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An experimental investigation on partial replacement of coarse aggregate with plastic waste in rigid pavement

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ABSTRACT

This paper reports **"An Experimental Investigation on Partial Replacement of Coarse Aggregate with Plastic Waste in Rigid Pavement"** in which the natural aggregate are partially replaced by the waste plastic (HDPE) in the Rigid pavement. The main objective of this project is to use the waste plastic into an efficient way in the construction of road pavement which leads to a green eco system. Permeable pavements help in improving the flow of water, ground water recharge and increase life time of pavement. By using the plastic as an aggregate in the concrete reduce the cost and weight of the pavement. All of the concrete mixture were tested at room temperature. The Fresh Concrete test include performing slump Cone Test, Compaction factor test and Flow Test. These harden concrete performing of compressive strength, flexural strengths and spilt tensile strength. Curing ages 7, 14, 28 days for the concrete mixture were applied in this work. This study insures that reusing and recycling of waste plastic as a natural aggregate substitution in concrete gives a good approach to reduce the cost of the materials and solve some of the solid waste problems posed by plastics.

Keywords: High Density Poly Ethylene, Plastic Coarse Aggregates, Rigid Pavement.

INTRODUCTION

The environmental problem such as disposal of waste plastic is major concern. To overcome the problems the modifiers (waste plastic) are used. In general there are two types of roads. [1-4]

- Rigid pavement
- Flexible pavement.

Now we are considering replacement of Coarse aggregate with plastic waste in rigid pavement. Development of industries and urban areas increase the waste generation is also increases, which is unfavorably carrying out the environment. Durability, sustainability and economy have made it the world's most widely used construction material. As the plastic waste is lighter than the natural aggregate so the concrete made from such aggregate possesses.

This project is to use the waste plastic High Density Poly Ethylene (HDPE). HDPE is a plastic made from petroleum and types of HDPE plastics include bottles with pigment and without. Those with pigment have a higher resistance to cracking and chemicals, so this type of bottle is ideal for packaging household items such as certain cleaning products. Other HDPE plastics are made into injection-molded containers that serve as various food packaging because they are resistant to warping. It is high strength-to-density Ratio, HDPE is used in the production of plastic bottles, corrosion-resistant piping,

Geo membranes and plastic lumber. HDPE is commonly recycled and has the number "2" as

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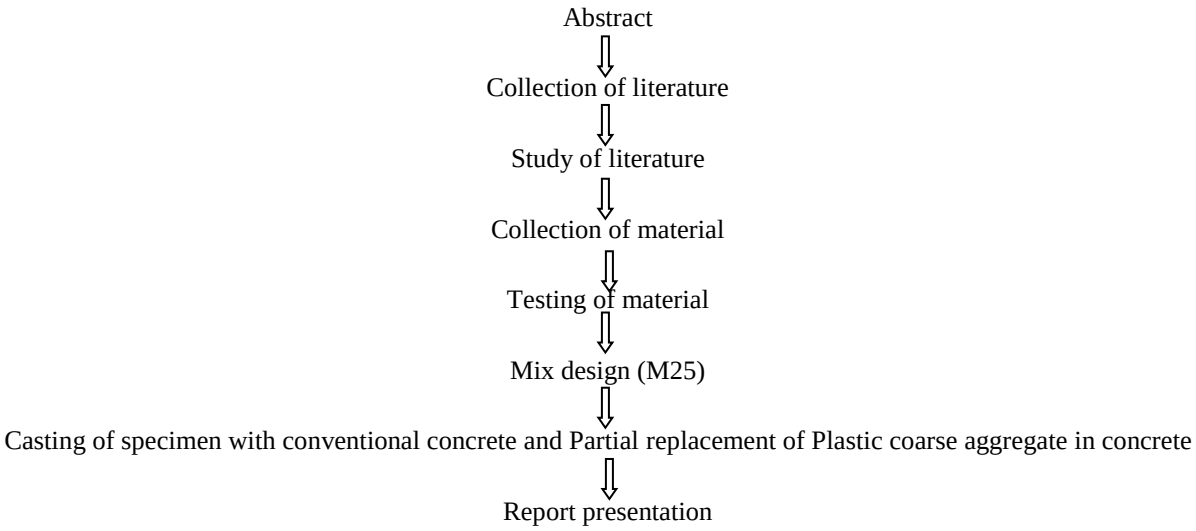
its resin identification code. In 2007, the global HDPE market reached a volume of more than 30 million tons. [5-12]

HDPE is known for its large strength-to-density ratio. The density of HDPE can range from 930 to 970 kg/m^3. Although the density of HDPE is only marginally higher than that of low-density polyethylene, HDPE has little branching, giving it stronger intermolecular forces and tensile strength than LDPE. The difference in strength exceeds the difference in density, giving HDPE a higher specific strength. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/248 °F for short periods). [13]

OBJECTIVES

- The natural aggregate are 50% replaced by the waste plastic (HDPE) in the Rigid pavement.
- To study properties of plastic waste used in concrete.
- To study influence plastic aggregates in concrete to conventional concrete.
- To find the strength of the harden concrete.

METHODOLOGY



MATERIAL TESTING

Water

Fresh potable water having p^H value water is 7 is used for making concrete and for curing the concrete cubes, prism and cylinder.

Cement

Ordinary Portland cement (OPC) is one of the most popular building materials used all across the globe. There is a fascinating story behind the naming of this widely used cement product. The chief chemical constituents of ordinary Portland cement (OPC) are Calcium, Alumina and Iron, Cement manufacturers continuously research and make effort to further strength and improve the quality and other features of this particular type of cement. We offer the 53 Grade OPC Cement which gives even higher cement strength to match the rising demands of higher strength building material in the urban world..

Table 1 Physical Properties of Cement.

Property	Value	Requirement (IS12269-1989)
Specific gravity	3.12	ISH99-1959
Initial setting time	30	Minimum 30 min.

Final setting time	390 min.	Maximum 600 min.
Soundness	5.80	Maximum 10mm
Standard consistency	27.20%	-

Fine aggregates

The size of aggregate less than 4.75 mm considered as fine aggregate. Fine aggregate is natural sand which has washed and sieved to remove particles larger than 5 mm and coarse aggregate gravel which has been crushed, washed and sieved so that the particles may vary from 5 up to 50 mm size. The fine aggregate should have rounded shape. Manufactured Sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word.

Properties of Fine aggregate

- Specific gravity test on fine aggregate G = 2.375

Fig 1Fine Aggregate

Sieve analysis

A sieve analysis is a practice or procedure used to assess the particle size distribution of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of aggregate.

Table 2 Sieve analysis test on fineaggregate

S.No	Is Sieve	Portable Size (mm)	Mass retained (g)	Cumulative % retained	Cumulative fineness %
1	4.75 mm	4.75	32	3.2	96.8
2	2.36 mm	2.36	33	3.3	93.5
3	1.18mm	1.18	134	13.4	80.1
4	600 micron	600	374	37.4	42.7
5	300 micron	300	341	34.1	8.6
6	150 micron	150	81	8.1	0.5
7	PAN		26	2.6	-2.1

Coarse aggregate (Natural)

Aggregate are the important constitutes in concrete. They give body to the concrete, reduce shrinkage and effect economy. The aggregates occupy 70 – 80percentof the volume of concrete, their impact on various characteristics. The size of aggregate bigger than 4.75 mm considered as coarse aggregate. The coarse aggregate has high crushing strength. The size of coarse aggregate depends up on the nature of work. The aggregates are free from dust before used in the concrete.

Table 3 Physical Properties on Coarse Aggregate (Natural)

S.No	Test	Value
1	Specific Gravity Test	2.50
2	Aggregate Crushing Value	23%
3	Water Absorption	2%
4	Impact Value	11.55%

Coarse aggregate (plastic)

The use of plastic is increasing day by day, although steps were taken to reduce its consumptions. This creates substantial garbage every day which is much unhealthy. A healthy and sustainable reuse of plastics offers a host of advantages. The suitability of recycled plastic as coarse aggregate in concrete and its advantages are discussed here. The initial questions arising of the bond strength and the heat of hydration regarding plastic aggregate were solved. Tests were conducted to determine the properties of plastic aggregate such as density, specific gravity, impact value, crushing value and water absorption. As 100% replacement of natural coarse aggregate with plastic coarse aggregate is not feasible, so partial replacement were examined.

Table 4 Physical Properties of Coarse Aggregate (Plastic)

S.No	Test	Value
1	Specific Gravity Test	2.50
2	Aggregate Crushing Value	23%
3	Water Absorption	2%
4	Impact Value	11.55%
5	Specific Density	0.93 to 0.97 g/cm^3

Fig 2 Coarse Aggregate

Propertise of HDPE

- ✓ HDPE is large strength-to-density ratio.
- ✓ The density range from 930 to 970 kg/m^3.
- ✓ The density of HDPE is only marginally higher than that of low-density polyethylene.
- ✓ The HDPE is having higher specific strength.
- ✓ It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/248 °F for short periods).
- ✓ HDPE is relatively hard and resistant to impact and can be subjected to temperatures of up to 120^{o}C without being affected.
- ✓ HDPE has a high density, with a specific gravity of 0.95.

FRESH CONCRETE TEST

Fresh concrete is that stage of concrete in which concrete can be moulded and it is in plastic state. The potential strength and durability of concrete of a given mix proportion is very dependent on the degree of its compaction.

- Slump Cone Test
- Compaction factor test
- Flow test.

Slump cone test

Unsupported fresh concrete flow to the sides and a sinking in height takes place. This vertical settlement is known as slump. Slump is a vertical measure indicating the consistency or workability of cement concrete. In this test fresh concrete is filled into a cone of specified shape and dimension and the settlement or slump is measured when supporting mould is removed. Slump increase as water content is increased. It gives an idea of water content needed for concrete be used for different works Bleeding of concrete is said to occur when excess water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

Table 5 Slumptest on fresh concrete

S.No	W/C Ratio	Slump Value
1	0.45	25mm
2	0.50	60mm
3	0.55	75mm

Flow test

The flow table test or flow test is a method to determine consistency of fresh concrete. Flow table test is also used to identify transport table moisture limit of solid bulk cargoes.

Table 6FlowTest on Fresh Concrete

S.NO	W/C RATIO	Value
1	0.45	0.844
2	0.50	0.852
3	0.55	0.89

Compaction factor test

Compaction factor test is more precise and sensitive than the slump test and is particularly using for concrete mixes of very low workability. This test work on the principle of determining the degree of compaction achieved by a standard amount of allowing the concrete work done by allowing the concrete to fall through a standard height. The degree of compaction is called compaction factor. It is measured by the density ratio. The density achieved in the test to density of same concrete fully compacted.

Table 7 Compaction Test on Fresh Concrete

S.No	W/C Ratio	Compaction Factor
1	0.45	0.830
2	0.50	0.949
3	0.55	0.973

HARDEN CONCRETE TEST

The water causes the hardening of concrete through a process called hydration. Hydration is a chemical reaction in which the major compounds in cement from chemical bonds with water molecules and become hydrates. The hardened concrete testes are

Compressive strength Test

The compression test specimens were tested on a compression tested on a compression testing machine (CTM) of capacity 2000 kN. The specimen was placed on machine in such a way that its position is at right angle to it shown

position which it had at the time of casting. load is applied gradually as the rate 14N/mm^2/min or 320 k N/min. Cube moulds of size 150 x 150 x 150 mm were casted and allowed for curing in a curing tank for 28 days and they were tested at 7, 14 and 28 days.

Fig 3 Compressive Strength

Split tensile strength

The determination of tensile strength of concrete in necessary to determine the load at which the concrete members crack. The cracking forms a tensile failure. The main of this experimental test is to determine the maximum load carrying capacity of test specimens. Cylinders of size 150mm in Diameter and 300mm height were cast for split tensile test. Two numbers of specimens were tested 28days.

Fig 4 Split Tensile Strength

Flexural strength

The main of this experimental test is to determine the maximum load carrying capacity of the beam specimens. Specimen is subjected to two points loading and the load at the failure of the specimen is noted down. Prism of size 100x100x500mm was cast. Two numbers of specimens for each set were tested for 28days. These specimens were tested in Universal Testing Machine (UTM) of capacity 1000kN. The main value of the specimen of each type is taken as final flexure value. Flexural strength of the specimen is expressed as the modules of rupture.100 x 100 x 500 mm sizes of the prism were cast. The specimens were demoulded after 24 hours of casting and transferred to curing tank for 28 days.

Table 8 Conventional Concrete Compressive Strength,Split Tensile Strength and Flexural Strength Results for M25 Grade of Concrete

S.No	Days	Compressive strength N/mm^2	Split Tensile Strength N/mm^2	Flexural StrengthN/mm^2
1	7	15.5	1.45	2.15
2	14	20	2.50	2.70
3	28	25	3	3.25

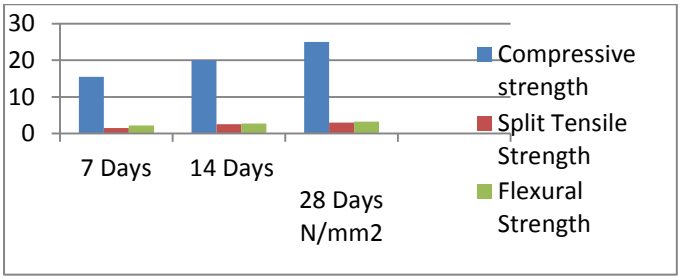


Fig 5 Flow Chart for Conventional Concrete Compression Strength, Flexural Strength and Split Tensile Strength Results for M25 Grade of Concrete

Table 9: Partially Replacing of Plastic Coarse Aggregate withConcrete Compressive Strength,Split Tensile Strength and Flexural Strength Results for M25 Grade of Concrete

S.No	Days	Compressive strength N/mm^2	Split Tensile Strength N/mm^2	Flexural StrengthN/mm^2
1	7	8.5	5.0	2.2
2	14	11.5	5.35	2.45
3	28	15	6	2.90

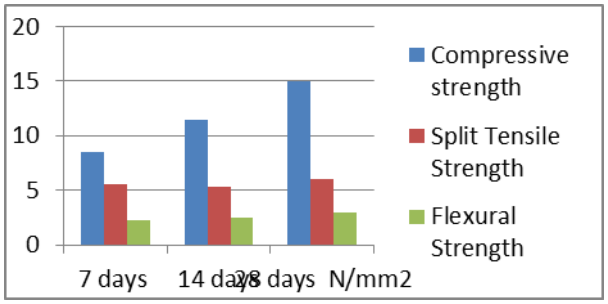


Fig 5 Flow Chart forPartially Replacing of Plastic Coarse Aggregate with Concrete Compression Strength, Flexural Strength and Split Tensile Strength Results for M25 Grade of Concrete

ADVANTAGES

Advantages

1. Strength of the road gets increased.
2. Better resistance to water & water stagnation.
3. No stripping & no potholes.
4. Increases binding & better bonding of the mix.
5. Better soundness property.
6. Maintenance cost of the road is almost nil.
7. No effect of radiation like UV.

CONCLUSION

The experimental investigation is to find out the M25 grade design ratio of conventional concrete test report and Partial Replacing of plastic Coarse Aggregate with the Concrete Test Report on this section.

Here using the ratio of concrete mix is 1:1.2:2.34 and Refering ofIS 10262-2019 and IS 456 – 2000 codes are using to find the concrete test. This project 7 days, 14 days and 28 days of Compressive Strength, split tensile strength and flexural strength were studied.

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