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Study on Strength Parameters of Concrete by Using Plastic Waste as Partially Replacing Course Aggregates

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Abstract **– The rapid industrialization and urbanization in the country leads lot of infrastructure development. This process leads to several problems like shortage of construction materials, increased productivity of wastes and other products. In this project waste plastics is used as partial replacement of course aggregates by increasing 0%, 2%, 4%, 6% and 8%.In this project fly ash is replaced by 35% of cement to this concrete to enhance the strength and workability of it. Tests was conducted on course aggregate, fine aggregates, cement and plastic to determine their physical properties. Casted concrete were tested for its compressive strength, tensile strength at 3, 7 and14 days. Concrete cylinders and beams were casted and tested for their strength after 28th day of curing of concrete as respective to the partially replaced plastic with coarse aggregates.**

Keywords- **cement, plastic, Concrete cylinders, compressive strength.**

I .INTRODUCTION

As the world population grows, wastes of various types are being generated. The creation of non-decaying and low biodegradable wastes materials, combined with growing consumer population as resulted in waste disposal crisis. One solution to this crisis is recycling wastes into useable products.

Many government agencies, private organizations and individuals have completed or in the process of completing a wide verities of studies and research projects concerning the feasibility, environmental suitability and performance of using of waste plastics in construction field which needs better and cost effective construction material and reuse of waste plastics and save our world from environmental pollution.

With increase in development, there is an increase in cost of construction and maintenance of pavements. So, the Engineers and Designers have been looking for new concept of using waste plastics in cement concrete paver blocks, solid blocks and beams. This concrete are less susceptible to rutting, minimum fatigue or thermal cracking, low stripping due to moisture and offer great durability, little or no impact on processing and also produce eco friendly construction and costs less.

II. OBJECTIVE

- To use the waste plastic to good use and productive material.
- To reduce the cost of the concrete.
- To produce eco-friendly concrete.
- To create employment opportunities.
- To reduce the landfills area.

III.METHODOLOGY

1. Materials and Methods

3.1 Preparation of materials

Materials used for the experimental study are as follows:

- Cement.
- Fly ash.
- Course aggregate.
- Fine aggregate.
- Plastic (HDPE).

Plastic materials are very dirty so, it cleans in water by using detergent and dried it up to 30 min. after it use to mix. Cement should be store in air tight place separately. Moulds are used-

- Square (150*150MM).
- Cylinder (150MM diameter 300MM height).
- Beam (500*150*150MM).

3.2 Cement

Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and non-specialty grout. It was developed from other types of hydraulic lime in England in the mid 19th century, and usually originates from limestone.

It is a fine powder, produced by heating limestone and clay minerals in a kiln to form clinker, grinding the clinker, and adding 2 to 3 percent of gypsum. Several types of Portland cement are available. The most common, called ordinary Portland cement is grey in color.

3.3 Fly ash

Fly ash a waste generated by thermal power plants is as such a big environmental concern. In modern decades, the industrialization and urbanization are the two phenomena that are spreading all over the world. Apart from the requirement of these phenomena, there should also be investigation into their negative impacts on the worldwide environment and common life.

Most important poor effect of these international processes has been the production of large quantities of industrial wastes. Therefore, the problems related with their safe management and dumping has turned into a major test to environmentalists and scientists.

Another problem is the stress on land, materials and resources to sustain the developmental activities, including infrastructure. The thermal power plants produce considerably large quantities of solid by product namely fly ash**.**

3.4 Course & fine aggregate

Construction aggregate, or simply "aggregate", is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo synthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and asphalt concrete.

The aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains. Aggregates are also used as base material under foundations, roads, and railroads.

3.5 Plastic (HDPE)

High-density polyethylene or polyethylene high-density is a polyethylene thermoplastic made from petroleum. It is sometimes called "alkathene" or "polythene" when used for pipes. With a 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 its resin identification code.

these plastics were cleaned in water and air dried to remove dust and dart since we are using recycled plastics downsized to 10mm to 20mm. the plastics were sieved and the plastics which were retained in 10 mm sieve and passed through 20 mm sieve were used as partial replacement for aggregates.

3.6 Tests which were conducted

3.6.1 Basic tests on cement

- Specific gravity
- Normal consistency
- Final setting time and initial setting time

3.6.2 Basic test on coarse aggregate

- Specific gravity
- Sieve analysis
- Water absorption

3.6.3 Basic test on fine aggregate

- Specific gravity

3.6.4 Basic test on plastic (HDPE)

- Melting point of plastic
- Flash point of plastic
- Fire point of plastic

2. Tests on Cement

3.1 Specific gravity of cement Procedure

- The density bottle should be free from the liquid that means it should be fully dry. Weigh the empty bottle. Which is W1?
- Next, fill the cement on the bottle up to half of the bottle around 50gm and weigh with its stopper. And it is W2.
- Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it.
- Weigh the bottle with cement and kerosene. And it is W3.
- Empty the bottle. Fill the bottle with kerosene up to the top and weigh the bottle for counting W4

Tabular column

Table 1 Average Value = 3.17

specifications	Notations (grams)	Trail 1	Trail 2
Wight of empty density bottle	W1	34	34
Wight of empty density bottle + cement	W2	60	65
Wight of empty density bottle + cement + kerosene	W3	100	103
Wight of empty density bottle +kerosene	W4	82	82
Specific gravity	(w2-w1)/[(w2-w1)-(w4-w3)]	3.25	3.10

3.2 Standard Consistency of Cement Procedure

- Take 400 g of cement and place it in the enameled tray.
- Mix about 25% water by weight of dry cement thoroughly to get a cement paste. Total time taken to obtain thoroughly mixed water cement paste i.e. "Gauging time" should not be more than 3 to 5 minutes.
- Fill the vicat's mould, resting upon a glass plate, with this cement paste.
- After filling the mould completely, smoothen the
- Surface of the paste, making it level with top of the mould.
- Place the whole assembly (i.e. mould + cement paste + glass plate) under the rod bearing plunger.
- Lower the plunger gently so as to touch the surface of the test block and quickly release the plunger allowing it to sink into the paste.
- Measure the depth of penetration and record it.
- Prepare trial pastes with varying percentages of water content and follow the steps (2 to 7) as described above, until the depth of penetration becomes 33 to 35 mm.

Table 2 Standard Consistency of Cement.

Trail number	Weight of cement taken in gram	% of water added	Quantity of water in ml	Penetration in mm
1	400	25	100	39
2	400	26	104	39
3	400	27	108	38
4	400	28	112	34
5	400	29	116	33
6	400	30	120	25
7	400	31	124	19
8	400	32	128	17
9	400	33	132	12
10	400	34	136	3

3.3 Initial and Final Setting Time of Cement procedure

3.3.1 Test block preparation

Before commencing setting time test, do the consistency test to obtain the water required to give the paste normal consistency (P).

- Take 400 g of cement and prepare a neat cement paste with 0.85P of water by weight of cement.
- Gauge time is kept between 3 to 5 minutes. Start the stop watch at the instant when the water is added to the cement. Record this time (t_1).
- Fill the Vicat's mould, resting on a glass plate, with the cement paste gauged as above. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared is called test block.

3.3.2Initial setting time

- Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle.
- Lower the needle gently until it comes in contact with the surface of test block and quick release, allowing it to penetrate into the test block.
- In the beginning the needle completely pierces the test block. Repeat this procedure i.e. quickly releasing the needle after every 2 minutes till the needle fails to pierce the block for about 5 mm measured from the bottom of the mould. Note this time (t_2).

3.3.4 Final setting time

- For determining the final setting time, replace the needle of the Vicat's apparatus by the needle with an annular attachment.
- The cement is considered finally set when upon applying the final setting needle gently to the surface of the test block; the needle makes an impression thereon, while the attachment fails to do so. Record this time (t_3)

Tabular Column

Table 3 Initial setting time = 30 minute, Final setting time = 285 minute

Trail no	Time in sec	Penetration from the bottom in mm
1	5	0
2	10	2
3	15	3
4	20	5
5	25	6
6	30	7

3.4 Testes on Coarse Aggregate

3.4.1 Specific Gravity of Coarse Aggregate Procedure

- About 2 kg of aggregate sample is washed thoroughly to remove fines, drained and placed in wire basket and immersed in distilled water at a temperature between 22- 32^o C and a cover of at least 5cm of water above the top of basket.

- Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop at the rate of about one drop per second. The basket and aggregate should remain completely immersed in water for a period of 24 hour afterwards.
- The basket and the sample are weighed while suspended in water at a temperature of 22° – 32°C. The weight while suspended in water is noted =W1g.
- The basket and aggregates are removed from water and allowed to drain for a few minutes, after which the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolted 25 times and weighed in water=W2g.
- The aggregates placed on the absorbent clothes are surface dried till no further moisture could be
- Removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. The surface dried aggregate is then weighed =W3 g.
- The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of 110° C for 24 hrs. It is then removed from the oven, cooled in an air tight container and weighted=W4 g

Tabular Column

Table 4 Specific gravity of coarse aggregate = 2.78

Water absorption

specification	notation	Trail 1	Trail 2	Average
Empty weight of pygnometer	w1	620gm	620 gm	
Weight of pygnometer + sand	w2	1094gm	1100 gm	
Weight of pygnometer + sand + water	w3	1766gm	1773 gm	
Weight of pycnometer + water	w4	1472gm	1472 gm	
Specific gravity of sand	(w2-w1)/[(w2-w1)-(w3-w4)]	2.63	2.62	**2.625**

Water absorption

Specifications	Trail
Weight of saturation surface dry sample (grams) (a)	1004
Weight of oven dry sample (grams) (b)	994
Water absorption = [(a-b)/b]*100	**1.0%**

3.4.2 Sieve analysis coarse aggregates Procedure

- Using the sieve sizes required by the specification, arrange sieves in descending order with the largest size on top.
- If using a mechanical sieve shaker, place the set of sieves onto a pan and pour the prepared aggregate onto the top sieve, cover the stack of sieves and pan, turn on the machine, and set it to shake for at least 5 minutes.
- If hand sieving, start with the largest size, and progress toward the smaller sieve sizes; move the sieves in lateral and vertical motions accompanied by a jarring action to keep the material moving continuously over the surface of the sieves. Hand manipulation without forcing particles through the sieve is permitted
- For either mechanical or hand sieving, sieve the material until not more than 1% by mass of the residue on any individual sieve will pass that sieve during 1 minute of continuous hand sieving.
- Using a scale with a capacity large enough to obtain the mass of the total sample, determine the mass of the fine aggregate to the nearest 0.1 g and coarse aggregate to the nearest 1 g.
- First, determine the mass of the aggregate retained on the largest sieve size and record the value.
- Add the contents of the next largest sieve size on the scale, obtain the cumulative mass of the two sizes and record this mass.
- Finally, add the contents of the next size, and repeat this operation until the contents of the smallest sieve size used is empty, and cumulative mass has been obtained and recorded.

Tabular Column

Table 5 Sieve analysis coarse aggregates

Is sieve size	Weight of coarse aggregate(g)	% weight retained	Cumulative % retained	% passing
20 mm	0	0	0	100
16 mm	47.3	4.73	4.73	95.27
12.5 mm	494	49.4	54.13	45.87
10 mm	374.7	37.47	91.60	8.4
4.75 mm	76	7.60	99.20	0.8
pan	8	0.85	100	0

3.5 Testes on Fine Aggregate

3.5.1 Specific gravity of fine aggregate Procedure

- Clean and dry the Pycnometer. Tightly screw its cap. Take its mass (M_1) to the nearest of 0.1 g.
- Mark the cap and Pycnometer with a vertical line parallel to the axis of the Pycnometer to ensure that the cap is screwed to the same mark each time.
- Unscrew the cap and place about 200 g of fine aggregate in the Pycnometer. Screw the cap. Determine the mass (M_2).
- Unscrew the cap and add sufficient amount of de-aired water to the Pycnometer so as to cover the fine aggregate. Screw on the cap.
- Shake well the contents. Connect the Pycnometer to a vacuum pump to remove the entrapped air, for about 20 minutes

Tabular Column

Table 6 Specific Gravity of Fine Aggregate= 2.65.

specification	notation	Trail 1	Trail 2	Average
Empty weight of pygnometer	w1	620gm	620 gm	
Weight of pygnometer + sand	w2	1094gm	1100 gm	
Weight of pygnometer + sand + water	w3	1766gm	1773 gm	
Weight of pycnometer + water	w4	1472gm	1472 gm	
Specific gravity of sand	(w2-w1)/[(w2-w1)-(w3-w4)]	2.63	2.62	**2.625**

3.6 Test on Fly ash

3.6.1 Specific gravity of Fly Ash Procedure

- The density bottle should be free from the liquid that means it should be fully dry. Weigh the empty bottle. Which is W1.
- Next, fill the fly ash on the bottle up to half of the bottle around 50gm and weigh with its stopper. And it is W2.
- Add Kerosene to the cement up to the top of the bottle. Mix well to remove the air bubbles in it.
- Weigh the bottle with cement and kerosene. And it is W3.
- Empty the bottle. Fill the bottle with kerosene up to the top and weigh the bottle for counting W4.

Tabular Column

Table 7 Specific Gravity of Fly Ash= 2.24

specifications	Notations (grams)	Trail 1	Trail 2	average
Weight of density bottle	W1	30	30	
Weight of density bottle +fly ash	W2	43	44	
Weight of density bottle + fly ash + kerosene	W3	80	84	
Weight of density bottle + kerosene	W4	76	76	
Specific gravity	(w2-w1)/[(w2-w1)-(w4-w3)]	2.16	2.33	**2.24**

3.7 Tests on Plastic (Hdpe)

- Melting point of plastic = 75 c.
- Flash point of plastic = 256c.
- Fire point of plastic = 315 c.

3.8 Mix Design

Mix Proportion by Weight = 1: 1.5: 2.696.

3.9 Quantity Calculation

3.9.1 Square mould (150*150*150mm)

Cement= (1/5.196)*w.

Cube, L=15cm B=15cm D=15cm.

Volume= L*B*D = 15*15*15= 3375cm^3.

Density of concrete = 24kn/m^3 = 24*10^3/9.81*^3 = 2.44*10^-3 = 0.00244kg/m^3.

Mass = density*volume= 0.00244*3375 = 8.23kg.

Cement = (1/5.196)*8.23 = 1.58kg.

Fine aggregate = (1.5/5.196)*8.23 = 2.40kg.

Coarse aggregate = (2.696/5.196)*8.23 = 4.27kg.

3.9.2 Quantity calculation for 2%

Replacement of cement by fly ash 35%.

Cement = 7.3*(35/100) = 2.55kg fly ash.

Cement content = 7.3-2.55 = 4.77kg.

Partially Replacement of Aggregate by plastic.

19.521*(2/100) = 0.3904kg.
Plastic = 390gm, aggregate = 19.13kg.

3.9.3 Quantity calculation for 4%

Replacement of cement by fly ash 35%.
Cement = 7.3*(35/100) = 2.55kg fly ash.
Cement content = 7.3-2.55 = 4.77kg.
Partially Replacement of Aggregate by plastic
19.521*(4/100) = 0.780kg.
Plastic = 780gm, aggregate = 18.74kg.

3.9.4 Quantity calculation for 6%

Replacement of cement by fly ash 35%.
Cement = 7.3*(35/100) = 2.55kg fly ash.
Cement content = 7.3-2.55 = 4.77kg.
Partially Replacement of Aggregate by plastic
19.521*(6/100) = 1.171kg.
Plastic = 1.171kg, aggregate = 18.34.

3.9.5 Quantity calculation for 8%

Replacement of cement by fly ash 35%.
Cement = 7.3*(35/100) = 2.55kg fly ash.
Cement content = 7.3-2.55 = 4.77kg.
Partially Replacement of Aggregate by plastic
19.521*(8/100) = 1.5kg.
Plastic = 1.56kg, aggregate = 17.959kg.

3.9.6 Cylinder mould (150mm dia 300mm height)

Cylinder, D = 15CM, H = 30CM.
Volume = area*height 5301.427cm^3.
Density of concrete = 24kn/m^3.
Mass = density*volume= 0.00244*5301.167 = 12.93kg.
Cement = (1/5.196)*12.93 = 2.488kg.
Fine aggregate = (1.5/5.196)*12.93 = 3.73kg.
Coarse aggregate = (2.696/5.196)*12.93 = 6.70kg.

3.9.4 Beam mould (500*150*150MM)

Volume = 50*15*15 = 11250cm^3.
Density of concrete = 24kn/m^3.
Mass = density*volume= 0.00244*11250 = 27.45kg.
Cement = (1/5.196)*27.45 = 5.28kg.
Fine aggregate = (1.5/5.196)*27.45 = 7.92kg.
Coarse aggregate = (2.696/5.196)*27.45 = 14.24kg.

IV. RESULTS AND DISCUSSIONS

1. Compression test on square mould

Table 8 compression strength of square mould

Days of curing/% of plastic added	Compression strength for 0%(N/mm^2)	2%	4%	6%	8%
3	15.27	11.44	10.66	8.24	7.96
7	28.28	18.81	12.07	9.10	8.22
14	36.47	28.83	12.89	10.71	8.90

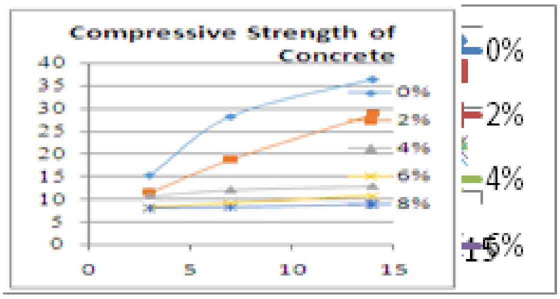

Fig.1 Compressive Strength of Concrete

2. Split tensile test on cylinder

Table 9 Split tensile strength of cylinder

Days of curing/% of plastic added	Split tensile strength for 0%(N/mm^2)	2%	4%	6%	8%
28	2.67	1.850	1.34	1.32	1.30

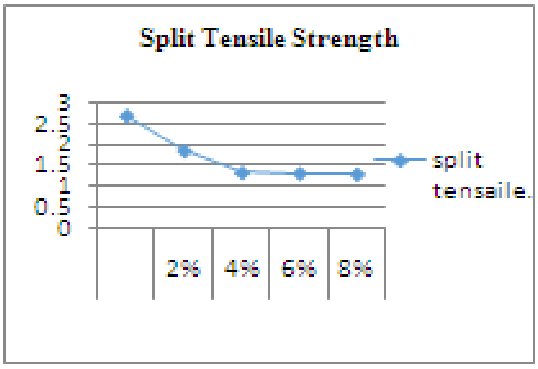

Fig.2 Split Tensile Strength

3. Tension test on beam

Table 4.3.1 Tension strength of beam

Days of curing/% of plastic added	Buckling strength for 0%(N/mm^2)	2%	4%
28	0.249	0.17	0.16

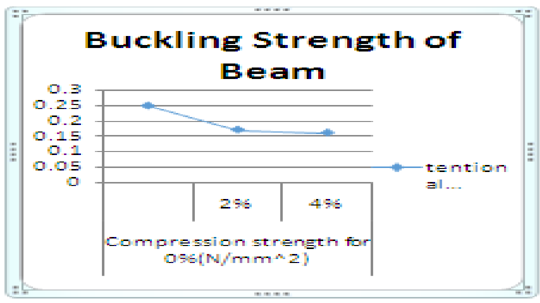

Fig. 3 Tensile strength of beam.

V. CONCLUSION

Based on the above results, the following conclusions are drawn.

- The waste generated is utilized in the concrete in the form of plastic and fly ash which provides eco-friendly concrete. This reduces the land fill area and in the mass production it provides employment opportunity.
- Addition of2% plastics with coarse aggregates, by which the strength of the concrete will not get reduced till greater extent.
- The obtained compression strength of square block modified concrete is 28.83 N/mm^2 when tested in compressive testing machine for 2% of partially replaced plastics with coarse aggregates.
- The obtained Split tensile strength of cylinder modified concrete is 1.850 N/mm^2 when tested in compressive testing machine for 2% of partially replaced plastics with coarse aggregates.
- The obtained tension strength of beam modified concrete is 0.17 N/mm^{2}when tested in tension testing machine for 2% of partially replaced plastics with coarse aggregates.
- Addition of 35% of fly ash, at same percentage of water content increase the workability of the concrete. It also reduces the manufacturing cost of the concrete.

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