An Experimental Investigation on the Characteristics of Plastics in Concrete

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***Abstract:*-Nowadays one of the major problems in construction industries is insufficient and unavailability of construction materials, on the other side the main environmental problem is the disposal of the waste plastics. In this experimental study, an attempt has been made to use the plastics in concrete and studies have been conducted to focus on the behavior of flexural and compression members under various proportions of plastics. Four types of plastics namely Polythene Sheets, Raw Plastics, Road Waste and Plastics Straw were selected and mixed with concrete in various proportions (0.1 % to 2%). The specimens R.C columns were casted and tested for its flexural and compression strength respectively. Among four types of plastic products used, polythene sheet mixed except plastic straw all the other products were found to give better results in compression. The efficiency in taking compression load is 5% to 25%.**

Key Words: Additives, Acceleration, Adhesive strength, Aggregates, Softening Point, Density, Thermal Conductivity

I. INTRODUCTION

The Indian concrete industry is today consuming about 400 million tons of concrete every year and it is expected, that this may reach a billion tones in less than a decade. All the materials required to produce such huge quantities of concrete, come from the earth's crust, thus depleting its resources every year creating ecological strains. On the other hand human activities on earth produce waste plastics. The use of plastics in various places as packing materials and the products such as bottle, polythene sheet, containers packing strips etc. are increasing day by day. This results in production of plastic waste from all sort livings from industrial manufactures to domestic users. So we are in need to search for new construction materials as well as a method to dispose the plastic waste. To find a solution to the above problems one of them can be used to solve the other.

Plastics are the organic polymer materials having carbon as the common element in their makeup. The polymers consist of combination of carbon with oxygen, hydrogen, nitrogen and other organic substances. Plastic are normally stable and not biodegradable, so, their disposal poses problems.

Research works are going on in make use of plastics wastes effectively as additives in bitumen mixes for the road pavements **(**Lakshmipathy et.,al ,2003), **(**Vasudevan 2004**),** Repair and up gradation of reinforced concrete silos using Fiber Reinforced Plastics(FRP) **(**Bhedasgaonkar et.,al 2004), A laboratory experimental study carried out to utilize waste plastics (in the form of strips) obtained from milk pouches in the pavement construction (Chandrakaran 2004), Pilot level studies using industrial PVC scrap to develop PVC board (Agarwal 2004). Reengineered plastics are used for solving the solid waste management problems to great extent. This study attempt is to give a contribution to the effective use of domestic wastes plastics in concrete in order to prevent the environmental strains caused by them, also to limit the consumption of high amount of natural resources.

II. EXPERIMENTAL PROGRAM

The objective of this investigation is to establish the behavior of plain and reinforced cement concrete in flexure and compression by addition of plastic in different percentages. Four types of plastic were selected and separately mixed with concrete in Varying percentages (0.1 % to 2 %) to study its strength characteristics under various percentages based on the studies the optimum percentages of plastic to be mixed with concrete was identified.

III. MATERIALS

Commercially available 43 grade ordinary Portland cement were used, coarse aggregate was maximum size 20mm with a specific gravity 2.6, fineness modulus was 7.3 , sand was ordinary river sand with specific gravity 2 .6 and its fineness modulus was 3.5, Potable water was used for mixing.

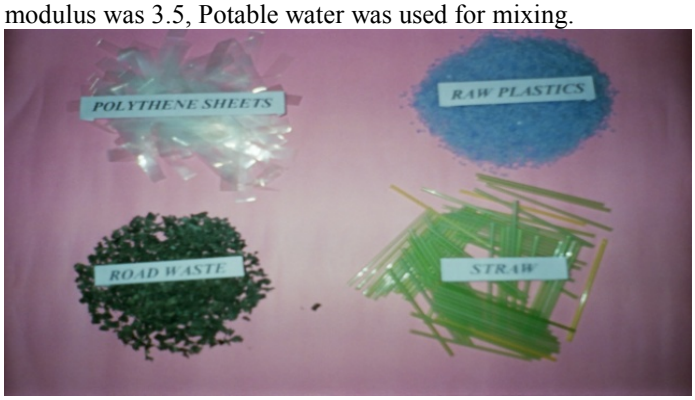

Fig 1 Photograph Showing Various Types of Plastic Materials Used in the Investigation

Four types of plastics which were thermo-plastic product were used. First one polythene sheets these are organic polymers containing carbon in addition to hydrogen, oxygen, nitrogen. Thickness of the polythene sheet used was 250 micron, second one road waste these are nothing but the waste plastics found on the road side, which were collected and heated, after heating the products were cooled and the result product was shredded. The shredded plastic products were selected to mix along with concrete. The third type of plastic was raw plastic, these are the raw materials used for manufacturing the plastic straw and fourth one was plastic straw these are the tubular plastic products used in day to day life. These were mixed along with concrete after cutting that along its cross section. The cut straws were arranged inside the moulds in layer by layer after that concrete was poured in to the mould.

Table.1 Properties of HDPE

S. No.	Properties	Values
1	Density (kg/m^3)	9.5 x 10^2
2	Softening Point (°C)	90 – 100
3	Thermal Conductivity (watt/m/K)	0.42 – 0.55
4	Thermal Expansion (Kelvin $^{-1}$)	120 x 10^{-6}
5	Specific Heat Capacity (J kg^{-1} K^{-1})	2100 – 2310
6	Tensile strength (MN/m^2)	20 – 30
7	Compressive Strength (MN/m^2)	20 – 25
8	Elongation at Break (%)	300 – 800
9	Coefficient of Friction	0.25
10	Young's Modulus (N/mm^2)	550 – 1050

IV. CONCRETE MIXING, PLACING AND CURING

After weighing the materials, mixing was done in an ordinary mixer to get a good uniform homogeneous concrete. This concrete was placed in layers in the mould and each layer was compacted by using the mechanical vibrator. In between each layer of concrete, the cut polythene sheets were placed and well compacted and specimens were prepared. Similarly the plastic straw was placed in concrete and the specimens were prepared. The other plastic materials like road waste and raw plastic were mixed along with concrete and poured in to the mould. The percentage of plastic mixed was varied from 0.1 % to 1.5 % by weight. Table vibrator was used to achieve the better compaction. The mould were demoulded on next day and subjected to 7 days curing.

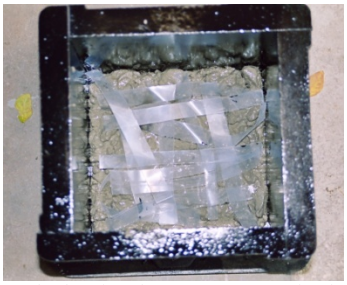

Fig 2 Photograph Showing the Arrangement of Polythene Sheet in Cube Mould

Fig 3 Photograph Showing the Arrangements of Plastic Straw in Prism Mould

Fig 4 Photograph Showing the Mixing of Raw Plastic with Concrete

Fig 5 Photograph Showing the Mixing of Road Waste with Concrete

4.1 Optimum Mix Percentage of Plastics

Cube specimens of size 150mm x 150mm , cylinder specimens of size 150mm diameter and 300 mm height and prism specimens of size 100mm x 100mm x 500 mm were prepared and allowed for curing. After 7 days curing the cube specimens were subjected to compressive load in compressive testing machine as per IS 16:1959 to find the compressive strength. The prism specimen were subjected to two point load as per IS516:1959 to find the flexural strength.

Table 2 Cube Compressive Strength

Types of Plastic	Designation	% of Addition	Average Cube Compressive Strength (N/mm²)
--	OC	--	18.41
Polythene sheet	P	0.10	14.65
		0.15	13.73
		0.20	24.20
		0.25	10.27
		0.50	07.56
		0.75	07.27
		1.00	04.58
Raw plastics	RP	0.25	18.31
		0.50	16.86
		0.75	15.74
		1.00	14.17
Road wastes	RW	0.50	19.62
		0.75	26.38
		1.00	28.12
		1.25	30.38
		1.50	22.45
Plastic straw	PS	0.10	08.50
		0.15	08.72
		0.20	05.45
		0.25	05.12

Table 3 Flexural Strength

Type of Plastic	Designation	% of Addition	Average Flexural Strength (N/mm²)
--	OC	--	5.00
Polythene sheet	P	0.10	5.50
		0.15	5.00
		0.20	4.90
		0.25	2.90
Raw plastics	RP	0.25	5.40
		0.50	3.12
		0.75	2.60
		1.00	3.52
Road wastes	RW	0.50	5.30
		0.75	4.20
		1.00	3.00
		1.25	3.00
		1.50	2.88
Plastic straw	PS	0.10	5.20
		0.15	4.30
		0.20	4.65
		0.25	2.50

Table 4 Split Tensile Strength

Type of Plastic	Designation	% of Addition	Average Split Tensile Strength (N/mm²)
--	OC	--	3.05
Polythene sheet	P	0.10	3.47
		0.15	2.98
		0.20	2.36
		0.25	1.94
Raw plastics	RP	0.25	2.91
		0.50	2.36
		0.75	1.94
		1.00	1.53
Road wastes	RW	0.50	2.57
		0.75	2.36
		1.00	2.57
		1.25	3.19
		1.50	2.78
Plastic straw	PS	0.10	3.12
		0.15	2.78
		0.20	2.08
		0.25	1.67

From the preliminary studies conducted, the optimum mix percentage of plastics that is to be mixed with concrete from the flexure studies are given in the table.

Table 5 Optimum Mix Percentage of Plastics

Type of Plastic	Optimum Mix Percentage
Polythene Sheet	0.10
Raw plastics	0.25
Road Wastes	0.50
Plastic Straw	0.10

Table 6 Standard Deviation for Plastic Mixed Concrete

Type of Plastics	% of Plastic added	Standard Deviation
Polythene Sheet Mixed Concrete	0.20	4.02
Raw Plastic Mixed Concrete	0.25	3.11
Road Waste Mixed Concrete	1.25	3.95
Plastic Straw Mixed Concrete	0.10	3.19

Table 7 Percentage Increase in Strength

Designation	% increase in Compressive Strength	% increase in Split Tensile Strength	% increase in Flexural Strength
P	31.45	13.77	9.09
RP	4.83	4.59	9.06
RW	65.02	4.59	6.00
PS	-52.63	2.29	4.00

V. EXPERIMENTAL INVESTIGATION

The test specimens, reinforced concrete column of size 100 mm x 750 mm were casted with optimum percentage of plastic mix. Column reinforcement details are
Longitudinal Bar – 6 Nos. of 6 mm dia
Lateral Ties – 4 mm Dia Plain bars @ 75 mm c/c

5.1 Testing procedure

Before testing the vertical member the steel pellets were fixed to the selected demec points (11.25cm, 26.25 cm with a gauge length of 15 cm) to measure the strains. Three dial gauges were fixed at 18.75 cm intervals on one side of the column. Load is applied on the specimen gradually. Strain reading and deflections were noted at predetermined load levels. The load is applied continuously till the failure of the specimen takes place. The type of failure was noted down carefully

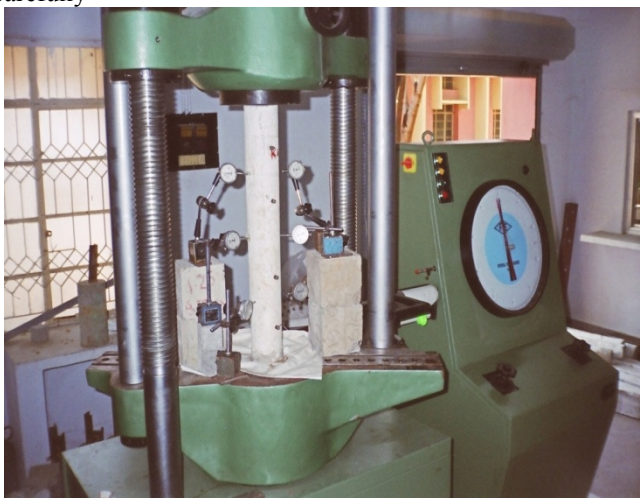

Fig 6 Photograph Showing the Test Set-up for RC Column

5.2 Test Results

Table 8 Compressive Strength of Reference RC Columns

S. No	Load (kN)	Strain x 10^{-3}	Lateral Deflection (mm)
1	0	0	0
2	10	--	0.02
3	20	0.07	0.03
4	30	--	0.05
5	40	0.12	0.06
6	50	--	0.215
7	60	0.12	0.48
8	70	--	0.54
9	80	0.19	0.72
10	90	--	1.02
11	100	0.20	2.10

Table 9 Compressive Strength of Polythene Sheet Mixed RC Columns

S. No	Load (kN)	Strain x 10^{-3}	Lateral Deflection(mm)
1	0	0	0
2	10	--	0.08
3	20	0.16	0.63
4	30	--	0.84
5	40	0.19	1.05
6	50	--	1.10
7	60	0.37	1.17
8	70	--	1.25
9	80	1.67	1.30
10	90	--	1.30
11	100	2.59	1.30
12	105.5	2.67	1.30

Table 10 Compressive Strength of Raw Plastics Mixed RC Columns

S. No	Load (kN)	Strain x 10^{-3}	Lateral Deflection (mm)
1	0	0	0
2	10	--	0.02
3	20	1.23	0.07
4	30	--	0.11
5	40	3.80	0.31
6	50	--	0.74
7	60	5.40	0.98
8	70	--	1.02
9	80	5.09	1.1
10	90	--	1.17
11	100	5.12	1.20
12	108.5	5.14	1.30

Table 11Compressive Strength of Road Waste Mixed RC Columns

S. No	Load (kN)	Strain x 10^{-3}	Lateral Deflection (mm)
1	0	0	0
2	10	--	0.05
3	20	0.08	0.24
4	30	--	0.34
5	40	0.09	0.40
6	50	--	0.53
7	60	0.11	0.59
8	70	--	0.68
9	80	0.20	0.77
10	90	--	0.86
11	100	0.23	0.95
12	110	--	1.01
13	120	0.24	1.10
14	122.5	0.25	1.23

Table 12 Compressive Strength of Plastic Straw Mixed RC Columns

S. No	Load (kN)	Strain x 10^{-3}	Lateral Deflection (mm)
1	0	0	0
2	10	--	0.06
3	20	0.027	0.15
4	30	--	0.25
5	40	0.16	0.42
6	50	--	0.52
7	60	1.25	0.61
8	70	--	0.68
9	80	1.33	0.71
10	90	--	0.73
11	91.55	1.37	0.76

5.3 Analysis of Test Results

Five beams and columns with various designations were tested for its load-deformation behavior and ultimate strength characteristics. The comparison of ultimate load carrying capacity of the RC columns with various plastics is given in Table and it is graphically shown in Figure.

Table.13. Ultimate Load for RC columns

Type of RC Columns	Ultimate Load (kN)
Reference RC Columns	100
Polythene Sheet Mixed	105.5
Road Waste Mixed	122.5
Raw Plastic Mixed	108.5
Plastic Straw Mixed	91.55

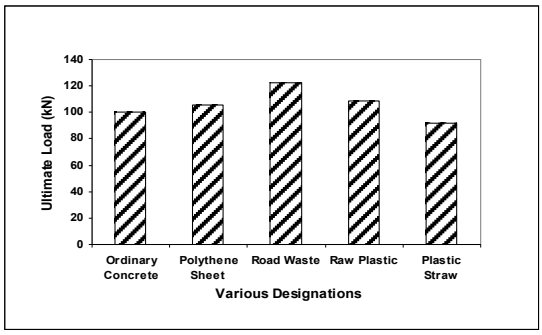

Fig.7 Ultimate Load Carrying Capacity of RC Columns

5.4 Load – Deflection Behavior

The lateral deflection of plastic mixed RC columns under various loads is shown in Figure

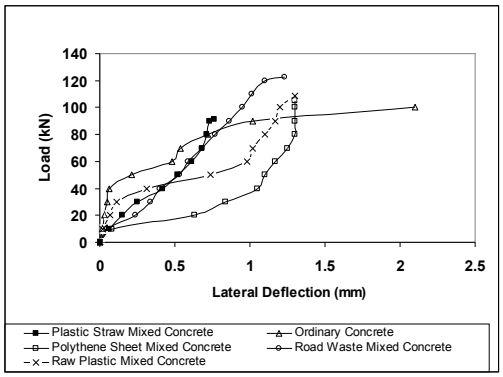

Fig 8 Load vs. Lateral Deflection for RC Columns

The lateral deflection value for the polythene sheet mixed RC columns were around 1.3mm for a maximum load of 105.5kN. The lateral deflection was found to be more or less constant above 70kN. Ordinary RC columns underwent a maximum lateral deflection of 2.25mm at the ultimate load i.e. at 100kN. The lateral deflections for polythene sheet mixed RC columns were less when compared with ordinary concrete RC columns. Road waste mixed RC columns were found to have a maximum lateral deflection of 1.2mm which was less than ordinary RC columns as well as polythene sheet mixed RC columns. Similarly, raw plastic mixed RC columns were also found to have a maximum lateral deflection of 1.2mm at a maximum load of 108.5kN. Plastic straw mixed RC columns were found to undergo a maximum lateral deflection of 0.75mm at the ultimate load of 91.55kN. The lateral deflections of plastic straw mixed RC columns were found to be less than any other RC columns. Generally, the ordinary RC columns were found to deflect more than the plastics mixed RC columns.

VI. BEHAVIOR AND MODE OF FAILURE

All the columns were subjected to axial compression. The columns withstand up to the ultimate load and fails by crushing of concrete. The addition of plastic waste influences the behavior and mode of failure of RC columns. The failure patterns of RC columns with various plastic materials are shown in Figure

Fig 9 Photograph Showing the Tested RC Column Specimens

VII. CONCLUSION

From the above experimental study, the specimens R.C columns were casted and tested for its flexural and compression strength respectively. Among four types of plastic products used, polythene sheet mixed RC beam were found to give better results in flexure and except plastic straw all the other products were found to give better results in compression.

The efficiency in taking flexural load is found to increase by 10% to 20% and for compression load is 5% to 25%. It is concluded that the addition of plastic waste in our regular concrete works will not affect the strength and behavior of the concrete. Moreover, the addition of the plastic waste may improve, some of the properties of the concrete.

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