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EXAMINING HOW METAKAOLIN AND BLAST FURNACE AFFECT CONCRETE'S STRENGTH IN COMPRESSION

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ABSTRACT

The intricate relationship between blast furnace slag, metakaolin, and concrete's Strength in compression is examined in this thesis. This work aims to provide a thorough knowledge of their combined impact as extra chemicals that resemble cement (SCMs) in mixers for concrete designs. The capacity of supplemental cementations materials (SCMs) to enhance concrete performance and reduce the environmental consequences associated with cement manufacture is gaining more and more recognition.

Both metakaolin and blast furnace slag, which are recognized for their pozzolanic qualities, enhance the qualities of concrete when added to mixtures. The iron production sector produces trash called blast furnace slag, while calcined kaolin clay is used to make metakaolin. However, further research is necessary to determine the extent of their influence on concrete's Strength in compression as well as the underlying mechanisms that account for these effects. This research employs a systematic approach to assess the compressive capacity of concrete samples using laboratory testing. These samples are created by substituting a portion of the cement used in Portland with various ratios of blast furnace slag and metakaolin. Additionally, the study looks at the microscopic characteristics, rate of fluid absorption, and capacity of blast furnace slag and metakaolin to react with calcium hydroxide in order to comprehend how these factors impact the features of concrete.

By examining the results and contrasting them with control samples, the thesis seeks to illuminate the relationship between these supplemental cement-based substances (SCMs) and the matrix that contains cement. It highlights how these SCMs help to make concrete stronger and more resilient. Furthermore, a number of factors, including the range of particle sizes, chemical makeup, and interactions between cementitious binders and other ingredients, are closely scrutinised in order to pinpoint the primary mechanisms responsible for differences in concrete performance. The study's conclusions have a significant impact on how Mix Grade are made and provide essential information to experts, researchers, and engineers working on sustainable construction techniques. Understanding how blast furnace slag and metakaolin impact the characteristics of concrete allows one to make well-informed judgments when choosing and altering the amounts of components. This promotes the building of more robust and ecologically friendly concrete buildings.

Furthermore, by advancing our understanding of concrete technology, this work facilitates the widespread use of supplementary cementations materials (SCMs) in building industry procedures. This thesis looks closely at how blast furnace slag and metakaolin affect concrete's Strength in compression in an effort to support the construction of robust and sustainable infrastructure.

Key Words: Meta-kaolin, Blast Furnace, Concrete, additives, Material Properties

1. INTRODUCTION

Concrete stands as the foremost choice in construction globally. It finds extensive application in various infrastructure endeavors. This amalgam of cement, water, and a blend of sand and gravel undergoes a series of processes including transportation, placement, and compaction, finishing, and curing. Its composition comprises active elements such as cement and water, alongside inert components like fine and coarse aggregates. Renowned for its robust Strength in compression and superior durability, concrete reigns as the paramount construction material of choice.

Achieving an economical concrete mix requires striking a balance between cost and strength when it comes to cement content. While hardened concrete needs strength and durability, fresh concrete must be workable. The water-cement ratio is essential to mix design since it directly affects concrete strength along with other elements including aggregate to grout ratio, aggregate grading, texture, and trapped air levels. Excellent performance concrete because or HPC, developed from high-strength concrete, is used because workability and durability have a significant impact on concrete's performance. With the use of chemical and mineral blends in addition to standard components, HPC prioritises a ratio of water to cement that is low for better properties.

Pozzolanic materials such as fly-ash, the mineral metakaolin slag, coal grain ash, and quartz oxide have gained popularity as cement substitutes in recent years to enhance the properties of High Tension Concrete (HSC). These materials are stronger, more durable, and have better workability while decreasing permeability. Metakaolin, a relatively recent addition to the concrete industry, greatly enhances air-void networks, lowers sulphate attack, and boosts strength. This amalgam of cement, water, and a blend of sand and gravel undergoes a series of processes including transportation, placement, compaction, finishing, and curing. The results of this approach include greater durability, lower porosity, and higher strength. These materials are stronger, more durable, and have better workability while decreasing permeability. Concrete's pozzolanic qualities have been greatly improved with metakaolin. These characteristics cause the sodium hydroxide (portlandite), a result of cement hydration, to react chemically with the active ingredients. This reaction increases the strength of the concrete and causes binding phases such C4AH13, C3AH6, C2ASH8, and secondary C-S-H gel. a while ago, air-cooled blast foundry slag (ACBFS) has begun to be used in some applications in lieu of coarse aggregates. Previous research has shown a comparable Strength in compression between concrete prepared with inorganic aggregates and ACBFS.

Mineral admixtures' use in concrete

The usage of mineral admixtures, such as ash from fly ash, kaolin, met and ACBFS, in the manufacturing of concrete has increased recently due to concerns about sustainability. This research examined the effects of additional components added to concrete, such as fly ash, metakaolin, or and ACBFS, on its mechanical qualities.

When dissolved in water and combined with limestone, metakaolin—a white, amorphous, extremely reactive aluminum oxide pozzolan—produces stable hydrates. This contact imparts hydraulic properties to the concrete.

When used as a fine aggregate in concrete, ACBFS has an angular, approximately cubic form. Its textures range from glassy, or smooth, with conchoidal cracks, to rough and vesicular, or porous. The density of coarse gravel particles may be up to 20% lower compared with that that exists in organic aggregates with the same gradation, whereas the density of fine slag screens is equivalent to that of natural sand

- Utilizing fly ash yields any or all of the following advantages:
- Reducing the amount of cement to save money
- increasing workability
- lowering the heat of hydration
- enhancing durability
- reaching the necessary strength levels

2. OBJECTIVES

Your study aims to evaluate the feasibility and consequences of replacing cement in various ratios with fly ash and met kaolin and coarse aggregates in varying proportions made from blast furnace slag. In spite of a rising need for building materials from the infrastructure development sector, such an approach seeks to safeguard the ecological balance and protect natural resources. As this requirement grows fast, it is imperative to reduce reliance on strengthen and natural aggregates. This approach maximizes the usage of waste materials while reducing the impact on habitat and cement production.

The current study has the following particular goals stated:

- More research is necessary to determine how the tensile and shear limits of concrete are affected when fly ash is partly substituted for cement.
- To assess the effects of varying proportions of ventilated blast furnace residue substituted for natural aggregates on the torsional and compressive limits of concrete made with fly ash.
- .To assess the flexural and tensional qualities of concrete mixed with fly ash, metakaolin, and air-cooled blast moulding waste.
- To examine the effects of using fly ash or metakaolin in various ratios in place of mortar, both as a binary when tri mix mixes.

3. LITERATURE REVIEW

The proper quantity of fly ash should be added to a specific quantity of cement to create fly ash concrete. Using mineral admixtures like fly ash has allowed for significant breakthroughs in the area of high performance concrete (HPC). It has been shown that the mechanical properties of both freshly produced and cured concrete may be significantly enhanced by mixing fly ash with metakaolin and cooling it using slag from an air blast furnace. Concrete's resistance to permeability, permeability chemical attack, and other factors is increased when metakaolin is added to it to enhance its strength, endurance, and stacking density.

Review of previous studies

Davis (1937) examined many fly ash characteristics as Pozzolans and discovered that:

(i) The exact chemical composition of fly ash varies, but its carbon content is the primary factor that impacts concrete. Furthermore, research has shown that fly ash pieces are often finer and more spherical than cement particles.

(ii) Significant pozzolanic characteristics are shown by fly ash. Furthermore, it is possible to substitute as much as 30 of the concrete with fly ash, which has very little carbon and high fineness, in concrete that is normally wet-cured at temperatures ranging from 27 ± 20°C and 60% relative humidity.

(iii) After being damp-cured, fly ash may need Renewal to the extent of 50%.

(iv) The results are rather good when using an excessive grit mortar or a normal mortar with a high lime load.

(vi) Concrete that contains fly ash in addition to cement will function exceptionally well and have a greater early strength.

Haque et al.(1984) It was discovered that adding a significant amount of fly ash strengthened the concrete under compression. There was no discernible strength loss when comparing mixed with water-to-cement ratios using 0.40 and 0.50 in instances of hyper plasticized concrete. The presence that consistency of various admixtures seem to have an impact on how quickly strength varies. Furthermore, it was shown that high volume fly ash concret (HVFC) had greater workability compared to the slump test findings suggested. Within 40 minutes of the first test, all mixes showed a normal loss of approximately 25 to thirty feet (1 to 1.2 inches), and the no-slump concrete showed an HVFC feature as it stiffened nearer the conclusion of the casting duration. Additionally, for a certain aggregate-cement ratio, the compressive force of HVFC reduced as the fly ash concentration rose. An average slump loss of thirty-five millimetres (1 inch) was seen after a forty-minute period in the lab; a larger loss was likely experienced during the workability in real-world usage.

Berry et al. (1986) According to reports, fly ash concrete performed better when pumped than regular concrete and showed lesser bleeding and sedimentation under comparable circumstances. The dispersion achieved using fly ashes was consistent, as stated by Singh et al. High-Volume Ash Fly Ash Epoxy (HVFC) often has very little bleeding because it contains less water.

Ravina & Mehta (1986) Using two ASTM category and eight Ams Level C fly ashes, the research examined the effects of substituting thirty-five percent to of the concrete in slim mix grade in fly ashes affecting strength in compression. Based on test results, aggregate in a fly ash refill of between 35 to 50% attained the requisite intensity in 35 to 170 days, depending on the amount of renewal and the properties of the fly ash used.

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Parrott (1987) It has been found that a number of factors, including the degree of compaction, amount of atmospheric carbon dioxide, the duration of wet curing, permeability, which ambient the climate and humidity, mix %s, saturation extent and the presence of calcium hydroxide, influence how quickly concrete carbonates. The water-to-cement ratio (W/CM) stood out among these variables as being crucial in regulating the pace of carbonation. In general, the depth of carbonation was shown to decrease with a drop in W/CM. Increased wet curing times were beneficial for systems with sluggish reactivity, including those containing fly ash. This was explained by the fact that when internal relative humidity fell to around 80%, cement hydration in the exterior layers of drying concrete tended to stop. As a consequence, this circumstance increased the surface layers' porosity and permeability, which increased the pace at which carbon dioxide diffused.

Lame (1989) The effects of substituting varying quantities of fly ash (0 to 55%) for cement were examined in the research. Three assortments of Mix Grade were produced, each with a different water-to-cementitious material ratio (0.3, 0.4, and 0.5). Early on, it was found that fly ash made relatively little influence on strength. In comparison to the same quantity of Portland cement concrete, after three days the average drop in compressible strength was 16% for flying ash substitutes of 15% and 66% for flow ash equivalents of 55%. When compared to cement made with Portland cement mixes, the cohesion of fly ash mixes fell by 44% on average after 28 days, even with a 55% Renewal of fly ash. However, fly ash's later contribution to the advancement of Strength in compression was notable.

Sivasundereram et al. (1990) Some Mix Grade, particularly those with high cementitious material content, were found to have delayed setting because of an excess of naphthalene-based superplasticizer. This material is often used to guarantee appropriate workability in large quantities of Massive production fly ash concrete (HVFC). Furthermore, it was shown by Rao et al. that even at fly ash concentrations of 60% discovered that the concrete made from fly ash seemed more controllable than controlled concrete.

Reddy et al. (1994) The primary goal of the experiment was to determine how fly ash from the the Nellore area Electric Power Place affected six thin Mix Grade with supplementation quantities ranging from 10% to 50%. In comparison to reference concrete, fly ash concrete demonstrated a slower rate of growth in compressive property throughout the first 28 days. It did, however, surpass the reference mix in the subsequent periods, reaching 80% of its baseline activity at 90 days.

Naik et al. (1994) The research addresses the effects of fly ash type and amount on concrete's durability and strength. We assessed the strength's involuntary properties in flexural, elasticity, compression, and bending. The quantity and origin of fly ash were shown to have had an important impact on the concrete's strength and longevity. Additionally, 40% fly ash concrete's strength and durability was either superior to or identical to those of a typical 40% fly debris composite.

In all cases, fly ash concrete was either equally resistant to salt expansion as concrete without fly ash, or more so, unless a particular fly ash supplier had been used at a 60 percent level of renewal.

No matter how much fly ash was used, every combination satisfied the requirements for increased structural durability and strength. The research also looked at the concrete's strength in stress and resistance to scratch when fly ash was added to a maximum of 70 of the cement. The results showed that adding more fly ash to the concrete improved its strength under pressure and resistance to abrasion.

Malhotra et al. (1994) The quantity carbon in fly ash has been shown to be a major influence in determining the quantities of water required to generate concrete that is workable and mortar. For fly ash with a greater carbon content, more water is required to obtain a homogenous paste consistency. Remarkably, fly ashes with lower calcium content often have carbon levels that are 2–10% higher.

It has been shown that the variety of charcoal and the method of combustion utilised throughout the process affect the characteristics of fly ash.

Mehta (1998) shown that one of the most important factors was the strength of the surface to surface bond, which is also referred to as the conversion zone in Portland cement. This is because extremely massive crystals of Ca(0H)2 are present in this zone, finding room adjacent to the coarse particles as a result of the wall effect. Further discussion of the possibility of plastic shrinkage in significant quantities fly ash (HVFA) concrete was provided by Langley and Leaman (1998).

HVFA concrete has less bleed water to use in evaporation because of its low unit water content, which can worsen plastic shrinkage. In order to reduce the quantity of evaporated portion of water and lessen plastic shrinkage, they advised wet curing HVFA concrete right away after pouring.

Rangaswamy (1999) India launched the National Mission on the Management of Fly Ash Utilisation. Furthermore, the government of Andhra Pradesh ordered that fly ash from all of the state's thermal power plants be given to cement and construction material producers for free. Moreover, ash ponds that have been abandoned have been reclaimed by a number of nations and turned into playgrounds, parking lots, and grazing pastures.

Rao and associates (1999) The research found that fly ash mortar was more workable than regular concrete, even at a 50% fly ash component. Nevertheless, there was a little drop in flexibility when fly ash concentrations increased over 40%. Furthermore, it was shown that, although the aggregate-to-cement ratio remained constant, the strength under compression of Massive production fly ash composite (HVFC) dropped as fly ash concentration rose.

Gopalakrishanan et al. (2001) the research examined the durability and strength characteristics of ash-based brickwork with varying Renewal quantities of fly ash. It was found that adding fly ash to reinforced concrete at a 25% Renewal level improved the material's durability and resistance to corrosion while still enabling it to achieve the required strength requirements.

Krishna and others, 2002 Despite efforts made worldwide to utilize fly ash and the identification of various potential applications as well as attractive government incentives, it was stated that just a small % of fly ash was being employed in India. As a result, lagoons have seen a large buildup of fly ash, which has made the degradation of the land, water, and air worse.

In contrast, fly Ash has now been added to around 10% of the rock that is produced worldwide. Use of fly ash is very common in China, Denmark, Singapore, the Netherlands, and Hong Kong. Therefore, there is a great deal of opportunity to increase the usage of fly ash in concrete globally.

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4. METHODOLOGY

General

The present research set out to determine the effects of cementing the blend with fly ash and metakaolin (a) and employing ACBFS versus coarse particles on the concrete's flexural and stiffness in compressions. A brief description of the basic characteristics of the components that go into making concrete is given in this chapter, including met, fly ash, kaolin, mortar, and ACBFS. Additionally, it offers comprehensive guidance on the ingredients of concrete mixtures as well as the procedures for assessment, curing, and casting.

Test programme

Comparing the qualities of Mix Grade with plain cement and those with binary, secondary, and quaternary compositions in terms of the aforementioned attributes was the primary goal of this study. Included in the test programmed were the following tasks.

The goal of the inquiry was to ascertain, in compliance with relevant Indian Standards, the characteristics of the coarse, fine, and cement particulate components of concrete. The reference mixes (M30) for concrete was created by the study using the rules of practice specified in the course of the study, among them ARE 10262-2009. Different ratios of fly ash, metakaolin, and air blast chamber waste were employed to create ternary and quadri concrete combinations. After being cast, the samples were cured. The following mixes were assessed for strength in compressions: the starting point mix, a binary mix with fly ash, triple mix with ash from fly ashes or the mineral metakaolin.

Physical Properties of Materials

To ascertain the qualities of the different materials utilized in this research, laboratory tests were carried out in compliance with recognized standards of practice. Cement, metakaolin, are fly ash, air blast furnace byproduct, and both fine and coarse aggregate were among these components. The test findings and each material's characteristics are thoroughly described in the chapters that follow.

Cement

The concrete mixtures included ordinary Portland cement, also known as OPC, in the grade 43 (Ultratech) from a single lot. To ensure colour uniformity, lumplessness, and freshness, the cement was hand-picked. The cement was tested for normal uniformity specific gravity, starting and final setting periods, and compression strength at 3, 7, then 28 days in accordance with IS: 8112-2013 standards. Table 4.1 displays the results of these tests.

Table 4.1 Physical Properties of cement

Sr. No.	Properties	Experimental value	Specified Value asperIS:8112- 2013
1	Normal consistency	32%	-
2	G	3.11	3.12
3	Init. Set	110 min	Less than 35 min
4	Final Set.	250 min	<600 min
5	Strength in compression (Newton per mm2) 3 days 7days 28days	30 41 49	>25 >34 >44

Aggregates

Aggregates are essential to the strength, longevity, and general functionality of concrete. They are made up of coarse, inert elements that provide concrete body and aid in reducing shrinkage, improving its economy. The fine aggregate in the combination helps make it workable and homogenous.

It mostly travels down a 4.75 mm IS sieve. Additionally, it helps to keep the coarse aggregate particles suspended in the cement paste, which encourages plasticity and inhibits segregation. For the concrete mixture to have bulk, coarse aggregates—which are mostly filtered on a 4.75 mm IS sieve—are necessary. Based on their sieve sizes, fine and coarse aggregates are classified in accordance with IS: 383-2011 standards, indicating their different functions in the composition and functionality of concrete.

Fine Aggregates- The study's fine aggregate came from a nearby quarry called Burj Kotian, which is close to Chandimandir. The sand was well cleaned to remove any dust before it was used, and it was then dried. The characteristics of the sand were evaluated by laboratory testing, which included The analysis of sieves and other pertinent procedures. Table 3.2 provides a full overview of the sieve analysis findings, while Table 3.3 lists the sand's physical characteristics.

Table 4.2 Sieve Analysis of Fine Aggregates

Sieve Size	Retained Wight	Cum. Weight Retained	Cum. Weight Retained %	Percentage Passing	IS383-2011 Need for Zone-II
10	-	-	0	100	100
4.75	0	0	0	100	80-90
2.26	20	30	30	97	70-80
1.18	30	60	50	87	55-65
600	60	100	60	59	30-60
300	40	300	70	30	10-35
150	30	400	80	09	0-10
pan	10	1000	90	100	100

Cumulative % weight retained =218 Fineness Modulus (F.M.) = 2.18

Table 4.3 The fine aggregates' physical characteristics

Features	**Outcomes**
Assessing Niceness Gravity Specific Modulus	Grading Zone II
Absorption of Water (%)	2.5
Content of Free Moisture (%)	2.7
Features	.55
Assessing Niceness Gravity Specific Modulus	2.1

Coarse Aggregates- Two size fragments of coarse aggregates, 20 mm below ground level and 10 mm down, were acquired from a stone crushed at Burj Kotian, near Chandimandir, for use in the construction material mixes. These combined fractions were cleaned to get rid of any last bits of dirt and dust, and then they were surface dried. Laboratory testing, including a screening procedure and other relevant investigations, was conducted to assess the coarse aggregates' properties. To meet IS 383-2011 requirements, a 60:40 blend of crushed stone stones with thicknesses of 20 mm and a thickness of 10 mm was used. Table 4.4 presents a comprehensive summary of all the sieve analytical results, whereas Table 4.5 illustrates the physical characteristics.

Table 4.4 Sieve Analysis of Proportioned Coarse Aggregates

Sieve Size	Retained Wight	Cum. Weight Retained	Cum. Weight Retained %	Percentage Passing	IS383-2011 Need for Zone-II	Sieve Size
80	0	0	0	0	0	98
40	0	0	0	0	0	99
20	0	0	0	6.5	.18	87
10	738	4800	3309	3200	65	34
4.75	4200	100	1700	5000	98	.60
PAN	630	80	30	4000	-	-

Fineness Modulus (F.M.)= $\frac{0.108+64.704+99.408+500}{}$ = 6.64= 100

Table 4.5 The Coarse Aggregates' Physical Characteristics

Features	Outcome
Color	Grey
Type	Crushed
Shape	Rounded
G	2.7
W	2%
Fineness modulus	5.5
water (%)	-

Fly Ash

Ultratech Cement Corporation Pvt Ltd., Panchkula, supplied fly ash from the Guru Nanak Devi The core Power Plant (GNDTP) in Bathinda in in a single batch. The properties of fly ash were assessed using laboratory tests conducted by the Federal Soil nad Resource Research Laboratory from New Delhi & CBRI in Roorkee. The chemical and index properties of the fly ash are shown in Tables 4.6 and 4.7.

Table 4.6 Chemicalpropertiesofflyash

S.NO	Features Diminished upon igniting	Bathinda Fly Ash Value %, GNDTP
1	Silica (SiO2)	5.5
2	Iron Oxide (Fe2O3)	56.45
3	Alumina (Al2O3)	43.34
4	Features Diminished upon igniting	5.34

Table 4.7 Index characteristics of Bathinda fly ash and GNDTP

S.N.	Property	Value	Requirements as per code provisions
1	Density	1000	
2	Surface Area	400.6	.320
3	G	2.03	-
4	Reactivity	4.8	4.5
5	Strength	85	Not less than 80%

Metakaolin

Metakaolin is a white, amorphous, very reactive aluminum silicate pozzolan that, when combined with marble in water, produces stable hydrates and provides the hydraulic qualities of mortar. The main chemical component of the procedure, kaolinite (Al2O3.2SiO2.2H2O), is heated in clay to temperatures ranging from 500°C to 600°C. This results in the structural water being lost, which deforms the crystalline framework of kaolinite and forms metakaolinite, an anhydrate reactive form. Tables 3.8 and 3.9 list the chemical nature and physical properties of metakaolin, demonstrating its distinct chemical composition, which is mostly made up of 58.03% SiO2 and 36.32% Al2O3. The product has a distinct particle size distribution on the physical level.

Table 4.8 Chemical properties of metakaolin

SiO_2	58.03%	Al_2O_3	36.32%
Fe_2O_3	0.95%	TiO_2	1.3%
Cao	0.06%	MgO	0.36%
Na_2O	0.12%	K_2O	0%
LOI	2.85%	SO_4	0.5%

Table 4.9 Metakaolin's Physical Characteristics

Specific gravity	2.40to2.60
Physical form	Powder
Colour	Light Pink
Brightness	80-82Hunter L
BET	15m^2/gram
Specific surface	8-15 m^2/g

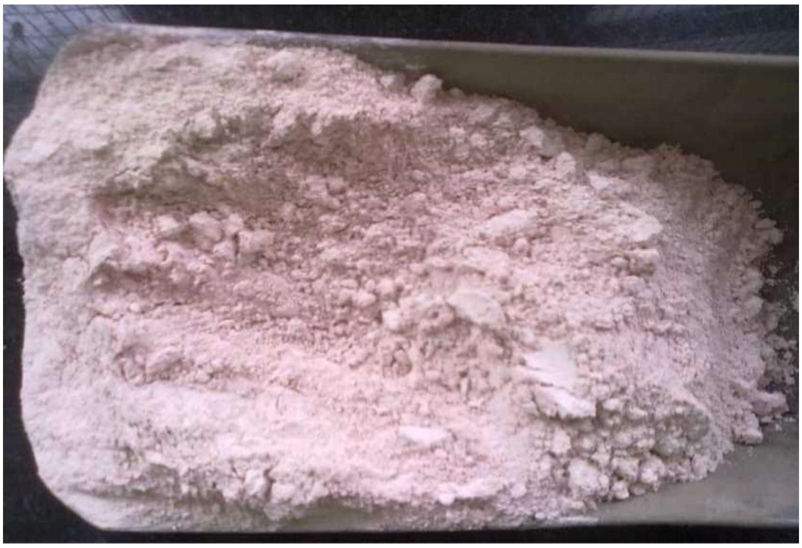

Plate 4.1 Meta kaolin sample

The metakaolin utilized in this investigation came from Jeetmull Jaichandlall (M) Pvt Ltd, a company located in Chennai. As Plate 3.1 shows, it was rather rosy. In Morbi, Tamil Nadu, the National Polyester Centre investigated both its physical and chemical characteristics.

Super plasticizer

In this investigation, a super plasticizer named "Fosroc Complots SP430G8" that was purchased from M/s Fosroc Companies Pvt Ltd. in Chandigarh was used. Table 3.10 provides a complete list of the super plasticizer's attributes as supplied by the provider. Through on-site studies with the concrete mix, the ideal dose was established, allowing for evaluation of the impacts on workability, strength increase, or cement reduction. "Fosroc Conplast SP430G8" is a brown liquid super plasticizer that dissolves quickly in water. It is made of sulphonated naphthalene compound formaldehyde polymers. Its unique design enables it to generate high-quality concrete with less permeability while maintaining substantial water savings of up to 25% without sacrificing workability. Its primary goals are to produce denser, close-textured marble with less porosity, which results in increased durability, and to improve workability and strength.

Table 4.10 Propertiesof Super plasticizer

S.NO	Test	Values obtained	Limit as per IS9103:1999
	Gravity	2.1	0.02 of the manufacturer's claimed value
	pH	6.9	Minimum: 6
	Dry Material	50.1	.00 5% of the manufacturer's declared value (%by mass)
	Chloride Content	.023	Within 10% of the value or inside

Water

In the current investigation, the specimens were cast and cured using potable tap water from the P.G. Building Engineering Laboratory. This water supply is typically suitable for producing and curing concrete since it satisfies the requirements stated in IS: 456-2000.

5. RESULT

Results

Strength in compression

The impact of fly ash on concrete's Strength in compression was examined under a couple of **Renewal Scenarios:**

- A binary mix formed by fly ash partly replaces cement.
- Metakaolin partly replaces fly ash to make a ternary mix.
- The quaternary mix formed by ACBFS replaces coarse aggregates.

Figures 5.2 and 5.1 With varying amounts of fly ash substituted by ACBFS, both figures show the variations in masonry shear toughness at different wet curing times of fourteen days as well as twenty-eight days. Tables 4.1 to 4.6 provide the findings of durability in compression tests carried out with 25% fly ash substituted for partly cement and with different percentages (20%, 40%, or 60%) of finer stones substituted with rainy curing periods of 7 and 28 days.

Table 5.1: Strength in compression (Mixture Reference)

S.NO.	Mix Design	Curing in days.	Failure Load	Comp Strength. Newton per mm2	Avg. Strength Newton per mm2
1	M0	7	577.3	25.66	26.01
			587.7	26.12	
			590.4	26.24	
2	M0	28	866.7	38.52	38.48
			877.7	39.01	
			852.9	37.91	

Table 5.2: Strength in compression (M1-cement replaced by 25% flyash)

S.NO.	Mix Design	Curing in days.	Failure Load	Comp Strength. Newton per mm2	Avg. Strength Newton per mm2
1	M1	7	379.3	16.86	16.06
			365.4	16.24	
			339.5	15.09	
2	M1	28	647.3	28.77	28.92
			642.6	28.56	
			662.4	29.44	

Table 5.3: Strength in compression

(M2-Cement is swapped out for 25% fly ash and 20% ACBFS for coarse aggregate.)

S.NO.	Mix Design	Curing in days.	Failure Load	Comp Strength. Newton per mm2	Avg. Strength Newton per mm2
1	M2	7	490.6	21.8	20.93
			465	20.7	
			457	20.31	
2	M2	28	818.1	36.36	34.58
			699.7	31.10	
			816.5	36.29	

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Table 5.4: Strength in Compression

(M3Fine aggregate replaced by 40% ACBFS; cement replaced by 25% fly ash)

S.NO.	Mix Design	Curing in days.	Failure Load	Comp Strength. Newton per mm2	Avg. Strength Newton per mm2
1	M3	7	498	22.13	21.29
			488	21.69	
			451	20.05	
2	M3	28	813.7	36.16	35.82
			811	36.05	
			793	35.24	

Table 5.5: Strength in Compression

(M4-Fly ash replaces 25% of cement, coarse aggregate replaces 60% of ACBFS.)

S.NO.	Mix Design	Curing in days.	Failure Load	Comp Strength. Newton per mm2	Avg. Strength Newton per mm2
1	M4	7	530	23.56	22.92
			510	22.67	
			507	22.53	
2	M4	28	830	36.89	36.3
			813	36.13	
			807	35.87	

Table4.6: Compression strength for varying cement Renewal amounts by flying as hand ACBFS

Mix Designation	% Renewal by fly ash%	% Renewal by ACBFS%	Strength in Compression (Newton per mm2)	
			Curing Period (days)	
			7	**28**
M0	0	0	26	38
M1	25	20	15	28
M2	25	40	20	36
M3	25	60	22	36
M4	25	70	23	37

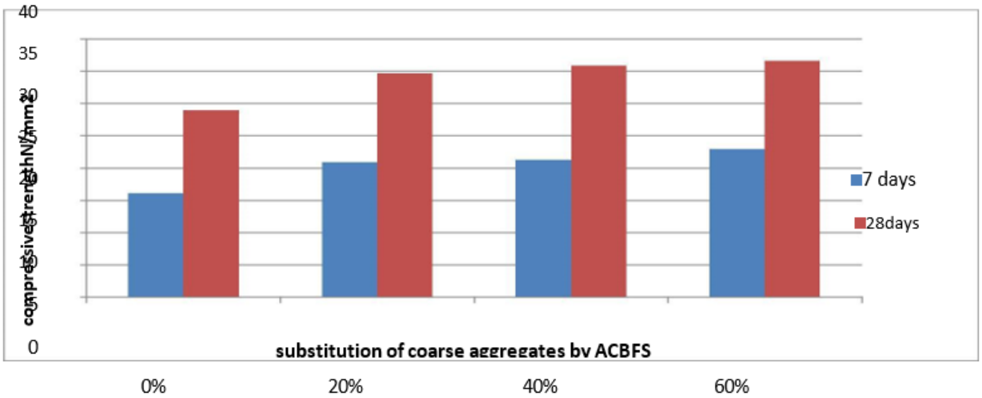

Fig4.1: Stress strength and the percentage of ACBFS-replaced coarse aggregate in fly ash-based concrete

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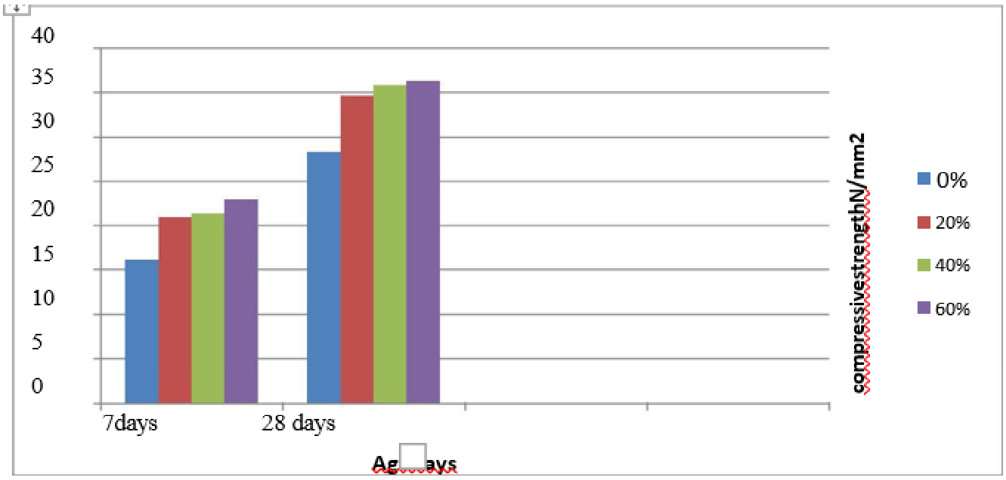

Fig.4.2: Compression strength in fly ash concrete at various coarse aggregate Renewal levels by ACBFS.

As can be seen in Tables 4.6 through Photos 4.1 and 4.2, the final binary blend with fly ash had a lower Strength in compression after seven days than the original mix. Additionally, after a month, the laminate mix's strength at compression was lower than the mix's strength without fly ash for all replace quantities of ACBFS. When lime in both cement and sand clinker interact, C-S-H gel is produced, which might account for the increased Strength in compression seen in triple Mix Grade incorporating fly ash + ACBFS outside of specific Renewal levels..

After 28 days, the baseline mix (M0) revealed a compressive force of 38.48 MPa. With varying proportions of ACBFS (0%, 20%, 40%, etc 60%) and fly ash concentrations ranging from 0% to 25%, the fly ash Mix Grade produced strengths of 28.92MPa, 34.58 metres per second, 35.82meters per second, and 36.30MPa, in that order.

The highest reduction in Strength in compression is seen in concrete holding 25% flyash, as shown in Figures 4.1 and 4.2. The maximum strength of the reference mix was seen at 7 and 28 days, however.Flyash concrete toughened more swiftly after 28 days than it did within the first age of time because of the pozzolanic impact of the fly ash.

Less cement in the form of fly ash was used, which reduced the cohesiveness of the paste made from cement and the adhesion of the particles to the aggregate, lowering the material's compressible strength at younger ages. At the peak of OPC's hydration, over 75% of the constituent minerals solidify and become distinguishable. Nevertheless, when fly ash replaces cement, the excess $Ca(OH)_2$ does not materially increase strength because fly ash's cementitious power does not start the chemical reaction. Furthermore, the extra lime produced by OPC hydration catalyses pozzolanic reactions, which eventually result in secondary hydrated nanoscale and greater strength. By fine-tuning the action by grains and pores, this reaction promotes a robust transition region and increased strength. Together, the two hydrated mineralogy modalities provide these outcomes..:

By creating a packing effect and so improving physical qualities, the unreactive portion of fly ash adds to the hydrated cement paste's microstructure. According to research by Lewandowski, R., a delayed pozzolanic reaction may cause as much as 50% of level F fly ash to stay unreacted for nearly a year. Consequently, it is possible to think of the unreactive component as a microaggregate that increases strength. Nevertheless, even if the unreactive part of fly ash contributes via the packing effect, it's important to remember that the reactive fraction of fly ash determines strength. Thus, it was expected that after 28 days, fly ash concrete's Strength in compression would rise dramatically. Additionally, Figures 4.3 to 4.8 illustrate how the relative amounts of ash from fly ash, ACBFS, plus metakaolin (a affect Strength in compression as a function of age.

6. CONCLUSION

- The findings of this experiment led to the following conclusions: i. The concrete's compressive and flexural strengths decreased at 7 and 28 days when flyash was partially substituted for cement. After 28 days, the Strength in compression and flexural strength of the flyash-replaced 25% of the cement mix were 17% and 25% lower, respectively, than the reference mix.
- After seventeen and twenty-eight days, the grout's flexural and compressive characteristics were enhanced by the addition of slag from an air blast furnace that had been cooled. The fraction of cooled blast furnace slag that was made of air grew along with the tension and flexural strengths. Specifically, a mix of 25% fly ash and 60% air-cooled furnace slag (M4) demonstrated a maximum improvement of 25% in compressive force and 8% in flexural stiffness in contrast to the reference mix (M0)

- Concrete's flexural and Strength in compressions improved when metakaolin was partially substituted with lyash. Furthermore, when the amount of metakaolin grew, the mixes' intensity increased.
- The mixture with the greatest compression and flexural strengths was made up of 60% ventilated blast furnace slag, 15% metakaolin, and 10% flyash (M16).
- It is possible to substitute coarse aggregate with air-cooled blast furnace slag and replace cement with a mixture of fly ash and metakaolin. A cost comparison involving the reference mix (M0) and a blend that has 10% metakaolin, 15% of fly ash, and 60% air-cooled slag from a blast furnace (M12) serves as an example of this.

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