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Study on Plastic Waste in Making Concrete

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ABSTRACT

The rapid industrialization and urbanization in the country leads to lot of infrastructure development. This process leads to several problems like shortage of construction materials, increased productivity of wastes and other products. This project deals with the reuse of waste plastics as partial replacement of coarse aggregate in M30 concrete. Usually M30 concrete is used for most construction works. Waste Plastics were incrementally added in10%, 20%, 30% to replace the same amount of Aggregate. Tests were conducted on coarse aggregates, fine aggregates, cement and waste plastics to determine their physical properties. Paver Blocks and Solid Blocks of size 200 mm X 150 mm X 60 mm and 200 mm X 100 mm X 65 mm were casted and tested for 7, 14- and 28-days strength.

I. INTRODUCTION

GENERAL: Disposal of plastic waste in environment is considered to be a big problem due to its very low bio degradability and presence in large quantities. In recent time significant research is underwent to study the possibility of disposal of these wastes in mass concrete where strength of concrete may not be major criteria under consideration, such as heavy mass of concreting in PCC in pavements. If plastic wastes can be mixed in the concrete mass in some form, without significant effect on its other properties or slight compromise in strength, we can consume large quantities of plastic waste by mixing it in the concrete mass. Plastic is one component of municipal solid waste (MSW) which is becoming a major research issue for its possible use in concrete especially in self-compacting concrete and light weight concrete. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementitious binder phase or as aggregates, it is important to realize that not all waste materials are suitable for such use. Recently, research works showed that, the plastic is becoming a major research in concrete of in self-compacting concrete and light weight concrete .Hence in order to overcome the above said problems waste products should be employed as construction material. Fine aggregates used in cement concrete is replaced by fine crushed plastics in known percentagesand the optimum percentage at which higher strength is obtained is being calculated. In this investigation, we made the comparison of yield strength as well as ultimate strength for conventional concrete and concrete containing plastics at 7, 14, 28 days respectively. M30 grade concrete is chosen for the investigation. An attempt is made to find the optimum sand replacement by pulverized plastic in concrete.

II. MATERIALS USED

PLASTICS: The seven types of plastics are PET-Polyethylene, Terephthalate, HDPE- High Density Polyethylene, PVC-Polyvinyl chloride, LDPE- Low density Polyethylene, PP – Polypropylene, PS- Polystyrene, and Other PC- Polycarbonate. Combination of those plastics was adopted to be the replacementmaterial. This is mainly because of the easy availability of the plastic material, its density &workability. The various stages of processing of plastics into fine grains form the properties of plastics are then analyzed by performing density, specific gravity & sieve analysis tests. Density of the material is determined by finding the weight and volume of a specified material. Then sieve analysis and specific gravity were done for a given amount of sample. It is also studied that there is lesser reaction between aggregate and reinforcements as the cleaned plastic material is almost inert.Plastics are usually classified by the chemical structure of the polymer's backbone and side chains; some important groups in these classifications are: the acrylics, polyesters, silicones, polyurethanes, and halogenated plastics. Plastics can also be classified by the chemical process used in their synthesis, such as condensation, poly addition, and cross-linking.

CEMENT: Cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most-consumed resource. Cements used in construction are usually inorganic, often lime or calcium silicate based, which can be characterized as non-hydraulic or hydraulic respectively, depending on the ability of the cement to set in the presence of water.

FINE AGGREGATE: Aggregate is the granular material used to produce concrete or mortar and when the particles of the granular material are so fine that they pass through a 4.75mm sieve, it is called fine aggregate. Fine aggregates are usually sand or crushed stone that are less than 9.55mm in diameter. Typically the most common size of aggregate used in construction is 20mm. A larger size, 40mm, is more common in mass concrete. Larger aggregate diameters reduce the quantity of cement and water needed. Fine aggregate is off the major constituents of concrete which can influence concrete mix design substantially. Various factors such as fine aggregate fineness modulus, moisture content, specific gravity, and silt content affect the mix proportions of concrete

COARSE AGGREGATE: Aggregates make up some 60 -80% of the concrete mix. Coarse aggregates are particulates that are greater than 4.75mm. The usual range employed is between 9.5mm and 37.5mm in diameter. Fine aggregates are usually sand or crushed stone that are less than 9.55mm in diameter. Generally coarse aggregate is blended with finer aggregates (such as sand) to fill in the spaces left between the large pieces and to "lock" the larger pieces together. This reduces the amount of cement paste required and decreases the amount of shrinkage that could occur. Coarse aggregates have several uses in construction. The most obvious is as part of the mix in concrete. They are also used in the preparation of the moisture break under the slab and vapor barrier. They are part of the base for driveways and roadways.

III. LITERATURE REVIEW

Karthikeyan M, Bharath Kumar V (2019) "Utilization of plastic waste in concrete" reported that detectable reduction in compressive strength are observed with increasing the percentage of plastic.

GibrinSule, Ismaila Joseph (2018), "Use of waste plastic in cement- based composite for lightweight concrete production" reported that there is an increase in slump decrease with increase in plastic and will grossly reduce the rate of solid waste accumulation.

Anil Kumar Arya, Neelesh Kumar Singh (2017) "Use of plastic as partial replacement of fine aggregate in fiber reinforced concrete" reported that the compressive strength of concrete keeps on decreasing as the percentage of plastic is increased in concrete as replacement of fine aggregate

A Muthadhi, A MuhamedBasid, (2017) "Experimental investigations on concrete with E plastic waste" reported that use of E-Plastic waste as coarse aggregate in the mix does not affect the compressive strngth and tensile strength of concrete up to 10% replacement

S Das, M T Alam (2016) "Utilization of plastic waste in concrete as a partial replacement of fine aggregate" reported that compressive strength of concrete has been found decreasing gradually with increase in adding plastic.

Amalu R G, AseefAsharf (2016) "Use of waste plastic as fine aggregate substitute in concrete" reported that the compressive strength of the waste plastic concrete mixture tend to decrease below the value for the reference concrete mixtures with increasing the waste plastic ratio at all curing ages.

N.M. Mary Treasa Shinu, S. Needhidasan (2019), "An Experimental study of replacing conventional coarse aggregate with E-waste plastic for M40 grade concrete using river sand" reported that the compressive strength, split tensile strength and modulus of rupture of specimen with E-waste plastic was lower than that of control mix concrete specimen

Xuemiao Li, Tung-Chai Ling (2019),"Functions and impacts of plastic/rubber wastes as eco-friendly aggregate in concrete- A review" reported that the case of plastic aggregates, the shape and particle of aggregate was found to influence the workability

NeedhidasanSandanam, B.Ramesh (2019), "Concrete blend with E-waste plastic for sustainable future" reported that reusing the E-waste plastics to replace the coarse aggregates partially(10% and 20%) is possibleand the best alternative for the conventional concrete.

R.J. Ball, J. Thorneycroft (2017), "Performance of structural concrete with recycled plastic waste as a partial replacement for sand" reported that through appropriate mix design reductions in strength can be minimized to acceptable levels

Awaham Mohammed Hameed, Bilal Abdul (2018), "Employment the plastic waste to produce the light weight concrete" reported that adding the plastic waste to the cement mortar lead to increase the mechanical properties of this mortar at a particular content of PET

Azad Khajuria, Puneet Sharma (2019), "Use of plastic Aggregates in Concrete" reported that the material used in the experiments is good and workable; the admixture used in the experiments gave the great impact on the strength of concrete.

IV. SIGNIFICANCE AND OBJECTIVES OF STUDY

SIGNIFICANCE: Concrete, one of the most common construction materials, requires a large amount of natural resources and energy. Natural resources used in concrete mixtures include lime stone, clay, sand, natural gravel, crushed stone, and water. With the rapid development in urban areas around the world in the recent years, our natural resources are depleting in an ever-increasing rate. Therefore, it is necessary to develop a new material that consumes less natural resources and energy in order to make our construction methods more sustainable. Many efforts have been made to study the use of waste / by product materials, such as fly ash, slag, silica fume, and natural pozzolan, to replace Portland cement in a concrete mixture. Others studied effects of plastic in concrete mixtures as aggregate replacement on material properties. While the previous studies showed potential advantages of using plastics in concrete (e.g., light weight and low energy consumption), they also reported some disadvantages, such as decreases in compressive strength and flexural strength of plastic concrete mixtures with the increase of the plastic ratio in the mixtures. Furthermore, material properties of plastic concrete mixtures may vary depending on the type of plastics that is used in the mixtures. For this reason, it was of interest of this research to study effects of one type of plastics, high-density polyethylene (HDPE), on concrete properties. This paper investigated the application of HDPE plastic on partial / full fine aggregate replacement for concrete mixtures.

OBJECTIVES: The objective of study is to study the behavior of the concrete which is made of the recycled plastic materials along with the study of the some of the physical properties that are related. Usually M20 grade of the concrete is the most commonly used in the constructional works, hence in this study M30 cement concrete is considered in which the recycled plastic waste is used as the replacement of fine aggregate in the concrete. Concrete cube and beam were casted taking 10% to 30% of plastic as partial replacement of fine aggregate and tested for 28 days of compressive strength and flexural strength of concrete.

SCOPE OF WORK: The use of recycled plastics in concrete is relatively a new development in the world of concrete technology and lot of research must go in before this material is actively used in concrete construction. The use of plastics in concrete lowered the strength of resultant concrete, therefore, the research must be oriented towards ternary systems that help in overcoming this drawback of use of plastics in concrete. Emphasis has been given to grind the waste into fine powder and mix into such proportion so as to achieve maximum packing density which may result to increase in compressive strength.

V. EXPERIMENTAL INVESTIGATION

PRELIMINARY TESTS : The test program consisting of casting and testing of concrete cubes (100mm x 100mm x 100mm) 6 No's are made to determine the compressive strength of M30 concrete with the ingredients of ordinary Portland cement 53 Grade, natural river sand and the crushed stone of maximum size 20 mm and also casting and testing of partially plastic waste replaced (10%, 20% & 30% of replacement with fine aggregate in concrete) concrete cubes (100 mm x 100 mm x 100 mm), cylinders(100mm x 200 mm),prisms (500mm x 100mm x100), cylinders (150mm x 300mm) are made to determine the compressive strength, flexural strength, modulus of elasticity and durability properties of concerned specimens with the grad of M30 concrete with ingredients of ordinary Portland cement 53 Grade, natural river sand and the crushed stone of maximum size 20 mm were used. Each three numbers of specimens of average value gives the mechanical and durability properties of concrete for curing period of 7 and 28 days.

Table 5.1 Preliminary test results on materials

Materials	Specific Gravity	Fineness Modulus
Cement	3.15	-
Coarse aggregate	2.70	-
Fine aggregate	2.69	2.5
Plastic waste	1.1	3.75

MIX PROPORTION : Mix Proportion is a ratio of fine aggregates, coarse aggregates and water to a constant Weight of Cement to design a Concrete for carrying a specified amount of Load including factor of Safety. In terms of the ratio for concrete, it depends on what strength you are trying to achieve, but as a general guide a standard concrete mix would be 1 part cement to 2 parts sand to 4 parts aggregates. For foundations, a mix of 1 part cement to 3 parts sand to 6 parts aggregates can be used. The grade of concrete used in the present investigation was M20.The mix was designed using IS 10262-2009. The mix design and the proportions of the mixes of materials required for 1 cubic meter of concrete in ordinary grade concrete

DATA REQUIRED FOR MIX DESIGN

5.1.1 CONCRETE MIX DESIGN STIPULATION

(a) Characteristic compressive strength required in the field at 28 days grade designation — M 30

(b) Nominal maximum size of aggregate — 20 mm

(c) Shape of CA — Angular

(d) Degree of workability required at site — 50-75 mm (slump)

(e) Degree of quality control available at site — As per IS: 456

(f) Type of exposure the structure will be subjected to (as defined in IS: 456) — Mild

(g) Type of cement: PSC conforming IS: 455

(h) Method of concrete placing: pump able concrete

TEST DATA OF MATERIAL (TO BE DETERMINED IN THE LABORATORY)

(a) Specific gravity of cement — 3.15

(b) Specific gravity of FA — 2.64

(c) Specific gravity of CA — 2.84

(d) Aggregates are assumed to be in saturated surface dry condition.

(e) Fine aggregates confirm to Zone II of IS – 383

PROCEDURE FOR CONCRETE MIX DESIGN OF M30 CONCRETE

Step 1 — Determination of Target Strength

Himsworth constant for 5% risk factor is 1.65. In this case standard deviation is taken from IS: 456 against M 20 is 4.0.

$\mathbf{f_{target} = f_{ck} + 1.65 \times S}$

$\mathbf{= 25 + 1.65 \times 4.0 = 31.6\ N/mm^2}$

Where,

S = standard deviation in N/mm^2 = 4 (as per table -1 of IS 10262- 2009)

Step 2 — Selection of water / cement ratio:-

From Table 5 of IS 456, (page no 20)

Maximum water-cement ratio for Mild exposure condition = 0.55

Based on experience, adopt water-cement ratio as 0.5.

0.5< 0.55 hence OK.

Step 3 — Selection of Water Content

From Table 2 of IS 10262- 2009,

Maximum water content = 186 Kg (for Nominal maximum size of aggregate — 20 mm)

Step 4 — Selection of Cement Content

Water-cement ratio = 0.5

Corrected water content = 191.6 kg /m^3

Cement content

From Table 5 of IS 456,

Minimum cement Content for mild exposure condition = 300 kg/m^3

383.2 kg/m^3 > 300 kg/m^3, hence OK.

This value is to be checked for durability requirement from IS: 456.

In the present example against mild exposure and for the case of reinforced concrete the minimum cement content is 300 kg/m^3 which is less than 383.2 kg/m^3. Hence cement content adopted = 383.2 kg/m^3.

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 kg/m^3.

Step 5: Estimation of Coarse Aggregate proportion:-

From Table 3 of IS 10262- 2009,

For Nominal maximum size of aggregate = 20 mm,

Zone of fine aggregate = Zone II

And For w/c = 0.5

Volume of coarse aggregate per unit volume of total aggregate = 0.62

Step 6: Estimation of the mix ingredients

a) Volume of concrete = 1 m^3

b) Volume of cement = (Mass of cement / Specific gravity of cement) x (1/100)

= (383.2/3.15) x (1/1000) = 0.122 m^3

c) Volume of water = (Mass of water / Specific gravity of water) x (1/1000)

= (191.6/1) x (1/1000) = 0.1916 m^3

d) Volume of total aggregates = a – (b + c) = 1 – (0.122 + 0.1916) = 0.6864 m^3

e) Mass of coarse aggregates = 0.6864 x 0.558 x 2.84 x 1000 = 1087.75 kg/m^3

f) Mass of fine aggregates = 0.6864 x 0.442 x 2.64 x 1000 = 800.94 kg/m^3

Concrete mix proportions for trial mix 1

Cement = 383.2 kg/m^3

Water = 191.6 kg/m^3

Fine aggregates = 800.94 kg/m^3

Coarse aggregate = 1087.75 kg/m^3

W/c = 0.5

For trial -1 casting of concrete in lab, to check its properties.

It will satisfy durability & economy.

For casting trial -1, mass of ingredients required were calculated for 4 no's cube assuming 25% wastage.

Volume of concrete required for 4 cubes = 4 x (0.15^3 x1.25) = 0.016878 m^3

Cement = (383.2 x 0.016878) kg/m^3 = 6.47 kg

Water = (191.6 x 0.016878) kg/m^3 =3.23 kg

Coarse aggregate = (1087.75 x 0.016878) kg/m^3 =18.36 kg

Fine aggregates = (800.94 x 0.016878) kg/m^3 = 13.52 kg

Step 7: Correction due to absorbing / moist aggregate:-

Since the aggregate is saturated surface dry condition hence no correction is required.

Step 8: Concrete Trial Mixes: -

Concrete Trial Mix 1:

The mix proportion as calculated in Step 6 forms trial mix1. With this proportion, concrete is manufactured and tested for fresh concrete properties requirement i.e. workability, bleeding and finishing qualities.

In this case,

Slump value = 25 mm

Compaction Factor = 0.844

So, from slump test we can say,

Mix is cohesive, workable and had a true slump of about 25 mm and it is free from segregation and bleeding.

Desired slump = 50-75 mm

So modifications are needed in trial mix 1 to arrive at the desired workability.

Concrete Trial Mix 2:

To increase the workability from 25 mm to 50-75 mm an increase in water content by +3% is to be made.

The corrected water content = 191.6 x 1.03 = 197.4 kg.

As mentioned earlier to adjust fresh concrete properties the water cement ratio will not be changed. Hence

Cement Content = (197.4/0.5) = 394.8 kg/m^3

Which also satisfies durability requirement.

Volume of all in aggregate = 1 – [{394.8/(3.15×1000)} + {197.4/(1 x 1000)}]

= 0.6773 m^3

Mass of coarse aggregate = 0.6773 x 0.558 x 2.84 x 1000

= 1073.33 kg/m^3

Mass of fine aggregate = 0.6773 x 0.442 x 2.64 x 1000

= 790.3 kg/m^3

Concrete Mix Proportions for Trial Mix 2

Cement = 384.8 kg/m^3

Water = 197.4 kg/m^3

Fine aggregate =790.3 kg/m^3

Coarse aggregate = 1073.33 kg/m^3

For casting trial-2, mass of ingredients required were calculated for 4 no's cube assuming 25% wastage.

Volume of concrete required for 4 cubes

= 4 x (0.15^3 x1.25) = 0.016878 m^3

Cement = (384.8 x 0.016878) kg/m^3 = 6.66 kg

Water = (197.4 x 0.016878) kg/m^3 =3.33 kg

Coarse aggregate = (1073.33 x 0.016878) kg/m^3

=18.11 kg

Fine aggregates = (790.3 x 0.016878) kg/m^3

= 13.34 kg

In this case,

Slump value = 60 mm

Compaction Factor = 0.852

So, from slump test we can say,

Mix is very cohesive, workable and had a true slump of about 60 mm.

It virtually flowed during vibration but did not exhibit any segregation and bleeding.

Desired slump = 50-75 mm

So, it has achieved desired workability by satisfying the requirement of 50-75 mm slump value.

Now, we need to go for trial mix-3.

Concrete Trial Mix 3:

In case of trial mix 3 water cement ratio is varied by +10% keeping water content constant. In the present example water cement ratio is raised to 0.55 from 0.5.

An increase of 0.05 in the w/c will entail a reduction in the coarse aggregate fraction by 0.01.

Hence the coarse aggregate as percentage of total aggregate = 0.558 – 0.01 = 0.548

W/c = 0.55

Water content will be kept constant.

Cement content = (197.4/0.55) = 358.9 kg/m^3

Hence, volume of all in aggregate

= 1 – [{(358.9/(3.15 x 1000)} + (197.4/1000)] =0.688 m^3

Mass of coarse aggregate = 0.688 x 0.548 x 2.84 x 1000 = 1070.75 kg/m^3

Mass of fine aggregate = 0.688 x 0.452 x 2.64 x 1000 = 821 kg/m^3

Concrete Mix Proportions of Trial Mix 3

Cement = 358.9 kg/m^3

Water = 197.4 kg/m^3

FA = 821 kg/m^3

CA = 1070.75 kg/m^3

For casting trial -3, mass of ingredients required were calculated for 4 no's cube assuming 25% wastage.

Volume of concrete required for 4 cubes = 4 x (0.15^3 x1.25) = 0.016878 m^3

Cement = (358.9 x 0.016878) kg/m^3 = 6.06 kg

Water = (197.4 x 0.016878) kg/m^3 =3.33 kg

Coarse aggregate = (1070.75 x 0.016878) kg/m^3 =18.07 kg

Fine aggregates = (821 x 0.016878) kg/m^3 = 13.85 kg

In this case,

Slump value = 75 mm

Compaction Factor = 0.89

So, from slump test we can say,

Mix is stable, cohesive, and workable and had a true slump of about 75 mm.

Desired slump = 50-75 mm

So, it has achieved desired workability by satisfying the requirement of 50-75 mm slump value.

VI. RESULT AND DISCUSSION

COMPRESSIVE STRENGTH TEST: In the case of cubes, the specimen is placed in the machines such a manner that the load is applied to opposite sides of the cubes as cast as shown in Figure, the axis of the specimen is carefully aligned with the center of thrust of the spherically seated plate. No packaging is used between the face of the test specimens and the steel plate of the testing machine. A spherically seated block is brought to bear on the specimens; the movable portion is rotating gently by hand so that uniform seating may be obtained. The load is applied without shock and increased continuously until the resistance of the specimen to the increasing load can be sustained. The maximum load to the specimens is then recorded.
Compressive strength = Ultimate load / Area of specimen

MODULUS OF ELASTICITY: For cylinder of size 150mm diameter and 300mm long were cast to determine the Modulus of Elasticity of concrete. The cylinder was placed inside the young's modulus testing apparatus called compressometer, providing equal clearance to top and bottom of specimen. Each cylinder was tested in 300T capacity compression testing machine (CTM). Loads were applied by means of 1T and the reading is noted in the deflectometer.The results of modulus of elasticity of concrete containing different percentages of plastic aggregates. They concluded that the value of modulus of elasticity decreased with increase of plastic waste partially replaced as fine aggregate in concrete

FLEXURAL STRENGTH TEST: For each mix two prisms of size 500mm long, 100mm breadth, and 100mm depth were cast to determine the flexural strength of concrete. The prisms were placed on the two supports. The applied load is distributed by two points (two-point load).

VII. CONCLUSION

- Recycling of plastic waste with river sand reduces its negative environmental impact of river sand quarries, reduces the depletion of natural resources.
- Reuses the waste plastic products of plastic industry and reduces the amount of waste correlated with these industries.
- Replacements of river sand with different percentages of plastic waste (10%, 20% &30% of partial replacement) did not have a huge negative effect on the consistency of fresh concrete properties of concrete up to 20% of replacement. As for the hardened concrete properties, average reductions of 25.2%, 22.76 and 13.6% were recorded relative to the control mix in the compressive strength, modulus of elasticity and flexural strength values respectively. The Reductions were not significantly affected by the percentage replacement of normal concrete with plastic partially replaced concrete.

- Results of this test program have a positive impact on the usage of waste plastic fine aggregate in concrete making.

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Table 4.3 Mix Proportions for Partially Replaced Plastic Waste Concrete

% of plastic waste replacement (design mix) (C:F.A:C.A:P.W)	CEMENT		FINE AGGREGATE				COARSE AGGREGATE		WATER (l/m^3)	W/C
			SAND		PLASTIC					
	Weight (kg)	Volume (kg/m^3)	Weight (kg)	Volume (kg/m^3)	Weight (kg)	Volume (kg/m^3)	Weight (kg)	Volume (kg/m^3)		
10% Plastic Waste Replacement **(1:1.6:3.09:0.1)**	1207	383	1664	618.75	50.116	45.56	320	1185	192	0.5
20% Plastic Waste Replacement **(1:1.5:3.09:0.2)**	1207	383	1542	573.2	100.2	91.12	320	1185	192	0.5
30% Plastic Waste Replacement (**1:1.4:3.09:0.3**)	1207	383	1418.2	527.24	150.34	136.68	320	1185	192	0.5

Table 4.2 Mix Proportion for Reference Concrete

CEMENT		FINE AGGREGATE		COARSE AGGREGATE		WATER (l/m^3)	W/ C
Weight (kg)	**Volume (kg/m^3)**	**Weight (kg)**	**Volume (kg/m^3)**	**Weight (kg)**	**Volume (kg/m^3)**		
1207	383.2	1786	664.32	3120	1185	191.2	0.5

Table 6.1 Result of Compressive strength

Specimen (cube100mmx100mm x100mm)	Avg compressive strength results (7days)	Avg compressive strength results (28days)
Reference concrete	19.5	26.6
10% partially plastic waste replaced concrete	18.5	25.6
20% partially plastic waste replaced concrete	18.2	21.33
30% partially plastic waste replaced concrete	10.7	14.4

Table 6.2 Result of Elasticity

S. No	Concrete type	Experimental Value×10^4 (N/mm^2)	Theoretical Value × 10^4 (N/mm^2)
1	Reference concrete	2.25	2.23
2	10% of plastic waste replaced concrete	2.01	2.23
3	20% of plastic waste replaced concrete	1.80	2.23
4	30% of plastic waste replaced concrete	1.40	2.23

Table 6.3 Result of Flexural Strength

S. No	Concrete Type	Experimental Value (N/mm^2)	Theoretical Value (N/mm^2)
1	Reference concrete	3.4	3.13
2	10% of Plastic waste replaced concrete	3.2	3.13
3	20% of Plastic waste replaced concrete	3	3.13
4	30% of Plastic waste replaced concrete	2.6	3.13