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EXPERIMENTAL INVESTIGATION ON STRENGTHENING OF CONCRETE BY COARSE AGGREGATES COATED WITH WASTE PLASTIC

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ABSTRACT

The need to properly dispose of plastic garbage is becoming more and more important as its generation rises daily. Pavements are currently subjected to a variety of loading types, which affects pavement performance and results in a number of distresses. As a cutting-edge technology, the use of plastic in rigid pavement design enhanced the building of the roads while also lengthening their lifespan. In this project, several experiments on virgin aggregates, aggregates with plastic coatings, and concrete's compressive strength, flexural strength, and workability with and without plastic coated aggregates were carried out. On aggregates, the impact of the addition of waste plastic in the form of readily accessible local waste plastic covers (LDPE) has been studied. According to visual examination, aggregates were coated with 0%, 3%, 6%, 9%, and 12% plastic, and samples were examined for crushing, impact, and water absorption values. Studying the impact of waste plastic addition on the aggregates in M20 concrete mix, several experiments were conducted, including compressive strength, flexural strength under various curing conditions, and workability tests. Both the problem of disposing of plastic and the performance of roads are solved by employing plastic waste in hard pavements.

Keywords: LDPE, M20 compressive strength, flexural strength, and workability

1. INTRODUCTION

All the waste products in the world, plastics and municipal solid trash are of particular importance. The urgent requirement is to find an appropriate application for the disposed of plastic garbage. On the other hand, more load bearing capacities are required due to rising traffic on the roadways. The use of plastics coated aggregate for hard pavement enables the reuse of plastic waste (use polymer or plastic consistently; the focus is on plastic waste). Plastics are useful packaging materials that are widely utilized by people; however they have negative environmental effects. Plastic bags, cups, films, and foams composed of polyethylene, polypropylene, or polystyrene are the most often used plastic items after they have been used. By 2015, India's plastic usage is expected to increase by 15 million tones, making it the third-largest consumer of plastics worldwide. The majority about 55% is utilized for packaging. After the contents have been devoured, they are frequently dumped and left to pollute the surroundings. Municipal solid waste disposal is complicated by the non-biodegradable material, scattered plastics, which mingle with household garbage. Municipal solid trash is either burned or dumped on the ground. Both disposal techniques are not the ideal ways to get rid of the garbage, because they pollute both the land and the air. Additionally, burning municipal solid trash that comprises LDPE and HDPE waste might release dioxin-like hazardous fumes. The primary focus of current research efforts is the environmentally friendly disposal of plastic garbage. This initiative created a cutting-edge method for using used plastics to build hard pavement. This method can help waste plastic gain value and is environmentally benign. As we all know, the rapid industrialization needed a great quantity of construction materials as well as land needs, therefore it is a common phenomena in a big portion of the world for old buildings to be demolished together with its traffic infrastructure and replaced with new ones. In the current study, recovered plastics were employed to coat the coarse aggregates, offering a sustainable solution to today's problem of plastic waste.

There are several recycling factories throughout India, however when plastics are recycled, they lose their strength due to the plastic trash. Plastics have become an essential component of our modern lifestyle, and global plastic manufacturing has skyrocketed over the previous 50 years. Plastics have gradually been employed in a wide range of goods due to its advantageous qualities, which include low density, high strength-to-weight ratio, high durability, simplicity of design and manufacture, and low cost. Plastic is essentially inert, which means it is less impacted by chemicals and has a longer lifespan. So, based on the foregoing, we admit that we must conduct different tests on aggregates such as common aggregate and plastic-coated aggregate, compare all physical qualities and all needed tests, and investigate such a new item that will be employed in the future of civil engineering.

A. Bases of natural aggregate

The two main sources of natural aggregate are deposits of sand and gravel as well as exposed or nearby bedrock that may be crushed. These fundamental materials' sources may be divided into three categories: Using waste slag from the production of iron and steel, mining mineral aggregate resources, including those containing sand, gravel, and stone, and recycling concrete, which is mostly made from mineral aggregates themselves.

B. Identify, Research and collect idea

Plastic doesn't need to be introduced because it is a material that is used so often now on Earth. It may be utilized for a variety of purposes because to qualities including strength, durability, and ease of processing. Studies demonstrate that plastic is practically inert, meaning that it is more resistant to chemical deterioration and has a longer lifespan. Plastic garbage is extremely difficult to dispose of since it lacks organic elements and cannot decompose, endangering our ecosystem and posing several health risks. Plastic's long time to decompose and numerous negative effects on the environment make it a severe concern.

Therefore, we may use it in construction when we need to extend the life of the structure, and using waste plastic that has undergone little processing can assist us in reducing environmental waste, which is the new slogan of civil engineering. In order to alleviate disposal issues with college waste plastic, coarse aggregates were coated with it in this study. The plastic garbage produced by laboratories, academic buildings, canteens, and mess halls at the college.

C. Studies and findings

- Studying the characteristics of aggregates and conducting a comparison between ordinary aggregates and plastic aggregate.
- Analyze the one that is best for building.

D. Identifications of properties of aggregate

Despite the fact that some variance in aggregate attributes is to be expected, the following factors must be taken into account:

- grading;
- durability;
- particle shape and surface texture;
- Abrasion and skid resistance;
- unit weights and voids;
- Absorption and surface moisture.

F. Identifications role of aggregate in practical life

While aggregate serves as structural filler in concrete, its function goes beyond what that straightforward description may suggest. The workability, durability, strength, weight, and shrinkage of the concrete are all significantly influenced by the composition, shape, and size of the aggregate.

G. Utilization of aggregate all over world

Sand, gravel, crushed stone, slag, recycled concrete, and geo-synthetic aggregates are all examples of the broad category of coarse to medium grained particle materials known as "construction aggregate," or simply "aggregate." The most frequently mined materials worldwide are aggregates. In composite materials like concrete and asphalt concrete, aggregate is a component that acts as reinforcement to strengthen the composite material as a whole. Aggregates are frequently utilized in drainage applications such foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains due to the comparatively high hydraulic conductivity value when compared to most soils. Additionally, aggregates are utilized as the basis material for highways, rail lines, and foundations. Alternatively, aggregates can be used as a low-cost extender that binds with more costly cement or asphalt to create concrete, or they can be used as a strong foundation or road/rail base with predictable, consistent qualities (e.g. to help avoid differential settling under the road or structure).

H. Plastic

A plastic is a form of artificial or synthetic polymer that resembles natural resins found in trees and other plants in many respects. By 2015, India's plastic usage would increase by 15 million tones, making it the third-largest consumer of plastics worldwide. Plastic offers benefits like lightness, resilience, resistance to corrosion, color, fastness, transparency, ease of processing, etc. The plastic is divided into two major categories based on physical properties: (i) thermoplastics, and (ii) thermoset plastics. Various activities like packing consume nearly 50–60% of the total plastics produced. The majority of post-consumer plastics waste is made up of thermoplastics, which make about 80% of the total. The very long chain-like molecules are kept together in thermoplastic materials by relatively weak Van-der-Waals forces. The molecular structure of thermosetting polymers is kept together by strong chemical bonds, making them very stiff materials with insensitive mechanical characteristics to heat.

Table.1 Types of plastics

Thermoplastic	Thermosetting
Polyethylene Terephthalate (PET)	Bakelite
Polypropylene (PP)	Epoxy
Polyvinyl Acetate (PVA)	Melamine
Polyvinyl Chloride (PVC)	Polyester
Polystyrene (PS)	Polyurethane
Low Density Polyethylene (LDPE)	Urea – Formaldehyde
High Density Polyethylene (HDPE)	Alkyd

Table.2 Waste plastic and its sources

PET	Drinking water bottles etc.,
PP	Bottle caps and closures, wrappers of detergent, biscuit, vapors packets, microwave trays for readymade meal etc.,
PVC	Mineral water bottles, credit cards, toys, pipes and gutters; electrical fittings, furniture, folders and pens, medical disposables; etc
PS	Yoghurt pots, clear egg packs, bottle caps. Foamed Polystyrene: food trays, egg boxes, disposable cups, protective packaging etc
LDPE	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles
HDPE	Carry bags, bottle caps, house hold articles etc.

Plastics can also be categorized based on the chemicals that make them. The twenty or so basic varieties that are currently recognized may be divided into four broad categories: cellulose plastics, synthetic resin plastics, protein plastics, natural resins, elastomers, and fibres.

2. LITERATURE REVIEW SURVEY

Punitha P et.al [1] the workability (slump test) of RAC is the same for NAC based on the experimental results since RA's rate absorption is equivalent to NA's. In terms of specific gravity, water absorption, and aggregate impact value, RA and NA have similar overall features. RAC is compared to the sieve analysis test of coarse and fine aggregate.

Prabhat kumar et al [2] provided an analysis of the literature already in existence to fully grasp RCA and came to the conclusion from several investigations that natural aggregate and recycle aggregate may be combined in a ratio of 80:20 and 70:30. Because recycled aggregate is used in the building business, there is a potential for worsening mix characteristics and strength while also reducing the environmental effect of trash. Additionally, it will support long-term growth.

Praveen Mathew et. al [3] Recycled plastics as coarse aggregate for structural concrete was the subject of a 2013 study. They tested concrete using various ratios of plastic particles in lieu of coarse aggregates and discovered that 22% replacement of coarse aggregates with plastic aggregates produced the best results. They went on to examine the other qualities of concrete that contained 22% plastic particles and discovered that it had lower fire resistance.

Lhakpa Wangmo Thingh Tamang et. al [4] The completion of an experiment using plastics as coarse aggregate in concrete. They tested the mechanical characteristics of concrete that contained plastic particles. The percentages of plastic aggregates they utilize are 10%, 15%, and 20%. They discovered a little loss in strength and recommended 15% replacement as the ideal outcome.

Elango A and Ashok Kumar A [5] The completion of a study on concrete using plastic fine particles. They utilized crushed aggregates, river sand, and OPC 53 grade. 10%, 20%, and 30% of the fine particles were replaced with plastic. On their concrete samples, they put mechanical and durability attributes to the test. They discovered that concrete's strength had decreased. However, it was discovered that concrete exhibits improved flexibility and high resistance to acid assaults. Thus, they came to the conclusion that flexible aggregate concrete can be employed in locations where reduced compressive strength but more durability is required.

Shi-cong Kou , Chi-sun Poon a, Francisco Agrela [6] When compared to the control specimen, the compressive strength of concrete including recycled aggregate was reduced in a 2011 research, however it could be made up for by either 10% SF or 15% MK. However, the strength was decreased when 30% FA or 55% GGBS were used.

Chaitradip Sarkar et. al [7] Comparison of Concrete with Natural and Recycled Aggregates In this essay, they looked at According to the test results, recycled aggregate concrete performs satisfactorily even when coarse natural aggregate is completely replaced with coarse recycled aggregate. This indicates that there is a huge market for this aggregate both now and in the future, beyond just its mechanical properties.

S.K. SINGH et. al [8] In this essay, they looked at It has been determined that recycling and reusing building wastes is an adequate solution to the issues of dumping thousands of tones of rubbish together with a dearth of natural aggregates. Concrete made using recycled aggregates is a beneficial building material from a technical, environmental, and financial standpoint. In comparison to natural aggregate, recycled aggregate has better water absorption, lower bulk density, and crushing and impact values. Recycled aggregate concrete has a compressive strength that is up to 15% lower than natural aggregate concrete. The initial concrete from which the aggregates were derived also affects the fluctuation. The durability metrics examined at SERC (G) demonstrate that RCA & RAC are suitable for producing long-lasting concrete structures.

Parekh D. N. et al [9] analyzed the fundamental characteristics of recycled coarse aggregate and recycled fine aggregate. He also compares these characteristics to those of natural aggregates, with recycled aggregate emerging as the winner.

Y P Gupta [10] The investigation USE Of Recycled Aggregate In Concrete Construction: A Need For Sustainable Environment The research provided in this study assesses how recycled aggregate quality affects the characteristics of concrete. When samples from an unknown source were gathered and assessed over the course of six months, the evaluation of the combined physical and mechanical parameters revealed a tolerable fluctuation in attributes. The proportioning step and producing high packing density, however, might be used to overcome restrictions in gradation requirements, high absorption, and aggregate strength.

3. OBJECTIVE OF THE STUDY

• To examine the results of covering coarse aggregates with varying amounts of used plastic from colleges (0%- 12%).

• To investigate the distinction between regular aggregates and aggregates coated with plastic.

• To establish a 20 MPa mix design approach.

• To use the Slump test to assess the workability of freshly produced concrete.

• To calculate the cubes' compressive strength after 7, 14, and 28 days.

• To assess the 28-day flexural strength of beams

4. MATERIALS AND METHODOLOGY

A. Materials

In this project, following materials are used for study and experiment

- Ordinary Portland Cement (Grade 53)
- Fine aggregate
- Coarse aggregate
- Water
- Waste plastic

Table.3 Materials test results

Material	Test Name	Result
Cement	Fineness	5%
	Specific Gravity	3.15
	Standard Consistency	31%
	Initial Setting Time	28 mint
	Final Setting Time	398 mint
Coarse aggregate	Specific Gravity	2.8
	Water absorption	2%
Fine aggregate	Specific Gravity	2.66
	Water absorption	1.5%
Plastic (LDPE)	Specific Gravity	1.36
	Water absorption	0%

B. Methodology

LITERATURE REVIEW

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COLLECTION OF MATERIALS

↓

PLASTIC COATED WITH AGGREGATES & CHECK THE AGGREGATES PROPERTIES

↓

MIX DESIGN (M20)

↓

CASTING OF SPECIMENS CUBES & BEAMS

↓

TESTING OF SPECIMENS

↓

RESULT ANALYSIS

C. Mix design

In this project we are adopted M20 (1:1.5:3) grade of concrete, Assumed water cement ratio 0.5.

Table.4 Individual weight of materials M20 grade

Item name	For 1 cube (gms)	For 1 beam (gms)
Cement	1496.88	2217.6
Fine aggregates	2494.8	3696
Coarse aggregates	5613.3	8316
water	748.44	1108.8

5. EXPERIMENTAL WORK

The experimental work done for this research is described in the below. There are two sections to this chapter.

- The studies performed on uncoated aggregates and aggregates coated with plastic are covered in the first part.
- The studies performed on concrete with and without the use of plastic-coated aggregates are covered in the second half.

A. Plastic coated aggregates

Waste plastics are mostly comprised of polyethylene, polypropylene, and polystyrene, as well as LDPE and HDPE. They soften at temperatures ranging from 110°C to 140°C and don't emit any harmful gases when heated.

Procedure:

I used a shredding machine to shred the trash plastic I had gathered from colleges after first thoroughly drying it to remove any moisture.

- The size of each piece of split plastic is between 2-3 mm.
- The splitted plastic was melted by a batti at 100 to 140 degrees Celsius.
- Mix melted plastic with the aggregates.
- All of the aggregates must be evenly mixed with the plastic before cooling for 24 hours at room temperature.
- Test both aggregates with plastic coatings and uncoated aggregates.
- Check the values.

Fig.1 Splitted Plastic

Fig.2 Plastic waste heating on a Bhatti

Fig.3 Plastic Coated aggregates

B. Tests for Aggregates

Plastic is applied as a coating to the aggregates in percentages of 0%, 3%, 6%, 9%, and 12%. After covering the aggregates with plastic, let them cool for 24 hours at room temperature. Aggregates were tested after cooling as follows:

- [IS: 2386 (Part-IV)] Aggregate Crushing Value (%)

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- The total impact value (%) - IS: 2386 (Part-IV) (Part-IV)
- (%) Water Absorption - (IS:2386 Part III) (IS:2386 Part III)

Table.5 Tests results of aggregates

Test	Result (%)					Stand Value
	0%	3%	6%	9%	12%	
Crushing (%)	21	17.5	15	13.4	10	30% Max
Impact (%)	14	13	11	9.3	7.8	30% Max
Water absorption (%)	2	0.5	0	0	0	Max 2%

C. Preparation of concrete

All the required quantities of cement, fine aggregate coated and un-coated coarse aggregates weighed separately and mixed in dry condition. The obtained proportion of water is added to the composite mixture and mix thoroughly until a uniform mixture is formed. The complete mixing is done by hand mixing.

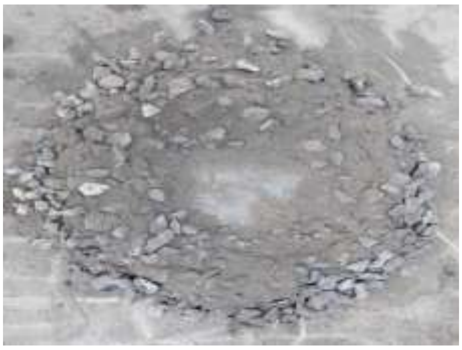


Fig.4 mixing of ingredients

Fig.5 Mixing of Concrete

After the concrete is mixed, the fresh concrete tests are to be carried out to measure the workability. The detailed explanation of the slump test is reported below.

Slump test:

Slump cone test is most simple and common test conducted to determine the workability of concrete mix. According to the IS 1199-1959, Slump test is carried out for every batch of mix.

Fig.6 Slump cone test

A sample of prepared concrete mix is taken for the test. The internal surface of the frustum of cone is cleaned and greased to avoid the adhesion of concrete. A non-porous base plate is placed on a uniform surface and the slump cone mould is fixed on it. Concrete mix is filled in three equal layers in the mould. The excess concrete is removed and leveled. Now, the cone is lifted in upward direction and the concrete slumps down. The slump (Vertical settlement) is measured in mm.

Casting of cubes:

Totally 45 cubes were cast for conducting various tests. For the preparation of cube specimens, the mixed concrete is poured into the cube moulds made of steel of dimensions of 150 X 150 X 150 mm. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in 3 layers (each layer more than 35 blows) into the moulds till the surface and leveled. The specimens are allowed to dry up for 24hrs

.

Fig.7 casting of cube

Casting of beams:

Totally 15 beams were cast for conducting flexural test. For the preparation of beam specimens, the mixed concrete is poured into the beam moulds made of steel of dimensions of 100mm x 500mm x 100mm. The moulds are cleaned and greased to avoid sticking of concrete to the moulds and tighten the bolts to prevent leakage of concrete. The concrete is put in 3 layers (each layer 35 blows) into the moulds till the surface and leveled. The specimens are allowed to dry up for 24hrs.

Fig.8 Casted of beams

Curing:

The next stage is curing of the specimens. It is an important phase as the water for hydration is to be maintained in the specimens. Proper curing gives good strength to the concrete. So, after removing from the moulds the specimens are transferred to the curing tank containing water free from impurities and cured for 28 days.

Fig.9 Specimens in Curing Tank

D. Experimental Procedure

In this section, the test setup and experimental procedure for conducting various tests are discussed.

Compressive strength test (IS 516-1989):

Compressive strength of concrete is the most important characteristic and it is an indexing property as concrete is designed to carry compressive loads. For this experimental study, 45 no. of cube specimens were cast in which 9 specimens. This test is conducted to determine the variation of strength of the specimens with varying ratios of coating of plastic to the coarse aggregate. Compressive strength test machine (CTM) with 2000KN capacity is used to conduct the test on cubes. After placing the cube between the plates in the CTM, load is applied until the crack is observed on the specimen. The load at the point of cracking is considered as failure load and it is noted. The compressive strength is calculated by

Compressive Strength (σ) = Failure load / Cross sectional area of specimen

Fig.10 testing of cube specimen

Flexural strength test (IS 516-1989):

The beam specimens were tested on universal testing machine for two-point loading to create a pure bending. The bearing surface of machine was wiped off clean and sand or other material is removed from the surface of the specimen. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span. Beam dimensions are 500mm×100mm×100mm. if the specimen breaks at the middle third of the span then the modulus of rupture is given by,

$$f_{rup} = \frac{Pl}{bd^2}$$

Where; P = load, d = depth of the beam, b = width of the beam.

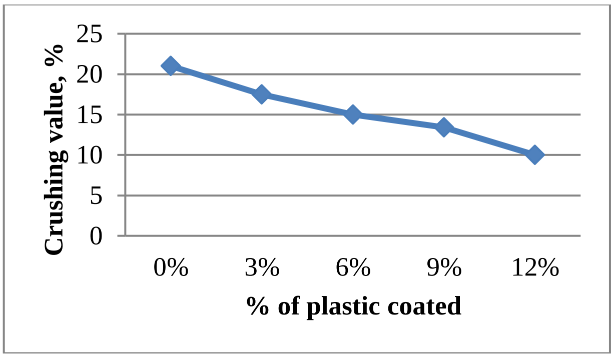
Fig.11 Flexural Strength tests of beam samples in UTM

6. RESULTS & DISCUSSIONS

A. Plotting curves for aggregate tests

3curves were plotted, i.e.:

- Aggregate Crushing Value (%) - [IS: 2386 (Part-IV)]
- Aggregate Impact Value (%) - IS: 2386 (Part-IV)
- Water Absorption (%) - (IS:2386 Part III)



Graph.1 crushing value of aggregates Vs % Plastic coated Aggregates

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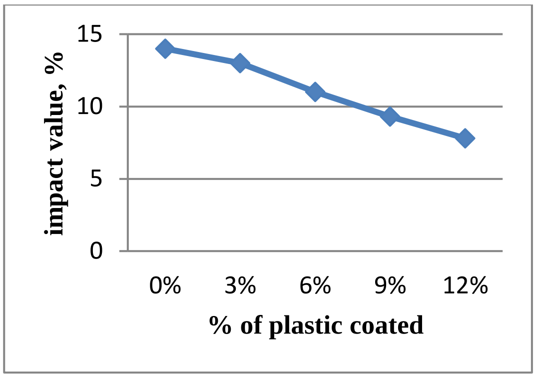
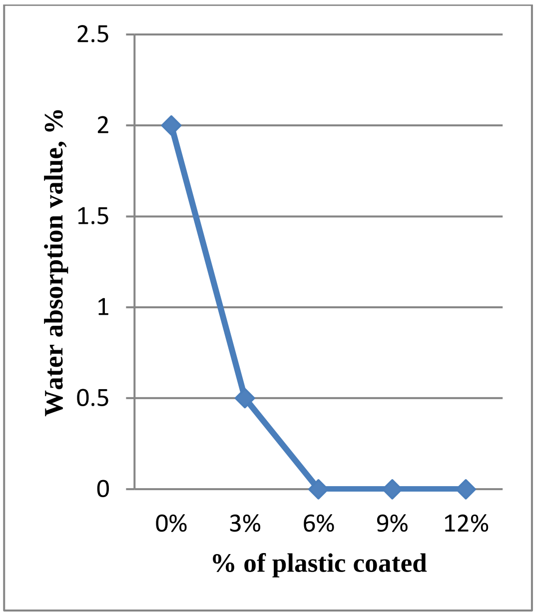


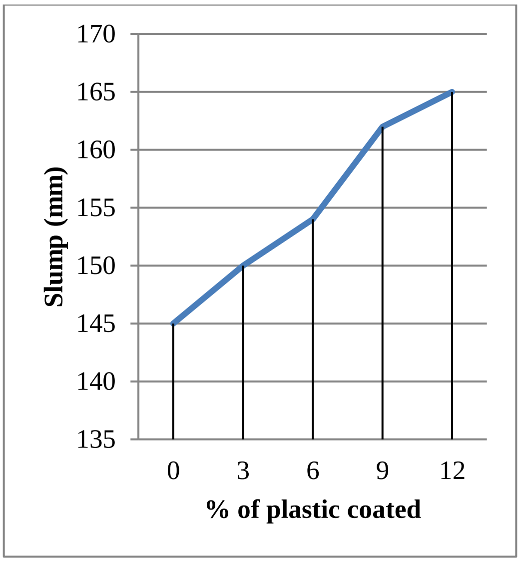
Graph.2 Impact value of aggregates Vs % Plastic coated Aggregates

Table.6 Slump values

Plastic coated (%)	Slump (mm)
0	145
3	150
6	154
9	162
12	165



Graph.3 Water absorption value of aggregates Vs % Plastic coated Aggregates



Graph.4 Slump graph

B. Fresh properties of concrete (slump cone test)

According to the plot of the Slump values for various percentages of plastic coated aggregates used in concrete, workability rises as the amount of plastic coated aggregates increases from 0 to 12%.

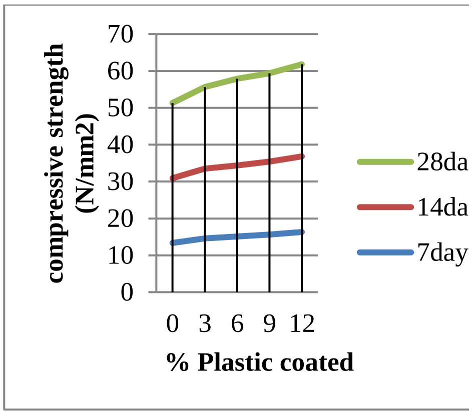
C. Harden properties of concrete

Compressive Strength Test:

The concrete's compressive strength was tested using cubes that were 15 cm x 15 cm x 15 cm. The findings are shown in below Table, and they support the assertion that when plastic coated aggregates are increased from 0 to 12%, compressive strength rises.

Table.7 Compressive strength

S. No.	%Plastic coated	Compressive strength of cubes (Average results) N/ mm²		
		7 days	14days	28days
1	0	13.35	17.56	20.4
2	3	14.6	18.9	22.1
3	6	15.1	19.3	23.5
4	9	15.6	19.8	24
5	12	16.32	20.5	24.98



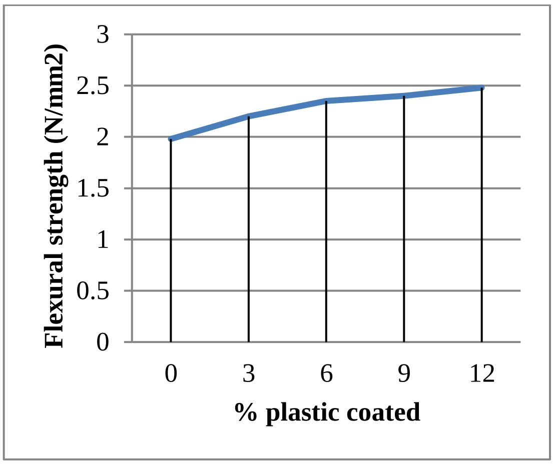
Graph.5 Compressive strength graphs

Flexural Strength Test:

The findings of the flexural test on UTM, which was carried out on beams of 50 x 10 x 10 cm, were used to determine the flexural strength of the plastic-coated particles used in concrete. According to the data shown below, plastic coated aggregates used in concrete had superior flexural strength than regular concrete (i.e. at 0% replacement). Additionally, it was shown that as the proportion of plastic coated particles in concrete grows, so does the beam's flexural strength.

Table.8 Flexural strength

Plastic coated (%)	Flexural strength (N/mm2)
0	1.98
3	2.2
6	2.35
9	2.4
12	2.48



Graph.6 Flexural strength graphs

7. CONCLUSIONS

The following findings are drawn from this study:

1. The slump value rises as the proportion of plastic-coated particles in concrete does. The workability of concrete increased as the amount of plastic-coated particles used in concrete increased.

2. When compared to conventional concrete and aggregates that were plastic coated, the highest compressive strength of M20 for 28 days was 24.98 N/mm^2 at an 18.33% increase.

3. When compared to ordinary concrete and the plastic coated aggregates used in concrete, the

maximum flexural strength of M20 for 28 days was 2.48 N/mm^2 at a 20.16% increase.

4. The compressive strength, flexural strength, and workability of the plastic covering increase with aggregates.

5. In this project limited up to 12% of plastic coated to the coarse aggregates, the compressive and flexural strength increases with increasing coating of plastic to the coarse aggregate.

6. By covering the plastic with aggregates, it is feasible to increase the mechanical qualities of concrete while also reducing the amount of plastic dumped in landfills and disposing of it more economically and environmentally friendly.

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