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GREEN CONCRETE: UTILISATION OF INDUSTRIAL WASTE VALUATION FOR SUSTAINABLE INFRASTRUCTURE

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Abstract
The main objective of the present study is to find out a suitable, effective and alternative material for partial replacement of cement and coarse aggregate, to find out possible utilization of waste materials in construction industry that in turn considerably minimize the usage of cement and coarse aggregate and ultimately reduce construction cost, to explore possibilities of improving mechanical properties of concrete using copper slag & pond ash instead of fine aggregate partially, to evaluate the effect of using copper slag & pond ash in concrete and to investigate the strength of replaced concrete with that of conventional concrete. This project is mainly undertaken to study the behavior and performance of concrete using waste materials such as copper slag & pond ash. This type of use of a waste material can solve problems of lack of aggregate in various construction sites and reduce environmental problems related to sand mining and waste disposal. The use of copper slag & pond ash can also reduce the cost of the concrete production and increase the workability.

Keywords
Cement Concrete, flexural strength, Pond ash, Strength parameters, water absorption, Workability.

1 Introduction

The fine aggregate and coarse aggregates generally occupy 60% to 75% of the concrete volume and therefore, strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. Crushed stone and gravel are most commonly used as a coarse aggregate in concrete, while natural sand or river sand as a fine aggregate in concrete. Environmental sustainability has been subject of discourse virtually in all human endeavours, especially in construction industries, where natural raw materials are consumed tremendously. Concrete, the most consumed artificial materials, consists of fine and coarse aggregates that occupy 60% to 75% of the concrete volume which strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy. The global concrete industry required 8 to 12 billion metric tons of natural aggregates annually. Conventional aggregates (fine or coarse) are mined from the earth, either dug out of pits or blasted out of quarries. This process has many significant environmental impacts. The need to mitigate these environmental stresses to make construction sustainable and to reduce rising costs of construction has necessitated research into the use of alternative cheap materials, more importantly, locally available ones which can replace conventional ones in concrete production. In this project, an attempt is made by utilizing steel slag as suitable substitutes for fine aggregates and walnut shell for coarse aggregates in concrete.

Pond ash is a by-product of the works in power plants. It has several applications in civil engineering mainly in the construction sector. In this blog, we will go through the basic details, properties, applications and limitations. Approx. 20% of total ash generated is delivered as bottom ash into dyke and approx. 80% of total ash is collected in dry form in ESP/ Silo System for dispatch to cement manufacturers and various fly ash users/ trading agencies. The un-lifted dry ash mixed with water and then disposed in to the ash dyke. The accumulated ash in the ash dyke is called pond ash. An ash pond, also called a coal ash basin or surface impoundment, is an engineered structure used at coal-fired power stations for the disposal of two types of coal combustion products: bottom ash and fly ash.

2 Literature Review

To supplement automated search, a manual search was also done. Any relevant references within those papers/reference books were followed up.

- **Masilamani et.al. (2025)** This research tests energy optimised furnace (EOF) steel slag as substitution for natural coarse aggregate in concrete. Steel slag's usefulness as a substitute for natural coarse aggregate in concrete is the primary goal of this research. According to IS:2386-1963, the characterization of EOF steel slag, as coarse, is done by examining the shape and size of a particle, mechanical properties, physical properties, soundness, and alkali-aggregate reactivity. Tests for detection of staining material in steel slag and hardness of inter-facial transition zone in hardened cement paste were also carried out. The chemical analysis of the steel slag reveals the stability of oxides present in the steel slag. Microstructural characterization by SEM (scanning electron microscope) analysis of steel slag aggregate was also employed to support the characterization and XRD analysis, and it was found that the EOF steel slag is crystalline. The digital image processing technique (DIP) is adopted to study the shape indices, circularity, sphericity, shape factor, and roundness of natural and EOF steel slag aggregate. According to the characterization and strength investigation, steel slag aggregate outperforms natural coarse aggregate.
- **Abebe Demissew (2025)** worked on comparative Analysis of Selected Concrete Mix Design Methods Based on Cost-Effectiveness for different industrial wastes. It was concluded that the result of the compressive strength test after 28 days showed that the specimens prepared using the mixing proportions obtained from the ACI standard met the extreme compressive strength requirement more than the other methods. On the other hand, the ACI, DOE, and EBCS methods are the most expensive to absorb an excessive quantity of cement when compared to the IS method. However, the overall result showed that the concrete designed as per the IS method is relatively easy to work 13 with and cost-effective for developing countries such as Ethiopia for the production of normal grade concerts.
- **Bang Tran (2024)** Steel slag was utilized to replace natural coarse aggregates in the CEAFS mixes. CEAFS was created by blending 50% crushed stone with 50% EAF slag in coarse aggregates, with fly ash (FA) and silica fume (SF) partially replacing cement at content levels (i.e. FA: 0, 20, 30, and 40%; SF: 0, 5, and 10%). The soil compaction approach was used to evaluate the optimal moisture level for CEAFS mixes containing EAF slag aggregate fly ash and silica fume. A testing program was used to investigate the weight of CEAFS units and their mechanical qualities (compressive strength, flexural strength, and elastic modulus). As a result, the fresh and hardened unit weights in the CEAFS are comparable. Moreover, variations in the concentration of mineral additives FA and SF in adhesives, as well as the CEAFS mixed aggregate ratio, have an impact on compressive strength, flexural strength, and elastic modulus at all ages. However, combining EAF slag aggregate with (FA0% +SF10%; FA10% +SF0%; FA10% +SF10%; and FA20% +SF10%) the CEAFS mixtures have improved mechanical characteristics over time. According to this study, CEAFS pavements can be made with EAF slag aggregate fly ash and silica fume. In addition, a formula correlation was suggested to compute CEAFS (i.e. compressive strength with elastic modulus and compressive strength with flexural strength).
- **Bharadwaj Nanda and Sudipta Rout (2023)** This study examines the behaviour of concrete manufactured by the complete replacement of natural sand with an optimum mixture of these ashes. The effect of fly ash and bottom ash mixture is ascertained through workability, strength tests, and resistance to acid attacks.s
- **K. Arumugam and M.Ramya Devi** (2017) The main aim of this research is to use mineral admixtures (silica fume) (SF) and pond ash (PA) in concrete as the replacement material for cement and fine aggregate. As we all know, the use of mineral admixtures gives the strength to the concrete but indeed the use of pond ash for the replacement of fine aggregate is a rare

combination. In this research, silica fume is partially replaced by 15% by the weight of cement and pond ash is replaced in varying proportions as 0%, 5%, 10%, 15% and 20% by weight of fine aggregate. The fresh property of the concrete is determined by slump cone test and hardened concrete properties of the concrete are determined by compressive strength and split tensile test. Conclusion The initial cost of silica fume is high, but it gives high strength, high durability, low workability, long life. Hence from the above results we conclude that the slump value for different mix proportions decreases when pond ash (PA) is use. The use of mineral admixtures (silica fume) (SF) gives us high strength.At 7 days strength, the mix proportion of silica fume gives high strength than pond ash.

- **Sreelakshmi R and Reshmi P R (2016)** presents the development of a sustainable lightweight wet-mix shotcrete by replacing natural coarse gravel with a kind of byproduct, nut shell (walnut). Fibers made from dumped polyethylene terephthalate (PET) bottles were mixed in the composite to improve the properties of the lightweight wet-mix shotcrete. The initial evaluation of the fresh concrete mixed with different volume fraction of walnut shell was carried out in terms of its performance capacities of mechanical properties (i.e., tensile and compressive strength), pumpability and shootability (i.e., slump, pressure drop per meter and rebound rate) and the results were compared with plain concrete. The Rapid chloride permeability test value for control concrete at 28 days is found to be 3748 Coulomb. Results shows charge passed goes on decreasing with the increase in the addition of percentage of inhibitor till the addition of inhibitor percentage is 2% and charge passed increases on further addition of inhibitor. The charge passed at 2% is 1524 coulombs, which indicates a low chloride ion permeability as per ASTM C1202. Gravimetric weight loss test results indicate the rate of corrosion decreases with the increase in the addition of inhibitor till 2% addition of inhibitor and rate of corrosion increases in the further addition of inhibitor. The rate of corrosion at 2% is obtained as 0.0026 mmpy. 19 Evaluation of Engineering Properties of Concrete incorporating Industrial Waste
- **K. Lini Dev and R. G. Robinson (2016)** This paper reviews the effective utilization of different types of ashes in flowable fill production and the main properties, advantages and applications in geotechnical engineering practice. Pond Ash Based Flowable FillPlastic properties such as flowability, bleeding and in service properties such as compressive strength, compressibility, permeability and CBR were determined as per the procedures mentioned in the previous sections as per the relevant ASTM standards.
- **Rath Badrinarayan , Deo Shirish and Ramtekkar Gangadha (2016) the** authors tried to investigate the early age shrinkage behavior of cement, when it is partially replaced with fly ash and pond ash individually and simultaneously by volume. In this research the shrinkage is measured by shrinkage meter .It consists of shrinkage cone which is used for measuring the swelling or shrinkage of various building material like paste, mortar, concrete etc. The cone consists of a container having diameter 11 cm and height 9 cm. After laying separation foil on the wall of container, paste or mortar are filled whose shrinkage property is to be observed. A laser is mounted on a beam stand and can be moved vertically by rack and pinion arrangement. The laser beam is focused constantly on specimen container and set on the working range by moving up and down vertically. The total system is controlled by computer. Pond ash swells initially when it comes in contact with water. So pond ash can also act as shrinkage resisting material. Figure 2.5:. Effect of Pond Ash on Shrinkage of Cement Paste.
- **K. M. Bagwan1 & S. S. Kulkarni (2015) This** paper presents the experimental investigation carried out to study use of pond ash in concrete. Now a day it is important to think about effective utilization of pond ash to preserve natural resources and to have sustainable development. The concrete was prepared with different percentage of pond ash (15, 25, 35, 45 and 55 %) and it was tested at different ages (3,7,28,56,90, and 180 days). Results of pond ash concrete were compared with control concrete. For all proportions slump in a range of 100-120 mm was maintained. A property of pond ash concrete in fresh state and hardened state was tested. IST

and FST of pond ash concrete goes on increasing as replacement level of pond ash with cement increases this is 21 Evaluation of Engineering Properties of Concrete incorporating Industrial Waste because of less content of cement it is found that rate of increase of compressive strength at early ages mainly 3,7 and 28 days was low and during later age this rate was faster. This shows that later age strength of pond ash concrete is very good and has a scope to use in concrete which are of great importance in the present context of sustainability in the construction field.

- **Prasenjit Ghosh and Sudha Goel (2014)** The objective of this study was to determine the environmental impacts of open dumping of pond ash around a thermal power plant. Physicochemical characterization of three pond ash samples collected from Kolaghat Thermal Power Plant was done. Physical characterization of the samples included determination of Total Solids, Volatile Solids, Fixed Solids, specific gravity, specific surface area, hydraulic conductivity, dry densities, particle size distribution and performing Scanning Electron Microscopy for obtaining morphological characteristics. Surface reactivity and EDS analyses were done to assess different chemical characteristics of the same pond ash samples. Specific surface area gave fineness data and EDS gave elemental composition of the ash samples. Finally, the potential hazards of the samples were assessed depending upon these results

3 Objectives

Following are the objectives of this work

- To design a mix for M 30 grade conventional concrete using IS 10262:2019.
- To evaluate the fresh concrete properties like workability of conventional concrete sample and concrete produced.
- Optimum percent of sand replacement with copper slag is to be determined.
- Effect on workability, compressive strength and flexural strength on addition of copper slag is to be studied. To evaluate strength parameters like compressive strength, split tensile strength and flexural strength of concrete for fine aggregate replacement with pond ash at various percentages.
- To find out the optimum percent replacement of fine aggregate with pond ash to give acceptable workability & hardened strength properties.

4 Methodology Adopted

In this work, the mix design and testing method is used to perform Utilisation of Pond ash & copper slag in Concrete as per IS-standards. In order to study the effect of pond ash as a partial replacement. The effect estimation of a given coarse total is 20-30%.and that can be utilized for street surfacing. Mix design is done for the present study. Mix design was done for control mix of M30 grade of concrete by using the IS code 10262: 2019 and specification given in the IS code 15658: 2006.

Table 1**:** *Concrete mix design parameters*

S.No.	Parameters	Data
1	Characteristic Compressive Strength	30 MPa
2	Type of cement	OPC Grade-53 (Ultra tech)
3	Specific gravity of cement	3.15
4	Nominal maximum size of Coarse aggregate	10 mm & 20 mm
5	Type of Coarse aggregate	Crushed natural stone aggregate
6	Type of fine aggregate	Natural River Sand
7	Water cement ratio	0.45(max.)
8	Exposure condition	Moderate
10	Admixture used	Super Plasticizer
11	Slump value	80 mm

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Table 2: Cases considered for study

		Using Pond ash & Copper Slag as Sand Replacement		
S.No.	**Sample ID**	**Sand %**	**Pond ash %**	**Copper Slag %**
1	CONC 0	100	0	0
2	PA 10	90	10	-
3	PA 20	80	20	-
4	PA 30	70	30	-
5	PA 40	60	40	-
6	PA 50	50	50	-
7	PA 60	40	60	-
8	CS 10	90	-	10
9	CS 20	80	-	20
10	CS 30	70	-	30
11	CS 40	60	-	40
12	CS 50	50	-	50
13	CS 60	40	-	60

5 Results

The results got from tests directed on solid clearing blocks have been talked about in this part.

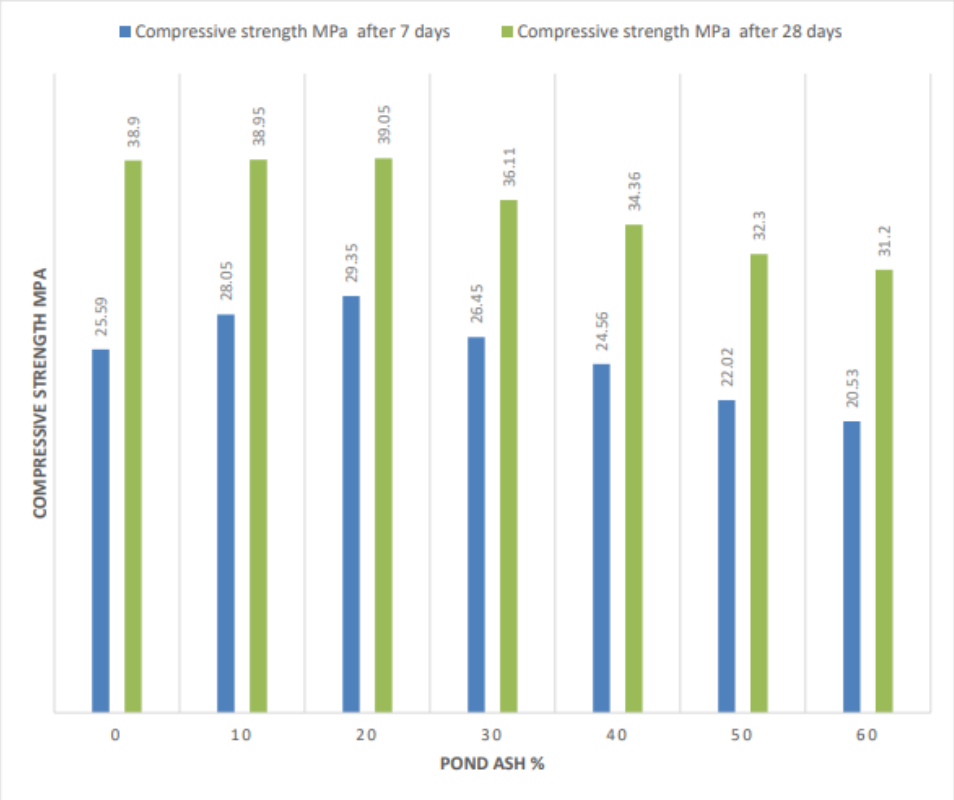

Figure 1: Comparative values of compressive strength at different age with pond ash

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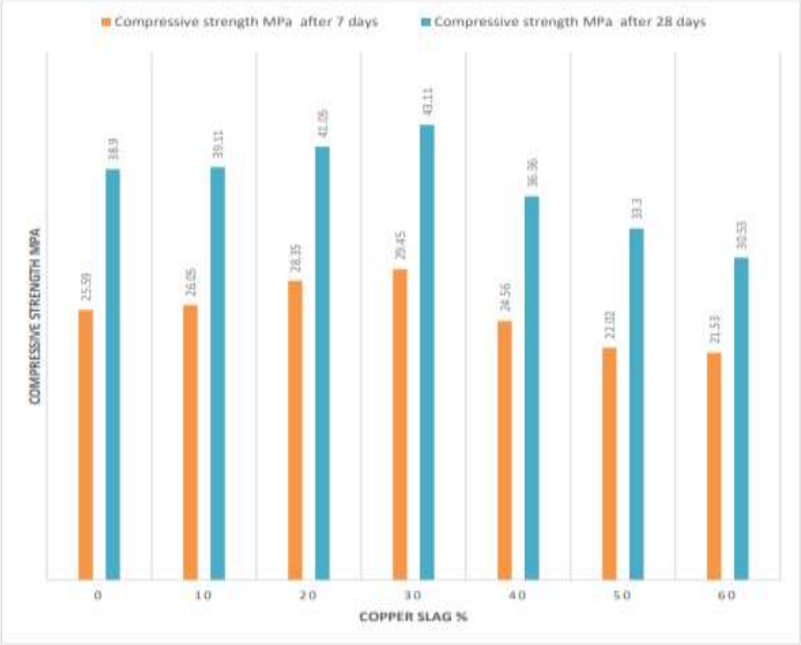

Figure 2: Comparative values of compressive strength at different age with copper slag

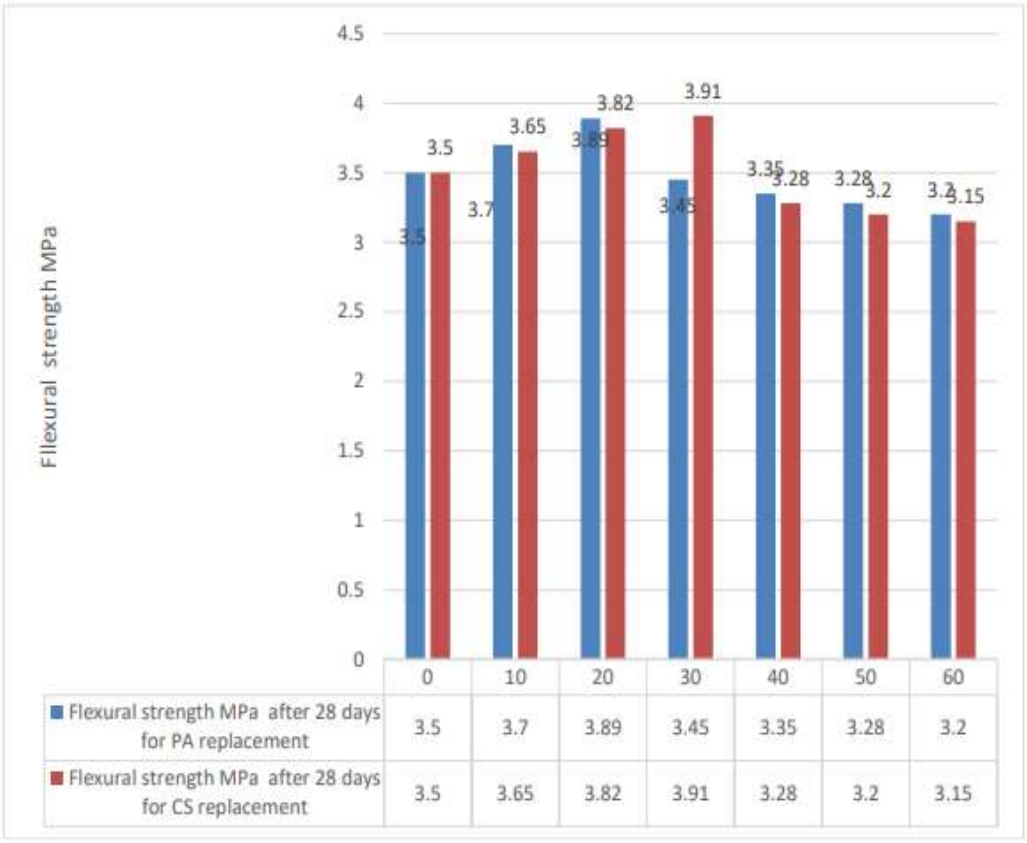

Figure 3: 28-days *Flexural* strength result MPa

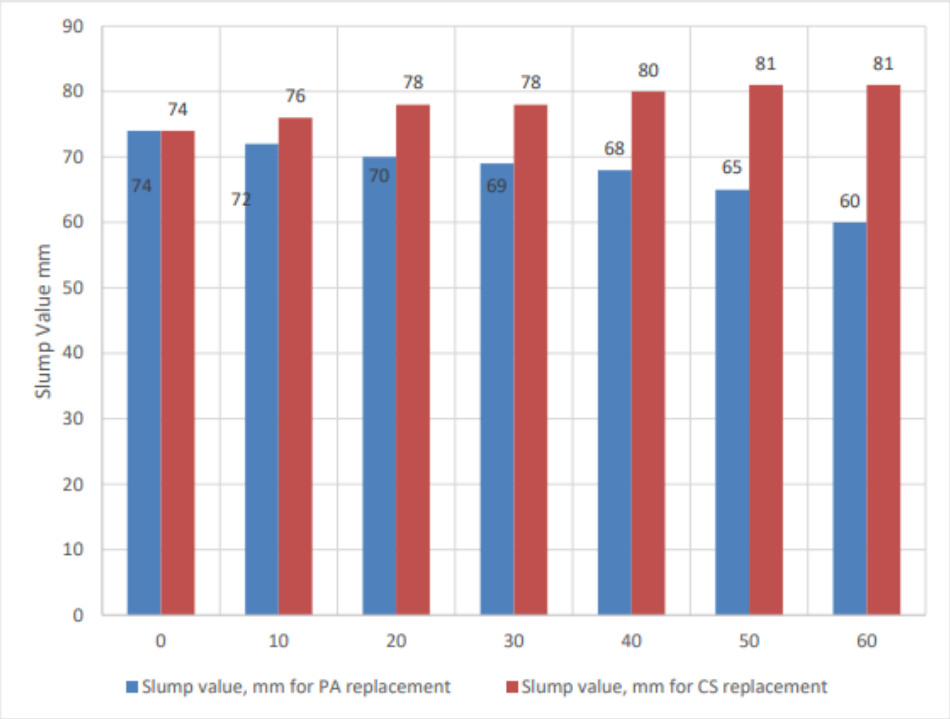

Figure 4: Slump cone test results

6 Conclusion

Partial replacement of sand with copper slag leads to increment in workability as show in slump value graph. In terms of Compressive Strength mix with 30% Copper Slag the 14th and 28th day strength was higher than control mix. All the experimental mixes satisfy the 28th day compressive strength expected from M30 grade of concrete. In terms of Compressive Strength mix with 20% Pond ash the 14th and 28th day strength was higher than control mix. It is observed that the flexural strength for concrete with replacements was increased when the copper slag was added up to level of 30% replacement & the flexural strength of the CS 30 mix designation is lower than the control concrete. Therefore, the conclusions of all these tests suggest that the mixture containing 30% copper slag or 20% Pond ash may be used as a suitable replacement for natural sand in concrete in moderate environments without compromising the strength..

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