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EXPERIMENTAL STUDY ON UTILIZATION OF WASTE PLASTIC AS AGGREGATE IN CEMENT MORTAR

Md Hashmath(Asst Prof)*, Md Meraj
* Dept of CIVIL, NSAKCET.
Dept of CIVIL, NSAKCET.

ABSTRACT

Solid waste management is one of the major environmental concerns in our country now a days. The present study covers the use or recycled plastics as replacement of coarse aggregates in concrete. The main aim of the study is to investigate the change in mechanical properties of concrete with the addition of plastics in concrete. Along with the mechanical properties, thermal characteristics of the resultant concrete is also studied

It is found that the use of plastic aggregates results in the formation of lightweight concrete. The compressive, as well as tensile strength of concrete reduces with the introduction of plastics. The most important change brought about by the use of plastics is that the thermal conductivity of concrete is reduced by using plastics in concrete. Therefore, it can be said that recycled plastics can be used for thermal insulation of buildings.

Research concerning the use of by-products to augment the properties of concrete has been going on for many years. In the recent decades, the efforts have been made to use industry by-products such as fly ash, silica fume, ground granulated blast furnace slag (GGBS), glass cullet, etc., in civil constructions. The potential applications of industry by-products in concrete are as partial aggregate replacement or as partial cement replacement, depending on their chemical composition and grain size. The use of these materials in concrete comes from the environmental constraints in the safe disposal of these products.

One of the new waste materials used in the concrete industry is recycled plastic. For solving the disposal of large amount of recycled plastic material, reuse of plastic in Concrete industry is considered as the most feasible application. Recycled plastic can be used as coarse aggregate in concrete. However, it is important to underline that re-using of wastes is not yet economicallyadvantageous, due to the high costs of transport and its effect on the total costs of production. Moreover, it is important not to neglect other costs, directly referable to the kind of wastes, due, in particular, to the need of measuring gas emission, during firing, and the presence of toxic and polluting elements.

KEYWORDS:.

INTRODUCTION

PLASTICS

The word “plastic” means substances which have plasticity, and accordingly, anythingthat is formed in a soft state and used in a solid state can be called a plastic Plastics can be separated into two types. The first type is thermoplastic, which can be melted for recycling in the plastic industry. These plastics are polyethylene, polypropylene,polyamide,polyoxymethylene,polytetrafluorethylene,andpolyethyleneterephthalate. The second type is thermosetting plastic. This plastic cannot be melted by heating because the molecular chains are bonded firmly with meshed crosslink. These plastic types are known as phenolic, melamine, unsaturated polyester, epoxy resin, silicone, and polyurethane. At present, these plastic wastes are disposed by either burning or burying. However, these processes are costly.

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Advantages of using plastics in concrete

The growth in the use of plastic is due to its beneficial properties, which include:Extreme versatility and ability to be tailored to meet specific technical needs.Lighter weight than competing materials reducing fuelconsumption during transportation.Durability and longevity.

Resistance to chemicals, water and impact.

Excellent thermal and electrical insulation properties.

Disadvantages of plastics

The followings are the main disadvantages of using the plastics in concrete are as follows:-

Plastics are having low bonding properties so that the strength of concrete getsreduced such as compressive, tensile and flexural strength.Its melting point is low so that it cannot be used in furnaces because it gets meltas its comes in contact with the heat at high temperature.

NEED FOR FURTHER WORK

It is necessary to work out a project proposal to carry out further studies on various aspects such as collection, processing and effective utilization of this waste material. To start with, such a study could be initiated with the following components:

Estimation of the types, quantity and useful components present in the waste plastic materials in the city and surrounding areas.

Methodology for collection and sorting out the useful components of the plastic waste.

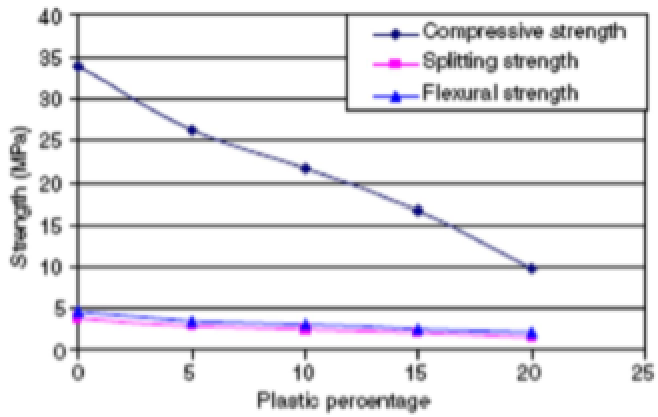
Methodology for processing the plastic bags as required for use in the preparation of modified bitumen, including cleaning, shredding and further processing of the plastic waste materials.

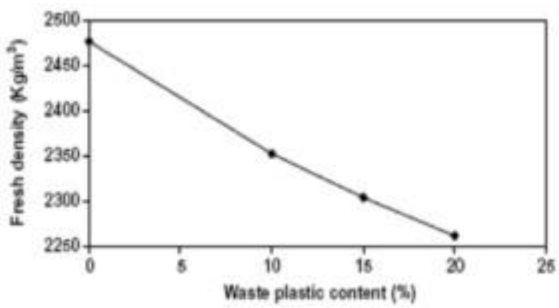
Identification of two or three construction companies / entrepreneurs who could incorporate appropriate mixing units in their hot mix plant to add and mix the required proportion of the processed plastic additive Carrying out further laboratory investigations, construction of some test tracks and field studies on the performance of concrete using the modified concrete Working out relative economics of using the modified concrete mixes in road construction works, considering the improved performance and increased service life of the pavement.Preparation of specifications and standards for the construction industry.

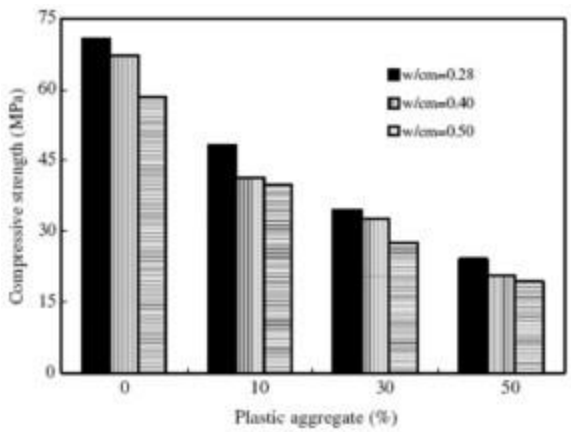
LITERATURE REVIEW

Batayneh et al. (2007) investigated the effect of ground plastic on the slump of concrete. Concrete mixes of up to 20% of plastic particles are proportioned to partially replace the fine aggregates. Details of mixture proportions and slump test results are given in Table 2.1. It was observed that there is a decrease in the slump with the increase in the plastic particle content. As shown in Fig. 2.1., for a 20% replacement, the slump has decreased to 25% of the original slump value with 0% plastic particle content. This decrease in the slump value is due to the shape of plastic particles, i.e., the plastic particles have sharper edges than the fine aggregate. Since the slump value at 20% plastic particle content is 58 mm, this value can be considered acceptable and the mix can be considered workable. Along with plastics, glass and crushed concrete was also used as replacement of coarse aggregates and it was observed that use of crushed aggregates leads to maximum slump reduction, while using crushed glass has least effect on slump of resultant concrete.

Relationship between tensile strength and % of plastic content, density and compressive strength







Shrinkage of concrete

Marzouk et al. (2007) in this research, the study of the durability was based on the study of various factors like sorptivity, sorption in gaseous phase, shrinkage under conditions of complete saturation and modulus of elasticity. The coefficient of sorptivity, whichreflects the facility of water penetration into the composite, varies from 0.0136 to 0.0014 cm3/cm2 s1/2 for a substitution of 50% by volume (Yazoghli-Marzouk et al., 2005). The non-sorptivity property of PET inclusions contributed to slow down the propagation ofthe imbibitions' front by forcing the hydrous flow to bypass them i.e. by increasing tortuosity. When the dry mortars were maintained in a temperature- controlled room under saturated atmosphere (100% relative humidity and 20 0C ± 2), experimental results reveal that a volumetric substitution lower than 100% decreases the rate of adsorptionwith respect to the reference mortar that contains no waste. The various rates of adsorption are lower than 6%. The coefficient of sorptivity can be 10 times weaker and the rates of adsorption are weak, this prominently highlights the durability present in the case of contact with water containing aggressive agents. The study of shrinkage under conditions of complete saturation (see Fig.2.25) shows that once the sand volume substituted with waste aggregates increases from 0% to 30%, the plastic aggregates do not exert an influence on shrinkage of composites in comparison with the reference mortar.

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Batayneh et al. (2007) demonstrated in their study that the addition of the plastic particles led to a reduction in the strength properties. For a 20% replacement, the compressive strength shows a sharp reduction up to 72% of the original strength. With 5% replacement the compressive strength shows a 23% reduction

EXPERIMENTAL PROGRAMME

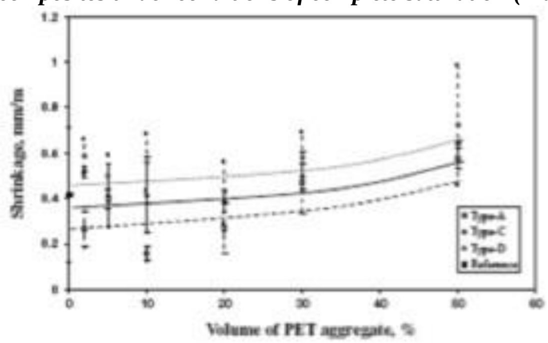
GENERAL

The aim of the experimental program is to compare the properties of concrete made with and without plastics, used as coarse aggregates. The basic tests cared out on materials used for casting concrete samples are discussed in this chapter, followed by a brief description about mix deign and curing procedure adopted. At the end, the various tests conducted on the specimens are discussed.

Plastics Aggregates

Recycled plastic was used to replace coarse aggregates for making concrete specimens. These aggregates were available in three different sizes as shown in Plate. 3.2. The sieve analysis of these aggregates were carried out individually and is presented in Table 3.7, Table 3.8 and Table.3.9 for coarse, medium and small size aggregates, respectively.

Fig. Shrinkage of composites under conditions of complete saturation (Marzouk et al., 2007)



Relationship between the compressive strengthand percentage of plastic content

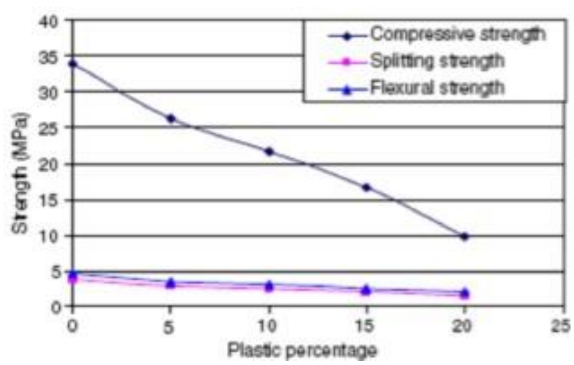


Plate.3.2. Three types of plastic

S.No.	Sieve No.	Mass Retained (gms)	%Retained	% Passing	Cumulative % Retained
1.	20mm	0	0.00	100	0.00
2.	12.5mm	292.5	21.35	78.65	21.35
3.	10mm	398.0	29.06	70.94	50.41
4.	5.6mm	510.0	37.23	62.77	87.64
5.	Pan	169.00	12.34	87.66	99.98

Percent Reduction in Compressive Strength versus Percent Plastics for Different *w/c*

All the three aggregates were mixed together in a proportion so as to achieve maximum packing density. Packing density is defined as the ratio of the volume of plastic aggregates to the volume of equivalent water. For finding the volume of aggregates in a container, the mass of aggregates filled in the container is found and is divided by the specific gravity of the aggregates.

$$\text{Packing density} = \frac{\text{volume of plastic aggregate}}{\text{Volume of equivalent water}}$$

$$\text{Volume of aggregate} = \frac{\text{mass of plastic aggregat}}{\text{Specific gravity of aggregate}}$$

It is clear that if combinations of big and medium size aggregates are used, the maximum packing density can be obtained by using a combination of 60% bigger size aggregates and 40% medium size aggregates. Further, 60% PB + 40% PM is used as base and to this combination, variable percentages of small size plastic aggregates (PS) are added, and the resultant packing density for each combination is obtained.

Coarser sized plastics aggregates and the medium sized plastics aggregates

Trials No.	Percentages of plastics aggregates		Packing density
	PB (%)	PM (%)	
1	100	0	0.543
2	90	10	0.547
3	80	20	0.555
4	70	30	0.564
5	60	40	0.568
6	50	50	0.565
7	40	60	0.564
8	30	70	0.555
9	20	80	0.558

When water is obtained from sources mentioned above, no sampling is necessary. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants or canneries, it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent discharge of harmful wastes into the stream.

MIXTURE PROPORTIONING

The tests are carried out on a wide range of water-cement ratios, ranging from 0.4 to 0.52.

The control mix is designed with the Indian Standard Codel guidelines. For making the mixes containing plastics, the amount of plastics is calculated by using the specific gravity of plastics, in place of the specific gravity of coarse aggregates. The resultant mix proportions of all the mixes are tabulated in Table

S.No	W/C Ratio	Water Kg/m^3	Cement Kg/m^3	Fine Aggregates Kg/m^3	Coarse Aggregates Kg/m^3	Plastics Kg/m^3	Mix Proportions
MC1	0.40	194.4	485.9	503.8	1121.4	-	1:1.04:2.31
MC2	0.42	194.4	462.8	517.8	1127.9	-	1:1.12:2.44
MC3	0.44	194.4	441.8	528.3	1134.3	-	1:1.20:2.57
MC4	0.46	194.4	422.5	542.6	1138.7	-	1:1.28:2.69
MC5	0.48	194.4	404.9	552.8	1143.2	-	1:1.37:2.82
MC6	0.50	194.4	388.7	566.1	1143.9	-	1:1.46:2.94
MC7	0.52	194.4	373.8	575.4	1144.3	-	1:1.54:2.99
MP1	0.40	194.4	485.9	503.8	-	474.3	1:1.04:0.98
MP2	0.42	194.4	462.8	517.8	-	476.7	1:1.12:1.03
MP3	0.44	194.4	441.8	528.3	-	479.5	1:1.20:1.08
MP4	0.46	194.4	422.5	542.6	-	481.8	1:1.28:1.14
MP5	0.48	194.4	404.9	552.8	-	483.4	1:1.37:1.19
MP6	0.50	194.4	388.7	566.1	-	484.2	1:1.46:1.25
___MP7	0.52	194.37	373.8	575.39	-	484.7	1:1.54:1.29

Compaction factor for the mix with plastics
Mix proportions for per m3 of W/C
CASTING AND CURING

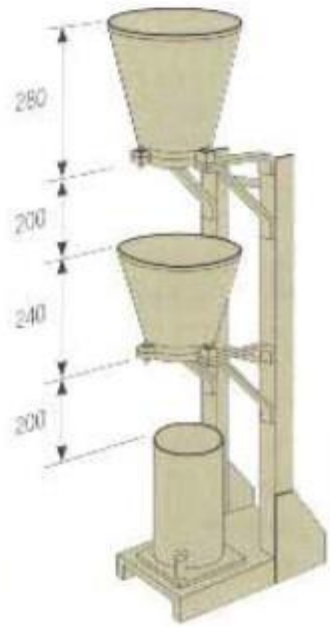
For casting, all the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there is no gaps left from where there is any possibility of leakage out of slurry. Careful procedure was adopted in the batching, mixing and casting operations. The coarse aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams. The concrete mixture was prepared by hand mixing on a watertight platform. On the watertight platform, the coarse and fine aggregates were mixed thoroughly. To this mixture, the cement was added. These were mixed to uniform colour. Then water was added carefully so that no water was lost during mixing. Clean and oiled moulds for each category were then placed on the vibrating table respectively and filled in three layers. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould The specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition. After that these were demoulded with care so that no edges were broken.

The specimens were allowed to remain in the steel mould for the first 24 hours at ambient condition.After that these were demoulded with care so that no edges were broken and were placed in the curing tank at the ambient temperature for curing. The ambient temperature 270 □□20 C was the room temperature during casting.

After de-moulding the specimen by loosening the screws of the steel moulds, the cubes and cylinders were allowed to dry for one day before placing them in the temperature controlled curing tank for a period of 28 days.

Compaction factor for the mix with plastics

S.No.	W/C ratio	Compaction factor
1.	0.40	0.877
2.	0.42	0.880
3.	0.44	0.892
4.	0.46	0.893
5.	0.48	0.891
6.	0.50	0.893
7.	0.52	0.898



RESULTS AND CONCLUSIONS

GENERAL

In this chapter the parameters studied on the control concrete and plastic replaced concrete are discussed. The parameters such as unit weight, compressive strength, splitting tensile strength and thermal conductivity are discussed and comparison between the control concrete and plastic added concrete is represented.

DRY DENSITY

The dry density is measured for the cubes taken from the curing tank, just prior to compressive strength test. The value of dry densities obtained for the control mixes and for plastic concrete is shown in Fig.4.1 for all water-cement ratios. It is found from the testing that the unit weight of there is considerable decrease in unit weight when compared with the control concrete without plastic replacement

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COMPRESSIVE STRENGTH

The compressive strength for different water cement ratios of plastic added concrete and control concrete were tested at the end of 28 days using compressive strength testing machine as shown in Plate 4.1. The water cement ratios were taken as 0.4, 0.42, 0.44, 0.46, 0.48, 0.50, and 0.52. Three cubes of each water cement ratio are casted and the average of three test results is taken for the accuracy of the results

w/c Ratio	Compressive strength (MPa)		Percentage reduction in compressive strength (%)
	control concrete	plastic concrete	
0.40	39.67	13.09	67.00
0.42	38.63	11.39	70.51
0.44	38.47	10.65	74.24
0.46	37.74	10.21	72.94
0.48	35.37	9.96	71.84
0.50	32.11	9.44	70.60
0.52	27.67	10.06	63.64

CONCLUSION

Following are the conclusions can be made based upon the studies made by various researchers:-

1. Plastics can be used to replace some of the aggregates in a concrete mixture. This contributes to reducing the unit weight of the concrete. This is useful in applications requiring nonbearing lightweight concrete, such as concrete panels used in facades.
2. For a given w/c, the use of plastics in the mix lowers the density, compressive strength and tensile strength of concrete.
3. The effect of water-cement ratio of strength development is not prominent in the case of plastic concrete. It is because of the fact that the plastic aggregates reduce the bond strength of concrete. Therefore, the failure of concrete occurs due to failure of bond between the cement paste and plastic aggregates.
4. Introduction of plastics in concrete tends to make concrete ductile, hence increasing the ability of concrete to significantly deform before failure. This characteristic makes the concrete useful in situations where it will be subjected to harsh weather such as expansion and contraction, or freeze and thaw.
5. The inclusion of recycled aggregates in the concrete of the buildings under investigation has been shown to be advantageous from an energy point of view. The use of [plastic aggregates helped in keeping the interior cooler, when the outside temperature is raised, as compared to the corresponding control concrete