Re-Use of Polyethylene Plastic Waste In Concrete

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***Abstract* - The increase in population and the changed lifestyle has resulted in a significant rise in the quantity of plastic waste. This project in particular deals with the possibility of using the waste polyethylene as partial replacement of fine or coarse aggregate in concrete. Concrete with 2%, 4%, 6% pulverized/non pulverized polyethylene material is prepared after doing the mix design. Various tests on cement like specific gravity, fineness, setting time, etc., tests on coarse and fine aggregates like sieve analysis, fineness modulus, specific gravity, etc. are performed. Mix design using IS Code method is done and cubes and cylinders are cast for M25 grade concrete with and without plastics and tests on concrete like slump, cube tests and cylinder tests are performed to understand their behavior and usefulness as replacement. The standard mechanical properties of concrete like compressive strength, split tensile strength are tested and compared with the results of standard specimen.**

***Index Terms* – Plastic, Cement, Fine aggregate, Coarse aggregate, Water**

I. INTRODUCTION

Due to rapid industrialization and urbanization in the country lots of infrastructure developments are taking place. this rapid development led to the acute shortage of construction materials, increased dumping of waste materials.
Hence to overcome the above said problems waste products should be employed as a construction material. Fine aggregate used in concrete is replaced partially by pulverized PET bottles in known percentages and properties are tested, the optimum percentage at which higher strength is obtained is calculated. Considerable researches were carried out in some countries like USA, UK on this topic however there have been very limited studies on plastics in India

II. LITERATURE REVIEW

Raghatate atul m., has done research on "Use Of Plastic In A Concrete To Improve Its Properties". Plastic bags which are commonly used for packing, carrying vegetables, meat etc creates a serious environmental problem. Plastic bag last in environment up to 1000 years because of plastic bag last so long the number of plastic bag accumulated increases each year. Disposal of large quantity of plastic bag may cause pollution of land, water bodies and air.The proposed concrete which is made up by adding plastic in concrete may help to reuse the plastic bag as one of the constituent's material of concrete, to improve the certain properties of concrete. The properties of concrete containing varying percentages of plastic were tested for compressive strength and Split tensile strength and shows that an appreciable improvement in tensile strength of concrete can be achieved by introducing cut pieces of plastic bags.
He concluded based on the Experimental result following points are summarized with regard to effect of plastic on the properties of concrete

- Compressive strength of concrete is affected by addition of plastic pieces and it goes on decreasing as the percentage of plastic increases addition of 1 % of plastic in concrete causes about 20% reduction in strength after 28 days curing.
- The splitting tensile strength observation shows the improvement of tensile strength of concrete. Up to 0.8 % of plastic improvement of strength recorded after that addition of strength of concrete decreases with addition of plastic.
- Thus it is conclude that the use plastic can be possible to increase the tensile strength of concrete.
- From the above discussion it is identified that the use of plastic can be possible to improve the properties of concrete which can act as a one of the plastic disposal method.

Malek batayneh ,Iqbal marie, Ibrahim asi has done research on "Use of selected waste materials in concrete mixes".
A modern lifestyle, alongside the advancement of technology has led to an increase in the amount and type of waste being generated, leading to a waste disposal crisis. This study tackles the problem of the waste that is generated from construction fields, such as demolished concrete, glass, and plastic. In order to dispose of or at least reduce the accumulation of certain kinds of waste, it has been suggested to reuse some of these waste materials to substitute a percentage of the primary materials used in the ordinary Portland cement concrete (OPC).
The waste materials considered to be recycled in this study consist of glass, plastics, and demolished concrete. Such recycling not only helps conserve natural resources, but also helps solve a growing waste disposal crisis.
Ground plastics and glass were used to replace upto 20% of fine aggregates in concrete mixes, while crushed concrete was used to replace up to 20% of coarse aggregates. To evaluate these replacements on the properties of the OPC mixes, a number of laboratory tests were carried out. These tests included workability, unit weight, compressive strength, flexural strength, and

indirect tensile strength (splitting). The main findings of this investigation revealed that the three types of waste materials could be reused successfully as partial substitutes for sand or coarse aggregates in concrete mixtures.
The researchers concluded that the tests carried out in this study were primarily designed to provide an indication of relative advantages and disadvantages of the use of a number of construction wastes, such as crushed concrete waste, plastics, and glass. This would provide an overview of the reuse of construction waste materials in the construction industry.
Based on the test results and on the physical observations, the following conclusions can be drawn:

1. Waste and recycling management plans should be developed for any construction project prior to the start of work in order to sustain environmental, economic, and social development principles.
2. The increase of the surface area of the recycled crushed concrete, due to its irregular shape, necessitates an increase of cement and water; hence the irregular shape negatively affects the workability of the said mix.
3. A comparison between the cost of crushing glass, plastic, and concrete with that of supplying prime aggregates (gravel) should be considered in the project management plans, taking into consideration the availability of prime materials, and location.
4. The strength of concrete mixes was improved by the partial replacement of fine aggregates with crushed glass aggregates, but the high alkali content of such aggregates would affect the long-term durability and strength, both of which need long-term investigation.
5. Using glass of different percentages showed no significant effect on the slump, unlike the use of plastic and crushed aggregates, which showed that higher the percentage used, the lesser was the slump.
6. In addition to recycling glass by its use in concrete mixes, glass aggregates can be used aesthetically in masonry, which can give a shiny clean finishing effect on the surface of the concrete product.
7. When up to 20% of plastic and crushed concrete was used in concrete, the strength of the concrete exhibited lower compressive and splitting-tensile strength than that of normal concrete using natural aggregates. Therefore, it is recommended that concrete with recycled materials of lower strength be used in certain civil engineering applications, especially in non-structural applications, where lower strength up to 25 MPa is required. This will contribute to cutting down the cost of using non-structural concrete.

Research was also done on Performance of concrete by using Non recyclable plastic wastes as concrete Constituent. The safe disposal of non-recyclable thin plastics bags is the most challenging issue for the solid waste management across the globe. Even today, at least 15% of total plastic waste remains untreated [1]. Concrete is the first choice for construction in many countries today. This has increased the fast vanishing of natural resources. It could be worth experimenting to use non recyclable plastic bags in concrete to overcome the dual issue of shortage of raw material and safe disposal of leftover plastic to environment. This paper presents a comparative study of compressive strength of concrete made by mixing of plastic bags as concrete constituent. This study focuses on the use of polyethylene plastic bags of 20 micron thick in M25 concrete. Plastic was added 0% to 1.2% by volume. The compressive - strength was compared for manually cut and shredded plastic form.
Based on the experimental data received after a wide range of samples with different proportions of polyethylene fibers, following conclusions are made,

1. The plastic bags could be used preferably in shredded form to avoid difficulty in workability.
2. Macro fibers made from bags by hand cut, are not suitable due to their low aspect ratio.
3. Beyond 0.6% of concrete volume of the fibers made from the plastic bags having thickness less than 20 microns reduced the strength and compacting factor nearly up to 30% and at 1.2% the strength reduced up to 50% compared to the controlled concrete.
4. The concrete prepared by addition of polyethylene fibers less than 20 micron thickness, could be suitably used for non structural works, where the strength of concrete is not a prime concern.
5. Various durability aspects must be checked with wider range of sampling and testing.
6. The authors are experimenting different types of post consumer plastic wastes in different form and proportions to check the feasibility of usage of such wastes in concrete to have an alternate solution towards the solid wastes.

However in the present project only mechanical properties of polyethylene plastic waste are investigated and presented.

III. OBJECTIVE OF THE PROJECT

The present Indian concrete industry is consuming about 370 million m3 of concrete every year and it is expected, that it shall reach about 580million m3 by 2022[1][6].The re-formation of
Natural sources are beyond the proportion of mankind. Hence the increased demand of concrete has raised a serious question on the quickly vanishing valuable natural sources. It is therefore has become a necessity to find an alternate material could be used along with the conventional materials and try to reduce the quick and huge usage of valuable sources .A new term evolved called Green concrete – it is a concrete prepared by using the waste products of different
Industries with the conventional materials. Wide variety of such wastes are already being added and tested for various observations and their effects on different aspects of concrete prop
Plastic bags which are used for carrying goods become a waste after use and create environmental problems. Large amount of plastic waste produced every year. Recycle and reused of plastic require vast manpower and processing cost thus the very small amount of plastic recycled and reused and rest going into landfills, incinerators and dumps. Here author suggested the use of these plastic bags pieces in a concrete as a plastic fiber to improve the properties of concrete. Use of plastic has a dual advantage cost of material is low also it solve the problem of disposal of plastic up to some extent.

Figure No. 1 Recycle the waste

In general, for any construction project, plans for recycling of waste materials should be developed prior to the commencement of work. These plans should identify the types of waste to be generated and the method of handling, and the recycling and disposal procedures. In addition, areas for the temporary accumulation or storage of the construction waste materials should be clearly designated .Collection of data by visiting a number of local construction sites in Jordan provided an important indication of the percentage of particular construction waste materials accumulated at the sites. Indicating the percentage of each type of waste materials generated on site. 20% of the total quantity of waste of 1721.8 tons consists of glass, plastic, and concrete. The weights of these materials are estimated to be: 35 tons of glass, 52 tons of plastic, and 240 tons of concrete. Hence, this waste should be incorporated in a waste management plan. The development of an action plan for waste management in every construction case is the responsibility of the owner or his agent. This is to ensure that all waste products generated by a construction project on a property are surveyed, handled and disposed of in a legal manner for the protection of the environment.

A waste management plan directs the construction activities towards an environmentally friendly process by reducing the amount of waste materials and their discard in landfills. The environmental and economic advantages that occur when waste materials are diverted from landfills include:

a. conservation of raw materials;
b. reduction in the cost of waste disposal; and
c. efficient use of the materials.

Waste materials must be kept clean and in separate batches in order to be used or recycled in an efficient manner.

Although separation can take place after the mixed waste is removed from the construction site, separation at the site increases the efficiency of recycling or reuse of that waste. It includes suggestions for a construction waste management plan. The reduction of waste construction materials can be achieved by starting with studying the design details of the building to ensure efficient use of materials, in addition, careful cutting and measuring should be applied accurately. The use of materials that are made from recycled materials and are recyclable should be included in the initial design of the structure.

Storage methods should be investigated to prevent damage From mishandling and weather conditions. In addition, the ordering of materials should be made just before the work commences. To complete the waste management plan, there should be an estimation of the amount and type of recyclable and non-recyclable waste materials that are expected to be generated on site. Listing of all the expected quantities of each type of waste gives an indication of what type of management activities are appropriate for the specified waste. At each stage of construction, there should be specific ways to reduce, reuse or recycle the wastes which may be produced

Figure No.2 Waste plastic made into fibers

IV. EXPERIMENTAL INVESTIGATION

4.1 *GENERAL*

Before going to make a concrete, first we have to determine the properties of materials such as bulk density, specific gravity, fines modulus, particle size distribution,etc.,used for making concrete. The limitations of those properties are given in IS 383-1984

4.2 *TESTS ON INGREDIENTS*

On the materials we have performed the following tests

1. Specific gravity.
2. Particle size distribution
3. Bulk density and
4. Water absorption

4.2.1Tests on cement

4.2.1.1 Specific Gravity of Cement : (Using Pycnometer Method)

$$G = \frac{(w_2 - w_1)}{(w_2 - w_1) - (w_3 - w_4)} * \frac{(w_4 - w_1)}{(w_5 - w_1)}$$

W_1	=	Empty weight of pycnometer	-	51.0g
W_2	=	Pycnometer + 1/3rd of cement	-	94.2g
W_3	=	Pycnometer + cement + kerosene	-	158.6g
W_4	=	Pycnometer + complete kerosene	-	126.5g
W_5	=	Pycnometer + complete water	-	146.2g

Figure No.1 Specific gravity bottle for cement

Result obtained G=3.1

4.2.1.2 *Fineness of Cement* (using IS sieve no:9)
(90microns confirming to IS : 460-1962)

Weight of cement taken (W1) = 100gms
Weight of residue after Sieving (W2) = 2gms
% residue of cement = 2%

4.2.1.3 *Consistency of cement*

Table No.1 Initial and final setting times of cement

% of water added	Initial reading (mm)	Final Reading (mm)	Depth of penetration (mm)
26	42	11	31
28	42	10	32
30	42	7	35

Result obtained:

Consistency of cement=30%

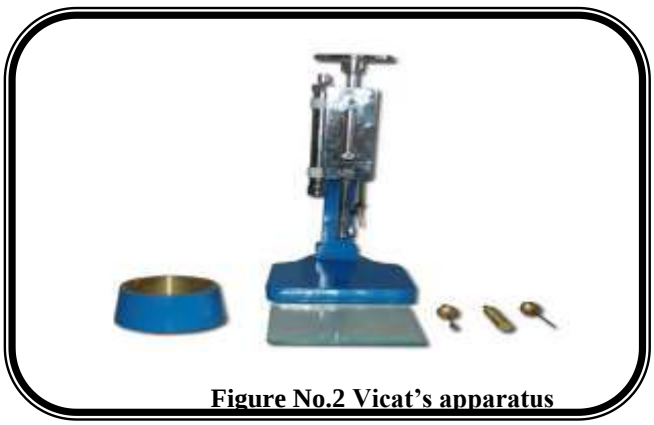

Figure No.2 Vicat's apparatus

4.2.1.4 Initial & Final setting time of cement

Table No.2 consistency of cement

S.No	% of water added	Volume of water(ml)	Time (min)	Final Reading (mm)
1	25.5	102	0	0
2	25.5	102	2	0
3	25.5	102	5	0
4	25.5	102	20	0
5	25.5	102	40	2
6	25.5	102	80	3
7	25.5	102	85	5

Result obtained:

Initial setting time=85mins
Final setting time=210mins

4.2.1.5 Compressive strength of cement (OPC 53 Grade)

Weight of cement=200gms
Weight of sand=600gms
Amount of water added=(P/4 + 3)%
7 days strength = P/A
$=135x10^3/50x10^2$
$=27N/mm^2$

PHYSICAL PROPERTRIES OF CEMENT

Table No.3 Comparison of setting tines as per IS values

physical property tested	According To IS12269-1987 Specifications	Results Obtained
Specific gravity	-	3.1
Standard consistency	-	30%
Initial setting time	>30 minutes	85 minutes
Final setting time	<600 minutes	210 minutes
Fineness of cement	< 10%	3%

4.2.1 Tests on fine aggregate

4.2.1.1 Sieve Analysis

Weight of sand taken=500gms

Table No.4 Sieve analysis results

S.No	Sieve Size	% retained	Cumulative %
1	4.75mm	1	1
2	2.36mm	8	9
3	1.18mm	25.6	35
4	600µ	33.6	69
5	300µ	24.8	94
6	180µ	4.04	99
7	150µ	0.1	99.1
8	75µ	0.2	99.3
9	Pan	0.8	100

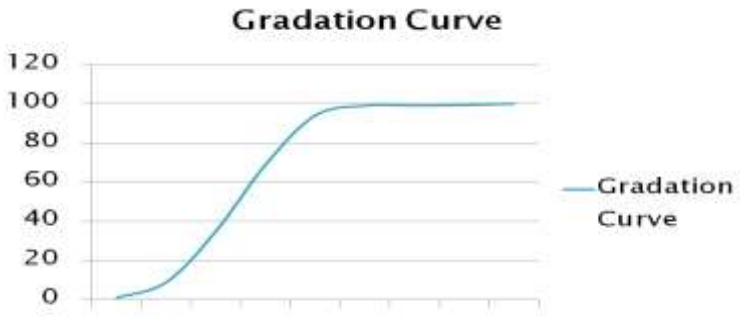

Figure No.3 Gradation curve

D_{10}=2.36mm, D_{30}=1.3mm, D_{60}=0.7mm
Coefficient of uniformity=D_{60}/D_{10} = 3.37
Coefficient of Curvature= $D_{30}^2/D_{60}XD_{10}$ = 1.02
Within the limits - **Well graded sand**

4.2.1.2 Specific Gravity of Fine Aggregate

The Pycnometer is cleaned for presence of dust, or moisture inside and its empty weight is taken. A small quantity of dry sand is put inside the pycnometer so as to fill about one fourth the pycnometer and the weight of pycnometer with sand is taken. The pycnometer is filled, completely with distilled water. Any entrapped air shall be eliminated by rotating the pycnometer on its side. The pycnometer shall be topped up with distilled water to remove any forth from the surface, dried on the outside and weighed. The pycnometer shall be emptied; care being taken to ensure that all aggregate is transferred. the pycnometer is filled with distilled water to the same level as before, dried on the outside and weighed

W_1	=	Empty weight of pycnometer	-	691.5gm
W_2	=	Pycnometer + 1/3rd of FA	-	1483.2gm-
W_3	=	Pycnometer + cement + kerosene	-	2077.1gm
W_4	=	Pycnometer + complete kerosene	-	1642.3gm

Result obtained: G=2.7

Table No.5 Sp gr and FM of cement

Physical property tested	Results obtained
Specific gravity	2.7
fineness modulus	3.1

4.2.2 Tests on coarse aggregate

The coarse aggregate used is locally available crushed blue granite stone aggregate of 20mm size. The tests were conducted to determine the following properties of the coarse aggregate used

4.2.2.1 Specific Gravity of Coarse aggregate:

$$G=\frac{(w_2-w_1)}{(w_2-w_1)-(w_3-w_4)}$$

W_1	=	Empty weight of pycnometer	-	691.5gm
W_2	=	Pycnometer + 1/3rd of CA	-	1381.5gm
W_3	=	Pycnometer + cement + kerosene	-	2094.2gm
W_4	=	Pycnometer + complete kerosene	-	1642.3gm

Result obtained: G=2.75

4.3 MIX DESIGN STEPS:

The following basic steps are required to be specified for design of a concrete mix:

a) Characteristic compressive strength(that is below which only a specified proportion of test results are allowed to fall) of concrete at 28 days(fck)'
b) Degree of workability desired,
c) Limitations on the water-cement ratio and the minimum cement content to ensure adequate durability
d) Type and maximum size of aggregates to be used, and
e) Standard deviation (s) of compressive strength of concrete.

STEP 1:
Grade of concrete = M25
Standard deviation = 4
Degree of quality control is to be good

STEP 2:
Target mean strength
Fck = fck + t x S
= fck + 1.65s
= 25 + 1.65(4)
= 31.6 N/mm^2

STEP 3:
Selection of mix proportions
(i) Selection of w/c ratio = 0.5
(ii) estimation of entrapped air
Maximum aggregate size = 20mm
Percentage air content = 2
Water content per cubic meter of concrete = 186 kg
Sand content = 35kg

For Sand confirming to grading zone 2 --------- % sand in total aggregates
Compaction factor (0.9) --------- 1.5% for zone 2

Therefore required water content = 186kg
Sand content = 36.9%

Determination of cement content:
w/c ratio = 0.5
Water = 186 l/m^3
186/0.5 = c
Cement = 372 kg/m3

(iii) Determination of coarse and fine aggregates

From table-3:
For w/c ratio-0.5
Volume of CA=60% of total aggregate
Volume of FA=40% of total aggregate
Volume of concrete=1m^3
Volume of cement = 372/3.15*1000 = 0.118 m^3
Volume of water = 0.118 m^3
Volume of total aggregate =0.696 m3
Mass of Coarse aggregate =1148.4 kg/m^3
Mass of fine aggregate =751.7 kg/m^3

FINAL PROPORTION:

CEMENT	FA	CA	WATER
372kg/m^3	751.7 kg/m^3	1148.4 kg/m^3	186 l/m^3

4.4 TESTING PROCEDURE

The test procedure comprised of casting cubical and cylindrical specimen and then testing these specimens for compressive strength and splitting tensile strength respectively. The specimens were compacted using the tamping rod 16 mm diameters, in three equal layers. The cubical specimen were casted in standard cylindrical moulds of 150mm diameter x 300 mm height . A rich mortar was used as capping for cylindrical specimens. These specimens were removed from moulds after 24 hours and then kept in water for curing

4.4.1 Test for compressive strength

The cubical specimen have been tested as per the procedure in IS 515:1959 code.the testing was done on pair of surfaces against which the cubes were casted. The compressive strength of 150mm x 150mm x 150mm cubes for 7 days were determined using a four pillared compressive strength testing machine.

4.5 Test results

Presentation of test results

The results of the test conducted on partial replacement of cement with fly ash in fiber reinforced concrete for mechanical properties have been tabulated as follow.

4.4.2 Compressive strength of concrete

The term "concrete strength "is usually used to indicate the uniaxial compressive strength of concrete. The compressive strength of concrete is defined as the strength of 28 days old specimens tested under monotonic uniaxial compressive load. Testing of cylindrical samples with 15 cm diameter and 30 cm height is standard. Cube specimens of 15 cm×15 cm×15 cm are also being used.

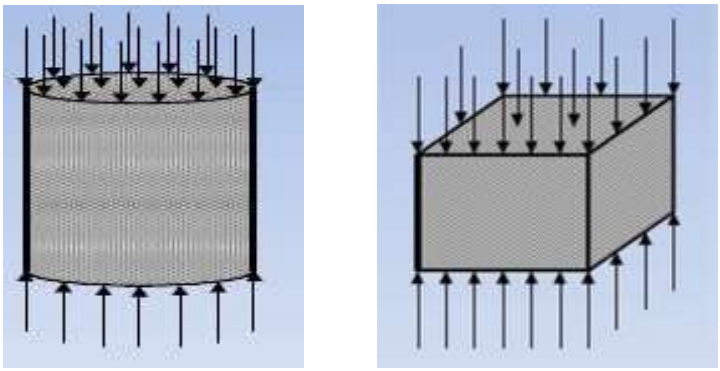

Figure No.16 cube and cylinder subjected to loading

There are three failure modes for cylinders.

a) Under axial compression concrete fails in shear.

b) The separation of the specimen into columnar pieces by what is known as splitting or columnar fracture.

c) Combination of shear and splitting failure**.**

Modes of failure of specimen

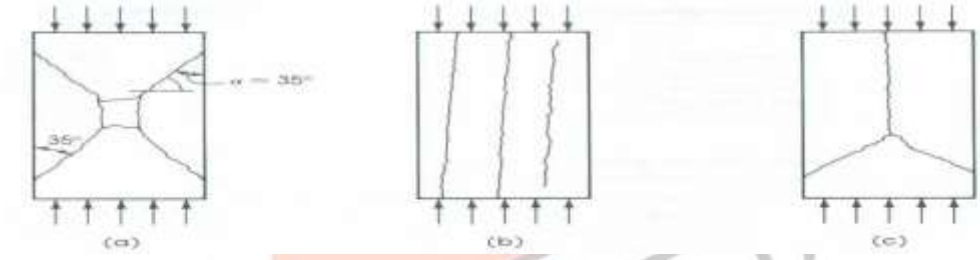

Figure No17 modes of failure of the specimen

V. RESULTS

1 Compressive Strength

The 3 days, 7 days and 28 days compressive strength result were presented. The compressive strength of concrete goes on reducing with increase in percentage of plastic pieces but the rate of reducing compressive strength is very low

Compressive Strength of Concrete

Table No. No.1 Compressive strength of concrete for various percentages

Plastic Percentage	*7 day(N/mm^2)*	*14 day(N/mm^2)*	*28 day(N/mm^2)*
0	*24.9*	*33.3*	*35.5*
2	*23*	*32.1*	*35.2*
4	*21.7*	*31.7*	*35.1*
6	21.4	30.6	34.8

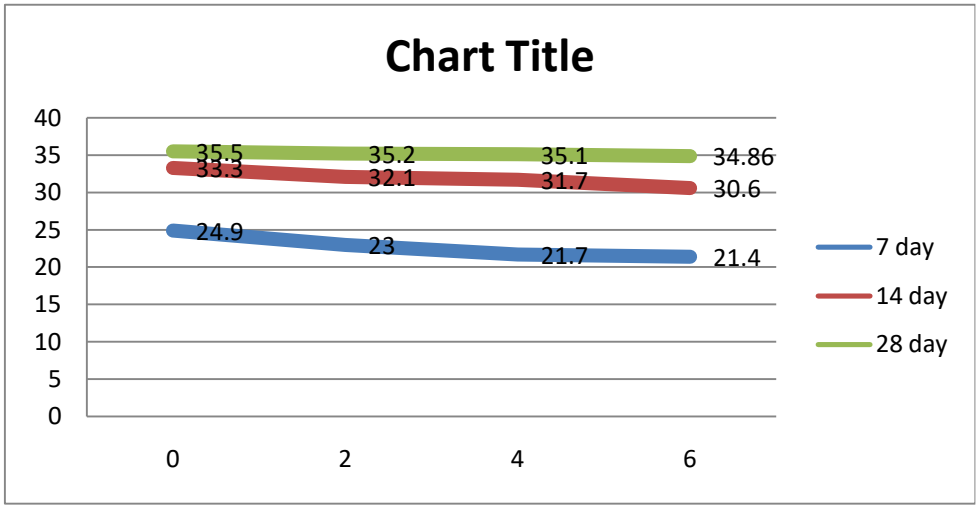

Figure No: comparison of compressive strength of concrete for various percentages of plastic

5.2 Tensile Strength

1) Result of Split tensile strength after 7 days, 14 days, and 28 days were presented in
Figure No.19. Decrease in splitting tensile strength after addition of plastic pieces in concrete was observed which show in Figure No.19.

2) The concept of mixing of plastic wastes in concrete could be a very environment friendly method of disposal of solid waste in the country, this study has shown a
Potential towards this concept.

3) Various durability aspects must be checked with wider range of sampling and testing.

4) The authors are experimenting different types of post consumer plastic wastes in different form and proportions to check the feasibility of usage of such wastes in concrete to have an alternate solution towards the solid wastes.

5) A comparison between the cost of crushing glass, plastic, and concrete with that of supplying prime aggregates (gravel) should be considered in the project management plans, taking into consideration the availability of prime materials, and location.

5.2.1 Split tensile strength

Table No.2 Split tensile strength of concrete for various percentages

S.No	Split Tensile Strength in N/mm^2		
Plastic %	7 day	14 day	28 day
0	0.48	0.8	0.96
2	0.42	0.76	0.92
4	0.38	0.76	0.9
6	0.36	0.75	0.89

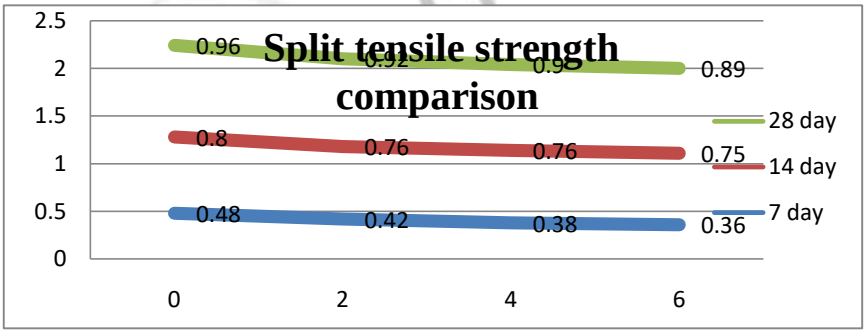

Figure No.23 Comparison of split tensile strength of concrete for various percentages of plastic

VI. CONCLUSION

- Waste plastic can be effectively re-used without affecting the mechanical properties considerably (5-10%).
- With increase in the percentage of plastic there has been a sudden decrease in early strength but the strength developed to the value as that of the conventional M25 concrete when 28 day tests were performed.
- It is observed that for more percentage addition of plastics i.e 6% in the present case, the 7 day strength has been decreased by --- when compared with conventional concrete.

- For less percentage addition (2-4%) of plastic, there is no considerable variation in 7 day, 14 day, and 28 day compression strength and split tensile strength.
- Since Specific gravity of waste plastic is less than that of fine aggregate, thus self weight of concrete reduces, thus it reduces the weight of the structure/structural component as a whole.
- Concrete with plastic waste can be used for less important works where concrete is not going to bear more loads.

VII. FURTHER SCOPE OF STUDY

- The studies can be further extended by addition of admixtures to make the concrete not to alter its strength considerably even with the addition of more percentage of plastic waste.
- Durability studies can be conducted so as to study its properties in the long run.
- Tensile strength can be studied where concrete needs more tensile capacity.

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