"Flexural & Tensile Strength of Concrete with Waste Plastic (High Density PVC) Aggregates As Partial Replacement of Coarse Aggregates."

[1] Lavang Kumar Agarwal, [2] Prof. Sherin Felix, [3] Dr. Shubha Agarwal.

Department of Civil Engineering, LNCT College Bhopal, UIT RGPV University Bhopal, Madhya Pradesh, India.

Abstract: *Use of plastic has increased to a great extent due to rapid growth and urbanization and thus generation of plastic waste due to it has resulted in many problems such as its disposal and many health & environmental problems. Among these plastic, polyvinyl chloride (PVC) is most hazardous one. Hence, this thesis deals with strengthen concrete by plastic covering aggregates as a partial replacement of coarse aggregates and a way to reuse waste plastic. Here, PVC pipe shells of approx. 1 inch cutting and internal & external dia. of 16mm & 21mm respectively, filled with 1:3 mortar, is used and termed as plastic aggregates. Almost 24 specimens of concrete were prepared, the concretes indirect split tensile strength and flexural strength (modulus of rupture) and their behavior is investigated along a time span of 7 days and 28 days with 10% replacement of coarse aggregates with High Density Polyvinyl Chloride waste plastic aggregates and also a sort of Portland pozzolanic cement with 30% fly ash. Result shows that the Indirect Split Tensile Strength of concrete for M25 grade at 7 days with 10% replacements shows fulfilling minimum satisfying criteria compared to basic values of M25 grade concrete but reduces to small extent of even min. satisfying criteria for 28 days of curing. Whereas, flexural strength Result shows that at 7 days a huge fall in strength to basic values, but gains strength to a good extent at 28 days of curing but still below or nearer to min. satisfying criteria.*

KEYWORDS: *High density PVC waste plastic, plastic aggregates, PVC, Concrete, Environment, Concrete strength & its behavior.*

I. INTRODUCTION

Use of plastic has increased to a great extent due to rapid growth and urbanization and thus generation of plastic waste due to it has resulted in many problems such as its disposal and many health & environmental problems. There is growing evidences that human actions are irremediably altering natural ecosystems and driving increasing numbers of plant and animal species to extinction. Plastic products has become an integral part as one of our basic needs. Just from packing films, wrapping materials, shopping and garbage bags, fluid containers, households, toys, clothing, industrial products and building materials it has many applications. Plastic do not degrade for several years and recycled plastic harms our environment in one or the other way. Among these plastic, polyvinyl chloride (PVC) is most hazardous one.

Recent Reports Says

- The world's annual utilization of plastic increased from 5 million tons to 100 million tons in just half century. Now, globally its production crossed 150 million tons per year.

Indian scenario

- Recent reports by environmental ministry says - India is producing 25000 tons of plastic waste in a day.
- Surat a city in Gujrat state of India produces 12.47% of its municipal solid waste is plastic while Chandigarh city in India produced 3.1% of plastic from municipal solid waste.
- Just from another survey carried out by central pollution control board (CPCB) it says that 4059 tons/day plastic wastes is generated by 60 major cities of India.

Thus, with the repeated efforts by Indian government over the years to ban or limit plastics use, plastic waste remains one of the biggest concern in urban areas of India. This data is generated from a study carried out by Indian Institute of Toxicological Research (IITR), Lucknow on behalf of CPCB, and also states that heavy metals, chlorides, phthalates, "Migrated from plastic waste into the surrounding medium" and can cause pollution problems by contaminating the surrounding soil, ground and surface water. Efforts where made so that chemicals cant penetrate landfills. A step forward by Maharashtra to use plastic waste in road construction and also implemented by several cities of India.

Thus the focus must be on Plastic waste management and recycling.

II. EXPERIMENTAL WORK/ PROCESS

Materials Taken

M25 grade of concrete as the main material is taken. Proportions of this grade is 1:1:2 (cement: sand: coarse aggregates) and water cement ratio is taken as 0.44 to 0.50.

Basic Materials	Specifications
Cement for normal M25 grade	Ordinary Portland Cement of grade 43 was used.
Cement for experimental M25 grade	Portland Pozzalanic Cement of 43 grade with 30 % fly ash was used
Fine aggregates - Sand	Passing through BIS test Sieve 4.75 mm and usually natural sand is used
Coarse aggregates	Size of aggregates used from 12.5 mm to 20mm, specific gravity 2.72 were used.
Plastic waste	High density polyvinyl chloride plastic aggregates used. Size of plastic aggregate formed by PVC shells as outer covering = 20mm to 30mm length internal dia. as 16mm & external dia. as 21 mm and weight of hollow PVC 1 inch shell = 6gms. Weight of 1 plastic aggregate with mortar filled inside it= 18gms.
Water	Fresh water was used for mixing process & curing.

Brief About Plastic Aggregates

Plastic aggregate is the aggregate consist of polyvinyl chloride as the outer shell covering a (1:3) mortar of cement, sand inside it. This outer shell made of P.V.C. is hard and good in tensile properties, providing a good protection from various forces to the inner lying 1:3 mortar. This mortar is prepared by using cement, sand 1:3 ratio and an appropriate water content. Plastic aggregate is generally made using P.V.C. pipes of different diameters. These P.V.C. pipes are cut down using a cutter machine in small pieces. The sizes of these small pieces is approximately 1 inch length. The freshly prepared mortar of (1:3) cement, sand is filled inside the 1 inch plastic shells of P.V.C. pipes. Then, for 24 hours these were left undisturbed to make a unit structure, which we named as plastic aggregates. Also these plastic aggregates were cured to gain strength.

Size of plastic P.V.C. shells which forms the outer covering = approx. 25 mm length. And are cylindrical in shapes.

P.V.C. **internal diameter** as 16 mm & **external diameter** as 21 mm, **Weight** of P.V.C. shell of 1 inch = approx. 6 gms,

Volume of 1 plastic shell - (pi* r^2 *h) = (Pi * 8^2 * 22) mm = 4423.36mm^3 =0.000004423m^3

Weight of one plastic aggregate consisting of mortar. = approx. 18 gms.

The ingredients of concrete for production of 1m^3 concrete in kg - Cement -554.4 kg, sand – 558.25 kg, coarse aggregates – 1155 kg.

Procedure

- **Mixing of Materials -** Different calculated quantities have been weighed and mixed in proportion of M25 grade for normal concrete and also different calculated quantities have been weighed and mixed in proportion of M25 grade for experimental concrete with 10% coarse aggregate replacement with plastic aggregates.
- **Slump Test / Test for Workability** – This test determines the consistency of concrete. Thus, for proper amount of water in the concrete mix this test is done. Slump values must be in range from 50- 80 mm according to IS code: 1199-1959.
- **Beam & Cylindral moulds** of size 150mm*150mm*700mm and 150mm dia. & 300mm length respectively are cleaned and oiled. These moulds are then filled with M25 grade concrete mix of normal type concrete and also with experimental type concrete containing 10% plastic aggregates replaced in place of coarse aggregates. Properly compacted each layer of concrete in mould to remove any air voids and to form a consistent mix temping by rod is done. These are then left for 24 hrs. undisturbed.
- **Curing of specimen** – these specimens are then taken out of moulds and placed in water tank for 7 & 28 days to achieve proper strength.

III. Tests carried out, Graphs & Results

1. Indirect Split Tensile Strength Test

Definition- Tensile strength is the ability of the concrete to survive under tension load.

- Based on **IS 516- 1959.**
- Expressed as minimum tensile stress needed to split the material apart.
- According to IS code, cylinder specimen are recommended.
- Moulds size **-** 150mm dia. & 300mm length.

Formula, fct = 2P/ (pi * D * L)

Where, P= Load

D = diameter of specimen (150mm)

L = length of specimen (300 mm)

Values & Calculations

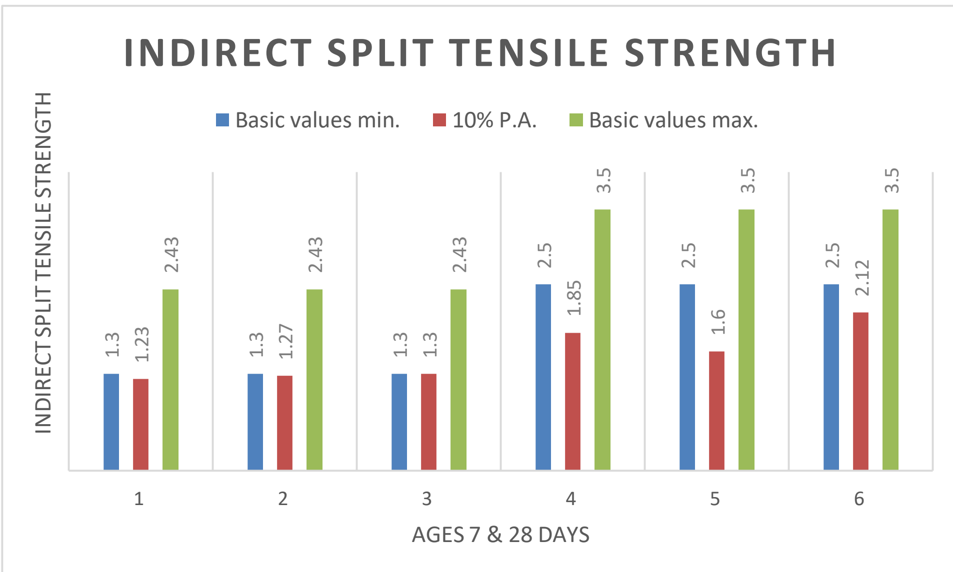
Table 1 Normal M 25 grade concrete

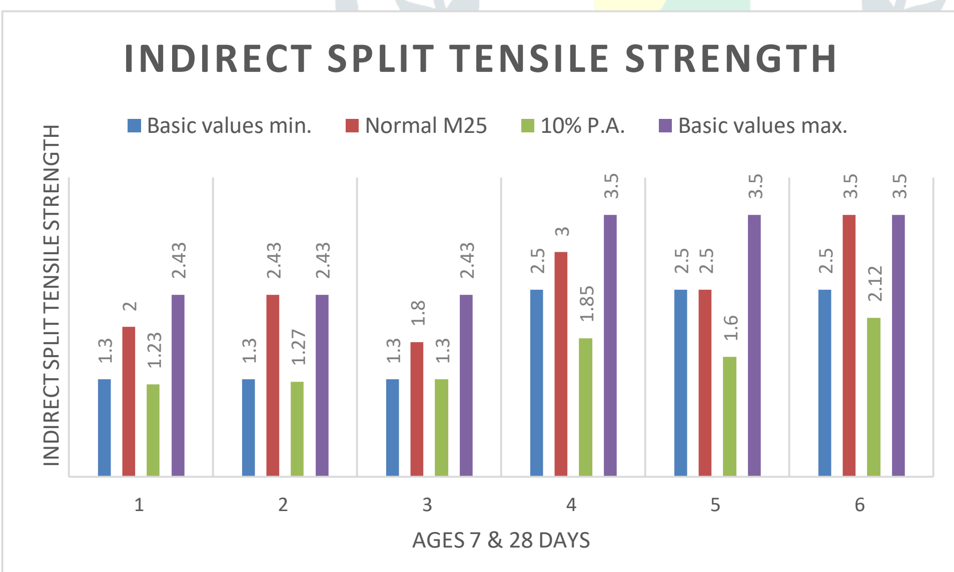
No. of specimens	Grade of concrete	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	141.37	2.00	2.07
2	M25	171.76	2.43	
3	M25	127.23	1.80	
4	M25	212.05	3.00	3
5	M25	176.71	2.50	
6	M25	247.40	3.50	

Table 2 Experimental concrete with 10% replacement of coarse aggregate with plastic aggregate and 30% cement replacement with fly ash (PPC)

No. of specimens	Grade of concrete	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	87.10	1.23	1.26
2	M25	90.00	1.27	
3	M25	92.00	1.30	
4	M25	131.40	1.85	1.85
5	M25	113.70	1.60	
6	M25	150.00	2.12	

Graphs





Result –

From the above calculated values and analysis of behavior of concrete and also by studying the graphs it is noted that from 10% replacement of coarse aggregates with plastic aggregates the Split Tensile Strength at 7 days shows good results but is near to the minimum value range of basic values of M25 grade i.e., graph touching the minimum range of 1.3 MPa of basic value range (1.3 MPa to 2.43 MPa). Also, at 28 days it reduces to small extent of basic values of M25 grade (Range 2.5 MPa to 3.5 MPa).

2. Flexural Strength of Concrete or Modulus of Rupture

Values and Calculations

I.S. code 516- 1959

Principle – Flexural strength is the ability to resist an applied bending load.

Mould size – 150mm * 150mm * 700mm

Here, a >20cm (15cm specimen)

Therefore, Formula **$F_b = (P*L)/(bd^2)$**

Where, b = measured width of the specimen (cm) = 150 mm

D = measured depth at the point of failure = 150 mm

L = length of span (cm) = 600 mm

P = max. Load

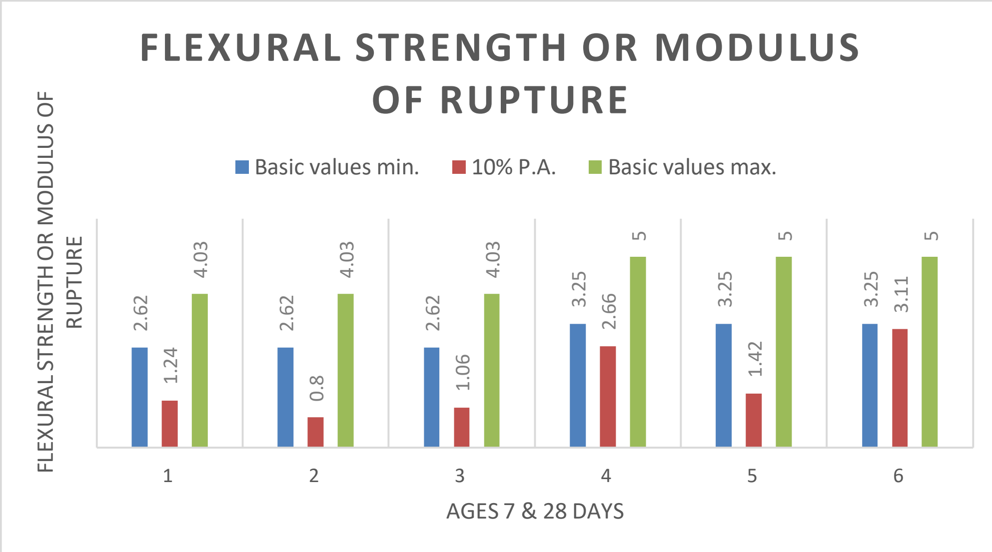
Table 3 Normal M 25 grade concrete

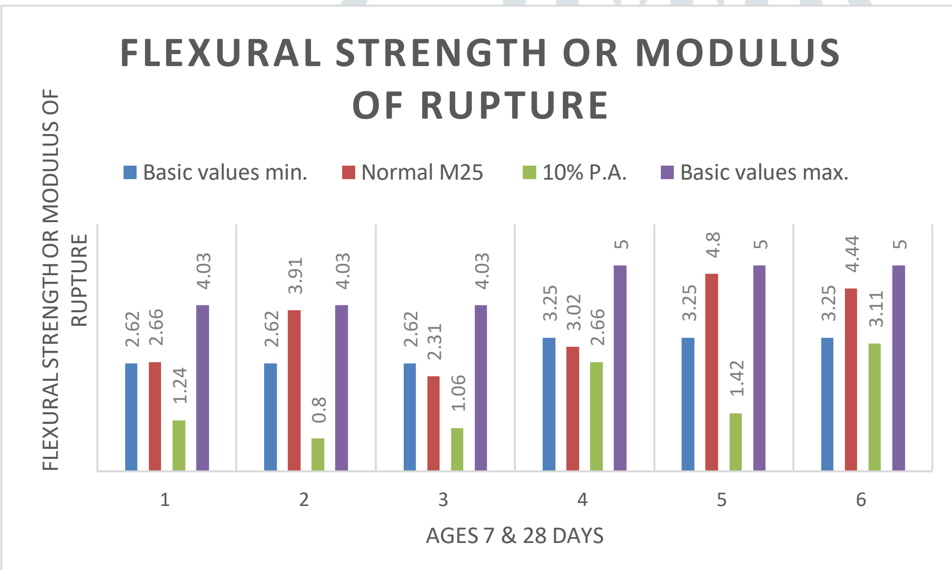
No. of specimens	Grade of concrete	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	15	2.66	2.96
2	M25	22	3.91	
3	M25	13	2.31	
4	M25	17	3.02	4.08
5	M25	27	4.80	
6	M25	25	4.44	

Table 4 Experimental concrete with 10% replacement of coarse aggregate with plastic aggregate and 30% cement replacement with fly ash (PPC)

No. of specimens	Grade of concrete	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	7	1.24	1.03
2	M25	4.5	0.80	
3	M25	6	1.06	
4	M25	15	2.66	2.39
5	M25	8	1.42	
6	M25	17.5	3.11	

Graphs





Result –

Whereas, flexural strength Result shows that at 7 days a huge fall in strength to basic values, but gains strength to a good extent at 28 days of curing but still below or nearer to min. satisfying criteria.

IV. <u>Conclusion</u>

For Indirect Split Tensile Strength

Hence, it can be concluded from the above result and graphs that by replacing 10% coarse aggregates with plastic aggregates the early strength at 7 days is almost to the minimum satisfying criteria but at further ageing of concrete at 28 days it reduces to small extent of minimum satisfying criteria.

For Flexural Strength or Modulus of Rupture

It can be concluded from the above result and graphs that by replacing 10% coarse aggregates with plastic aggregates the early strength at 7 days reduces to a great extent of the basic values of M25 grade. But with ageing of concrete at 28 days it gains strength but still remains below the minimum satisfying criteria for safe design.

These fall in strength could be either due to smooth and curved surfaces of plastic aggregates used, which may lead to bond failures between aggregates and different ingredients of concrete.

Hence, these plastic aggregates can't be used in concrete structural members but can be taken in use in non-structural members like roads, highways etc. to some extent.

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