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Strength and Behavior of Concrete Contains Waste Plastic (High Density PVC) Aggregates As Partial Replacement of Coarse Aggregates

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***Abstract*: The rapid growth and urbanization all over the world has resulted in a large accumulation of waste plastic materials. Among these plastic, PVC is the most hazardous to health and environment. Hence, a best way is to be implemented to use these waste plastic in one or the other form and drastically reduce their impact on our environment. Thus, present study has selected Polyvinyl Chloride (PVC), to investigate its possible use as plastic aggregates in concrete applications. 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 30 specimens of concrete were prepared, the concretes compressive strength and its behavior is investigated along a time span of 7 days and 28 days with 6%, 10%, 12%, & 15% 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 compressive strength of concrete for M25 grade at 7 days with 6% replacements shows nearer equal strength and for 28 days shows an increment or nearer equal strength compared with normal or basic values of M25 grade concrete. Whereas, with 10% replacements shows a small decrease in strength both at 7 & 28 days. With 12% replacements shows a great decrement in strength both at 7 & 28 days, whereas, with 15% replacements shows, strength almost reaches to 0 N/mm^2.**

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

I. INTRODUCTION

The rapid growth and urbanization all over the world has resulted in a large accumulation of waste plastic materials. These waste plastic materials are almost non – degradable even after long exposure in natural environment and results in a great impact on our environment.

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.

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 waste management and recycling. Plastic waste must be reused in one or the other way. Construction industry sector may use this plastic waste in different ways. Hence, the aim of this research is to investigate effect of high density waste plastic (PVC) on concrete strength.

II. EXPERIMENTAL WORK/ PROCESS

Materials Used

Concrete with M25 grade as the main material has been used. Mix proportions of this grade is 1:1:2 (cement: sand: coarse aggregates) and water cement ratio taken as 0.44 to 0.50.

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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 = approx. 18 gms.
Water	Fresh water was used for mixing process & curing.

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 = 20mm to 30mm length.

Two types of P.V.C. pipes where used –

- white P.V.C. – Rigid & hard, cylindrical in shapes
- Yellow P.V.C. – Little flexible & hard, cylindrical in shapes.

With white P.V.C. **internal diameter** as 16 mm & **external diameter** as 21 mm And yellow P.V.C. with **internal diameter** as 18mm & **external diameter** as 22 mm.

Weight of white P.V.C. shell of 1 inch – 6 gms. **Weight** of yellow P.V.C. shell of 1 inch – 5 gms.

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

Process

- **Mixing of Materials** - Different calculated quantities have been batched and mixed in proportion of M25 grade for normal concrete and also different calculated quantities have been batched and mixed in proportion of M25 grade for experimental concrete with 6%, 10%, 12% & 15% 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.
- **Cube moulds** of size 150mm*150mm*150mm 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 6%, 10%, 12% & 15% 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, VALUES & CALCULATIONS

Compressive strength test

One of the important properties of concrete in it's harden state is its compressive strength. Compressive strength of concrete is important because other strengths such as flexural, bond and resistance to abrasion improves with increase in its compressive strength. The compressive strength of concrete depends upon proportions of ingredients used in concrete. It is therefore, important to find strength of concrete using different proportions of ingredients to meet the structural importance. Cube specimens of size 150mm*150mm*150mm are tested for 7 & 28 days. Tests are carried out on compressive testing machine. The compressive test is performed according to IS Code 516:1959.

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Values & Calculations

Table 1. Normal M 25 grade concrete

No. of specimens & age of testing	Grade of concrete	Weight in gm	Volume in cc	Density gm/cc	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1.	M25	8500	3375	2.51	382.5	17.0	17.06
2	M25	8350	3375	2.47	405.0	18.0	
3	M25	8400	3375	2.48	365.6	16.2	
4	M25	8250	3375	2.44	562.5	25.0	25.33
5	M25	8650	3375	2.56	585.0	26.0	
6	M25	8500	3375	2.51	562.5	25.0	

Table 2. Experimental concrete with 6% replacement of coarse aggregate with plastic aggregate and 30% cement replacement with fly ash (PPC)

No. of specimens	Grade of concrete	Weight in gm	Volume in cc	Density gm/cc	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	8270	3375	2.45	273.70	12.14	14.29
2	M25	8310	3375	2.46	365.62	16.25	
3	M25	8110	3375	2.40	326.25	14.50	
4	M25	8730	3375	2.58	644.00	28.62	27.62
5	M25	8510	3375	2.52	601.00	26.71	
6	M25	8210	3375	2.43	620.00	27.55	

Table 3. 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	Weight in gm	Volume in cc	Density gm/cc	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	8160	3375	2.41	309.2	13.74	12.55
2	M25	8110	3375	2.40	255.7	11.36	
3	M25	8030	3375	2.37	282.8	12.56	
4	M25	8090	3375	2.39	503.2	22.36	19.5
5	M25	8070	3375	2.39	363.0	16.13	
6	M25	8020	3375	2.37	450.4	20.01	

Table 4. Experimental concrete with 12% replacement of coarse aggregate with plastic aggregate and 30% cement replacement with fly ash (PPC)

No. of specimens	Grade of concrete	Weight in gm	Volume in cc	Density gm/cc	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	7730	3375	2.29	54.80	2.43	2.43
2	M25	7830	3375	2.32	60.00	2.66	
3	M25	7900	3375	2.34	50.00	2.22	
4	M25	7210	3375	2.13	85.00	3.77	3.48
5	M25	7460	3375	2.21	70.00	3.12	
6	M25	7500	3375	2.22	80.00	3.55	

Table 5. Experimental concrete with 15% replacement of coarse aggregate with plastic aggregate and 30% cement replacement with fly ash (PPC)

No. of specimens	Grade of concrete	Weight in gm	Volume in cc	Density gm/cc	Load at failure kN	Specimen strength N/MM^2	Average of 3 specimens
1	M25	7017.5	3375	2.07	0	0	0
2	M25	7117.5	3375	2.10	0	0	
3	M25	7187.5	3375	2.12	0	0	
4	M25	6497.5	3375	1.92	0	0	0
5	M25	6747.5	3375	1.99	0	0	
6	M25	6787.5	3375	2.01	0	0	

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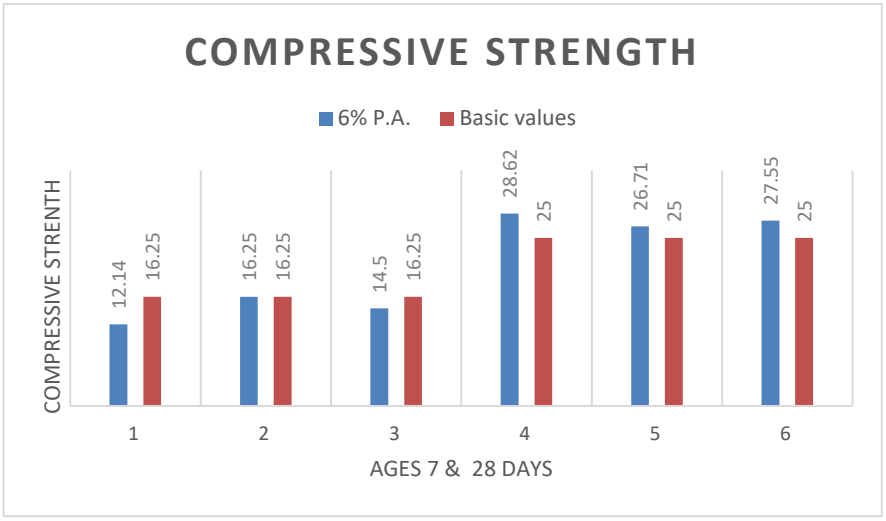
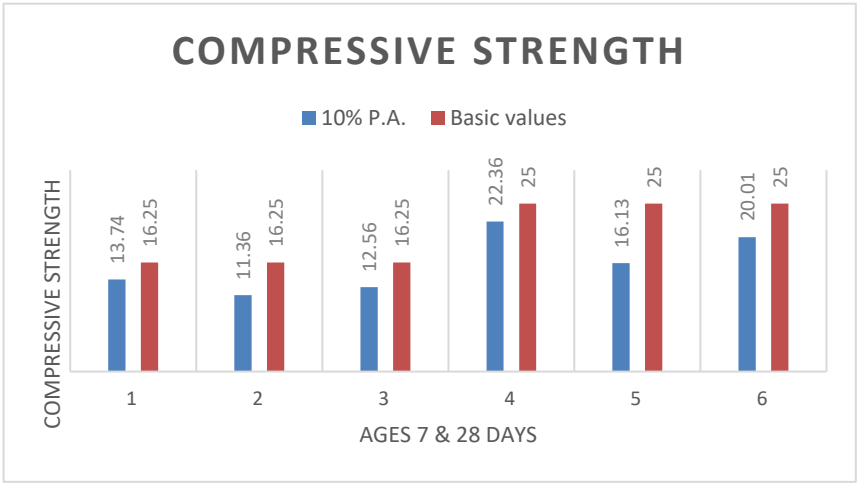
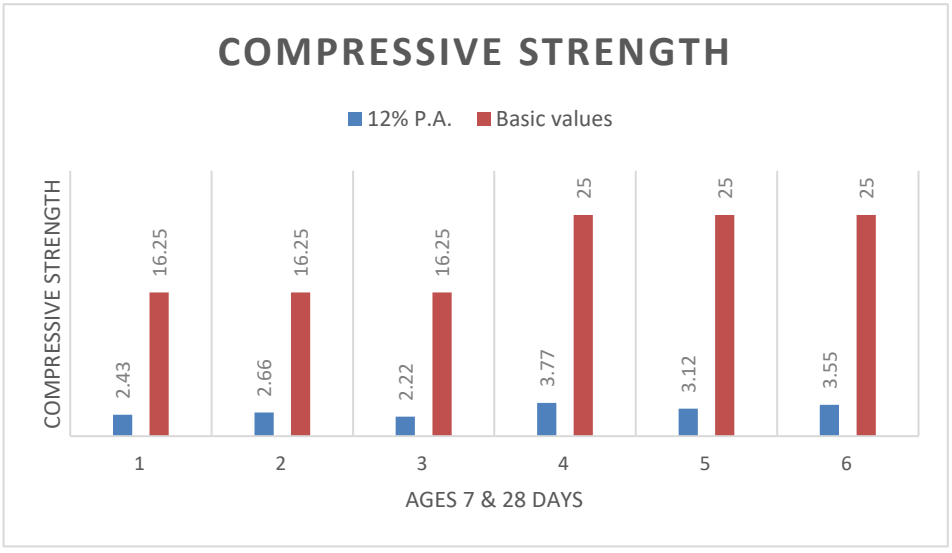
Graphs







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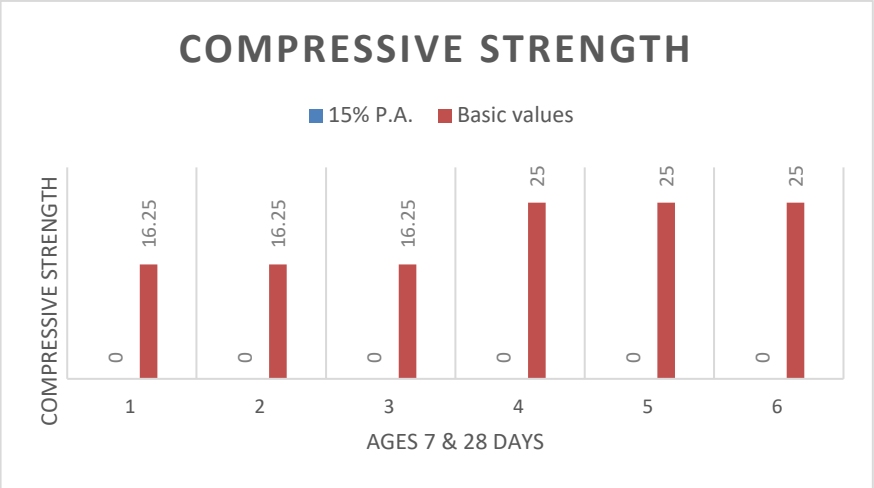

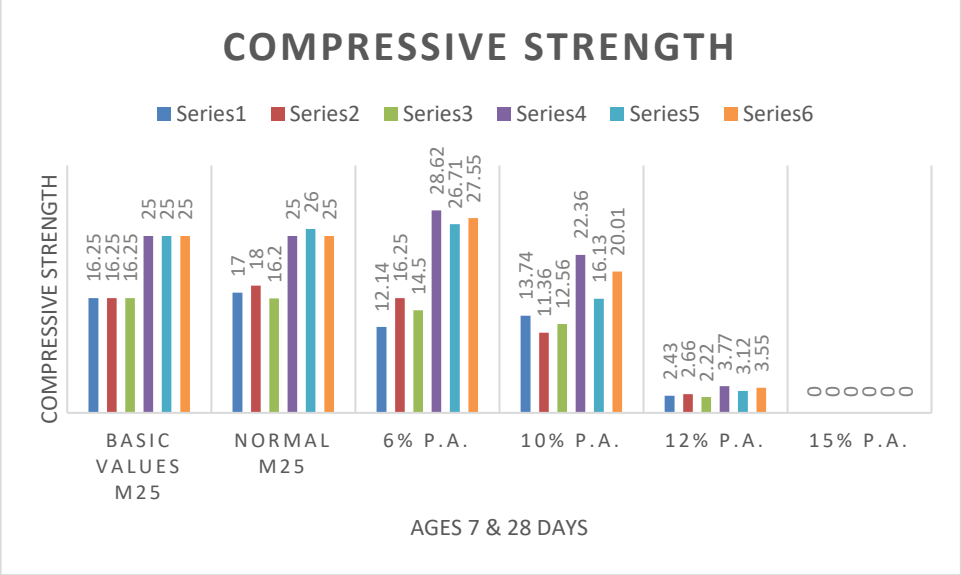

IV. RESULTS

From the above calculated values and analysis of behavior of concrete also by studying the graphs it is noted that

- for 6% replacement of coarse aggregates with high density PVC plastic aggregates the compressive strength at 7 days reduces a little or remains same as of normal basic values of M25 grade, but at 28 days it increases to a good extent.
- For 10 % replacement of coarse aggregates with high density PVC plastic aggregates the compressive strength at 7 days reduces a little of basic values of M25 grade and at 28 days it reduces a little of basic values.
- For 12% replacement of coarse aggregates with high density PVC plastic aggregates the compressive strength at 7 days reduces drastically to a great extent and at 28 days it again reduces drastically to a great extent.
- For 15% replacement of coarse aggregates with high density PVC plastic aggregates the compressive strength at 7 days reaches almost to 0 N/mm^2 and at 28 days it again reduces drastically and reaches almost to 0 N/mm^2

V. CONCLUSION

Hence, it can be concluded from the above result and graphs that by replacing the quantities of coarse aggregates by plastic aggregates from 6% to 10% to 12% to 15% compressive strength reduces to almost 0 N/mm^2 for 15% replacements, whereas, 10% replacement shows little reduction in compressive strength and at 6% replacement shows at 7 days no or little reduction and remains nearer and at 28 days strength is nearer or an increase in compressive strength as compared to basic M25 grade strength values.

Thus, 6% replacement concretes may be used in small concrete structural members and may be used in non-structural members.

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These 10% replacement concretes may be used in non-structural members.

12% & 15% replacement concretes can't be even used in non-structural members.

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