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Use of Plastic Aggregates in Concrete

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A B S T R A C T

Solid waste management is the biggest environmental problem in our country today. The use of plastic is increasing day by day, although measures have been taken to reduce its consumption. The dumping or disposal of these wastes causes environmental and health problems. It generates a lot of waste every day which is very unhealthy. Healthy and sustainable recycling offers many benefits. This project should be considered as an approach to wider research on the use of plastic aggregate as a substitute for coarse aggregates in concrete. In this work, research was done by adding different percentages of plastic aggregates (20%, 25%, 30%) to find the optimal percentage and to determine the performance of plastic aggregates in concrete. The mechanical and durability properties of concrete containing plastic stone and its suitability as a construction material are investigated. In addition, the properties of the concrete mix mixed with plastic aggregates were investigated and compared with a reference mix with conventional aggregates.

Keywords: Plastic Aggregates, Concrete, Optimum Percentage, Compressive Strength, Flexural Strength, Split Tensile Strength.

1. INTRODUCTION

Concrete is the most used material in the construction industry and the second most used material on earth after water. Simply put, it is defined as a mixture of four ingredients: coarse aggregates that make up the majority of the mixture, fine aggregates such as sand that act as void fillers, a binder such as lime or portland cement that binds these materials together, and water that reacts with the link. Mixing these four materials gives us a paste called a matrix. At this stage, it is called fresh concrete or green concrete and hardens when the water reacts with the binder. This reaction is called concrete hydration. Fresh concrete can be cast into the desired shape by placing it in molds. This property of concrete helps to use concrete in the most efficient way. Plastic needs no introduction as it is the most used material on our planet today. Due to its properties such as strength, durability, and easy handling, it can be used for many purposes. Research shows that plastic is almost inert. This means that chemicals do not affect it a bit and its durability is better. The disposal of plastic waste is a big problem because without organic compounds, it is a non-degradable material and turns out to be a threat to our environment because it has many health risks. Because plastic degradation is a serious problem because it takes a very long time and affects the environment in many ways. So, we can use it in construction, where it is necessary to improve the service life of the structure, and the use of plastic waste after some processing can help reduce environmental waste, which is the new motto of civil engineering.

Fig. Accumulation of Plastics

2. SCOPE

Most aggregates are obtained by mining and then crushing. As rock mining causes changes in the geological aspects of an area, fracking causes dust particles to enter the environment. Thus, it has a detrimental effect on the environment in two ways. To minimize this, the researchers focused on waste materials that also have a negative impact on the environment. The use of these waste materials thus serves a dual role by minimizing the use of raw materials for concrete and using waste materials that have an impact on the environment.

Coverage of manufactured plastic aggregates used in concrete refers to the areas of use and benefits that can be achieved by adding plastic aggregate to the concrete mix. Plastic aggregates are usually made from recycled plastic materials and can be used to partially replace traditional aggregates such as sand and gravel in concrete production.

3. LITERATURE REVIEW

Prof. Elson John and Anumol S:- Solid waste management is the biggest environmental problem in our country today. The use of plastic is increasing day by day, although measures have been taken to reduce its consumption. Throwing away or disposing of these wastes causes environmental and health problems. This creates a lot of waste every day, which is very unhealthy. Healthy and sustainable recycling offers many benefits. This project should be considered as an approach to wider research on the use of plastic aggregate as a substitute for coarse aggregates in concrete. In this work, research was done by adding different percentages of plastic aggregates (10%, 15%, 20%) to find the optimal percentage and also to determine the performance of plastic aggregates in concrete. The mechanical and durability properties of concrete containing plastic stone and its suitability as a building material are investigated. In addition, the properties of the concrete mix mixed with plastic aggregates were investigated and compared with a reference mix with conventional aggregates.

Prof. Shital Navghare and Rohit Khobragade:- The healthy and sustainable recycling of plastic offers the least advantages; discusses the durability of conventional aggregates in relation to recycled plastic aggregate in construction and its advantages. The initial question arises here about its strength and heat of hydration, so experiments are carried out to find out the filling properties of both aggregates (general aggregate and plastic aggregate) such as specific gravity, also crushing value, impact value etc. compare the physical properties of plastic aggregates and general aggregates. The purpose of this study was to look at general aggregate and plastic waste, and in this paper, we mainly focused on plastic aggregate, as we used plastic (recycled) aggregate in a larger structure. In this study, plastic coarse aggregate was used instead of natural coarse aggregates. Some recent studies show that they can be used in the construction industry due to their certain properties such as inert behavior and resistance to decay.

Prof. Saurav Yadav and Parwez Alam:- As today, in the fastest developing world, construction around the world is at its peak, and as we know, concrete is the main ingredient in house construction. In addition, plastic waste is one of the most dangerous things for the environment today. Plastic lasts all year round. The idea behind this research is to overcome this plastic waste through construction material to overcome the environmental problem facing the world. The purpose of this paper is to review the use of this plastic in the alternation of layer and fine aggregate and its effect on concrete properties such as workability, tensile strength tests and other tests, which are divided into compressive strength tests and other tests. And the results of the partially replaced concrete sample (150 mm × 150 mm × 150 mm) cube were checked after 7 days, 14 days and 28 days and compared with the conventional concrete cube mixed with 0% plastic waste. The removal of natural aggregates with recycled plastic waste can be a sustainable development approach to ecological construction, and in our test, we ensure that the proportion of plastic in the volume of concrete is 0 to 25% and adopt and control a mixed structure as Indian Standard characteristics.

Prof. Darshan M. K. and Arvind:- In recent years, a significant increase in plastic consumption has been observed all over the world, leading to a huge amount of plastic-related waste. Recycling plastic waste to make new materials such as concrete or mortar is one of the best solutions to get rid of plastic waste because of its economic and environmental benefits. Evaluation of the properties of cement compounds containing different types of plastic waste, such as aggregate, filler or fiber, has been or is being carried out. This report presents our position on the recycling of plastic waste as an aggregate in cement and concrete production. For a better presentation, Portis is divided into four different parts and a production and conclusion part. In the first part, the types of plastic and the methods used are plastic aggregate and the subject, so the assessment of the various properties of aggregate and concrete was briefly discussed. We strive to reduce plastic waste in the environment by replacing it with aggregates to produce multi-purpose lightweight polymer concrete. It is an ecological and economic solution for recycling plastic waste. It is useful to study the effect of replacing natural aggregate with plastic aggregate on concrete mass.

Prof. Smitha K. K. and Aleesha Saju:- The use of plastic waste in concrete has attracted worldwide attention. The addition or partial replacement of filler with plastic waste in concrete provides an economical building material. Polyethylene terephthalate (PET) bottle waste is widely used today and can be used as concrete aggregate. Plastic aggregate has the same compressive strength development as traditional concrete and provides comparable compressive strength and increased durability and impact strength. This type of concrete can withstand more loads after cracking. Reduced water absorption increased chemical resistance and workability were observed in concrete mixed with plastic. The modulus of elasticity of concrete depends on the compressive strength, the type of aggregate and the water-cement ratio. The modulus of elasticity of different types of concrete varies according to the compressive strength, but not as high as that of ordinary concrete. For the structural use of plastic aggregate concrete, its elasticity coefficient must be evaluated. The inclusion of plastic stone concrete in the construction industry is a big step towards sustainable development and the green building concept.

4. OBJECTIVES

The main goal of this research is to find out the possibility of using plastic waste in concrete as a concrete aggregate and to reduce the problems related to the disposal of plastic waste and the removal of natural aggregates from the environment. Other objectives of the study include:

- To obtain an optimum percentage of aggregate replacement.
- To observe failure of section in the form of fractures.
- To calculate flexure strength of sections.
- To analyze the M25 and M30 mixed proportions.
- Identify the compressive strength of plastic mixed concrete blocks.

5. METHODOLOGY

- Preparing the mix design of plastic concrete blocks.
- Casting of plastic concrete cubes.
- Curing of blocks cubes for 7, 14 and 28 days respectively.
- To check the strength of the cube on a CTM Machine.
- Comparing cement concrete blocks of grade M25 and M30 with plastic concrete blocks.

6. EXPERIMENTAL INVESTIGATION

6.1 Cement:- Ordinary Portland cement to determine the properties. Laboratory tests were conducted to determine the properties of cement.

6.2 Fine Aggregate:- Locally available river sand passing through a 4.75 mm IS sieve was used for the experiments. Laboratory tests were conducted to determine different physical properties as per IS383-1970. The specific gravity of the fine aggregate is 2.6 and the grading zone is I.

6.3 Coarse Aggregate:- For proper gradation, a combination of 12.5 mm and 20 mm aggregates are used. Laboratory tests were conducted to determine the different physical properties as per IS383-1970. The specific gravity of the coarse aggregate is 2.8.

6.4 Plastic Aggregates:- Plastic aggregates represent the discarded waste from plastic covers that is collected from the disposal area and it is then melted and shredded into specific sizes using shredding machines. Specific gravity is 2.1.

Fig. Plastic Aggregates

6.5 Water:- Clean water was used for casting as well as curing the test specimens. pH is between 6 and 7.

6.6 Mix Proportion:-

- For the M25 grade, the final proportion will be 1:2.68:5.5 (Cement:Fine Aggregate:Coarse Aggregate) with a w/c ratio of 0.45.
- For the M30 grade, the final proportion will be 1:1.29:2.64 (Cement:Fine Aggregate:Coarse Aggregate) with a w/c ratio of 0.5.

Sr. No.	Concrete Name	Natural Coarse Aggregates (NCA) %	Plastic Coarse Aggregates (PCA) %
1	M1	100	0
2	M2	80	20
3	M3	75	25
4	M4	70	30

Table. Percentage of Replacement of NCA by PCA

6. EXPERIMENTAL PROCEDURE

6.1 Design of Concrete Mix:-

Concrete mix is the way by which we choose the different constituents used in the concrete and determine their amount and by taking care of the economy and various properties of the concrete like workability, slump value, strength criteria etc. For designing the concrete mix, we followed IS:10262-2019. A design mix for M25 & M30 grade concrete was prepared and trial mixes were prepared to check the mix design and to adjust the amount of admixture and water cement ratio. The following parameters were used for mix design:-

Grade of Concrete : M25 and M30

Type of Cement : OPC - 43 Grade

Cement Manufacturer : Birla Shakti

Zone of Fine Aggregates : Zone II

Sp. Gravity of Cement : 3.16

Sp. Gravity of Fine Aggregates : 2.60

Sp. Gravity of Course Aggregates of 20mm : 2.65

Water-Cement ratio : For M25 w/c ratio is 0.45; For M30 w/c ratio is 0.4.

Unit of Batch	**Mix Grades**	**Cement (kg)**	**Fine Aggregates (kg)**	**Coarse Aggregates of 20 mm (kg)**	**Water (kg)**
Cubic meter content	M25	443.25 kg/m^3	543.62 kg/m^3	1109 kg/m^3	202.8 kg/m^3
	M30	471.62 kg/m^3	651 kg/m^3	1149 kg/m^3	186.5 kg/m^3
Ratio	M25	1	2.68	5.5	
	M30	1	1.29	2.64	

Table. Mix Proportion of M25 and M30 grade Concrete

The design mix was strictly followed to achieve the desired results. The cement content was increased by manual mixing. And the replacement of plastic waste is done with percentage of replacement natural raw aggregates.

6.2 Specimens for Compressive Strength:-

To check the compressive strength of the concrete mixture, cube-shaped specimens with dimensions of 150 mm × 150 mm × 150 mm were prepared. The required amounts of material were weighed according to the mixing ratio. Aggregates and cement were first thoroughly mixed. Water was then added to the dry mixture. A total of 9 identical cubes, three cubes each, were thrown during the 7 day, 14 day and 28 day testing. After 24 hours of casting, the cubes were removed from the mould and placed in a curing tank.

Fig. Compressive Strength Test on Concrete Cubes

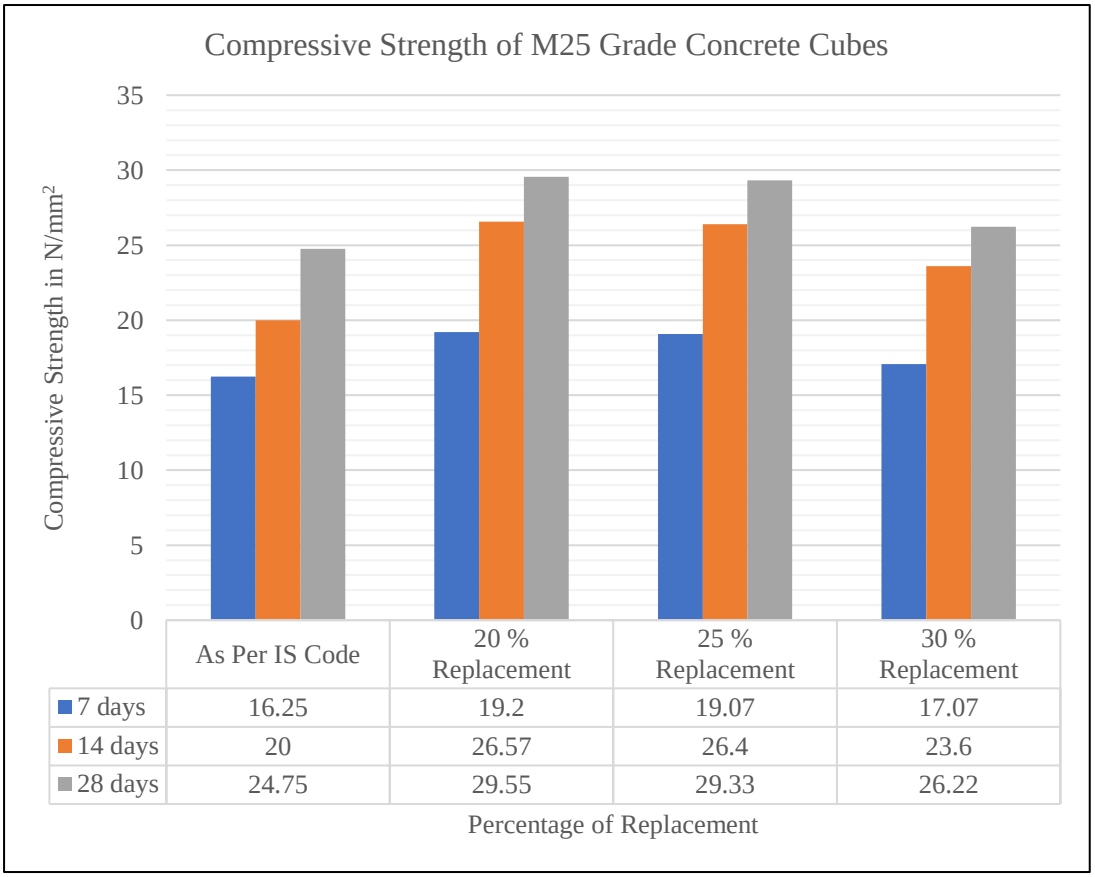

Fig. Compressive Strength of M25 Grade Concrete Cubes

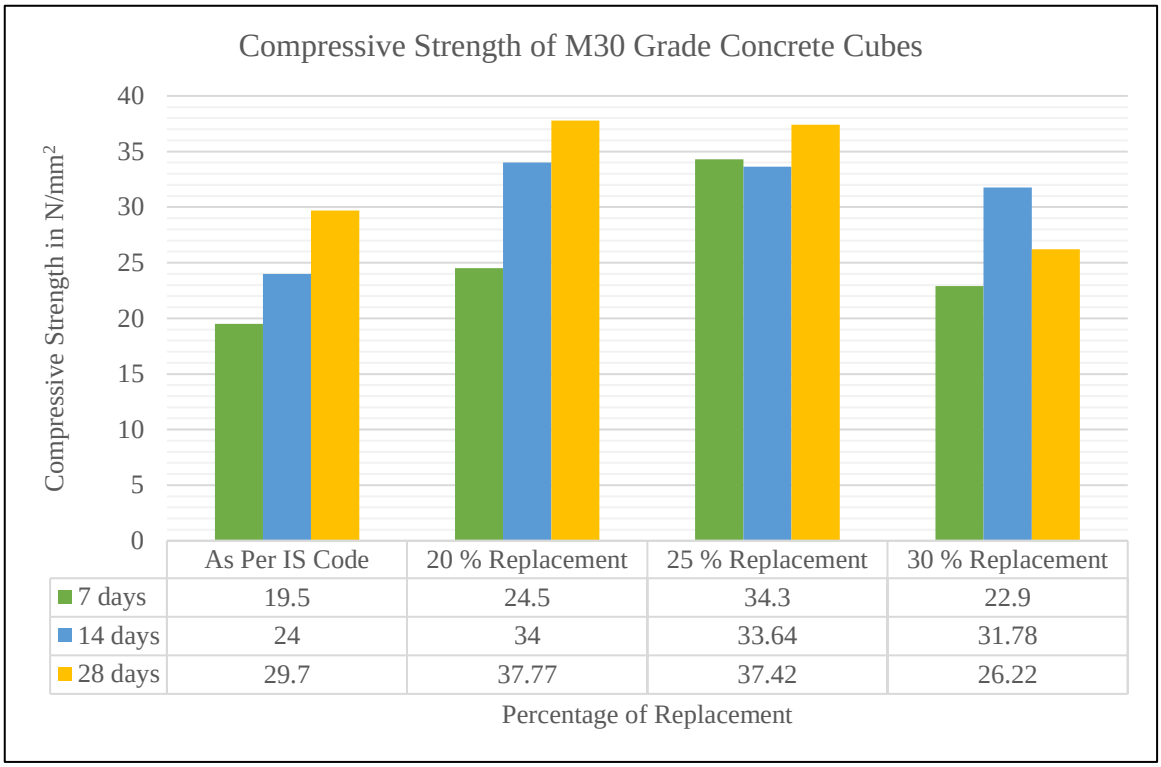

Fig. Compressive Strength of M30 Grade Concrete Cubes

6.3 Specimens for Flexure Strength:-

To check the flexural strength of the concrete mix, 100 mm × 100 mm × 500 mm beam specimens were prepared. The required amounts of material were weighed according to the mixing ratio. Aggregates and cement were first thoroughly mixed. Water was then added to the dry mixture. During the 7 day, 14 day and 28 day testing, a total of 3 identical bars, three bars each, were cast. After 24 hours of casting, the beams were removed from the mould and then placed in a solidification tank.

Fig. Flexural Strength Test on Beam

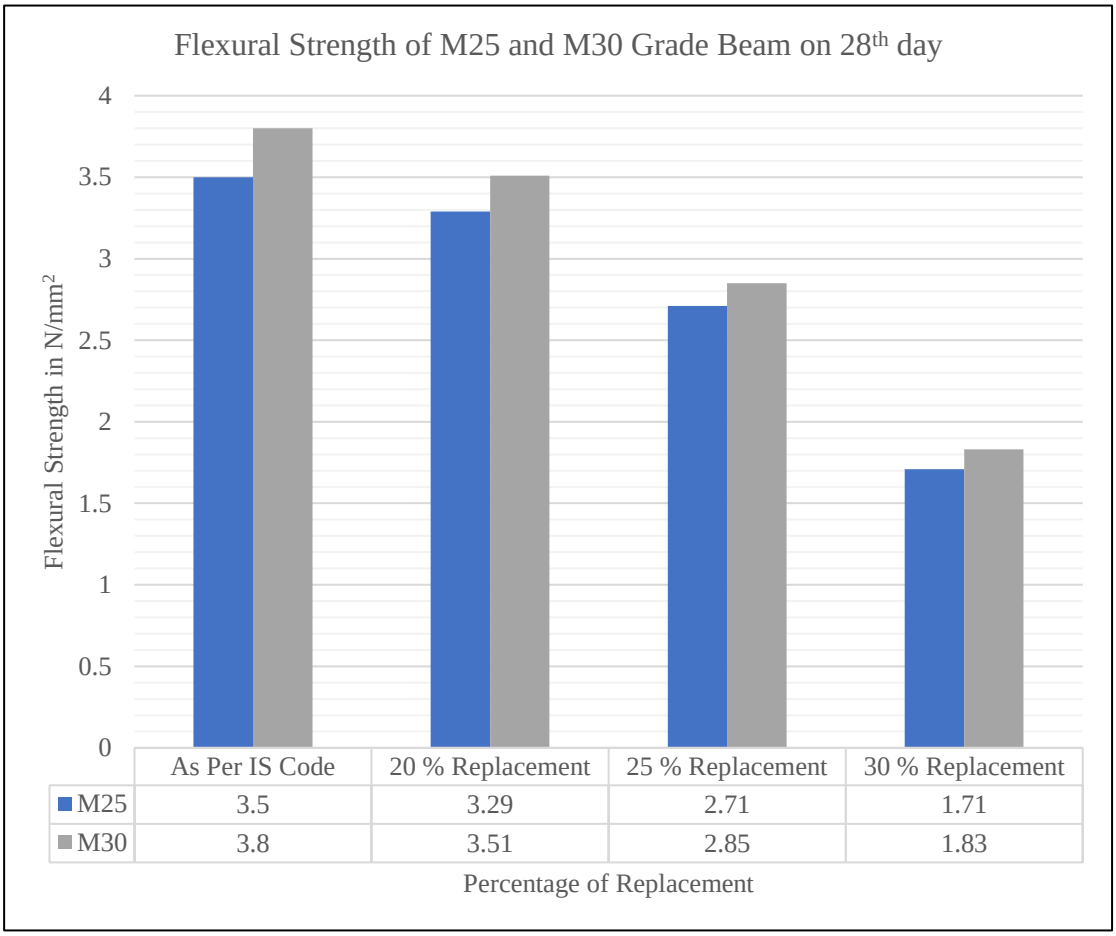

Fig. Flexural Strength of M25 and M30 Grade Beam

6.4 Specimens for Flexure Strength:-

Cylindrical specimens with a diameter of 150 mm and a height of 300 mm were prepared to check the cracked tensile strength of the cylindrical mixture. The required amounts of material were weighed according to the mixing ratio. Aggregates and cement were first thoroughly mixed. Water was then added to the dry mixture. A total of 3 identical cylinders, three cylinders each for 7 days, 14 days and 28 days testing. After 24 hours of casting, the cylinders were removed from the mould and then placed in a curing tank.

Fig. Split Tensile Strength Test on Cylinder

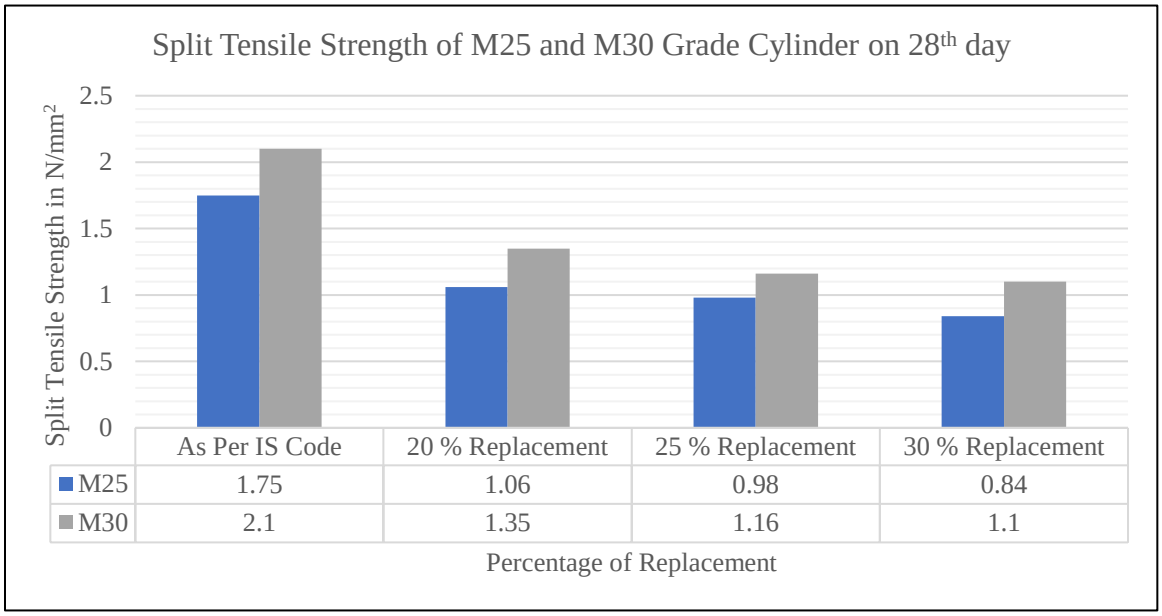

Fig. Split Tensile Strength of M25 and M30 Grade Cylinder

7. ADVANTAGE

- To reduce self-weight of structure about 20 to 25 %.
- The process of Reduce, Recycle and Reuse is very fast.
- For the 1 Tons of PAC it takes approximately 1.4 Tons of plastic waste for the manufacturing.

8. CONCLUSION

The strength characteristics of plastic concrete mixers tend to decrease when a higher percentage of plastic aggregates are added. This may be due to the weakening of the adhesive force between the surface of the plastic materials and the cement paste. In addition, plastic is a hydrophobic material that does not participate in hydration. As we see today, the depletion of natural resources in the main parts, so we must move to our next option, which is plastic or recycled aggregate, so our research on plastic waste can show that we can provide a better choice for society and our world. Instead of coarse aggregates, plastic was added to the concrete in a proportion of 20%, 25%, 30%. Based on the results of this study, M25 and M30 are mixed. The material used in the tests is good and working. The specific gravity of plastic was lower than that of fillers. In the experiment, it was observed that the compressive strength of concrete initially increased at 15 to 20 % PCA, but further increase in PCA shows a decrease in strength.

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