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UTILIZING CRUSHED PVC PLASTIC AS PARTIAL REPLACEMENT OF FINE AGGREGATES IN CONCRETE: A SUSTAINABLE APPROACH FOR WASTE REDUCTION AND ENHANCED STRENGTH FOR INDUSTRIAL APPLICATION

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Abstract
Concrete is the most widely used construction material globally, yet researchers are actively seeking alternative materials to address environmental concerns. The escalating generation of plastic waste, including LDPE, HDPE, and PVC, poses significant disposal challenges and environmental hazards. In response, the construction industry is exploring cost-effective materials to enhance concrete strength while promoting sustainable development through waste reduction. This study investigates the partial replacement of sand (fine aggregates) with crushed PVC plastic aggregate in concrete. Modified concrete mixes are formulated by varying the replacement proportion from 0% to 10%, while maintaining a constant fly ash percentage of 10%. Tests of compressive strength are performed on specimens that have been cured for 7, 14, and 28 days to evaluate the effectiveness of PVC plastic aggregate substitution. The analysis aims to compare the performance of normal concrete with modified mixes, shedding light on the potential of PVC plastics to serve as substitutes for fine aggregates and contribute to waste reduction in concrete production, thereby mitigating global warming.
Keywords: Concrete, plastic waste, fine aggregate, fly ash, compressive strength, waste materials.

1.Introduction
Concrete is the most widely used building material in the construction industry. Because they are naturally occurring, the primary ingredients of concrete come in small quantities. The environment is being subjected to over exploitation of natural resources due to its growing utilization in numerous civic projects.In order to protect the environment and stop the loss of natural resources, it is necessary to look for alternatives to current materials.Rapid sand extraction from river beds results in a number of issues, including agriculture due to low water tables in wells, the deepening of riverbeds, the loss of flora along riverbanks, disturbance of aquatic life, etc. Industries in developing nations are under pressure to choose substitute resources for river sand.
Waste called fly ash is created in factories when coal is burned for energy production. The primary sources of fly ash generation include thermal power plants, the steel and fertilizer industries, and others. Fly ash disposal is a difficult procedure that needs enough space and water.To get rid of them, which is already declining rapidly due to overpopulation. Despite the fact that a lot of fly ash is utilized in many agricultural and building applications. However, the disposal of the remaining fraction still poses a risk to the environment.
Strict regulations are being developed to limit the use of plastics in terms of both amount and quality because of its disposal issue and negative impacts on the living things and environment. The current effort is a portion of a project that aims to determine if fly ash, waste plastic, waste copper slag, and waste quarry dust may be used in place of some or all of cement and sand (fine aggregate), respectively. Strict regulations are being developed to limit the use of plastics in terms of both amount and quality because of its disposal issue and negative impacts on the living things and environment. The current effort is a portion of a project that aims to determine if fly ash, waste plastic, waste copper slag, and waste quarry dust may be used in place of some or all of cement and sand (fine aggregate), respectively.
The hazardous waste dump that the world is resting on could eventually replace natural sand. Concrete is the foundation of all building activity, regardless of the location, magnitude, or type of project. With about three tons used annually for each person on Earth, concrete is actually the second

most consumed resource behind water. India is thought to consume 450 million cubic meters of concrete a year, or around one ton per person. We still have a long way to go before we have enough sand to make mortar and concrete, according to global consumption figures.Even during the economic downturn, the construction industry's value increased by an astounding 15% yearly, and during the previous eight years, it has provided 7-8% of the nation's GDP (at current values). As a result, it is become more and more annoying for regular people to discuss the industry's greening without having a useful response to this important query.As it happened, we were perched on a dump that held possible sand substitutes. Construction projects can make excellent use of industrial waste and by-products from nearly every industry, which have negatively impacted the environment, agriculture, and public health. This is advantageous for both the economics and the preservation of these resources. surroundings as well. Various industrial wastes have the ability to replace the desirable natural river bed sand, according to study done by some researchers in an effort to develop alternatives to natural sand.

2. Material and Methods

2.1 Materials

Different ratios of the primary ingredients below are used to generate the many varieties of concrete that are available. The finished product can be modified in this mode, or by changing out the aggregate phases and cement, to be applied with different strength, density, or qualities related to chemical and thermal resistance.

2.1.1 Cement

Throughout the duration of the examination, J.K. Super grade 53 ordinary Portland pozzolana cement (OPC) from a single batch was utilized in this study. The characteristics of the cement that was used are as follows:

Table 1: Cement's Physical Characteristics

Examine	Worth
Final setting times	200 minutes
Initial setting times	90 minutes
Normal consistency	30%
Fineness	3.34%

2.1.2. Fine Aggregate

For this project, earthy river sand was used. The specific gravity, fineness modulus, and water absorption of the fine aggregate were measured by sieve analysis. The characteristics of fine aggregate were as follows:

Table 2: Fine Aggregate's Physical Properties

Examine	Worth
Specific Gravity	2.60
Fineness Modulus	2.89
Moisture Content	1.2%
Water Absorption	0.1%
Density(loose state)(kg/m3)	1600

2.1.3. Coarse Aggregate

The characteristics of freshly mixed concrete are more influenced by the aggregate's surface roughness and particle form than by the attributes of hardened concrete. Angular, elongated particles, rough-textured require more water than compact, smooth and rounded particles to create workable concrete. In this experiment, nominally 20 mm and 12.5 mm crushed stone were used.Angular in shape coarse aggregate used in this study.

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Table 3: Coarse Aggregate's Physical Properties

Examine	Worth
Specific Gravity	2.68
Fineness Modulus	7.065
Moisture Content	0.1%
Water Absorption	1%
Density(loose state)(kg/m3)	1514

2.1.4. Fly ash

Waste called fly ash is created in factories when coal is burned for energy production. Among other industries, steel, thermal power plants and fertilizer are the main producers of fly ash. Because fly ash contains components of pozzolanic materials, it can combine with lime to create cementitious materials.Fly ash is thus utilized in dams, concrete, landfills, and mines. The type "C"fly ash utilized in this experiment was acquired from Plutton Cement Plant Pvt. Ltd.

Table 4: Physical Properties of Fly Ash

Examine	Worth
Specific Gravity	2.43
Size	10-20 micron
Shape	Spherical glassy
Color	Dark Grey
Density(loose state)(kg/m3)	1514

Figure 1: Fly Ash Material

2.1.5. Plastic waste

Because of the enormous production of plastics for a wide range of purposes and applications in every facet of life, the current and previous eras can be referred to as the age of plastic.Plastic waste is the common term for a wide range of synthetic or semi-synthetic amorphous organic solids derived from petroleum or natural gas. In this investigation, the waste plastic used was PVC shredded tubes.

Table 5: Physical characteristics of waste plastic

Examine	Worth
Specific gravity	1.54
Fineness modulus	2
Water absorption	0.28%
Type	PVC
Density(loose state)(kg/m3)	1480

Figure 2: Plastic waste Material

2.2 Methods

In the current study, concrete of grade M25 was utilized. Concrete was mixed in a 1:1:2 ratio with a water-cement ratio of 0.44. After seven days and twenty-eight days of moist curing, density, workability in green concrete, and compressive and flexural strength in its cured state were all assessed for the specimen concrete.

2.2.1 Experimental Work and Mix Design

2.2.1.1 Mix design

In order to achieve a balance between placement needs and workability, trial mixes must be created and adjusted in order to satisfy durability requirements while also meeting workability and strength requirements. The approach used to determine the percentage of M25 grade concrete is in accordance with IS 10262, and the resultant mix ratio was 1:1:2.

2.2.2 Methodology

The workability metrics, such as the compacting factor and slump value, were examined in their fresh form. Flexural strength, compressive strength and split tensile strength tests were examined and carried out for every mix in its hardened form.The obtained results are tabulated. The talks and findings led to the conclusions.

2.2.3 Sample Preparation

Samples were made and allowed to cure in accordance with IS-516 and the molds were made in accordance with IS-10086. Three cubes measuring 150X150X150 mm were cast for every percentage of replacement and tested at 7, 14 and 28 days for every combination. Replacement of Fine Aggregate by PVC plastic is shown in table:

Table 6: Quantities of different materials

Replacement (%)	PVC Plastics(kg)	Sand(kg)	Fly Ash(kg)
2	0.050	2.444	0.1871
4	0.0998	2.394	0.1871
6	0.149	2.345	0.1871
8	0.199	2.295	0.1871
10	0.249	2.245	0.1871

Figure 3: Cubes with Partially Replaced PVC

Figure 4: Cube testing on CTM

3. Results And Discussion

3.1 Hardened Concrete's Properties (Plastic Waste)

4.1.1 Compressive Strength

The most popular test for determining both the concrete's hardened quality and the concrete's capacity to support the load is the compressive strength test.

The concrete's compressive strength after it was using fly ash and plastic waste is displayed in the table below.The same outcomes are displayed graphically so that different patterns can be seen.

Table 7: Concrete's compressive strength

S. No.	Water-Cement Ratio	Cube	Substitution with Plastic in percentage (%)	Substitution with Fly Ash in percentage (%)	Compressive Strength (N/mm^2)		
					7 Days	14 Days	28 Days
1	0.44	CP1	0	0	22.32	29.625	34.506
2	0.44	CP2	2	0	20.12	28.824	33.486
3	0.44	CP3	4	0	18.966	26.666	31.246
4	0.44	CP4	6	0	14.533	23.835	28.98
5	0.44	CP5	8	0	13.216	16.722	21.273
6	0.44	CP6	10	0	11.22	11.327	16.73
7	0.44	CPF1	0	10	21.266	29.365	34.593
8	0.44	CPF2	2	10	19.053	27.829	32.058
9	0.44	CPF3	4	10	18.953	25.209	30.773
10	0.44	CPF4	6	10	13.413	24.33	29.013
11	0.44	CPF5	8	10	11.273	17.433	22.34
12	0.44	CPF6	10	10	10.166	12.318	17.813

After curing of 28 days, the table clearly demonstrates that the amount of fine aggregate replaced decreased the compressive strength. For a Substitution level of 2 to 10%, the range of the compressive strength decrease is 2.29 -51.52%.

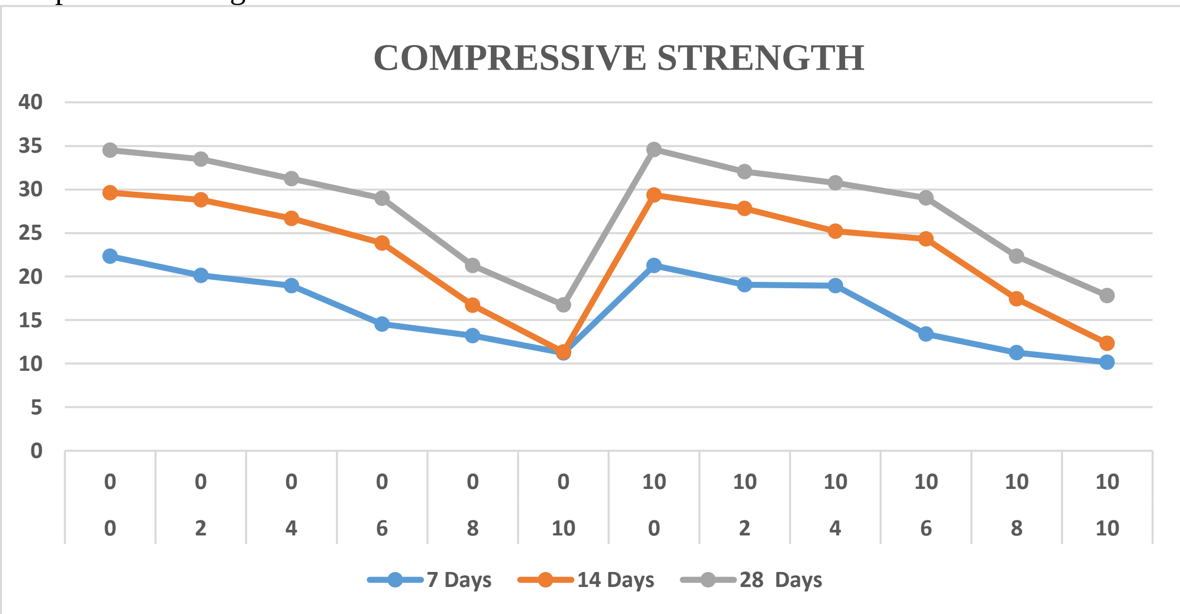

Figure 5: Compressive strength variation at various replacement levels

After 28 days of curing, the table shows that adding fly ash in place of 10% regular portland cement enhanced the compressive strength by 2.41%. Between 0.38 to 48.29% drop in compressive strength occurs when replacing 2% to 10% of plastic trash with fly ash.

4. Conclusion

1. The results of this experimental study indicate that quarry dust has potential use as a useful building material and as a replacement for river sand.
2. The specifications for fine aggregate are met by the physical and chemical characteristics of quarry dust. According to the research, choosing stone dust as a fine aggregate substitute is highly appropriate.

3. The HSC qualities are demonstrated in the design of M25 grade concrete, which will replace 50% of the copper slag. River sand and copper slag both work similarly since they both include silica (SiO2).
4. It has been noted that the concrete's unit weight increases progressively as the fraction of fine aggregate replaced by copper slag increases. Concrete that has up to 50% of its sand substitute with copper slag has compressive strength that is comparable to that of a control mix.
5. It was shown that when the replacement amount increased, The concrete produced with discarded plastic has a lower compressive strength.
6. 10% fly ash can partially replace cement in cases where the use of discarded plastic results in a reduction in compressive strength.

References

[1] Ariyamuthu, A. and Varadarajan, R. (2015), "Experimental study on effects of shredded waste plastics in rigid pavements." International Journal of Emerging Technology and Advanced Engineering (IJETAE) Volume 5, Issue 2, February 2015, ISSN 2250-2459.
[2] Chaudhary, M., Srivastava, V. and Agarwal, V.C. (2014) "Effect of Waste Low Density Polyethylene on Mechanical Properties of Concrete." Journal of Academia and Industrial Research (JAIR) Volume 3, Issue 3, pp.123-126.
[3] Sivakumar, A. and Prakash, M. (2011), "Characteristic studies on the mechanical properties of quarry dust addition in conventional concrete," Journal of civil engineering and construction technology, vol. 2(10), Pg. No.218 to 235.
[4] Joel, M. (2010), **"**Use of crushed granite fine as replacement in river sand in concrete production," Leonardo Electronic Journal of Practices and Technologies, Pg. No. 85 to 96,Issue 17.
[5] Brindha, D., Baskaran, T. and Nagan, S. (2010) "Assessment of Corrosion and DurabilityCharacteristics of Copper Slag Admixed Concrete," International Journal of Civil and Structural Engineering 1: pp. 192-211.
[6] Al-Jabri, K.S., Hisada, MSK., Al-Saidy, AH (2009) "Copper Slag as Sand Replacement for High Performance Concrete," Cement & Concrete Composites 31: 483-488.
[7] Mumthas, M., Anand, V., Dethan, P., and Kavitha, S. (2018)"Influence of Stone Dust as Partially Replacing Material of Cement and Sand on some Mechanical Properties of Mortar,"International Research Journal of Engineering and Technology (IRJET),Volume: 05 Issue: 10, page no. 1870-1873.
[8] IS 10262 (2009) Guidelines for Indian Standard Concrete Mix Design Proportioning. CED 2: Cement and Concrete.
[9] IS 1199 (1959) Indian Standard Methods of sampling and analysis of concrete. CED 2: Cement and Concrete.
[10] IS 10086 (1982) Indian Standard Specification for moulds for use in tests of cement and concrete. CED 2: Cement and Concrete.