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IMPACT ON CONCRETE BY PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED PLASTIC GRANULES

Salman Farooq[1], Mohd Zeeshan Khan[2]

[1]*PG Scholar, Construction Technology & Management, AL-Falah School of Engineering and Technology, Al-Falah University, Haryana, India*
[2]*Assistant Professor, Dept. of Civil Engineering, AL-Falah School of Engineering and Technology, Al-Falah University, Haryana, India*

Abstract*— How Low Density Polyethylene (LDPE) can be used as a replacement for coarse aggregate in order to produce concrete cubes and cylinders is being researched and thus reported in this paper. The concrete material prepared by this process was manually experimented and treated by the process of compression and split tension. It is found that the strength of the plastic replaced by concrete because of compression and split tension can be compared to the conventional concrete. In this paper the study is aimed at how LDPE (in some certain amount) can increase the tensile strength to the concrete produced in order to reduce the fragility of the material previously used. This mixture of cubes and cylinders was subjected to compression and split tension in order to ascertain the parameter of strength. Hence the use of treated plastic wastes in concrete is not only beneficial but also helpful in disposal of plastic wastes, thus reducing the environmental pollution to a large extent. The concrete thus developed, can increase the strength of structures and hence reducing the various environmental hazards.

Keywords*— Compressive strength, Split Tensile Strength, Slump Test, Eco-Friendly

I. INTRODUCTION

Dumping and disposition of solid wastes is a major environmental problem globally which has thus given rise to economical and social crisis. This problem can be tackled only if; certain systems to manage this increasing waste can be implemented like reduction, reusing, recycling, land filling and incineration etc. Typically no plastic can be recycled, in any other thing, it always remains the same and only changes its form, which can be used to make more products and thus non-recyclable. This leads to the increasing need of biodegradable plastics. If we can mix such type of plastics with the non-recyclable plastics, the product attained can thus no longer be destroyed or recycled because of the variation in their properties and melting points.

Observing and dealing with such type of problem lead me to this idea of converting plastic waste materials into granules as a substitute for coarse aggregate in concrete composites. Thus this project can be used to evaluate the possibility of implementing this method and in deriving the desired results which can help in reducing the increasing level of plastic wastes.

In contrast to other waste materials, plastic waste requires keen attention because of its having non-biodegradable property. Its production leads to the increasing need of it in daily purposes and thus increasing dumping of it , which has given place to the heaps of accumulated plastic. In India millions of tonnes of solid material is produced annually, which is increasing at the rate of 2% every year. Out of all the waste material, plastic constitutes of about 12.3% produced by the discarded water bottles. Dumping inside the earth or burning plastic cannot be implemented because it can lead to other type of pollutions like air pollution, which can lead to fatal health problems, also it can lead to contamination of soil and thus vegetation.

Studies and researches were carried out on a large scale in many countries like USA and UK on this topic. However, in India there has been limited work done in order to control the increasing levels of plastic. Hence my project is an attempt in this discourse of how LDPE granules can be used as a replacement of coarse aggregate, which can be done by investigating its mechanical behaviour.

II. LITERATURE REVIEW

Four students from SJB Institute Bangalore in their topic "Recycled plastics used as coarse aggregate for constructional concrete" have mentioned how Landfill sites are overcrowded for the disposal of waste material and what efforts should be made in order to tackle the building problem and thus minimize the quantities of materials which are getting delivered to these sites. They have also discussed about the fact that how these non-biodegradable waste materials contaminate soil, ground water and in accordingly air. In this paper these engineers have proposed that how recycling of plastic can be advantageous economically if used with concrete. They have proposed the fact of using nonconventional aggregate, such as polystyrene foam wastes, HDPE, and polyethylene terephthalate (PET) as a replacement in order to create concrete which can improve the properties of concrete and reduce the cost. In their project they have shown how this method can contribute in creating the sustainability of the structures and thus environment.

R Lakshmi a Research Scholar of K.L.N. College of Information Technology Sivagangai has worked upon the utilization of waste materials and by-products as a partial solution to tackle environmental problems in her topic "Studies on Concrete containing E plastic waste". In her project she has worked upon the fact that how use of these materials can not only makes them get utilized in cement abut also in other construction material as well. She has also put forward the solution that how use of these waste can reduce the consumption of other resources which can lead to the indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. In this project she focuses on the electronic waste or e-waste which consists of discarded electronics appliances like computers, televisions, refrigerators, radios etc. Also her study also includes the efforts which have been made in order to use bio-degradable components of e-waste as a replacement of coarse aggregate. She has also suggested how Ultrasonic tests were executed on strength properties and thus how the feasibility of utilizing E-plastic particles as partial replacement of coarse aggregate can be presented. In her project she has done the experimental study by collecting the waste plastic of LDPE (Low Density Poly Ethylene) from the south localities of Bangalore and then mixed with OPC and sand in varying proportions (0%, 20%, 30%, and 40%). After implementing this method the compressive strength for each variant is carried and thus determined in the laboratory.

Ankit Arora a UG student in collaboration with Dr. Urmil V. Dave, Senior Professor, Institute of Technology, Nirma University, Ahmadabad, has published a paper in the International Journal of Students research in Technology and Management. In this Paper they have mentioned about the growing crisis of E-waste and plastic waste todays scenario. They have asserted attention on the fact that how plastic was grinder in order to recycle it and reuse, but the whole process failed as grinned particles has got flattened shape and thus couldn't give best results. They then suggest that if the particles can be used in the mixture with concrete, it can help improve us economically hence a good way to dispose all the plastic. Their project typically deals with the grinding, rubbing and mixing technician order to reuse the plastic and e-wastes in concrete . They have shown that how e-wastes which are known to be electronic wastes can be processed and thus reused. they have put forward the technique by which the waste products can be converted into different minute sizes like 2mm by grinding them into pulverizing machine. Also the particles obtained are then rubbed against each other in friction roller machine. By this process the grinder particles are made of irregular shapes so that they can bond well with cement when mixed. This process can lead to the strength in the structures built with the acquired cement , hence reducing the plastic wastes and in accordingly environmental pollution.

III. MATERIAL USED

- **PLASTIC**

Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organics that are malleable and can be moulded into solid objects of diverse shapes. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plasticity is the general property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of mouldable polymers that their name is an emphasis on this ability. Due to their relatively low cost, ease of manufacture, versatility, and imperviousness to water, plastics are used in an enormous and expanding range of products, from paper clips to spaceships. They have already displaced many traditional materials, such as wood, stone, horn and bone, leather, paper, metal, glass, and ceramic, in most of their former uses. In developed countries, about a third of plastic is used in packaging and another third in buildings such as piping used in plumbing or vinyl siding. Other uses include automobiles (up to 20% plastic), furniture, and toys. In the developing world, the ratios may be different for example; reportedly 42% of India's consumption is used in packaging. Plastics have many uses in the medical field as well, to include polymer implants, however the field of plastic surgery is not named for use of plastic material, but rather the more generic meaning of the word plasticity in regards to the reshaping of flesh.

- **CEMENT**

Cement is a binder, a substance that sets and hardens and can bind other materials together. The word "cement" traces to the Romans, who used the term opus caementicium to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick supplements that were added to the burnt lime, to obtain a hydraulic binder, were later referred to as cementum, cimentum and cement. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. Non-hydraulic cement will not set in wet conditions or underwater, rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting.

- **COARSE AGGREGATE**

Crushed coarse aggregates which are locally available were used. Analysis of the coarse aggregates was carried out. The coarse aggregates used in this experiment investigation are of 20 mm crushed angular in shape. The aggregates are free from dust before used in concrete. The fineness modulus was found to be 6.3 and specific gravity of coarse aggregates is 2.68.

- **FINE AGGREGATE**

Coarse sand was used which is locally available. As per IS 383-1870 sieve analysis of the fine aggregates was carried out in the laboratory. The material whose particles are of size as are retained on IS sieve no 480(4.75mm) is termed as coarse sand. Fineness modulus of sand was found to be as 2.69 and specific gravity of fine aggregates is 2.65

IV. EXPERIMENTAL INVESTIGATION

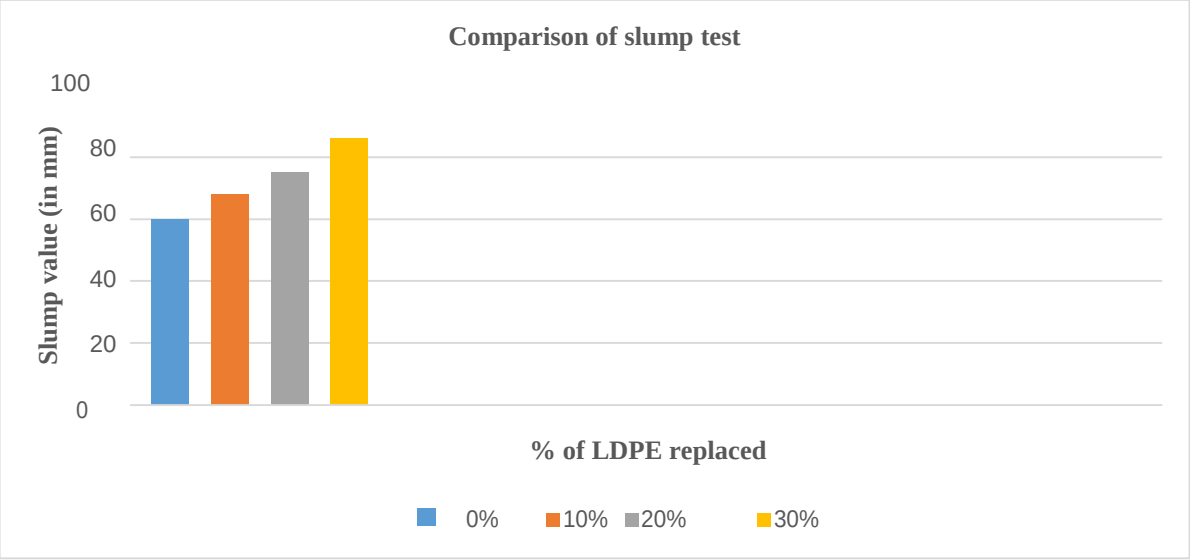
SLUMP TEST

Workability is a term associated with freshly prepared concrete. This can be defined as the ease with which concrete can mixed, placed, compacted and finished. Slump test is the most commonly used method of measuring 'workability' of concrete in a laboratory or at site of work. It is used conveniently as a control test and gives an indication of uniformity of concrete from batch to batch. Vertical settlement of a standard cone of freshly prepared concrete is called 'SLUMP'.

Table Shows Observation for Slump Test

S. NO.	W/C ratio	Percentage of plastic replaced (%)	Height of mould H_1 (mm)	Height of subsided concrete H_2 (mm)	Slump H_1–H_2 (in mm)
1.	0.5	0	300	240	60
2.	0.5	10	300	232	68
3.	0.5	20	300	225	75
4.	0.5	30	300	214	86

Graph Shows Comparison of Slump Value



COMPRESSIVE STRENGTH TEST

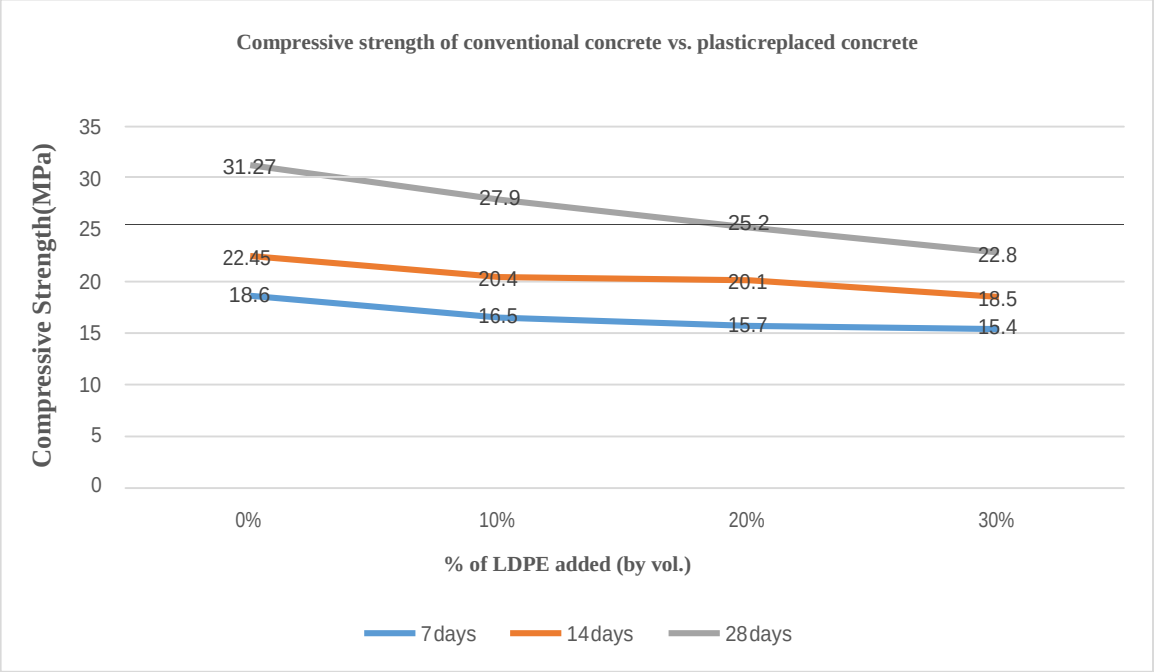
Testing hardened concrete plays an important role in controlling and conforming the quality of cement concrete work. The main factor in favour of the use of concrete in structures is its compressive strength. One of the important properties of the hardened concrete is its strength which represents its ability to resist forces. The compressive strength of the concrete is considered to be the most important and is often taken as an index of the overall quality of concrete. The compressive strength of concrete is defined as the load which causes the failure of specimen per unit cross section on compression under given rate of loading.

Table Shows Compressive Strength Test

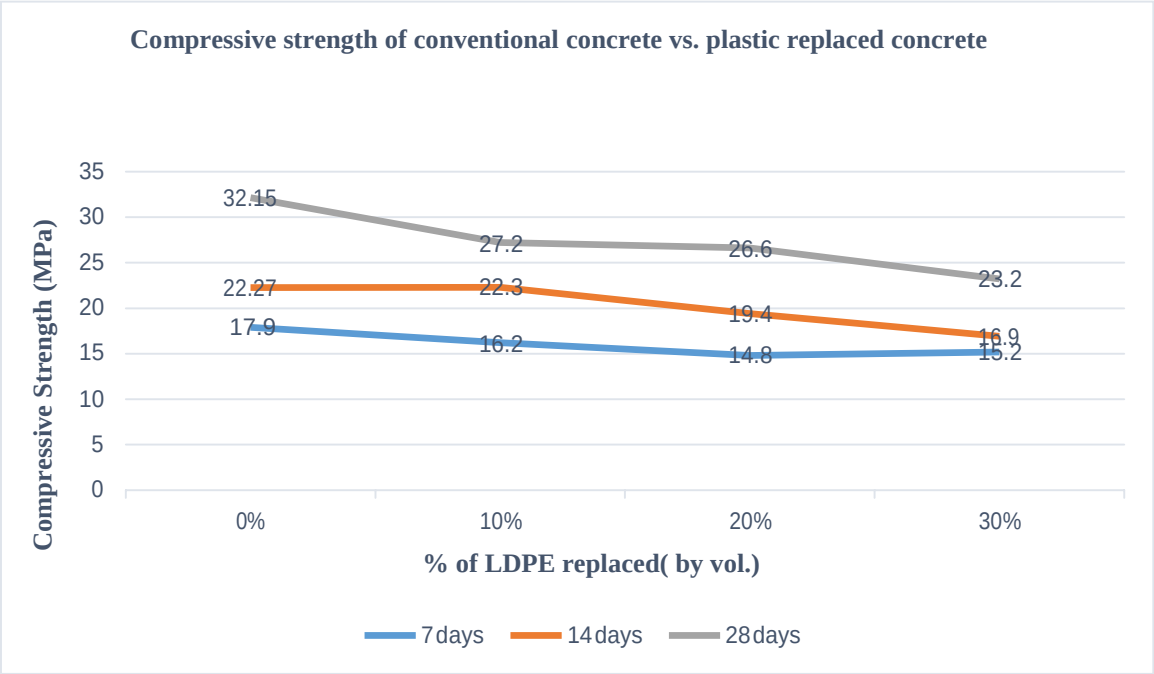
% Granules added	Weight (kg)			Peak load (kN)			Compressive Strength (MPa)		
	7^{th} days	14^{th} days	28^{th} days	7^{th} days	14^{th} days	28^{th} days	7^{th} days	14^{th} days	28^{th} days
0 %	8.20	8.27	8.29	418.50	505.12	703.57	18.60	22.45	31.27
	8.10	8.17	8.22	402.75	501.07	723.37	17.90	22.27	32.15
10 %	7.96	7.99	8.00	371.5	391.90	562.20	16.50	20.40	27.90
	8.06	7.91	7.80	321.2	502.90	612.50	16.20	22.30	27.20
20 %	7.83	7.91	7.66	309	453.20	635.50	15.70	20.10	25.20
	7.60	7.76	7.75	334.6	438.00	621.50	14.80	19.40	26.60
30 %	7.83	7.75	7.80	373.9	416.30	739.80	15.40	18.50	22.80
	7.87	7.56	7.87	387.6	380.70	742.20	15.20	16.90	23.20

Graph Shows Compressive strength of 0%, 10%, 20% and 30%

(Sample 1)



Sample 2



SPLIT TENSILE TEST

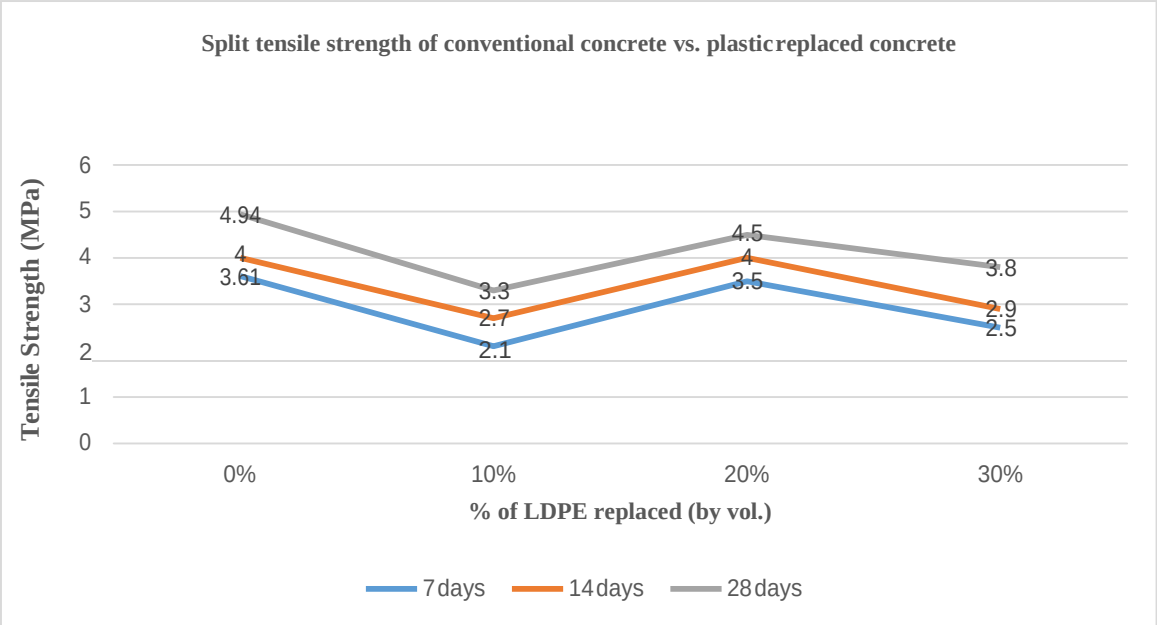
Concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However the determination of tensile strength is necessary to determine the load at which the concrete members may crack. The cracking is a form of tensile failure.

Table Shows Split Tensile Test

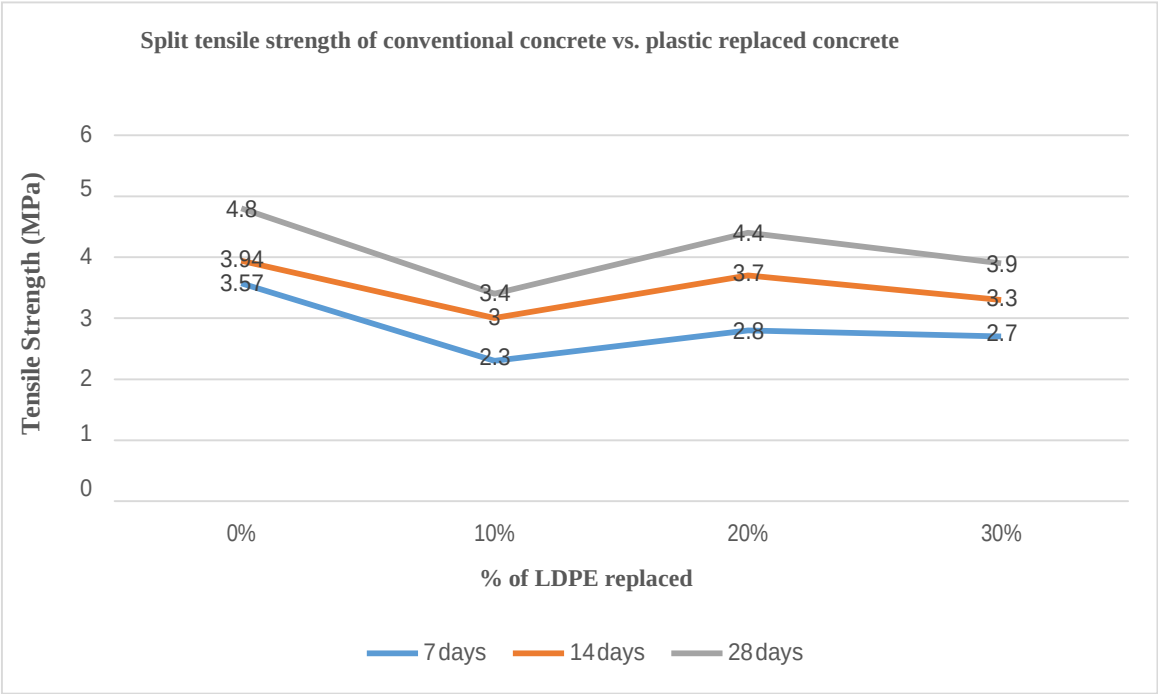
% Granules added	Weight (kg)			Peak load (kN)			Compressive Strength MPa)		
	7th days	14th days	28th days	7th days	14th days	28th days	7th days	14th days	28th days
0 %	12.45	12.49	12.50	165.87	183.80	226.99	3.61	4.00	4.94
	12.39	12.52	12.48	164.04	181.04	220.56	3.57	3.94	4.80
10 %	12.30	12.44	12.16	96.50	123.60	150.00	2.10	2.70	3.30
	12.20	12.30	12.38	103.90	135.10	154.40	2.30	3.00	3.40
20 %	12.01	12.11	12.10	161.30	180.30	206.60	3.50	4.00	4.50
	12.00	12.14	12.08	127.20	166.70	204.20	2.80	3.70	4.40
30 %	11.82	11.86	11.73	116.40	134.60	172.80	2.50	2.90	3.80
	11.76	11.72	11.67	124.60	150.80	179.70	2.70	3.30	3.90

Graph Split tensile strength of 0%, 10%, 20% and 30%"

(Sample 1)



(Sample 1)



V. CONCLUSION

The results shows that we can use waste plastic material in making concrete/mortar and it can provide an alternative solution to minimize the environmental impact due to unscientific disposal of waste plastic. The following conclusions were drawn:

- The properties of concrete adding different percentage of plastic (0%, 10%, 20%, and 30%) were tested for its physical properties and compressive strength.
- The waste plastic used for experiments is of LDPE (Low Density Poly Ethylene), 5-7mm size and specific gravity of waste plastic is found to be 0.92.
- The compressive strength of test concrete is compared with plain concrete and it is found that the compressive strength up to 77% is achieved for a mix of waste plastic up to 30% (as a replacement for coarse aggregate) in concrete. Hence it can be used for light weight concrete structures.
- The mechanical properties of the test concrete did not display any notable differences depending on the color of the plastic waste.
- This research also has potential application for the production of lightweight concrete, for minimizing the amount of polymer wastes in landfills, and the creation of decorative, attractive landscaping products.

Advantages and Disadvantages

Advantages:

- A better workability can be achieved using plastic reinforced concrete in comparison to the conventional one.
- Considerable reduction in the weight results in the formation of light weight concrete.
- Recycled plastic in the construction purpose can set a benchmark by utilizing the non-bio-degradable waste and eventually minimizing the environmental pollution.

Disadvantages:

- Strength achieved for the plastic reinforcement concrete is slightly less than the conventional concrete but it can be improved by using admixtures.
- Cost of plastic is high at the place where we need to buy from the dealers and hence the cost of construction may also increase.
- There is no proper bonding of plastic materials in the matrix unless admixtures are added.

Scope of future work

The present research can be extended to

- The test can be carried out using different grades of concrete.
- Admixtures can be added to improve the strength.
- Experimental study can be conducted using different form of plastics like HDPE, PP, and PET.
- The durability of such a concrete has to be tested for beams and columns with varying proportions of waste plastic at different ages.

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