates perilous gases in various stages of production, with growing demand to control contamination and utilize squander materials from various enterprises [6]

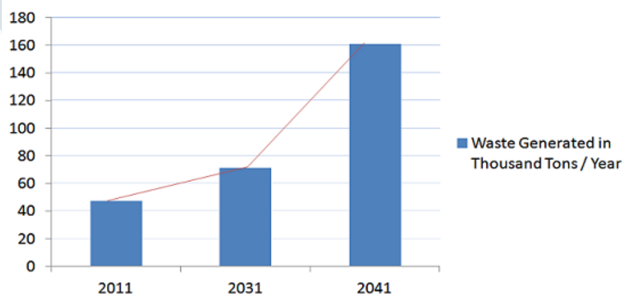

Fig.1. Generation of plastic waste in thousand tons/year [7]

1.1 Scenario and Adverse effect of Plastic waste

Plastic is very commonly used material, quite often used form of plastic are carry baggage, cups, water bottle packing material etc. made up of polyethylene, polypropylene or polystyrene. Other moulded plastic created from poly ethylene terepthalate (PET) and poly vinyl chloride (PVC). In 2007, a world's annual consumption of PET drink covers of roughly 10 million tons, which shows 250 milliards bottles approximately [8].Waste PVC was gathered from residential waste, mineral water jugs, MasterCard's, toys, pipes and canals, electrical fittings, furniture, organizers and pens, restorative disposables and so forth. There are many uses of plastics as structural materials and road materials. Waste plastic utilize in road construction work it increased its resistance and performance [9].Plastics will expand the softening point of the bitumen [10] in some cases it also increased its fatigue resistance [11-12].

2. PROPERTIES OF CONCRETE CONTAINING PLASTIC WASTE

2.1 Compressive Strength

Mohammadhosseini et al., 2017[13] Obtained the compressive strength of concrete containing polypropylene carpet fibre at various volume fractions ranging from 0.25% to 1.25%. Results showed decrement in compressive strength when carpet fibre content was increased. Reinforcement of plain concrete with carpet fibres resulted in decrease by 6%, 7.5%, 11.15%, 18.06% and 21.23% in cube compressive strength of mixture with carpet fibre content of 0.25%, 0.5%, 0.75%, 1.0% and 1.25% respectively. Reason behind this behaviour of concrete was presence of voids due to the addition of carpet fibre and existence of weak interfacial bonds among the carpet fibres and cement particles.

Al-Tayeb et al., 2017 [14] investigated the behaviour of concrete by replacing sand with waste plastic, result shown systematic reduction in concrete compressive strength with the increase of plastic content. The initial 28-day compressive strength of almost 43 MPa decreased to about 26 MPa when 15% replacement of sand by plastic waste was made as shown in table 1. The compressive stress is reduced by 21%, 33% and 40% with the sand replacement by plastic by 5%, 10%, and 15% of volumes, respectively.

Table 1Compressive strength after replacement of sand by plastic waste.

S.No	Plastic percent %	Average compressive stress (Mpa)
1	0	43
2	5	34
3	10	29
4	15	26

The reduction of compressive strength of concrete was associate to the weak compressive strength of the plastic particles compared to the compressive stress of the natural sand. In addition to that the frail bond between plastic particles and the concrete glue and the deformability of the plastic particles, which result in the start of breaks around the plastic particles.This diminishment may likewise be because of evaluating, as the molecule size of sand utilized as a part of this examination was littler than the molecule size of the plastic waste which increased the voids between the aggregate.

2.2 Impact Resistance

Mohammadhosseiniet al., 2017 [13] investigated the influence of polypropylene carpet fibre at various volume fractions ranging from 0.25% to 1.25% on impact resistance of concrete incorporating 20% Palm oil fuel ash was investigated.The impact resistance of concrete for different volume fractions of polypropylene fibre was investigated through the number of hammer blows necessary to obtain the initial crack (N1) and failure (N2) of the concrete disk. It has been found that, with the addition of polypropylene carpet fibres into the concrete mixtures, the number of blow for the first crack was increased by 54%, 158%, 221%, 300% and 367% for B1 to B6 mixes, respectively. The inclusion of carpet fibre also raised the percentage rise in the number of post-first-crack blows to failure value over the specimens made without fibre. This indicates that the carpet fibre greatly reduced the brittleness of the concrete mixture. The combined effect of carpet fibre and palm oil fuel ash improved the impact resistance of concrete.From the Fig 2 it has been shown that replacement of POFA in carpet fibre reinforced concrete, the impact resistance decreased. This may be the effect of lower strength development due to slower pozzolanic action of POFA. However, a positive interaction has been shown to occur between the POFA and fibres, in the sense that the combination of fibre and POFA exhibited a higher resistance in terms of the number of blows and energy absorption when compared to that of control OPC concrete alone.

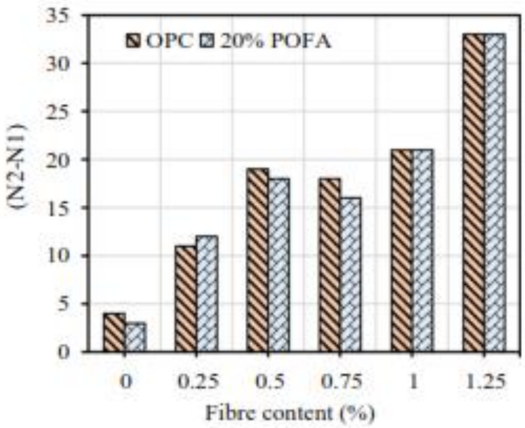

Fig. 2. Variation of impact resistance with plastic fibre

Al-Tayeb et al., 2017 [14]investigated the ultimate failure resistance of concrete with 5%, 10% and 15 % of sand replacements by waste plastic of vehicles under impact. The number of blows of the hammer required to induce the ultimate failure of the cubes were recorded as shown in fig. 3.

The ultimate failure resistance increases by 21, 52 and 81% with 5, 10, and 15 % of plastic replacements respectively. The enhanced ultimate failure impact resistance is due to the enhanced flexibility of the composite mix by the addition of plastic. The enhanced ultimate failure impact resistance is due to the enhanced flexibility of the composite mix by the addition of plastic. The increases in flexibility are attributed to the high ductility of plastic which when added to the concrete, improves the mix ductility and the ability to absorb the impact load.

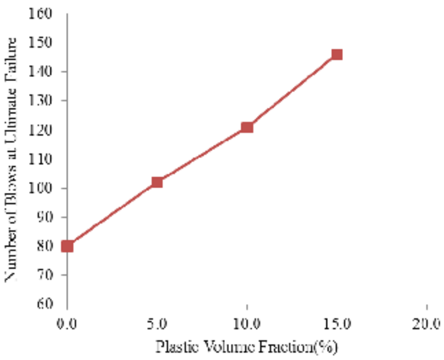

Fig.3 Ultimate failure impact resistance against volume fraction of plastic.

Bhogayata et al., 2018 [15] studied the strength and durability properties of concrete reinforced with metalized plastic waste fibers generated from the discarded food packaging plastics. In this study drop weight hammer test was employed to obtain the response of hardened concrete consisting MPW fibers (Fig 4.) , subjected to the impact loading. Impact load test was carried out on concrete disks of 165 mm and 65 mm in the diameter and thickness respectively as per ACI 544 committee. The results revealed that the conventional concrete developed the initial and final cracking with fewer numbers of the blows than the concrete reinforced with MPW fibers. Type B and C fibers demonstrated better impact resistance compared to type Afibers as shown in Figs. 5– 7.

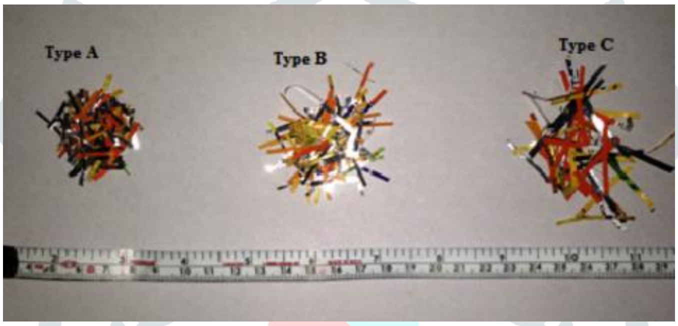

Fig.4 MPW fibers (Type A-5mm, Type B-10 mm, Type C-20 mm).

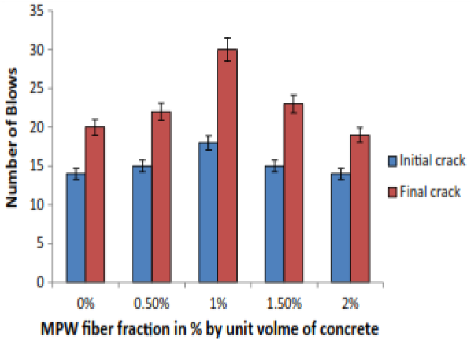

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Fig.5 Impact load cracking response by MPW fibre type A

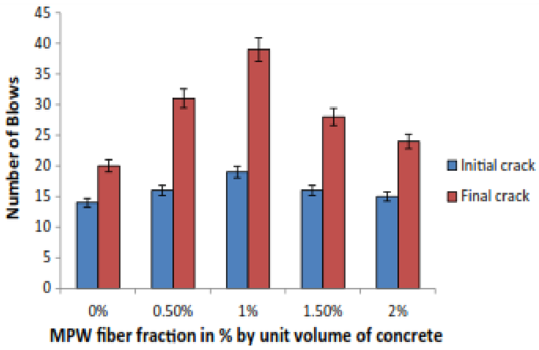

Fig.6 Impact load cracking response by MPW fiber type B

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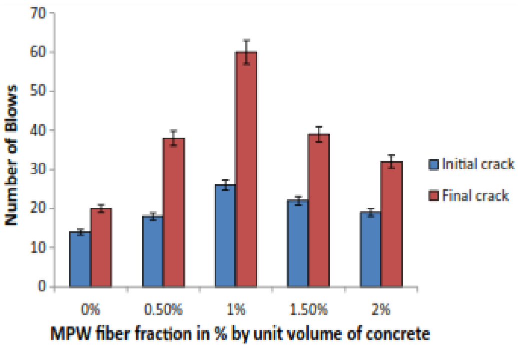

Fig.7 Impact load cracking response by MPW fiber type C

The impact strength of concrete influenced by the length of the MPW fibers for a given dosage. The MPW fibers type C with 20mm length effectively improved the impact resistance by enhancing the crack resistance and stress distribution amongst the hardened concrete constituents.

The ductility and deformation of the plain conventional concrete were improved due to the addition of MPW fibers. However, the short length and medium length fibers with 5 mm and 10 mm length respectively enhanced the impact resistance at the reduced rate. For all impact load test conditions, the concrete specimens reinforced with MPW fibers showed the good development compared to the control specimens.

2.2 Acid Attack Test

Araghi et al. 2015 [16] studied the concrete mixes modified with PET (Polyethylene Terephthalate) at different replacement level of 0%, 5%, 10%, and 15% as an alternative of aggregate. Mix proportion was shown in table 2.All of samples were cured at 20° C and 95% RH for 28 days and finally 3 samples of each mix design were tested.eight changes in samples with higher percentage of PET particles is decreased. So that, in samples included 0%, 5%, 10%, and 15% of PET particles, 13.45, 10.26, 8.98, and 6.57 percent decrement in weight was occurred, respectively in comparison with their weight after 28 days curing as shown in Fig 8. From the test result it has been found that the weight loss values for samples modified at 0%, 5%, 10%, 15% by PET particles are 13.47%, 10.26%, 8.98%, 6.57%, respectively. From the test result it can be concluded that samples with 15% of PET particles have lower weight losses and better resistance against sulfuric acid attack.

Table 2 Mix proportion of concreteW/C -0.54, Content (kg/m^3)

S.No	Component	0% PET	5% PET	10% PET	15% PET
1	Cement	379.6	379.6	379.6	379.6
2	Water	210.2	210.2	210.2	210.2
3	Gravel	976.1	976.1	976.1	976.1
4	Sand	745.9	708.6	671.3	634
5	PET	-	10	20.1	30.1

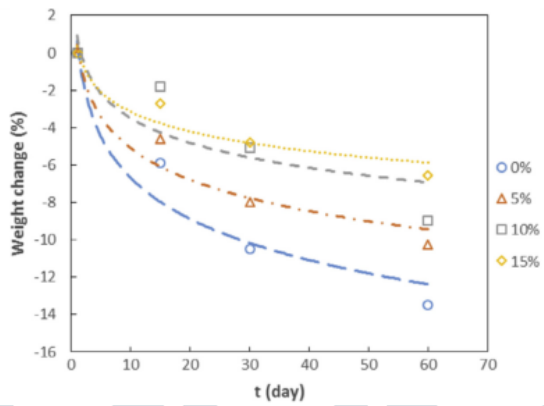

Fig.8 Weight changes in samples with 0%, 5%, 10%, and 15% of PET particles attacked by 5% sulfuric acid solution.

Bhogayata et al., 2018 [15] study the modified concrete incorporating with various type of plastic fibre on sulphate resistance properties. Effect of MPW fibers on weight loss of concrete was shown in fig. 9. At 0.5% dosage of MPW fibers, the weight difference of concrete specimens reduced in the range of 30%, 17% and 11% for the MPW fibers type A, type B, and type C respectively. At the higher dosage of 1–1.5% the sulphate resistance was improved at the reduced rate in the range of 34%, 20%, 14% and 31%, 17%, 11% for the fibers type A, type B, and type C respectively. The resistance against sulphate attack of concrete were improved due tothe addition of 5 mm length short MPW fibers.

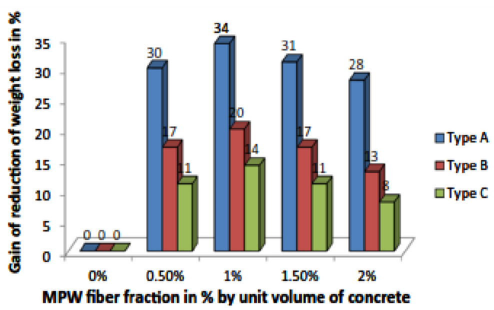

Fig.9 Effect of MPW fibers on weight loss of concrete specimens due to sulphate attack.

2.3 Carbonation

Akçaözoğlu et al., 2010 [17] determine the effect of shredded waste PET bottle as light weight aggregate in cement mortar. Experimental study include investigation in two groups one made with only PET aggregates and, second made with PET and sand aggregates together. Further, blast-furnace slag was also used as the replacement of cement on mass basis at the replacement ratio of 50% to reduce the amount of cement used and provide savings. The water–binder (w/b) ratio and PET–binder (PET/b) ratio used in the mixtures were 0.45 and 0.50, respectively. Mix proportion of mortar is shown in table 3.

Table3Mix proportions of the mortar by weight (%).

Mixture Name	Binder NPC	GBFS	Aggregate PET	SAND	WATER	TOTAL
M1	51.28	-	25.64	-	23.08	100
M2	25.64	25.64	25.64	-	23.08	100
M3	33.90	-	16.95	33.90	15.25	100
M4	16.95	16.95	16.95	33.90	15.25	100

Fig 10 shows carbonation depths of mortars of various mixtures. Carbonation depths of M1 and M2 specimens at 28 days were 1.2 and 1.7 mm. These values reached 5.0 and 7.6 mm at 180 days, respectively. It can be observed from Fig. 16 that, carbonation depths of M2 and M4 mortars (modified with slag) were higher than M1 and M3 mortars (used only cement as binder). The carbonation values of M3 and M4 mortars were higher than M1 and M2 mortars at all days.

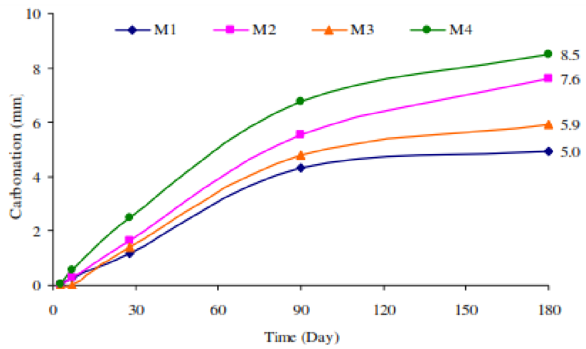

Fig.10 Carbonation depth of mortar

Silva et al., 2013 [18] determine the durability properties of concrete utilizing plastic waste aggregates. In the study the effect of curing conditions on the durability of concrete mixes containing plastic waste aggregates was investigated. Concrete mixes were prepared incorporating 0%, 7.5% and 15% of plastic (PET) in place of natural aggregates. The test to determine the carbonation depth was conducted according to Specifications LNEC E-391. Variation of the carbonation depth in various environments was shown in table 4. From the test result it was revealed that higher depth of carbonation was found in specimens cured in the laboratory environment as opposed to those cured in the wet chamber, which had the lowest values. From the study it was found that concrete modified with plastic waste has higher depth of carbonation.

Table 4Variation of carbonation depth at 91 days

Mix code	Outdoor environment		Laboratory environment		Wet chamber	
	Carbonation depth at 91 days (mm)	Variation (%)	Carbonation depth at 91 days (mm)	Variation (%)	Carbonation depth at 91 days (mm)	Variation (%)
RC	14.0	0.0	18.7	0.0	12.9	0.0
C7.5PC	34.2	144.2	28.4	52.2	21.8	68.1
C7.5PP	18.3	30.4	22.4	19.7	15.4	18.8
C15PP	18.6	32.6	20.8	11.0	15.3	17.9
C7.5PF	21.3	52.2	25.7	37.5	18.1	39.6
C15PF	28.8	105.8	36.9	97.7	24.9	92.3

3. CONCLUDING REMARKS

The essence of this investigation was to stimulate the utilization of solid waste to limit the disposal cost of waste material, diminish the natural danger of contamination and spare the landfill space.The utilization of plastic waste in various forms and in combination of other material in concrete and mortar as a partial replacement of natural aggregates has been broadly investigated in current years. This review paper has presented an assortment of aspects on plastic waste and its usage in concrete, which may possibly concise and concluded as:

1.) The result show that with increase of plastic waste in concrete compressive strength of concrete gradually decrease.
2.) Concrete modified with plastic waste has positive influence on impact resistance property. Incorporation of plastic waste enhances the strength property of concrete.
3.) With increasing amount of plastic waste resistance to sulphate attack and carbonation depth of concrete increases depending upon the type of plastic waste, its replacement level and ratio of mix proportion.
4.) Plastic waste can be reused as aggregate in concrete and mortar so as to decrease the amount of plastic waste accumulation and to produce sustainable concrete.

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