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AN EXPERIMENTAL INVESTIGATION ON POLYWASTE MATERIALS IN CONCRETE

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Abstract - *During the past few decades Indian construction industries are facing problems due to insufficient and unavailability of construction materials. And also large scale depletions of these Natural resources have led to many environmental impacts. In order to overcome these impacts, an alternative has to be found in order to replace any of coarser and fine aggregate. In other side one of the main environmental problems today is disposal of plastic wastes. To overcome the above two problems one can be replaced by other. High Density Polyethylene (HDPE) is one of the plastic materials that can be used as a replacement for coarse aggregate. HDPE, which are obtained as a waste material are used for construction purposes as a replacement for coarse aggregate. HDPE has been used in large scale in day to day life and also used in the manufacture of milk jugs, grocery bags, juice cans etc. In this investigation, we carried out to study the compressive strength, split tensile strength (cube and cylinder), flexural strength and durability properties of concrete using HDPE as a replacement of coarse aggregate by 10%, 15%, and 20% of the weight of coarse aggregate. The present investigations mainly focused on the strength and durability properties of M25 grade of concrete using HDPE as a replacement for coarse aggregate.*

Key Words*: *Insufficient, Plastic, High Density Polyethylene, Replacement, Coarse aggregate.

1. INTRODUCTION

Now days due to the lack of availability of construction materials, many experimental investigations on concrete are carried out and result are discussed. By this way of investigation, the excess poly waste materials as a landfill are used as a partial replacement based on their physical and mechanical property. Poly waste concrete is the concrete mix which contains poly waste as a replacement for aggregate in concrete. This present investigation is based on the partial replacement of poly waste in concrete as a replacement for coarse aggregate in concrete mix at a ratio of 10%, 15% and 20%. Most of the materials that are called plastic are polymers. Polymers are made from natural materials such as cellulose, coal, natural gas, salt, and crude oil through a polymerization or poly condensation process. Plastics are normally stable and not biodegradable. According to the properties and behaviors plastics are of various types. High Density Polyethylene (HDPE) is one of the types of plastics which are dense and strong which can be studied and examined to give a contribution to the effective use of waste plastics in concrete in order to prevent the ecological and environmental strain caused by poly waste. The property of the material used in this investigation was completely studied. The aim of the experimentation is to investigate the strength and durability properties of High Density Polyethylene (HDPE) as a replacement for coarse aggregate in M_{25} Grade concrete mix comparing to conventional concrete mix. The scope of the present investigation is to study the effect of durability and the strength of concrete for different framed members with the partial replacement of High density polyethylene by coarse aggregate. To find the mechanical properties and durability properties at 7 days, 14 days and 28 days for replacement of 10%, 15% and 20% High density polyethylene as a coarse aggregate mix concrete.

2. MATERIALS IN MIX

Normal strength concrete has compressive strength of up to 50 MPa. The hardening is caused by chemical reaction between water and cement and continues for a long time after the concrete has a sufficient strength for the work intended. Concrete is a mixture of cement, water, sand and gravel or crushed aggregate. The ingredients are ranged as 7 – 15% of cement, 60 – 80% of aggregates, 14 – 18% of water and 2 – 8% of air. By adding the respective percentage of mixtures the normal concrete can be obtained.

Table -1: Materials in HDPE concrete mix.

S.NO	MATERIALS	DESCRIPTION
1	Cement	OPC 53 grade
2	Fine aggregate	Manufactured sand
3	Coarse aggregate	Normal gravels replaced with 10%, 15% and 20% of HDPE
4	Water	Tap water
5	Coarse aggregate size	12.5 mm angular type & 20 mm angular type

Table -2: Materials in conventional concrete mix.

S.NO	MATERIALS	DESCRIPTION
1	Cement	OPC 53 grade
2	Fine aggregate	Manufactured sand
3	Coarse aggregate	Normal gravels replaced with 10%, 15% and 20% of HDPE
4	Water	Tap water
5	Coarse aggregate size	12.5 mm angular type & 20 mm angular type

3. TEST ON MATERIALS

3.1 Cement

The most important uses of cement are as an ingredient in the production of mortar in masonry, and of concrete, a combination of cement and an aggregate to form a strong building material.

Table -3: Test result of cement

S.NO	TEST	RESULT
1	Specific Gravity of cement	3.15
2	Fineness of cement	4%
3	Standard consistency test	30%
4	Initial setting time	35 minutes
5	Final setting time	600 minutes

3.2 Fine aggregate

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. M-Sand is dust-free, the sizes of m-sand can be controlled easily so that it meets the required grading for the given construction.

Table -4: Test result of fine aggregate

S.NO	TEST	RESULT
1	Specific gravity	2.65
2	Fineness	3.9
3	Bulk density	1632 kg/m^3

3.3 Coarse aggregate

The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete.

Table -5: Test result of coarse aggregate

S.NO	TEST	RESULT
1	Specific gravity	2.85
2	Bulk density	1386 kg/m^3

3.4 High density polyethylene

A linear polymer, High Density Polyethylene (HDPE) is prepared from ethylene by a catalytic process. HDPE is harder and more opaque and it can withstand higher temperatures of 120^o Celsius for short period and 110^o Celsius for continuous period.

Table -6: Test result of high density polyethylene

S.NO	TEST	RESULT
1	Specific gravity	1.10
2	Bulk density	950 kg/m^3

4. MIX DESIGN

Table -7: Mix design ratio

S.NO	% of HDPE with C.A	Cement	Fine Aggregate	Coarse aggregate	HDPE	Water
1	10%	419 **(1**	866 **2.1**	1014.30 **2.42**	112.7 **0.26**	197 **0.47)**
2	15%	419 **(1**	866 **2.1**	958 **2.29**	169.7 **0.41**	197 **0.47)**
3	20%	419 **(1**	866 **2.1**	901.8 **2.15**	225.4 **0.53**	197 **0.47)**

5. TEST ON SPECIMEN

The specimens are casted and cured for period of 7 days, 14 days and 28 days.

Table -8: Size of specimens

S.NO	SPECIMEN	SIZE
1	Cube	150*150*150 (mm)
2	Cylinder	D150*H300 (mm)
3	Beam	L1200*B150*H150 (mm)

Experimental investigation have been carried out on the concrete mix replaced using HDPE at 10%, 15% and 20% to ascertain mechanical properties and durability properties.

5.1 Mechanical properties

1. Compression strength of cube
2. Compression strength of cylinder
3. Split tensile strength of cylinder
4. Flexural strength of beam

a. Compression strength of cube

For each trial mix, three cubes were tested at the age of 7, 14 and 28 days of curing.

Table -9: Compression strength of cube at **7 days curing**

S.No.	% of HDPE Added	Specimen	Wt (kg)	Compressive strength (N/mm²)
1	Conventional Mix	1	7.96	17
2	10%	A1	7.95	15.55
3	15%	B1	7.88	13.34
4	20%	C1	7.83.	9.33

Table -10: Compression strength of cube at **14 days curing**

S.No.	% of HDPE Added	Specimen	Wt (kg)	Compressive strength (N/mm²)
1	Conventional Mix	2	8.24	22.5
2	10%	A2	8.21	22.22
3	15%	B2	8.16	18.89
4	20%	C2	8.13	13.33

Table -11: Compression strength of cube at **28 days curing**

S.No.	% of HDPE Added	Specimen	Wt (kg)	Compressive strength (N/mm²)
1	Conventional Mix	3	8.95	25
2	10%	A3	8.92	24.22
3	15%	B3	8.85	20.6
4	20%	C3	8.82	16

Table -12: Compression strength of cubes comparison

S.NO	% of HDPE Added	Compressive Strength (N/mm²)		
		7 DAYS	14 DAYS	28 DAYS
1	Conventional Mix	17	22.5	25
2	10%	15.55	22.22	24.22
3	15%	13.34	18.89	20.6
4	20%	9.33	13.33	16

b. Compression strength of cylinder

For each trial mix, one cylinder was tested at the age of 28 days of curing.

Table -13: Compression strength of cylinder at **28 days curing**

S.No.	% of HDPE Added	Specimen	Wt (kg)	Compressive strength (N/mm²)
1	Conventional Mix	4	12.98	20
2	10%	A4	13.01	19.37
3	15%	B4	13.39	16.48
4	20%	C4	13.32	12.8

c. Split tensile strength of cylinder

For each trial mix, one cylinder was tested at the age of 28 days of curing.

Table -14: Split tensile strength of cylinder at **28 days curing**

S.No.	% of HDPE Added	Specimen	Wt (kg)	Split Tensile strength (N/mm²)
1	Conventional Mix	5	13.31	3.5
2	10%	A5	13.24	3.44
3	15%	B5	13.14	3.18
4	20%	C5	13.17	2.8

d. Flexural strength of beam

For each trial mix, one beam was tested at the age of 28 days of curing.

Table -15: Flexural strength of beam at **28 days curing**

S.NO	% of HDPE Added	Flexural strength of beam (N/mm²)
1	Conventional Mix	5
2	10%	4.75
3	15%	4.49
4	20%	4.26

5.2 Durability properties

a. Saturated water absorption test
b. Acid attack for dil. H_2SO_4 test
c. Acid attack for Na_2SO_4 test

a. Saturated water absorption test

For each trial mix, one cube was tested at the age of 28 days of curing in saturated water.

Table -16: Result of saturated water absorption test at **28 days curing**

S.NO	% of HDPE Added	Dry weight (kg)	Wet weight (kg)	Water absorption (%)
1	Conventional Mix	9.02	9.46	1.04
2	10%	8.95	9.29	1.03
3	15%	8.87	9.3	0.95
4	20%	8.79	9.06	0.97

b. Acid attack for dil. H_2SO_4 test

For each trial mix, one cube was tested at the age of 28 days of curing in dil. H_2SO_4.

Table -17: Result of acid attack on dil. H_2SO_4 test at **28 days curing**

S.No	% of HDPE Added	Dry weight (kg)	Weight after immersed in acid (kg)	Weight loss (%)
1	Conventional Mix	9.2	9.01	1.02
2	10%	9.41	9.20	1.02
3	15%	8.9	8.75	1.01
4	20%	8.73	8.60	1.01

c. Acid attack for Na_2SO_4 test

For each trial mix, one cube was tested at the age of 28 days of curing in dil. Na_2SO_4.

Table -18: Result of acid attack on dil. Na_2SO_4 test at **28 days curing**

S.NO	% of HDPE Added	Dry weight (kg)	Weight after immersed in acid (kg)	Weight loss (%)
1	Conventional Mix	8.8	8.63	1.02
2	10%	8.43	8.19	1.03
3	15%	8.57	8.41	1.02
4	20%	8.46	8.19	1.03

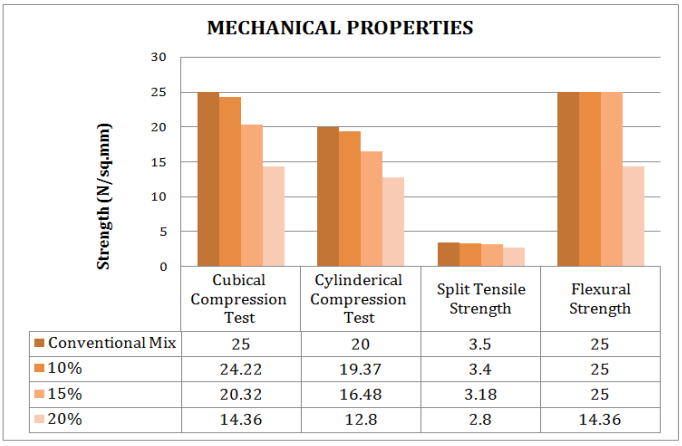

Chart -1: Mechanical properties of specimens

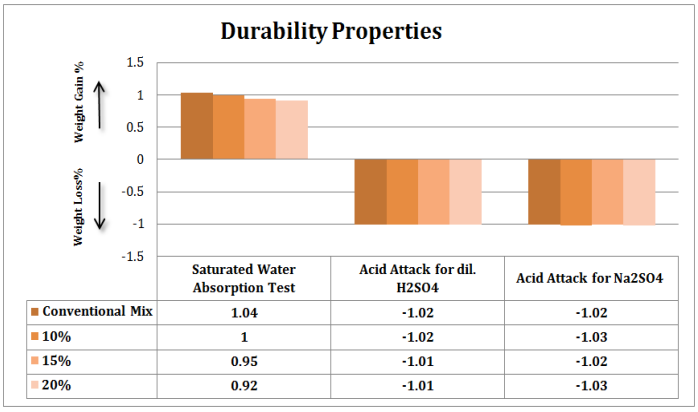

Chart -2: Durability properties of specimens

6. CONCLUSIONS

- The strength and durability tests were carried out for M_{25} grades of concrete by using HDPE with 10%, 15%, 20% of replacement with coarse aggregate.
- From these investigations the mechanical properties of M_{25} grade of concrete with 10%, 15% and 20% of HDPE is gradually decreasing from the mechanical properties of conventional concrete mix.
- The saturated water absorption percentage of concrete is decreasing respectively with 10%, 15% and 20% of HDPE mix.
- The acid attack test for dil. H_2SO_4 and Na_2SO_4 also results in decreasing of weight loss percentage with respect to 10%, 15% and 20% of HDPE mix.
- This investigation result shows usage of HDPE from 1% to 10% will result in good mechanical and durability properties of concrete
- This investigation results can be used for further modification of plastic materials as replacement for coarse aggregates in concrete with optimum percentage.

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