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Combined Effect of Incinerated Biomedical Waste Ash and Pond Ash On the Properties of Concrete

Shahneela Ashraf[1], and Ashish Kumar[2]

[1]M Tech Scholar, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India
[2] Assistant Professor, Department of Civil Engineering, RIMT University, Mandi Gobindgarh, Punjab, India

Correspondence should be addressed to Shahneela Ashraf;shahneela507@gmail.com

ABSTRACT- Concrete is one of the most widely used construction materials, but its production contributes to significant environmental concerns due to the high consumption of natural resources and the generation of large amounts of waste. In recent years, efforts have been made to incorporate industrial by-products, such as fly ash and slag, into concrete to enhance its sustainability and performance. This research paper investigates the combined effect of incinerated biomedical waste ash (IBWA) and pond ash (PA) as supplementary cementitious materials on the properties of concrete. The study involves an experimental investigation conducted to evaluate the fresh and hardened properties of concrete incorporating different proportions of IBWA and PA. Concrete mixes with varying replacement levels of cement by IBWA and PA are prepared and their workability, compressive strength, split tensile strength and flexural strength are examined. The results reveal that the compressive strength, split tensile strength and flexural strength of the concrete specimens are found to increase up to a certain replacement level and then gradually decrease. The improvements in concrete properties can be attributed to the pozzolanic and filler effects of IBWA and PA, which contribute to the formation of additional hydration products and denser microstructures. This research provides valuable insights into the potential utilization of incinerated biomedical waste ash and pond ash as sustainable alternatives to conventional cement in concrete production. The findings highlight the feasibility of reducing the environmental impact associated with the disposal of wastes while simultaneously enhancing the performance of concrete. The outcomes of this study can be instrumental in promoting the adoption of environmentally friendly practices in the construction industry and facilitating the development of guidelines for incorporating IBWA and PA in concrete mix designs.

KEYWORDS- Concrete, incinerated biomedical waste ash, Pond ash, sustainable materials, supplementary cementitious materials, compressive strength, flexural strength, split tensile strength

I. INTRODUCTION

In recent years, the escalating global concern for environmental sustainability has prompted extensive research into alternative materials and practices within the construction industry. As a significant contributor to environmental pollution and resource depletion, the concrete production process has become a focal point for innovative solutions that reduce its ecological impact. One such avenue of investigation involves the incorporation of waste materials, specifically incinerated biomedical waste ash (IBWA) and pond ash (PA), into concrete formulations.

The management of biomedical waste generated from healthcare facilities is an ongoing challenge, as it requires special attention due to its hazardous nature. Traditional disposal methods, such as landfilling and incineration, not only contribute to land and air pollution but also neglect the opportunity for resource recovery. On the other hand, pond ash, a by-product of coal combustion in thermal power plants, poses its own disposal challenges, with large quantities often being stored in ash ponds, occupying vast land areas and presenting risks of contamination.

The combination of IBWA and PA as potential supplementary cementitious materials (SCMs) in concrete production offers a two-fold advantage: addressing the environmental concerns associated with waste disposal while improving the mechanical and durability properties of concrete. The chemical composition of IBWA, enriched in silica and alumina, along with PA's pozzolanic nature, contribute to their cementitious properties when activated in the presence of calcium hydroxide. This activation process not only reduces the reliance on cement, a primary source of carbon dioxide emissions in concrete production, but also enhances the overall performance of the resulting concrete.

This research paper aims to investigate the combined effect of IBWA and PA on the properties of concrete. The study will encompass a comprehensive analysis of various aspects, including workability, compressive strength, flexural strength and split tensile strength incorporating different proportions of IBWA and PA.

By providing an in-depth understanding of the combined effect of IBWA and PA on concrete properties, this research aims to contribute to the growing body of knowledge surrounding sustainable waste management practices within the construction sector. The findings will offer valuable insights for engineers, architects, and policymakers to explore the viability and potential benefits of utilizing waste materials for concrete production, ultimately fostering a more sustainable and eco-friendly approach to waste disposal in the built environment.

Overall, the utilization of IBWA and PA in concrete has the potential to promote circular economy principles, mitigate environmental impacts, and create value from waste materials, making it an exciting avenue for sustainable waste management and resource conservation in the construction industry.

II. BACKGROUND

A. Incinerated Biomedical waste ash

When biomedical waste is incinerated, it undergoes a combustion process at high temperatures, resulting in the conversion of organic materials into ash. This ash contains various constituents, including metals, inorganic compounds, and trace amounts of organic matter. The composition of the incinerated biomedical waste ash can vary depending on factors such as the waste type, incineration conditions, and the efficiency of the incineration process.

The utilization of incinerated biomedical waste ash in concrete production has gained attention in recent years due to its potential benefits. The ash is used as a partial replacement for cement in concrete mixes, which help reduce the demand for cement and lower the carbon footprint associated with concrete production. Additionally, the incorporation of ash into concrete enhances certain properties, such as workability, strength, and durability.

Figure 1 shows the ground incinerated biomedical waste ash and table 1 gives the chemical composition of the IBWA.

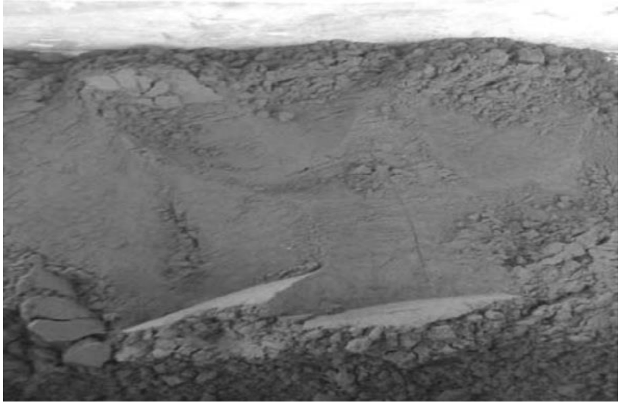

Figure 1: Incinerated biomedical waste ash

Table1: Chemical composition of Incinerated biomedical waste ash

Chemical Compound	Quantity (%)
SiO_2	18.6
Al_2O_3	6.73
Fe_2O_3	3.13
CaO	48.91
SO_3	2.42
Na_2O	0.3
K_2O	0.28
MgO	1.98

B. Pond Ash

Pond ash shown in figure 2 is a byproduct obtained from the combustion of coal in thermal power plants. It is a fine-grained material that is collected from the bottom of ash ponds, which are used for the disposal of coal combustion residues. Pond ash consists of fly ash, bottom ash, and other unburned carbonaceous materials.

The research on the combined effect of incinerated biomedical waste ash and pond ash in concrete aims to investigate the potential benefits of using these waste materials as partial replacements for cement. The addition of these waste ashes improve the engineering properties of concrete. This research provides insights into the suitability and optimal proportions of pond ash and incinerated biomedical waste ash for concrete production, promoting the use of these waste materials in the construction industry. Table 2 includes the chemical composition of pond ash

Figure 2: Pond Ash

Table 2: Chemical composition of Pond ASh

Chemical Compound	Quantity (%)
SiO2	35.7
CaO	23.56
MgO	2.18
SO3	1.34
Na2O	0.79

III. NEED OF PROJECT

- The utilization of IBWA and PA in concrete has environmental benefits as it can reduce the disposal of these wastes in landfills, reducing environmental pollution and promoting sustainable development.
- Resource conservation and cost saving: The use of these materials can conserve natural resources such as sand and cement, which are trending scarce. Also reduce the cost of construction as the waste materials are available at extremely low or no cost.
- The application of such wastes as partial replacements for cement in concrete production have proven to improve mechanical and thereby the durability properties of concrete, making it more suitable for construction purposes.

IV. OBJECTIVES OF STUDY

The study's specific goals are listed below.

- To design M30 grade concrete and to review its compressive strength after the prescribed 7 and 28 days respectively.
- To evaluate the mechanical characteristics of concrete; compressive strength, flexural strength and split tensile

strength by partially replacing cement with the combination of incinerated biomedical waste ash and pond ash at various dosages.

- To examine the impact of combination of IBWA and PA on the workability of concrete.
- To determine the optimum percentage of replacement of cement with the combination of IBWA and PA that gives the best results in terms of mechanical property and workability.
- To check the feasibility and effectiveness of using IBWA and PA as sustainable and economical partial replacements for cement in concrete production.

V. LITERATURE REVIEW

Focusing on building assets gives us the ability to identify openings in the relevant area and, as a result, gives us the amazing chance to fill such positions. The overview of related writing encourages the researcher to discuss the field's constraints. It explains the problem and aids the researcher in delimiting. The information on linked writing encourages the examiner to innovate on the works that others have completed and, as a result, to explain the objectives simply and effectively. By reviewing the linked composition, the professional may steer clear of fruitless and pointless areas. He can choose the locations where successful efforts are most likely to provide beneficial disclosures and would undoubtedly significantly add to the data. Finally, we may state that research activities should never be suppressed in favor of proactive work on problems directly or indirectly connected to a survey idea put out by a qualified expert. So probably the first step in the area of evaluation is to carefully review the research journals, books, compositions, proposal, and other sources of information on the topic to be examined. A sizable portion of the text is devoted to the study, which draws its motivation from the need to construct and validate the researcher review. A portion of the several earlier analyses conducted in a related topic include:

Hospital waste ash was used in trial of partially replacing cement, it was determined that hospital waste ash may be used to partially replace cement in concrete without compromising any of the characteristics governing its strength. It was discovered that both the density and retention of water of mixes reduced with an increase in the proportion of HWA in the mix while the setting time rose owing to an increase in surface area. Additionally, the use of HWA as a partial replacement for cement in mortar solved the issue of its disposal, keeping the environment pollution-free. [1]

An experimental enquiry was conducted on pond as partial cement replacement. A variety of phases (3, 7, 28, 56, 90, and 180 days) of testing were performed on concrete that included varied amounts of pond ash (15, 25, 35, 45, and 55%). The outcomes of the pond ash concrete were contrasted with control concrete. For all of the dimensions, the slump was maintained in the 100–120 mm range. It was noted that the rate of rise in compressive strength was low at young ages, that is at 3,7 and 28 days, but this rate was quicker at later ages. This showed that pond ash in concrete at later stage strengthened it and eventually proved to be beneficial for sustainable development and has a scope to be used in concrete. [2]

Concrete cubes cured for durations ranging from three days to ninety days were made using ash as a partial replacement for cement in amounts ranging from 0 to 40 by weight of cement. The findings demonstrated that water absorption rose as replacement levels increased, however compressive strength decreased as replacement levels climbed above 10%. [3]

The main objective in this analysis was to use IHWA efficiently in concrete making. The results revealed that the concrete constructed with biomedical waste ash has a lesser workability than normal concrete, also its density marginally dropped as replacement levels rose. But the compressible strength of the concrete made from biomedical waste ash met the standards for regular concrete. [4]

Concrete significance to the construction and the hazardous effect of plastic from various health care settings such as clinics, hospitals, etc. were examined in this experiment werein 4 concrete mixtures were made using the plastic replacement ratio of 0%, to 20% by volume of natural aggregate. However, results were not satisfactory as it decreased both the workability and the compressive strength of the concrete so formed. [5]

The impact of using pharmaceutical wastes as a cement substitute on the long-term durability of high-performance concrete. According to the experimental research, the 10% fineness modulus of ash in a chloride rich environment improves the mechanical properties of the material as well as its resistance to chloride ion migration and oxygen permeaba decrease in the pore proportion in the enlarged interfacial transition zone (ITZ) compared to the control specimen. Additionally, the cement and aggregate phases contained portlandite, ettringite, okenite, quartz, and calcite, according to an X-Ray Diffraction (XRD) pattern. This implies that the use of BWIA and BA has a considerable influence on the characteristics of high-strength concrete that is still being mixed, has hardened, and has a microstructure, and may thus be used to partially replace cement. [6]

Studied the effect of Bio-Medical Waste Ash on Concrete Compressive Strength. With a 1:2:4 mix and a 0.45 w/c ratio, the cement was substituted using ash in six batches at dosages of 1%, 3%, 5%, 7%, and 9% by weight of the cement. 48 cylinders were made in each batch. After 7, 14, 28, and 90 days, the same number of cylinders were cured and tested. One batch of the cylinders from the experiment's six prepared batches was cast with only conventional aggregates for comparison. The ideal dosage of the biomedical waste ash was found to be 3%, according to the results of the tests on weight, density, and compressive strength. The observed density of the mixtures was in excellent agreement with the reference values. However, the 3% dosage reduced the compressive strength by at least 26%. [7]

Producing geo-polymer concrete; a new technology that can replace traditional concrete. The main objective of this research is to check how the mechanical and flexural activity of GPC is impacted by bio-medical waste ash (IBWA) generated from incineration. In this research, incinerated biomedical waste ash is substituted for Ground granulated blast slag in various percentages of 0, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50%. A reference to IBWA makes the material ductile which results in significant improvements in toughness, energy absorption, tensile stress, and strain. Concrete specimens were tested to determine its bending strength, split tensile strength, and compressive strength of a cube, among other mechanical parameters. It was found that the introduction that adding IBWA to GPC improved both the material's mechanical behavior and the beams' capacity to support loads [8].

Conducted lab investigations to check the suitability of using medical waste incinerator ash and baggase ash in high strength concrete as partial replacement for cement. Based on its engineering Ash-cement samples were prepared according to ACI 211-4R-93 with varying proportions of IBW ash (0%, 2.5%, 5% and 7.5% by weight) and baggase ash (0%, 2.5%, 5% and 7.5%) in the laboratory under suitable conditions. The slump, flow capacity, density, and compaction factor of the newly laid concrete were evaluated. When the hardened concrete compressive strength was measured after 28 days, it was discovered to be 54.8 MPa and 52.5 MPa, respectively, for the mix codes BWIA and BA5 and BWIA and BA10. SEM analysis of the micro-structural characteristics of the hardened concrete showed that partial cement replacement with BWIA and BA results in reduced CH crystals, a denser C-S-H gel, and work. [9]

VI. METHODOLOGY AND MATERIALS

A. General

The materials to be utilized in the creation of concrete are cement, fine and coarse aggregates, incinerated biomedical waste ash as well as Pond ash as supplanted substitution of cement. This section contains a step-by-step procedure for carrying out the experiment as well as information on the ingredients and casting process.

- Collection of materials.
- Testing of materials (physical and chemical).
- Mix Design
- Material batching
- Mixing
- Casting of concrete cube, cylinder, beam
- Testing
- Compilation of test results
- Conclusion

B. Cement

OPC of grade 43, manufactured by JK Cement Factory in Anantnag (J&K), is used in this test, and its technical parameters are exactly in line with "the General Portland Cement." Each bag conatins 50kg of cement. To make cement, cement clinker is crushed along with gypsum, water, or performance enhancers like fly ash, etc.

Table 3 gives the physical characteristics of cement

Table 3: Cement's Physical Characteristics

S No.	Properties	Observations
1	Bulk Density	1440 kg/m^3
2	Specific Gravity	3.15
3	Initial Setting Time	30 minutes
4	Final Setting Time	240 minutes
5	Fineness	325 m^2/kg
6	Standard Consistency	31%

C. Fine aggregates

The naturally obtainable river sand was employed as fine aggregate. It was properly washed and classified by passing it through 4.75mm sieve before using in concrete, the analysis of which is given in table 4. The sand used is fine sand confirming to Zone 3 of IS: 383-1970 and has the fineness modulus = 2.41

Table 4: Sieve Analysis of fine aggregates

Sieve size (mm)	Weight of sample retained (g)	Cumulative weight retained (g)	Cumulative % retained	Percentage passing
4.75	22	22	1.1	98.9
2.36	112	134	6.7	93.3
1.18	210	344	17.2	82.8
0.60	280	624	31.2	68.8
0.30	1117	1741	87.05	12.95
0.15	215	1956	97.8	2.2
Pan	44	2000	100	0

D. Coarse aggregates

A crucial component of concrete, coarse aggregate offers the design stability and strength. It functions in combination with cement and fine aggregates to create a concrete mixture that is strong and long-lasting and can withstand a variety of physical and environmental pressures. The workability, strength, durability, surface tension, and other characteristics of freshly mixed and cured concrete are significantly influenced by aggregate properties. Less surface area results from larger coarse aggregate sizes, which means less fine aggregate is needed. Concrete's compressive strength is increased by 20% by aggregates with a rough texture, which enhances the cement and aggregate adhesion strength by 75%. The coarse gravel used in that study investigation measures 20 mm, is broken, and has a pointed appearance. The coarse aggregate has a specific gravity of 2.77 and water absorption of 0.47%.

E. Water

Water used in the mix is tap water; free from all sort of hazardous and organic materials, conforming to IS456:2000 is used in the experiment. The pH of the water used is 6.6

M-30 grade concrete Mix Design

Design requirement:

Target strength for mix proportioning

$f'_{ck} = f_{ck} + 1.65 * S$

Where S (standard deviation) = 5

f’ck = compressive strength of 28 Days,

Tolerance factor = 1.65

S = Standard deviation, S =5 N/mm^2, from IS 456; 2013, table no 8 Standard deviation can increase by +1 if your site management is not good. Therefore, target strength = 30 + 1.65 x 5 = 38.25 N/mm^2.

F. Selection of water - cement ratio

According to Table 3 & 4 of IS 456: 2000, the maximum water-cement ratio is 0.45. Water cement ratio is dependent on exposure conditions. Selection of water –content.

G. Selection of water content

From table 4, IS10262:2019

For 20mm aggregate size and slump value of 50mm, water content = 186 kg

For every 25mm increase in slump, 3% is added
186 + 6% of 186 = 197 kg

H. Calculation of cement content

Water-Cement ratio = 0.45
Cement = 197/0.45
Cement = 437.78 kg/m^3
Adopted cement content is 437.78 Kg/m^3 (450 < 437.78 > 320) Kg/m^3, hence safe.
So, final water cement ratio = 197/437.78 = 0.45

I. Proportion of volume of coarse aggregate and fine aggregate content

From IS code 10262-2019 table 5 clause 5.5, volume of coarse aggregate consequent to 20 mm size aggregate and fine aggregate zone 3 for water cement ratio of 0.45 = 0.65. Actual water cement ratio = 0.45, volume of coarse aggregate = 0.65. The Volume of fine aggregate content = 1 − 0.65 = 0.35.

J. The mix calculations per unit volume of concrete shall be as follows

The mix calculations per unit volume of concrete shall be as follows:
I.) Volume of concrete = 1m^3
(A) Volume of cement = Mass of cement/ specific gravity of cement X 1/1000 = 437.78/3.15 X 1/1000 = 0.139m^3
(B) Volume of water = Mass of Water/ specific gravity of water X 1/1000 = 197/1 X 1/1000
= 0.197m3
(C) Volume of all aggregate = [1-(A+B)] = [1-(0.139+0.197)] = 0.664 m3
(E) Mass of coarse aggregate (CA) = C x volume of coarse aggregate x Specific gravity of coarse Aggregate x 1000
= 0.664 x 0.65 x 2.77 x 1000 = 1195.532 Kg
(F) Mass of natural fine aggregate = C x volume of fine aggregate x Specific gravity of fine Aggregate x 1000 = 0.664 x 0.35 x 2.66 x 1000 = 618.184 Kg

K. Materials reuired for each casting of M30 grade concrete

Volume calculations
Volume of 1 cube = 3.375×10^{-3} m^3,
Volume of 1 beam=$5x10^{-3}$ m^3 and
Volume of 1 cylinder = $5.301x10^{-3}$ m^3
Total volume to be filled with concrete = (3.375×10^{-3} x numbers of cube + $5x10^{-3}$ x no. of beam casting + $5.301x10^{-3}$ x Numbers of cylinders)

1) Source of material

- Cement: JK Cement (OPC Grade 43)
- Coarse Aggregate: Larkipora
- Fine Aggregate: Local river
- Water: plant site
- Pond Ash: India Mart
- Incinerated Biomedical waste ash: Pulwama

2) Physical attributes of Coarse & Fine Aggregate

- Coarse aggregate: 20 mm nominal size
- Water absorption (%) = 0.47
- Specific gravity = 2.77
- Fine aggregate
- Fineness modulus = 2.41
- Specific gravity = 2.66
- Specific gravity of cement = 3.15

3) Fine gravel completion percentage

It is shown in Table 5

Table 5: Fine gravel completion percentage

IS Filter size (mm)	Percentage passing	Specific Level as per IS
4.75	98.9	90 – 100
2.36	93.3	85 – 100
1.18	82.8	75 – 100
0.60	68.8	60 – 79
0.30	12.95	12 – 40
0.15	2.2	0 – 10

L. Methodology: Tests conducted

1) Fresh concrete Properties (Plastic stage)

The term plastic stage of concrete refers to a phase of concrete development when the concrete is still fresh and workable. It is at this stage, concrete is malleable and hence can be molded or shaped into any form. It is also during the plastic stage that the various construction activities like pouring, vibrating and finishing takes place

2) Slump flow test

The slump flow test is a commonly used test to measure the workability or consistency of fresh concrete. It provides an indication of how easily the concrete can flow and spread under its own weight without segregation. The test is performed according to ASTM C143/C143M-19a or similar standards. Slump test for fresh aggregate is shown in figure 3.
Apparatus used:

- Slump cone: A frustum-shaped cone made of steel with dimensions specified in the standard.
- Tamping rod: A steel rod with a diameter of 16 mm and a length of about 600 mm. Trowel: For smoothing the concrete surface
- Measuring tape
- Stopwatch
- a firm, level surface on which to set the slump cone during the test.
- Non-absorbent base plate: A firm, level surface on which the slump cone is placed during the test.

Concrete Sample
4 equal layers of 75 mm each are filled by tamping each 25 times. It is mostly suitable for high and medium workability i,e; 25-125mm. It cannot be used to measure workability for aggregate size more than 40mm. Slump value at different scenarios is given in table 6.

Table 6: Slump value at different scenarios

Condition	Slump mix
For road construction	20-40mm
Beams and slabs	40-45mm
Mass concreting	25-50mm
Regular RCC construction	80-150mm
Vibrating concrete	10-25mm
Impermeable work	75-120mm

As the slump value increases, workability also increases.

Figure 3: Slump test for fresh concrete

3) Compressive strength test

The compressive strength of the concrete is defined as the capacity of the concrete to resist or withstand specific compression forces. For residential or commercial constructions, its strength at compression can vary from 15MPa (2200 psi) through 30MPa (4400 psi) even beyond. Compressive strength of concrete rely upon various factors such as;

- Water / cement ratio
- Cement strength
- Quality of concrete material
- Quality control during concrete production, etc.

According to IS 516-1959, the cube and cylindrical specimens shaped are used for testing compressive strength of concrete. The nominal size of a cubical specimen used is 15cm * 15cm * 15cm. the setup for compressive strength test is shown in figure 4.

Figure 4: Compressive strength test

4) Split tensile strength

The compressive strength of the concrete is acquired by applying a compression force throughout the length of the cylinder as can be seen in figure 5. The specimen used is cylinder with diameter of 15cm and the length of 30cm.The instrument used for the experiment is the universal testing machine (UTM). The specimens after being cured for 7 days and 28 days, the cylinders (specimen) were tested. Until the cylinder fails the diametric compressive load is supplied along its length.

At a certain compressive force, the cylinder fails by developing cracks. This is because the concrete is weaker in tension than in compression.

Split tensile strength (f_{ct}) in MPa = $2P/\pi DL$

Where, P is load applied in Newton.

D = diameter of cylindrical specimen in mm and

L = length of cylindrical specimen in mm

Figure 5: Split tensile strength test setup

5) Flexural strength test

To get the flexural strength of the concrete, beams with the dimensions of 100mm * 100mm * 500mm were casted. After proper curing, the beams were tested at 7 days and 28 days of curing. The specimen/beam is arranged in the machine such that the load is applied to the topmost surface in two-point loading system that are 13.3m apart as demonstrated in figure 6. The load is imparted gradually and the load where the specimen develops cracks or fails is noted.

The flexural strength is generally expressed as modulus of rupture; fb.

Flexural strength, fb = PL/bd^2

Where, P = maximum load applied (kg)

L = length of span on which beam was rested (cm)

b = width of beam (cm)

d = measured height of the beam at the point of failure (cm)

Also,

Flexural strength, fb = $3Pa/bd^2$

Where, ‘a’ = the distance between the line of fracture and the nearest support.

This assesses the resistance of a concrete beam and slab to twisting collapse. The breaking elasticity (MR), which is expressed as Mpa or PSi, serves as a representation of the results for the flexing test on masonry. This paper's testing protocol complies with ASTM C78.

To determine the concrete's breaking point, informal testing is conducted. This assesses how resistant the concrete structure or slab is to twisting-related fracture. The results of flexural tests on concrete are represented by a fracture modulus, denoted by the letters (MR) in MPa or PSi.

Figure 6: Flexural strength test

VII. RESULTS AND DISCUSSIONS

Results of tests and exams that were done in order to achieve the project's aim are included in this part. It includes the results of tests for slump, compressive strength, tensile strength, and flexural strength. Charts and tables are used to connect the results so that the trials may be thoroughly examined. These charts and tables provide a clearer picture of the results, which help the job achieve its primary objective.

Table 7 and 8 demonstrate the details of the specimen and batching and casting setup of the concrete specimen respectively.

Table 7: Details of the specimens

M30 grade	Percentage of pond ash by weight of cement with 10% ibwa fixed					
Name of specimen	M	M1	M2	M3	M4	TOTAL
Percentage of Pond Ash	0%	10%	20%	30%	40%	
Cubes	6	6	6	6	6	30
Beams	2	2	2	2	2	10
Cylinders	2	2	2	2	2	10
Total number of specimens						50

Table 8: batching and casting setup of concrete specimens

M30 grade concrete	For each percentage pond ash @ 10% ibwa	
Days of curing	7 days strength	28 DAYS STRENGTH
Cubes	3	3
Beams	1	1
Cylinders	1	1
Total specimen for each percentage		10

A. *Slump flow test results*

Table 9 shows the fresh characteristics acquired from all replacements (both with replacement and without replacement) and graphically represented in figure 7. The same quantity of water was added at the same time to all of the concrete mixtures. IBWA and PA added to concrete produced hard, cohesive, and sticky new concrete. M4 had the lowest slump value, which was approximately 108 mm. IBWA and PA has a low workability and a low lubricating effect as a result of its high water absorption rate and low water content. The material's rough texture and irregular form increase the material's interlocking and hardness, which lessens the ball bearing effect. All of these elements cause the water consumption for concrete containing IBMW and PA to increase and the slump to decrease.

Table 9: Slump low test results

Mix design	Cement (%)	PA (%)	IBWA (%)	Slump flow (mm)
Control mix	100	0	0	121
M-1	80	10	10	116
M-2	70	20	10	113
M-3	60	30	10	112
M-4	50	40	10	108

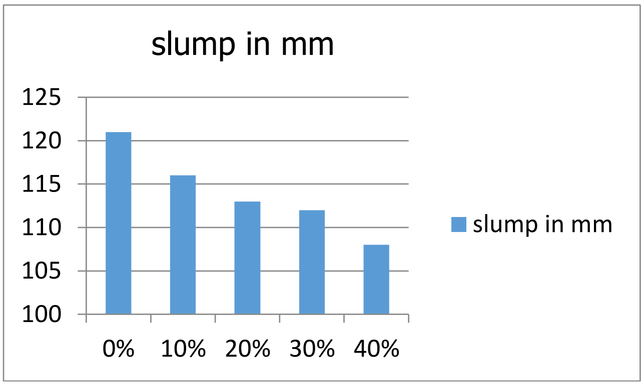

Figure 7: slump (mm) against Mix No. (%)

B. *Compressive strength test outcome*

Results for compression strength are shown in table 10 as the average of three specimens taken at 7and 28 days for each combination. At the age of 7 days, the compressive strength of M1 was calculated to be 25.46 MPa. In comparison to the control mix (i.e M), the compression strength of M2, M3 AND M4 exhibited nominal decrease in strength. At 10% replacement level, the greatest compressive strength gain was discovered. The graphical representation is shown in figure 8.

Table 10: Outcome of compressive strength test

Mix identity	Pond Ash (%)	IBWA (%)	Compressive Strength (MPa) 7 days	28 days
M	0	0	25.05	38.55
M1	10	10	25.46	39.18
M2	20	10	24.41	37.55
M3	30	10	22.24	34.22
M4	40	10	21.56	33.17

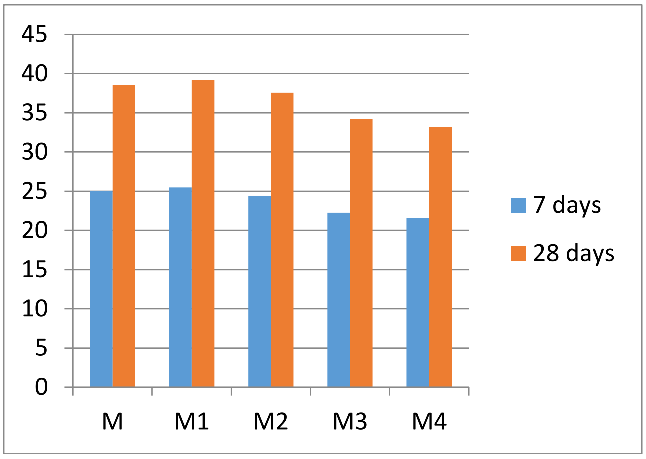

Figure 8: compressive strength graph of the cubes at 7 days and 28 days

C. *Tensile strength test outcome*

The 28th day split tensile strength showed a significant improvement when compared to the 7th day split tensile strength, indicating that the incorporation of IBWA and PA into concrete increased the split tensile strength when 20 percent of the cement was replaced,
as shown in Figure. 9. Split tensile strength was measured using IBWA and PA replacement in various percentages. As shown in table 11, it was discovered that adding IBWA and PA to concrete enhanced the split tensile strength when 20% of the cement was swapped out for IBWA and PA together. Tensile strength is impacted by concrete strength. At the age of 28days, it was discovered that M had a split tensile strength of 4.24MPa, while M1, M2, M3 and M4 had split tensile strengths of 4.30, 4.13, 3.76 and 3.64 MPa, respectively.

Table 11: tensile strength of the cylinders at 7 days and 28 days

Mix Design	Pond Ash (%)	IBWA (%)	Tensile Strength (MPa) 7 days	28 days
Control mix (M)	0	0	2.75	4.24
M1	10	10	2.80	4.30
M2	20	10	2.68	4.13
M3	30	10	2.45	3.76
M4	40	10	2.37	3.64

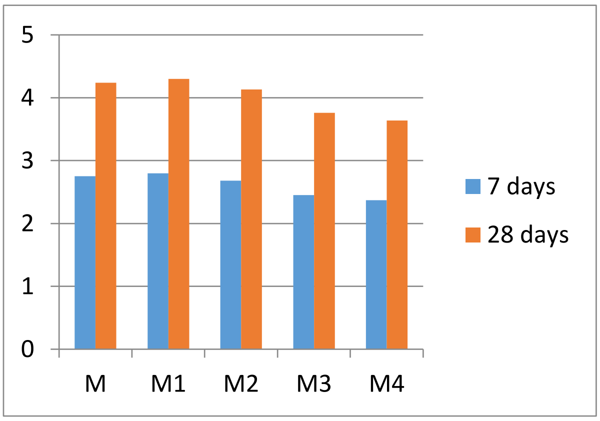

Figure 9: split tensile strength graph at 7 days and 28 days

D. *Flexural strength test outcome*

Figure 10 displays the results for the flexural strength of the beam after 7 and 28days and same is tabulated in table 12. The strength characteristics demonstrate a relatively low strength at 7 days and a considerable improvement is shown in 28 days, following a similar trend to that of split tensile strength. Flexural strength values reach their peak at 10% replacement of PA, much like compressive and split tensile strength.

Table 12: Flexural strength of the beams at 7 days and 28 days

Mix Design	Pond Ash (%)	IBWA (%)	flexural Strength (MPa) 7 days	28 days
M	0	0	3.50	5.40
M1	10	10	3.56	5.48
M2	20	10	3.41	5.25
M3	30	10	3.11	4.80
M4	40	10	3.02	4.64

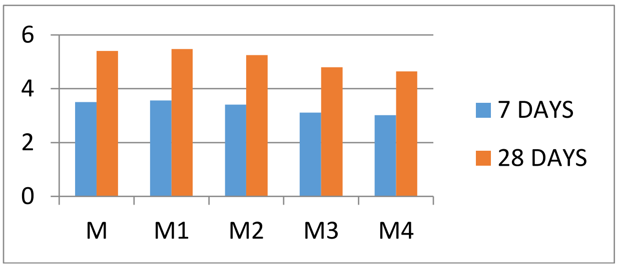

Figure 10: flexural strength graph of mixes at 7 days and 28days

VIII. CONCLUSIONS

The study tested the cement concrete's compressive strength, flexural strength, and tensile strength utilizing a variety of environmentally friendly ingredients, including pond ash and ash from the combustion of biomedical waste. The number of mixtures that were made were assessed for mechanical behaviour, and conclusions were formed. The following are the different mix proportions:

- The addition of incinerated biomedical waste ash and pond ash decreases the slump value, hence enhances water absorption. This is by virtue of the expansive nature of both IBWA and PA. Hence, the use of super-plasticizer is necessary to increase workability.
- Control mix M had a maximum slump value of 121mm compared to other mixes.
- Mix M1 containing 10% pond ash and 10% IBWA as replacement for cement achieved the maximum values for compressive strength, split tensile strength and flexural strength of the concrete compared to that of control mix in 28 days.
- Mix M2 containing 10% IBWA and 20% pond ash saw a decline in compressive strength compared to that of M1. At 28 days, the strength of M2 recorded was 37.55 MPa.
- Mixes M3 and M4 containing 10% IBWA and 30% and 40% pond ash respectively also reduced in the strength values. M3 has a compressive strength value of 34.22 MPa and M4 had a strength value of 33.17MPa.

- After comparing the results of all the mixes, M1 was selected as the better mix with compressive strength of 39.18 MPa.
- The pozzolanic property, densification, silica and calcium content in the ashes and enhanced packing by microfilling of IBWA and PA in the concrete are the potential reasons for the improvement of compressive strength.
- The Pozzolanic Activity Index is an important parameter used in the selection and optimization of pozzolanic materials for use in cement-based applications. It helps assess the potential contribution of a specific pozzolan to the development of strength and durability of the final cementitious product. It was found that the PAI of M1 is at par with the control mix.
- The addition of IBWA and PA both at 10% dosage has shown to reduce the voids and give denser matrix. As a result, it demonstrated an enhanced microstructure.
- The issue of limited space as well as costly land disposal cost can be resolved by using pond ash and incinerated biomedical waste ash as partial substitute for cement in concrete, leading to decrease in the environmental pollution.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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