Parametrical Analysis of Concrete Utilizing Different Percentage of HDPE Powder Replacing Fine Aggregates

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Abstract - *Now days, Solid waste management (SWM) is one of the foremost environmental apprehensions in our country. In recent years a significant expansion in the utilization of plastic is noted worldwide, which led to enormous quantities of waste related to plastic. Reprocessing of plastic waste to turn out new materials like concrete is one of the logical methods of setting out wastes, due to its financial and environmental benefits. Numerous works have been carried out or are under execution to assess the properties of concrete including plastic waste. In this project, study on the fractional replacement of sand with High Density Polyethylene powder is done. An assessment between traditional concrete and concrete with HDPE powder is accomplished to study the strength and durability parameters. In the present work different percentage replacements of sand with HDPE powder is examined.*

Key Words*: *High Density Polyethylene powder (HDPE), Solid waste management, Sand, Recycling plastic waste, Compressive Strength, Split tensile Strength and UPV.

1.INTRODUCTION

Since many years, research pertaining to the use of by-products to supplement the properties of concrete has been going on. In the last two decades, a determined attempt have been made to employ industry derivatives such as fly ash, ground granulated blast furnace slag (GGBS), glass cullet, silica fume, etc. in civil constructions. The possible applications of industry derivatives in concrete are as partial aggregate substitution or as partial cement replacement rely on their chemical composition and grain size. The utilization of these materials in concrete comes from the ecological constraints in the safe discarding of these products.

One of the various waste materials used in the concrete industry is recycled or reprocessed plastic. In order to dispose huge amount of recycled plastic material, reprocess of plastic in concrete manufacturing is considered as the most viable application. Recycled plastic can be employed as coarse aggregate or fine aggregate in concrete. Though, it is important to emphasize that re-using of wastes is not yet economically beneficial, due to the costs of transport and its result on the total cost of production.

2. METHODOLOGY

The aim of the experimental program is to study the behaviour of concrete in which fine aggregate is partially replaced by HDPE powder. In this chapter a detail has been explained about the material used and different tests conducted.

2.1 Materials

1. Cement

Ordinary Portland cement of specific gravity 3.15 (IS 4031-1988 part II) is used in this research program. To assess some parameters like fineness, consistency and setting time test. Different tests have been conducted done on cement.

Table 1.1 Properties of Cement

PROPERTIES	VALUES
Fineness	**1%**
Specific Gravity	**3.05**
Consistancy	**31%**
Initial Setting Time	**122 Minutes**
Final Setting Time	**329 Minutes**

2. Fine Aggregate: In this experimental program, sand is used as fine aggregate. Sand passing through sieve IS 4.75mm is utilized for a variety of tests.

Table 1.2 Properties of Sand

PROPERTIES	VALUES
Fineness Modulus	**2.98**
Specific Gravity	**2.82**
Zone	**II**

3. Coarse Aggregate: 20mm maximum size coarse aggregates have been used in this research program. Properties of coarse aggregates are tabulated below.

Table 1.3 Properties of Aggregates

PROPERTIES	VALUES
Fineness Modulus	**3.89**
Specific Gravity	**3.128**
Water Absorption	**2%**

4. Water: Normal tap (Potable) water has been used for casting and curing. The water is free from chemicals, organic matter and acids.

5. High Density Polyethylene (HDPE) Powder: HDPE powder is used for the partial replacement of fine aggregate in this project. HDPE powder is known for its large strength to density ratio.

3.2 Mix Design

Calculation of mix proportion like cement, coarse aggregate, admixture, water, fine aggregates and other constituents to formulate concrete as per required strength, workability and durability is known as Concrete Mix Design.

1. Requirements

a) Specified minimum strength = 20 N/Sq mm
b) Durability requirements: Exposure Moderate & Minimum Cement Content = 300 Kgs/cum
c) Cement (Refer Table No. 5 of IS: 456-2000)
Birla Cement, Type OPC & Grade 43
d) Degree of quality control: Good.

2. Test Data For Materials Supplied

A. CEMENT
i) Specific gravity = 3.05
ii) Avg. comp. strength 7 days = 46.5 more than 33.0 (OK)
iii) Avg. comp. strength 28 days = 55.0 more than 43.0 (OK)
B. COARSE AGGREGATE
i) 20mm Graded
ii) Type Crushed stone aggregate
iii) Specific gravity = 2.68
iv) Water absorption = 1.46
v) Free (surface) moisture = 0
C. FINE AGGREGATE (Coarse sand)
i) Type Natural
ii) Water absorption = 0.5
iii) Specific gravity = 2.6
iv) Surface moisture = 1.4

3. Target Mean Strength (TMS)

a) Statistical constant K = 1.65
b) Standard deviation S = 4.6
Thus, TMS = 27.59 N/Sq.mm

4. Selection of W/C Ratio

a) As required for TMS = 0.5
b) As required for 'Moderate' Exposure = 0.55
Assume W/c ratio of 0.5

5. Determination of Water & Sand Content For W/C = 0.5

a) Water content = 186 Kg/cum
b) Sand as percentage of total aggregate by absolute volume = 35 % , C.F. = 0.8
Max. Aggregate Size = 20 mm Thus, Net water content = 180.42 Kg/cum Net sand percentage = 33 %.

6. DETERMINATION OF CEMENT CONTENT W/C Ratio = 0.5

Water content = 180.42 Kg/cum
Thus, Cement content = 360.84 Kg/cum
Adequate for moderate exposure Say 360 Kg/cum

7. DETERMINATION OF COARSE AND FINE AGGREGATE CONTENT Assume Entrapped Air As 2 %

0.98 cum = [180.42+360/3.05 + {1/0.33}*{FA/2.6}]/1000
& 0.98 cum = [180.42+360/3.05 + {1/0.67}*{Ca/2.68}]/1000
Hence,
FA = 584 Kg/cum Ca = 1223.8 Kg/cum
The final mix proportions of M-20 grade of concrete become:

Water	Cement	FA	CA
180.42	360	584	1223.8
0.50	1.00	1.62	3.40

3.3 Tests Conducted

Test conducted in two categories i.e. fresh and hardened concrete.

A. Tests on Fresh Concrete:

1. Slump cone test

For determining the consistency or workability of concrete mix, slump cone test is the most popular test used at both laboratory in situ conditions. In order to obtain uniform quality, slump is checked at intervals i.e. from batch to batch during construction.

B. Tests on Hardened Concrete:

For an appropriate time interval after demoulding of moulds, specimens are kept in curing tank to lessen the heat of hydration. The specimens should be tested by standard testing process confirming IS: 516-1959.

1. Concrete compressive strength

Concrete is known for its good compressive strength and resilience. Concrete is mostly used in construction where load conveyed is mostly via compressive strength. Samples have been prepared of standard size i.e. 150 mm x 150 mm x 150 mm and kept in the curing tank for 7 and 28 days and then tested under CTM.

Fig. (1) Compressive Testing Machine

2. Split tensile strength

Concrete may also be subjected to tension in some cases and it is never designed to resist direct tension. Nevertheless, the load at which cracking would occur is significant and needs to be find out. The tensile strength of concrete as compared to its compressive strength is very less and it is found to be only 10-14 % of the crushing strength. There are some parameters which manipulate the tensile strength of concrete like age, curing, aggregates, air-entrainment and method of testing.

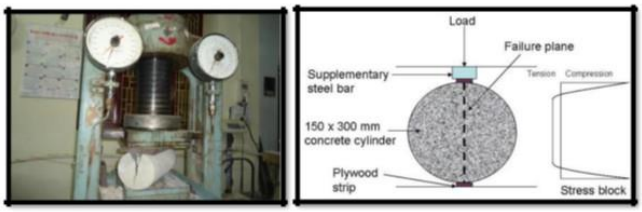

Fig. (2) Split Cylinder Test

3. Flexural strength:

In order to evaluate the indirect tensile strength of concrete, Flexural strength test is adopted. This test evaluates the capacity of concrete beam or slab (without steel) to resist failure in bending.

Fig. (3) Flexural Test Setup

4. Ultrasonic Pulse Velocity Test

For examining the quality of concrete, Ultrasonic Pulse Velocity (UPV) method is the worldwide adoptable NDT Technique. In this technique ultrasonic waves are passed from one end to another end of concrete element and velocity of these waves is noted. In case of good quality higher velocities will be received which shows higher density, homogeneity and uniformity. Whereas, in case of poor-quality concrete, low velocities are received.

Fig.(4) Ultrasonic Pulse Velocity Test Setup

4. RESULTS:

This chapter presents various results obtained in the experimental program. The results obtained by the experiments conducted are graphically represented.

4.1 Workability

Slump cone test is conducted to check the workability of concrete with or without replacing HDPE. There are various ways of determining workability but slump cone test is worldwide accepted as this method is quick and easy to do. In the present experimental program effect of partial substitution of HDPE on concrete is studied. HDPE Powder is replaced with fine aggregates in following percentages i.e. 0, 5, 10, 15, 20%. The results of replacement on workability are discussed below.

Table 4.1- Slump values and workability of concrete

Percentage of plastic replacing fine aggregate	Slump Value (mm)	Workability
HDPE (0%) Control Specimen	90	Mediam Workable Mix
HDPE (5%)	130	Highly Workable Mix
HDPE (10%)	110	Highly Workable Mix
HDPE (15%)	60	Mediam Workable Mix
HDPE (20%)	30	Low Workable Mix

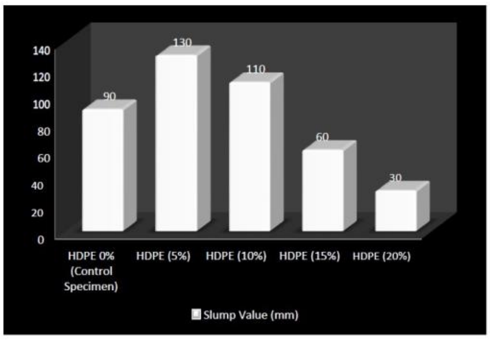

Fig.4.1 Slump Values

4.2 Compressive Strength

The compressive strength shown below is the average of compressive strength obtained from three identical cubes i.e. 150mm X 150mm X 150mm.

Table 4.2- Compressive Strength Test Result

sPercentage of plastic replacing fine aggregate	7th Day Strength (N/mm2)	28th Day Strength (N/mm2)
HDPE (0%)	19.25	30.11
HDPE (5%)	22.24	35.11
HDPE (10%)	21.14	32.88
HDPE (15%)	19.55	29.33
HDPE (20%)	18.07	27.11

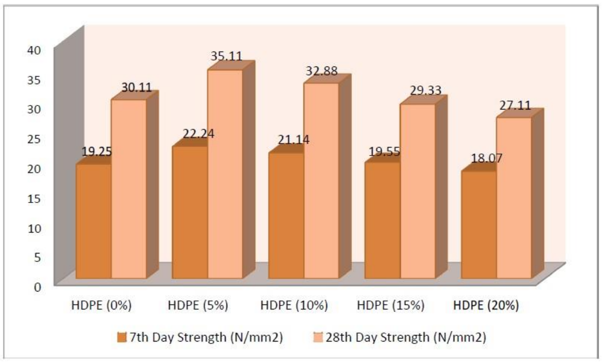

Fig.4.2 Compressive strength Test Results

4.3 Split tensile strength test

The tensile strength shown below is the average of tensile strength obtained from three identical cylinders i.e. 150mm X 300mm.

Table 4.3- Split tensile Strength Test Results

Percentage of plastic replacing fine aggregate	28th Day Strength (N/mm2)
HDPE (0%)	3.2
HDPE (5%)	3.93
HDPE (10%)	3.28
HDPE (15%)	3.16
HDPE (20%)	3.09

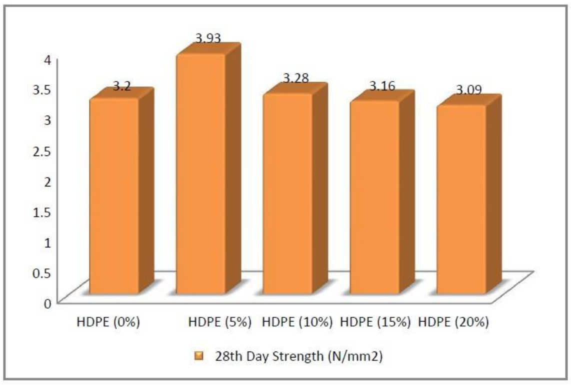

Fig.4.3- Comparison of split tensile strength

4.4 Flexural strength test

The flexural strength test is conducted on a beam of size 100 mm×100 mm×500 mm. The average flexural strength of three identical samples is shown below.

Table 4.4- Flexural Strength Test Results

Percentage of plastic replacing fine aggregate	28th Day Flexural Strength (N/mm2)
HDPE (0%)	5.125
HDPE (5%)	7.5
HDPE (10%)	6.75
HDPE (15%)	5.75
HDPE (20%)	5.5

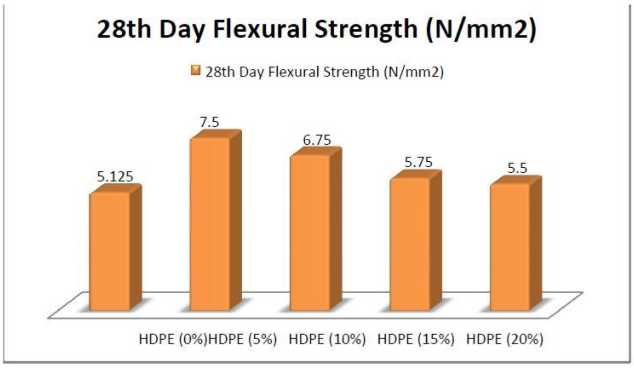

Fig.4.4- Comparison of flexural strength

4.5 Ultrasonic Pulse Velocity (UPV) test

The UPV test is conducted on concrete cubes having same size 150mm X 150mm X 150mm with dissimilar substitution of HDPE powder to check its effect. The results of UPV test are discussed below.

Table 4.5- UPV Test Results

Percentage of plastic replacing fine aggregate	Direct Transmission		Semi Direct Transmission	
	Time (µs)	Velocity (m/s)	Time (µs)	Velocity (m/s)
HDPE (0%)	27.8	5235	17.2	8200
HDPE (5%)	28.9	5190	18.9	7937
HDPE (10%)	29.8	5037	20.4	7353
HDPE (15%)	32.9	4559	21.8	6998
HDPE (20%)	33.1	4532	22.6	6535

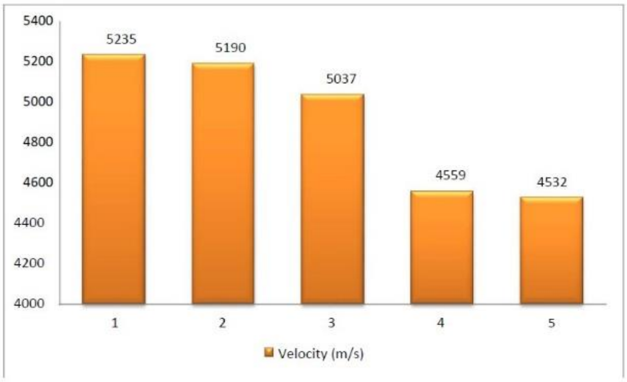

Fig.4.5- Comparison of UPV Results (Direct transmission)

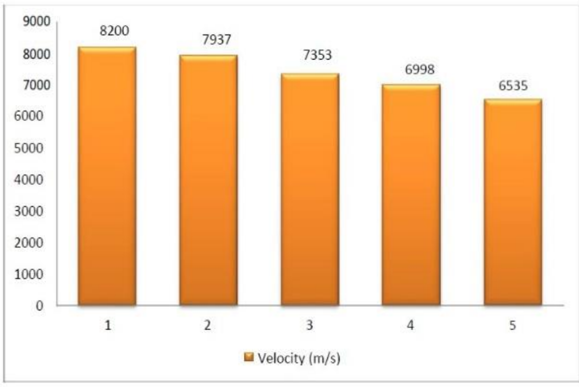

Fig.4.6- Comparison of UPV Results (Semi direct transmission)

5.0 Discussion and Conclusion

5.1 Discussion:

Following are the important points of discussion:

1. Results indicate that with increase in HDPE powder workability decreases. Optimum percentage of HDPE powder replacement is 5% with fine aggregates. At Replacement ranges between 5 to 10 % in concrete shows highly workable concrete.
2. If the replacement range is in between 5 to 10%, compressive strength increases when it kept side by sided to controlled specimen. Nevertheless, at 5% replacement, compressive strength enhances by 16%.
3. For split tensile strength, the best value is obtained at 5% replacement of fine aggregate by HDPE powder. However it has been noticed that the split tensile strength reduces with increase in percentage of HDPE powder more than 5%. Split tensile strength increases by 22.9% at 5% replacement of HDPE powder.
4. Also, in case of flexural strength, decrease with increase in percentage of HDPE powder has been noticed. 46.34% increment has been observed at 5% optimum value. However, at any replacement of HDPE powder strength is more than control specimen.
5. Reduction in UPV has been observed with the increment in UPV values, but still it falls under good quality concrete at any replacement percentage.

5.2 Conclusion

Following points of conclusion can be drawn from the results of experimental work:

1. It is found that plastic waste may be disposed by using it as a construction material in concrete.
2. All the properties such as workability, compressive strength, flexural strength and split tensile strength of concrete are affected by the inclusion of HDPE powder.
3. Compressive strength, flexural strength and split tensile strength of concrete decreases with increase in HDPE powder.
4. The optimum replacement of HDPE powder is found to be 5% .
5. At optimum replacement compressive strength increases by 16.6%. Split tensile strength increases by 22.815% and Flexural strength increases up to 46.34%
6. Density of cubes measured by UPV decreases with increase in HDPE powder.
7. As HDPE is the waste materials, hence by the use of this material in concrete makes environment eco-friendly.
8. By utilizing these materials economical construction may be done.

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