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Improving Strength of Concrete by Partial Replacement of Coarse Aggregate with UPVC Waste

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Abstract–This paper investigates the effect to fusing UPVC (unplasticized polyvinyl chloride) waste material on the concrete. UPVC Waste was collected from new constructed houses. Most plastics are not biodegradable. An important problem we are facing is dumping of plastic materials it causes lot of problems. Plastic due to its properties such as light weight and its ability to be molded into any desired shape has enhanced its popularity. The construction industry is one of the largest consumers of natural resources, including coarse aggregates, leading to environmental concerns and resource depletion. To address these issues, this study investigates the feasibility of replacing coarse aggregates with Crushed Value-added Plastic Concrete (UPVC) waste in M30 grade concrete. The research explores various replacement percentages, namely 0%, 5%, 10%, and 15%, to assess their impact on the mechanical properties of the concrete mix. Experimental investigations were carried out to evaluate the compressive strength and split tensile strength of the UPVC concrete specimens.

***Key Words*:** Cement, Aggregates and UPVC waste.

1. INTRODUCTION

Concrete is a widely used construction material due to its strength and durability. However, the production of concrete requires a significant amount of natural resources, such as coarse aggregates like gravel and sand. This extraction process can have negative environmental impacts, including habitat destruction and increased carbon emissions.

To address these concerns, researchers have been exploring alternative materials for concrete production. One such material is UPVC waste, which stands for unplasticized polyvinyl chloride. It is a type of plastic that is commonly used in pipes, windows, and other building applications.

The idea behind partial replacement is to substitute a portion of the traditional coarse aggregate with UPVC waste in concrete mixtures. This substitution can have several potential benefits. First, it can reduce the demand for natural resources by utilizing recycled UPVC waste. Second, it can help in waste management by diverting plastic waste from landfills. Finally, it can enhance the overall sustainability of concrete structures.

When it comes to the mechanical properties of concrete, researchers have found that the inclusion of UPVC waste can have mixed effects. Some studies have shown a decrease in compressive strength with higher plastic content, while others have reported improvements in flexural strength and impact resistance. It's important to note that the optimal percentage of UPVC waste replacement may vary

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depending on factors such as the type and quality of plastic, the concrete mix design, and the intended application.

Workability is another crucial aspect to consider when using UPVC waste in concrete. The addition of plastic particles can affect the flow and consistency of the mixture. Researchers have explored various methods to optimize the workability by adjusting the water-cement ratio.

2. LITERATUREREVIEW

Various researches for the partial replacement of coarse aggregate with waste materials, which are related to my work, areas under:

Muthusamy et al., (2013) This study focuses on investigating the possibility of integrating crushed rubber seed shell as partial coarse aggregate replacement material in concrete making. Total of five mixes consisting various content of crushed rubber seed shell as partial coarse aggregate replacement ranging from 0, 5, 10, 15 and 20%, respectively.

Thomas et al., (2014) EPS beads are used as partial replacement to coarse aggregates. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. At 28 days, it was found that compressive strength of 5%, 10%, 15%, 20%, 25% and 30% EPS incorporated concrete strengths were 91%, 77 %, 71%, 63%, 57%, and 45%, respectively when compared to concrete with no EPS case.

Umapathy et al., (2014) The results indicated effectiveness of tiles as coarse aggregate by partial replacement of conventional concrete by 20 %, 30%, 50%and cement as rice husk ash with 10%,15% and 20% without affecting the design strength.

Shelke et al., (2014) The characteristic properties of concrete such as compressive strength, flexural strength, impact resistance, bond strength & split tensile strength using the mix made by replacing coarse aggregate with crushed coconut shell aggregate were reviewed in the present work.

Bharat et al., (2015) In this dissertation coarse aggregate is partially replaced by coarse aggregate upto 25% with regular interval of 5%, along with fly ash partially replacing cement in concrete of grade M40 and properties like workability, compressive strength and flexural strength is evaluated.

Vanitha et al., (2015) Waste Plastics were incrementally added in 0%, 2%, 4%, 6%, 8% and 10% to replace the same amount of Aggregate. The result shows that the compressive strength of M20 concrete with waste plastics is 4% for Paver Blocks and 2% for Solid Blocks.

Sanjeev et al., (2016) It was observed that this preliminary study on parent and substitute aggregate was compulsory before replacing the parent aggregate with substitute aggregate. Partial replacement of such aggregates would prevent the usage of natural aggregates which are in the zone of depletion, thus protecting the natural resources and reducing landfilling of mine wastes.

Ishwariya (2016) In this study we use to find out the compressive strength of concrete by the replacement of coarse aggregate by crumb rubber in normal concrete in grade of M25 and M30.Finally a comparative study is made among the normal conventional beam over to the rubcrete beam.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

Ashwini (2016) An experimental study is made on the utilization of E-waste particles as fine and coarse aggregates in concrete with a percentage replacement ranging from 0 %, 20% to 30% i.e. (0%, 10%, 20% and 30%) on the strength criteria of M20 Concrete.

Chandran (2017) This study reviews the feasibility of using waste tires in the form of chips with different sizes in concrete to improve the strength as well as protecting the environment.

Varsha and Aruna (2019) The mix design of M20 grade of concrete for normal mix (without E-waste) and with a partial replacement of coarse aggregates with E-waste material with 5%, 10%, 15%, 20%, 25% and 30% is carried out. The effect of E-waste particle size using less than 10 mm, between 10 to 15 mm and up to 20 mm on compressive strength of concrete cubes and flexural strength of beam is also studied.

Jasim and Ban (2019) The results showed that light-weight concrete blocks units can be obtained at a 25% and 30% replacement ratio in all groups with satisfactory compressive strength. The optimum replacement ratio was about 20% in the three groups so that physical and mechanical properties were satisfactory.

Onyeka (2019) The compressive strength of concrete with 100% granite at 28 days is 26N/mm2, while that of concrete gave 25.04 N/mm2 strengths, 24.37N/mm2, 22.22 N/mm2 and 21.55N/mm2, for 15%, 25%, 35% and 45% replacement of granite with glass respectively.

Priyadharshini (2020) The partial replacement of the coarse aggregate in the proportion of 10%,20% and 30% replacement. the specific gravity of the shell was analyzed and 16mm shell were selected for the experiment.

Bharan et al., (2020) The partial replacement of M- sand by steel slag with 10%, 20% and 30% to find the optimum percentage of replacement. Using optimum percentage as constant, the Coarse Aggregate is replaced with certain percentage by E-Waste.

Suryakanta et al., (2021) The present study is aimed at concrete mix with partial replacement of coarse aggregate by LDPE granules (0%, 10%, 20% and 30%) that will provide an advantage in reducing the dead weight of structure. This mix in the form of cubes and cylinders were subjected to compression and split tension to ascertain the strength parameter. Hence the use of plastic granules in concrete making is not only beneficial but also helpful in disposal of plastic wastes.

Beiram and Mutairee (2021) The study focused on the effect of the partial replacement of coarse aggregates with waste rubber chips of different proportions 10%, 20%, and 30% in volume on the beams ultimate torque, and rotation, as well as the ductility index, stiffness, cracking torque, and failure modes.

Saurav et al., (2021) The partially replacing coarse aggregates at four levels, namely 7 percent, 12 percent, 17 percent, and 22 percent with a constant interval of 5 percent. The findings of the study conclude that the strength of concrete increase up to the level of 7 percent coarse aggregate is replaced by e-waste.

Musa Adamu (2021) The result obtained from AI-based models revealed that both HWM and SVM showed higher prediction skills in prediction of σ. Overall, the comparative performance results proved that HWM-M4 indicated an outstanding performance of 0.9953 and 0.9982 in both the training and testing stages, respectively.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Volume 13, Issue 03 March 2024

Anil et al., (2023) The rubber tire waste is split into coarse chips and then this crumb tire aggregate is added as 5%, 10%, 15% to replace the coarse aggregate. In this study, workability and compressive of rubberized concrete was evaluated to investigate the optimal use of crumb rubber as coarse aggregate in concrete.

3. MATERIALS USED

The constituent materials used in this project were gathered from different sources. Necessary tests were conducted on these materials to choose the kind and type of material.

3.1 CEMENT: Cement when mixed with minerals fragments and water, binds the particles into a whole compact. Cement is the most important and costliest ingredient of concrete. Ordinary Portland cement of 53 grade confirming to requirements of IS: 12269 – 1987.

Table -1 Physical properties of cement

S.NO	PROPERTIES	RESULTS
1	Specific gravity	3.05
2	Fineness test	3.34%
3	Normal consistency	30 %
4	Initial setting time	40 min
5	Final setting time	330 min

3.2 FINE AGGREGATE: As per IS 383-2016, Fine aggregate is defined as material that will pass a 4.75mm sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape.

Table -2 Physical properties of fine aggregate

S.NO	PROPERTIES	RESULTS
1	Specific gravity	2.67
2	Fineness modulus	2.55
3	Bulking	34%
4	Zone	II

International Journal of Engineering Research & Technology (IJERT)
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3.3 COARSE AGGREGATE: As per IS 383-2016, Coarse aggregates can be defined as irregular broken stone or naturally-occurring grounded gravel used for making concrete. Coarse aggregates are retained on the sieve of mesh size 4.75 mm. It acts as volume increasing component and is responsible for strength, hardness and durability of concrete.

Table -3 Physical properties of Coarse aggregate

S.NO	PROPERTIES	RESULTS
1	Specific gravity	2.8
2	Fineness modulus	7.2
3	Aggregate Impact value	20.27 %
4	Aggregate crushing value	21.06

3.4 UPVC WASTE: UPVC, which stands for unplasticized polyvinyl Chloride, is a low-maintenance building material used as a substitute for painted wood, mostly for window frames and sills when installing double glazing in new buildings, or to replace older single glazed windows.

Fig :1 Unplasticized polyvinyl chloride (UPVC)

International Journal of Engineering Research & Technology (IJERT)
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4. RESULTS AND DISCUSSIONS

4.1 Compressive strength:

The strength in compression has a definite relationship with all other properties of concrete. In India cubic a moulds of size 150 mm *150 mm*150 mm had casted and tested for 7 days, 14 days and 28 days . The test results are tabulated below.

Fig :2 Cube under compression testing machine

Table – 4 compressive strength values

S.NO	% replacement of UPVC waste	Compressive strength (N/mm^2)		
		7 Days	14 Days	28 Days
1	0	22.22	32.44	39.55
2	5	22.44	30.67	38.7
3	10	19.55	24.8	34.7
4	15	17.33	21.11	33.2

International Journal of Engineering Research & Technology (IJERT)
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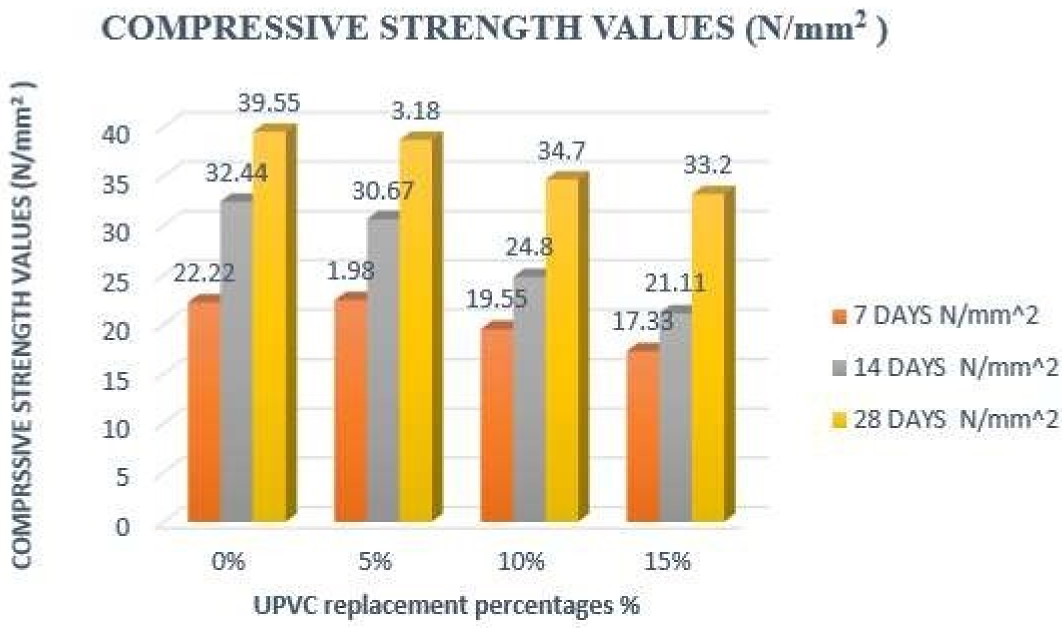

4.2 SPLIT TENSILE STRENGTH

The split tensile strength obtained by testing the dimension of cylinder is 300 mm height and 150 mm diameter for M30 grade of concrete to all the mixes designed for various replacement given below.

Fig:3 Cylinder under compression testing machine

International Journal of Engineering Research & Technology (IJERT)
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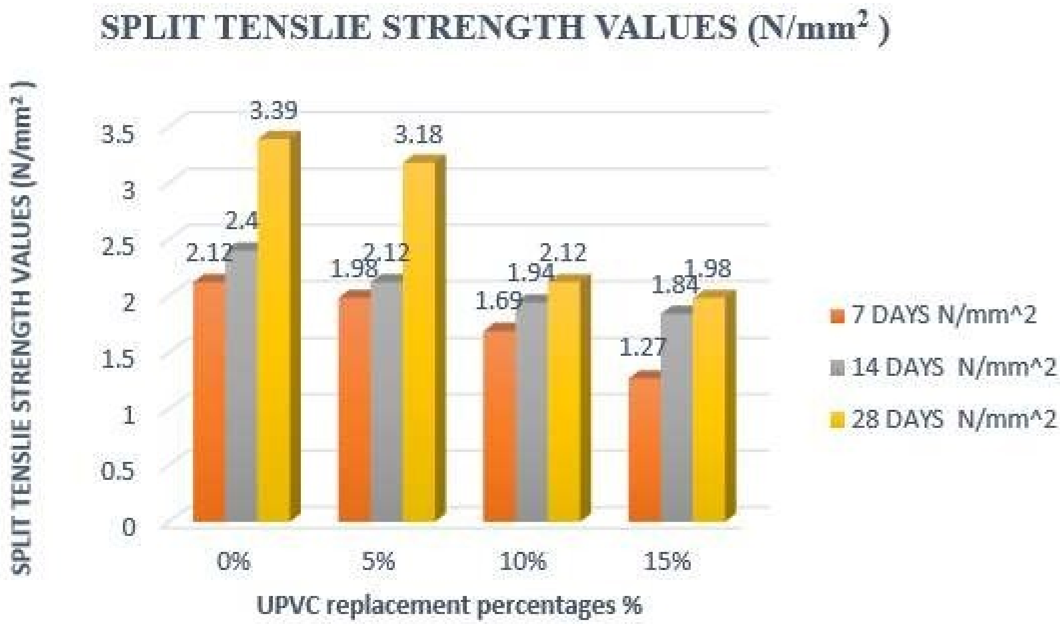
Table -5 Split tensile strength values

S.NO	% replacement of UPVC waste	Split tensile strength (N/mm²)		
		7 Days	14Days	28 days
1	0	2.12	2.4	3.39
2	5	1.98	2.12	3.18
3	10	1.69	1.94	2.12
4	15	1.27	1.84	1.98



CONCLUSIONS

- For a given water cement ratio, use of UPVC plastic waste in concrete lower the density, compressive strength and split tensile strength.
- The compressive strength for 0% replacement of coarse aggregate is 39.55 N/mm^2 and for 15% is 33.2 N/mm^2.The tensile strength for 0% replacement of coarse aggregate is 3.39 $N/mm^2$and for 15% is 1.98 N/mm^2.
- UPVC waste can be used to replace coarse aggregate in concrete. The compressive strength varies from 0% replacement to 5% replacement of Natural coarse aggregates, but with strength equal to or more than Target mean compressive strength.
- So, 5% Replacement of coarse aggregate with Plastics is suggestable. Compressive, tensile strength are decreases from 5% to 15% replacement with coarse aggregate.

International Journal of Engineering Research & Technology (IJERT)
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