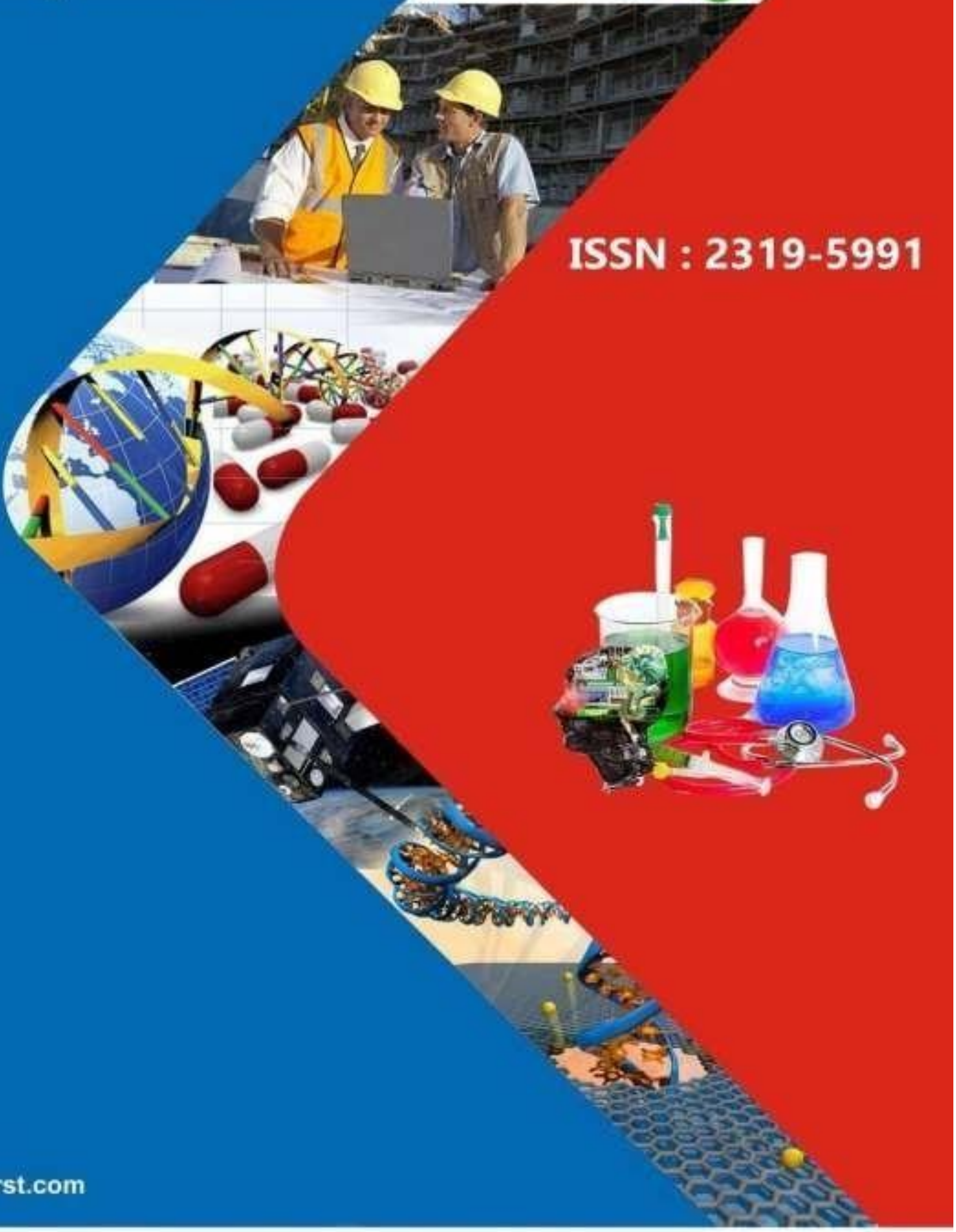
IJERST

International Journal of Engineering Research and Science & Technology



ISSN : 2319-5991

www.ijerst.com

Email: editor@ijerst.com or editor.ijerst@gmail.com

EXPLORING HIGH STRENGTH CONCRETE WITH PARTIAL CEMENT REPLACEMENT BY FLY ASH AND SAND SUBSTITUTION WITH STONE DUST: AN EXPERIMENTAL INVESTIGATION

[1]Md.Abdul Muneer,[2]Illangi.Vinod Kumar,[3]Banothu.Ramcharan Teja,[4]G.Arigasathya Priya
[123]Assistant Professor,[4]Student
Department of Civil Engineering
Abdul Kalam Institute of Technological Sciences,Kothagudem,Telangana

ABSTRACT

Since cement, a substance that generates a lot of carbon dioxide, makes up the bulk of concrete, it has a significant environmental impact. By reducing the amount of cement used as much as feasible by the inclusion of mineral additives like fly ash, concrete building may be made with less of an environmental effect without compromising durability requirements. One of the most urgent environmental problems is the disposal of fly ash, which is created by power plants that burn coal for fuel. It is even more difficult to find a solution to this issue when fly ash production increases and landfill capacity decreases at the same time. This paper analyzes and discusses the fly ash admixed concrete study. Numerous research investigations have been carried out about fly ash concrete and its advantages. This research examines the mechanical qualities, durability metrics, and microstructural details of fly ash concrete both while it is new and after it has hardened. Furthermore included is a summary of the helpful fly ash concrete application case studies provided by the American Coal Ash Association.

I. INTRODUCTION

1.1. General

In India, most families spend their life savings to build a beautiful home, making sustainability development the most important strategy for the country. To achieve this, we must work on effective building materials, particularly concrete, that are both affordable and of high quality. More research is needed in this area. As a material replacement in the concrete, I looked into the area of rock waste generated by the product.

Construction activity is increasing at a rapid pace, and the available sources of natural sand are becoming depleted. The only solution is to search for alternatives materials that can fully or partially replace naturally available materials in construction such as stone dust and cement. Fly ash, a byproduct of coal combustion, is being used to partially replace cement in some applications of concrete. This technique improves the performance of concrete while also being cost-efficient. In this project, we attempted to use fly ash in conjunction with stone dust and discussed the various mechanical properties of concrete such as compressive strength, tensile strength, flexural strength, and flexural strength by partially replacing fly ash with cement and partially replacing fine aggregate with stone dust in a concrete mix.

1.2. Pozzolanic Materials

Simply put, pozzolanas, also known as pozzolans, are materials which are not cementitious in themselves but include components that react with lime at a normal temperature and in the presence of water to provide cementing characteristics, despite the fact that they are not cementitious in themselves. Or Generally speaking, pozzolanic materials are finely divided siliceous and aluminous materials that have little or no cementitious value. When exposed to moisture at room temperature, they chemically react with calcium hydroxide released during hydration to form compounds with cementitious properties. Engineering benefits that may be derived from the use of pozzolanas in concrete include improved resistance to thermal cracking because of lower heat of hydration, increased ultimate strength and impermeability due to pore refinement, and improved durability against chemical attacks such as acid, sulphate water, and alkali-aggregate expansion, among other things.

Pozzolana: When the pozzolana reaction occurs, the lime generated during the hydration of C3S and C2S is converted into calcium silicate hydrate. In terms of mechanical strength characteristics and durability, this may be regarded to be the weakest link in the chain of hydration products of Portland cement. In the hydration process of mixed cement and pozzolan, C-S-H gel and Sulfoaluminates are produced. (See Figure 1). However, a pozzolanic reaction develops considerably more slowly than the hydration of Portland cement at room temperature, yet a water-cured concrete that includes a pozzolan develops greater strength over time while experiencing decreased permeability with time. Pozzolanas are divided into two groups, which are artificial pozzolanas and natural pozzolanas. The artificial group consists of fly ashes, silica fume, calcined clays and shales, metakaolin, and rice-husk ash,

ISSN 2319-5991 www.ijerst.com
Vol. 11, Issue 4, 2018

whereas the natural group consists of volcanic ashes, volcanic tiffs, trass, and zeolites. The natural group also contains calcined clays and shales, metakaolin, and rice-husk ash. The heating of natural pozzolans to temperatures ranging between 500 and 8000 degrees Celsius increases their pozzolanic reactivity (Malhotra and Malhotra, 1996). Sections 2 and 3 of this document describe the minerals that are employed as pozzolaonas, respectively.

1.3. Types of Pozzolanas:

1.3.1. Natural pozzolans

Natural pozzolanas are mostly composed of volcanic dust and ash, and the word "pozzolana" is derived from the Roman town of Pozzuoli, located in the slopes of Mount Vesuvius, which was a source of zeolitic tuff. Natural pozzolans such as clay and shale, diatomaceous earth, and other similar materials are treated via a process that includes crushing, grinding, and size preparation, as well as heat activation if required. Natural pozzolans have declined in popularity as a result of the advent of more active pozzolans that are now accessible to consumers.

1.3.2. Artificial pozzolanas (pozzolanas made of clay)

A variety of industrial by-products, such as burned diatomaceous earth and 'rice husk ash', as well as ground granulated blast furnace slag, micro silica, nano silica, and metakaoline, are used to make artificial pozzolanas. Artificial pozzolanas are simply clay and (including some brick) shale that has been burned.

1.4. Fly ash (also known as pyroclastic flow):

The use of fly ash in building has been steadily increasing in popularity over the past several decades, owing to the considerable improvements in material performance that it has shown. Several recent research have contributed to a better understanding of the function of fly ash in the cementitious matrix. This comprises the hydration of the cement, the mechanical characteristics of the concrete, and the microstructure of the concrete. Some of these impacts, on the other hand, are still not completely understood. The analysis of the nano-structure of the cementitious matrix in order to assess its impacts on concrete performance utilising sophisticated characterisation methods is also included in this project. Trimukth MinChem provided the fly ash for this experiment (Hyderabad). Specific gravity and bulk density of this fly ash were determined in the laboratory setting. Aside from the chemical and physical characteristics, Trimukth MinChem was consulted for the rest of the information (Hyderabad).

Fig 1.1 : Fly ash

1.5. Stone Dust

Stone dust is a byproduct of the crushing process that is produced from crusher facilities. A portion of it has the potential to be utilised in concrete as a partial substitute for natural river sand. It is possible to use quarry dust in concrete mixes as a good substitute for natural river sand, providing higher strength at a 50 percent replacement rate for natural river sand. This not only improves the quality of the concrete, but it also helps to conserve natural river sand for future generations (Balamurgan et al., 2013). When crushed stone dust is used as fine aggregate in concrete, it has been discovered that the compressive, flexural, and tensile strengths of the concrete are all increased significantly (Nagpal et al., 2013). It has been discovered that stone dust may be used to substitute fine aggregate in a ratio of 40 percent to 60 percent (Franklin et al., 2014). A 5-22 percent increase in the compressive strength of concrete was observed when natural sand was substituted with crusher dust. It was also discovered that among all of the mixes, the highest compressive strength was obtained when 40% of the natural sand was substituted with crusher dust (40 percent replacement of sand by crusher dust) (Quadri et al., 2013). Natural sand was unable to produce the necessary slump when used in conjunction with the specified parameters of the mix design. It was accomplished, however, by using manufactured sand of appropriate form and surface texture, as well as desired grading to reduce the amount of void content present, a highly workable mix with the specified parameter of mix design was obtained (M S Shetty, 2013). The compressive strength of concrete produced from stone powder was found to be 14.76 percent greater than the compressive strength of concrete manufactured from ordinary sand (Mahzuz et al., 2011). It has been discovered that the compressive and flexural strengths of concrete produced from Quarry Rock Dust are approximately 10% higher than the compressive and flexural strengths of conventional concrete (Suribabu et al., 2015). It is suggested in the current research to explore the optimal replacement of river sand with stone dust for concrete in terms of compressive strength performance at 7 days and 28 days after installation.

1.6. The purpose of the current research

The purpose of this study is to compare the M40 grade of concrete by partially replacing fly ash with cement and partially replacing fine aggregate with stone dust in order to determine the compressive strength, tensile strength, and flexural strength of concrete by replacing 50% of fine aggregate with stone dust.

OBJECTIVE OF THE STUDY

To investigate the different mechanical characteristics of concrete, such as compressive strength, tensile strength, and flexural strength, by partially replacing fly ash with cement and completely replacing fine aggregate with stone dust.

II. EXPERIMENTAL INVESTIGATION

2.1 INTRODUCTION

With the current research, the mechanical characteristics of concrete containing fly ash (0, 5, 10, 15, and 20% by weight of cement), stone dust (50 percent by weight of fine aggregate), and fine aggregate (50 percent by weight of fine aggregate) with concrete grade M40 are being investigated.

Targeted mix design M40		
Mix	Fly Ash percentage (by weight of cement)	Fine aggregate
Mix 1	0 %	River sand
Mix 2	0%	River sand replaced with Stone Dust 50%
Mix 3	5%	
Mix 4	10%	
Mix 5	15%	

Table No. 2.1 Mix Proportion percentages

2.2 Materials

2.2.1.Cement

The cement for the whole project was purchased in a single consignment and kept in a secure location. Ordinary Portland cement (53 grade) in accordance with IS:12269 was used in the construction. Cement (IS: 12269, 1987) was used in the study and the characteristics of the cement are shown in the table below.

s.no	property	Test results
1	Fineness	96%
2	Normal consistency	30%
3	Initial setting time	38 min
4	Final setting time	600 min
5	Specific gravity of cement	3.14
6	Compressive strength at 7 days 28 days	 34.1 N/mm2 55.2 N/mm2

Table: 2.2.1 Physical properties of ordinary Portland cement (OPC 53 grade)

2.2.2. Properties of fly ash:

The chemical composition and physical characteristics of Indian fly ashes are more variable than those of other fly ashes. Some of the characteristics of fly ash that have an impact on the strength and quality of concrete are described in more detail below:

a) Fineness:

The fineness of fly ash is a significant physical feature that has a greater impact on the activity of fly ash than any other physical component in the environment. Specific surface area is usually calculated using the air permeability technique and represented as a percentage of the total surface area. It has a range of 2194 to 6842cm2/gr (cm2/gram). According to appearances, the Indian fly ashes made in our nation are very good and similar to those produced in other countries.

When comparing Indian fly ashes to foreign fly ashes, sieve analysis reveals that the Indian fly ashes are coarser in texture. For example, although the majority of American fly ashes and more than 80 percent of the material passing the 45-micron IS sieve were found to fall into this group, just three Indian fly ashes were discovered to fall into this category. Some of the causes for this may be linked to the fact that fly ash is removed by mechanical collectors in the majority of Indian thermal power plants, and even this fraction gets mixed up with the corner fractions collected in the middle or bottom hoppers of the plants.

b) Particle Size :

Ashes from flying insects have been discovered to include black particles that are angular as well as spherical, as well as spheroidal glass and minute quartz grains.

The fractions that passed through the 45-micron filter included some rounded block particles as well as a significant amount of spheroidal glass. Particles are black (rounded) and quartz grains in ashes that have been maintained at a size greater than 150 microns or 75 microns. When compared to American fly ashes, the quantities of spheroidal glass (8-38 percent) in Indian fly ashes are much lower (50-90 percent).

c) Pozzolonic Activity :

The lime reactivity test is used to ascertain this value. In order for fly ash to be deemed acceptable for use as a pozzolon, it must demonstrate in the test that its lime reactivity test strength is more than 40 kg/cm2 on the basis of the test. The pozzolonaic activity of Indian fly ashes was shown to be very high. However, as compared to American fly ashes, Indian fly ashes are much less reactive. For example, when the bulk of American fly ashes were utilised as a 20 percent substitution of cement by weight, the compressive strength of the cement motor was 100 percent or more than the compressive strength of the equivalent aircraft motoris after just 90 days. When compared to this, none of the Indian fly ashes employed as a 20 percent substitution of cement by weight were found to be comparable to the compressive strength of the matching plane cement motor (1:3 cement-sand) even after one year of operation. Because Indian fly ashes respond less aggressively than foreign fly ashes

2.2.3. Use of fly ash in Concrete:

The most common application of fly ash is in the production of Portland pozzolona cement or in the partial replacement of cement.

When the oxides in the raw materials are exposed to high clinkering temperatures, they mix to create complex compounds in the cement manufacturing process. The following are the four main compounds:

I) Calcium silicate tricalcium (3CaOSiO2)

(ii) Dicalcium Silicate (2CaOSiO2)

(iii) Tricalcium Aluminate (3CaOAl2O3)

(iv) Tetra Calcium Alumino Ferrite (Tetra Calcium Alumino Ferrite) (4CaOAl2O3Fe2O3)

The most significant compounds responsible for strength are C3S and C2S. They make up 70 to 80 percent of cement when combined. Calcium silicate hydrate and calcium hydroxide are produced when C3S and C2S react with water.

$$2(3CaO.SiO_2)\ +6H_2O \qquad 3CaO.2SiO_2.3H_2O\ +3Ca\ (OH)_2$$

$$2(2CaO.SiO_2)\ +4H_2O \qquad 3CaO.2SiO_2.3H_2O\ +Ca\ (OH)_2$$

The calcium hydroxide that is so released has no effect on the strength. Furthermore, it is water soluble and is leached away, making the concentrate porous. As a result, this is a bad product. At usual temperatures, finely split fly ash reacts chemically with Ca (OH) 2 to produce compounds with cementitious characteristics, decreasing the detrimental effects of Ca (OH) 2. As a result, fly ash, which is a waste product with a significant disposal issue, is put to good use.

2.3. Aggregates

The aggregate size, shape, and gradation all play a part in producing appropriate concrete. The aggregate size will be determined by the rebar spacing.

The coarse aggregate selected has an angular form, is highly graded, and has a maximum size that is lower than that required for traditional concrete. The aggregate size in ordinary conventional concrete should not exceed 20mm. When selecting a coarse aggregate, grading is a crucial consideration.

2.3.1. Fine aggregate

In this study, the fine aggregate is made using locally accessible sand. Clayey materials, salts, and organic contaminants are absent from the sand. Sand has a specific gravity of 2.72 and has a fineness modulus of 2.56.

S.No.	Property	Test results
1	Specific gravity	2.62
2	Fineness modulus	3.64

Table: 2.3.1. Properties of Fine aggregate

Sieve Analysis is carried out for Fine aggregate as per IS:2386(part-III)-1963

s.no	Sieve size	Weight retained	% retained	% cumulative retained	% fineness
1	4.75mm	2.310	0.46	0.462	99.543
2	2.36mm	7.521	15.254	1.964	98.054
3	1.18mm	128.111	25.626	27.585	72.423

4	600 microns	153.312	30.666	58.249	41.765
5	300 microns	183.965	36.784	95.028	4.983
6	180 microns	23.424	4.685	99.775	0.325
7	150 microns	0.332	0.0614	99.762	0.244
8	75 microns	0.321	0.0644	99.829	0.187
9	Pan	0.201	0.0412	99.864	0.143

Table: 2.3.2 sieve analysis of sand

2.3.2. Stone dust

A nearby crushing mill provided the stone dust utilised in the laboratory experiments. Stone dust has a specific gravity of 2.5.

Stone dust is subjected to sieve analysis in accordance with IS:2386(part-III)-1963.

IS sieve size	Weight retained (kg)	Cumulative weight retained (kg)	Cumulative percentage retained	Cumulative percentage passing
4.75mm	0.16	0.16	16	84
2.36mm	0.174	0.334	33.4	66.6
1.18mm	0.201	0.53	53.5	46.5
600 micron	0.151	0.68	68.6	31.4
300 micron	0.189	0.87	87.5	12.5
150 micron	0.102	0.97	97.7	2.3
75 micron	0.02	0.99	99.7	0.3
pan	0.003	1	100	0

Table: 2.3.3 Sieve Analysis of Stone Dust

Fig. 2.3.4 Pycnometer with wet Stone Dust and Stone Dust in a try

2.4. Water

The concrete was made and cured using the tap water available in the concrete laboratory.

2.5 Superplasticizer

FORSOC chemical India ltd utilised and produced the superplasticizer CONPLASTSP430. Cement concrete contains this chemical additive. The increased workability has no effect on any strength or microstructure properties, but it does improve workability.

2.6.Mix proportions In the laboratory,

The quantities used in the mix preparation are determined according to the requirements of IS:10262: 2009.

Design specifications for concrete of the M40 grade

2.7. Grade Designation: M40

Type of cement: OPC-53 grade

Fine Aggregate: zone-2

2.8. Specific gravities:

Material	Cement	FA	CA(20mm)	Stone Dust
Specific gravities	3.14	2.62	2.64	2.5

Table 2.4: Specific gravities of different materials used

2.9. Summary of Mix proportions for M40 grade concrete

S.NO	Material	By Weight/m^3
1	Cement	420.01 kg/m^3
2	fine aggregate River sand Stone dust	714.1 kg/m^3 357 kg /m^3 357 kg/m^3
3	coarse aggregate	1162.6 kg/m^3
4	Water	174 kg/m^3
5	super plasticizer **(**CONPLASTSP430**)**	1% (by weight of cement)
	Water cement ratio	0.41

Table 2.5.: Mix proportions for M40 grade concrete

2.10. Preparing of test specimens

Quantities of material required per 1m3 of M40 grade concrete as required

Test specimen	cement in kg	Fly ash kg	F.A in kg	River sand (50%) in kg	Stone dust (50%) in kg	C.A in kg	Water in kg	Super plasticiser in kg
M1	420.01	0	714.1	0	0	1162.6	174	4.2
M2	420.01	0	0	357	357	1162.6	174	4.2
M3	411.6	21	0	357	357	1162.6	174	4.11
M4	407.4	42	0	357	357	1162.6	174	4.07
M5	403.2	63	0	357	357	1162.6	174	4.03

Table 2.6 : Quantities of material required per 1m3 of M40 grade concrete

2.11. Mixing

The materials are mixed in a revolving drum. Trowels are used to thoroughly mix the ingredients by hand. Wet mixing continues until a consistent colour and consistency is obtained, at which point the specimens may be cast.

2.12 Adaptability

With the use of superplasticizer, a slump of 10mm to 20mm is achieved for concrete workability..

Fig. 2.7 True Slump

2.13. Compaction

Compaction is the process of releasing trapped air from newly laid concrete and compacting the aggregate particles to improve the density of the concrete. Concrete compaction is an essential part of the concrete laying process. If compaction is not done properly, a succession of flaws may appear, and the concrete will lose a considerable amount of strength. In this experiment, an immersion vibration, also known as a needle vibrator, is utilised to achieve complete compaction and maximum density.

2.14 Casting of specimens

Before concrete is poured into the cast iron moulds, dust particles are removed and mineral oil is applied to all surfaces. The cubes are 150mm x 150mm x 150mm, the cylinder is 150mm x 300mm, and the beams are 100mm x 100mm x 500mm. The moulds are set on a flat surface. Vibrations using a needle vibrator fill the moulds with well-mixed concrete. With a trowel, excess concrete was removed, and the top surface was levelled and smoothed.

ISSN 2319-5991 www.ijerst.com

Vol. 11, Issue 4, 2018

Fig. 2.8. Split Tensile test Specimen

2.15. Curing of the specimen

After casting, the specimens are kept undisturbed at room temperature for approximately 24 hours. After that, the specimens are taken from the moulds and placed in a curing pond with clean and fresh water for 28 days.

2.16 Specimen analysis

After 7 days and 28 days of cure, the cast specimens are tested. The test findings are meticulously tabulated.

Tests conducted

2.16.1 Compression Test

The most significant property of hardened cement is its compressive strength. As a result, it's not unexpected that the strength of cement is usually evaluated in a laboratory before it's utilised in major projects. Concrete's main function in most structural applications is to withstand compressive stress. After 7 and 28 days of curing, a series of standard concrete cubes 150mm*150mm*150mm are evaluated in a compressive testing machine. At least three specimens, preferably from separate batches, must be produced for testing. The test is carried out in accordance with IS: 516-1959. The compressive strength of a specimen is determined by dividing the load by the area of the specimen, and the results are shown below.

$$Fc = P/A mm^2$$

Where,

P = cube compressive load affecting failure

A = cross section area of cube in mm^2

Fig. 2.9. Compressive Strength Test

2.16.2 Split Tensile Strength

One of the most fundamental and essential characteristics of concrete is its tensile strength. The design of concrete structural components requires an understanding of their importance. Concrete's direct tensile strength is difficult to establish. It is an indirect technique of determining concrete ensile strength. The specimen's length must be no less than the diameter and no more than twice the diameter. The specimen must be a cylinder with a diameter of 150mm and a length of 300mm. For testing, at least three specimens must be produced, preferably from separate batches. The test is carried out in accordance with IS: 516-1959. The base plate must be 6.5mm thick so that it does not protrude more than 0.02mm from the plant surface. The load is delivered to a cylinder that is positioned horizontally between the compressive testing machine's two plates. After 7 days of curing and 28 days of cure.

$Fst = 2P/PI LD mm^2$ Where,

Fst = Split tensile strength N/mm^2, P = maximum load in N , L = length of specimen

D = cross section diameter

Fig. 2.10. Split tensile strength Test

Fig.2.11. Flexural Test

2.16.3 Flexural strength test

The flexural test is used to determine the tensile strength of concrete. It examines the capacity of an unreinforced concrete beam to resist bending failure. It's worth noting that the two-point load test yielded the modulus of rupture value. The specimen was casted and will be 100mm * 100mm * 500mm to investigate the bending movement of concrete under two-point stress. The modulus of rupture is the highest tensile stress measured at the failure of a beam and is calculated. The modulus of rupture is used to represent the specimen's flexural strength (Fb). It's also calculated after 7 and 28 days of cure. For testing, at least three specimens must be produced, preferably from separate batches. The test is carried out according to IS: 516 – 1959, which states that if the distance between the line of action and the closer support is equivalent, it must be computed to the closest 0.5 kg/sq mm on the tensile side of the specimen.

$Fb = PL/aD^2$ N/mm^2

When a is greater than 200mm for 150 mm specimen or greater than 133 mm for a 100mm specimen, or

$Fb = 3Pa / bd^2$

When a is less than 200mm but greater tha 170mm for 150mm specimen, or less than 133mm but greater than 110mm for 100mm specimen

Where,

Fb = modulus of rupture

B = measured width of specimen

D= measured depth of specimen at the point of failure

L= length of the span on which the soecimen was supported

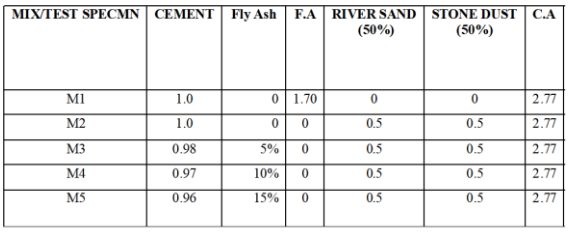
P = maximum load applied to the specimen

III. EXPERIMENTAL RESULTS

For M40 concrete of various specimens for 7 and 28 days of curing The purpose of this research is to determine the mechanical characteristics of concrete including Nano silica (2%, 3%, and 4% by weight of cement), stone dust (50%) and marble powder (50%) by weight of fine aggregate.

Targeted mix design M40 Test Specimens	
Fly Ash replacement percentage (by weight of cement)	
M1	0
M2	0 (with F.A 50%+50%)
M3	5%
M4	10%
M5	15%
Fine aggregate	River Sand 50% Stone Dust 50%

Table 3.1 : Targeted mix design M40 Test Specimens



MIX/TEST SPECMN	CEMENT	Fly Ash	F.A	RIVER SAND (50%)	STONE DUST (50%)	C.A
M1	1.0	0	1.70	0	0	2.77
M2	1.0	0	0	0.5	0.5	2.77
M3	0.98	5%	0	0.5	0.5	2.77
M4	0.97	10%	0	0.5	0.5	2.77
M5	0.96	15%	0	0.5	0.5	2.77

Table 3.2: Mix proportions for M40 grade concrete

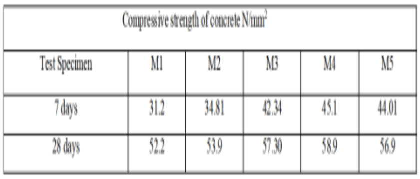
3.1.COMPRESSIVE STRENGTH OF CONCRETE

Concrete compressive strength tests are performed seven and twenty-eight days after casting and curing for M1, M2, M3, M4, and M5 mix fractions. The Compressive

ISSN 2319-5991 www.ijerst.com

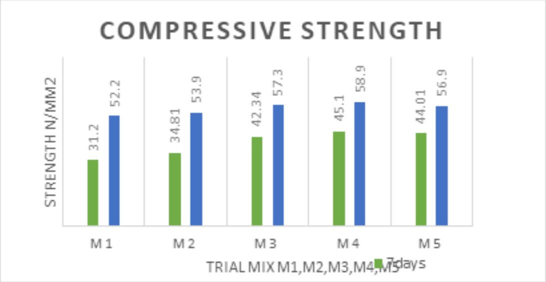
Vol. 11, Issue 4, 2018

Strength of Concrete for 7 and 28 days after casting is shown in the table below M1,M2,M3,M4 and M5.



Compressive strength of concrete N/mm²					
Test Specimen	M1	M2	M3	M4	M5
7 days	31.2	34.81	42.34	45.1	44.01
28 days	52.2	53.9	57.30	58.9	56.9

Table 3.3: Compressive strength of concrete N/mm^2

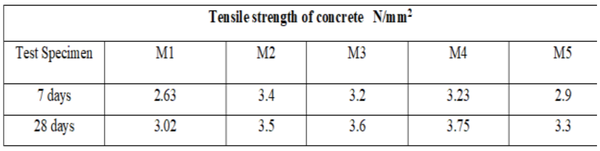


Graph 3.1 : Compressive Strength of Concrete at 7 and 28 day

Table 3.3 and Graph 1 show that the Compressive Strength of M4 at the 28th day rose by 9% compared to M2 and 12% compared to M1. When compared to M4, M5 strength has been reduced by 3%.

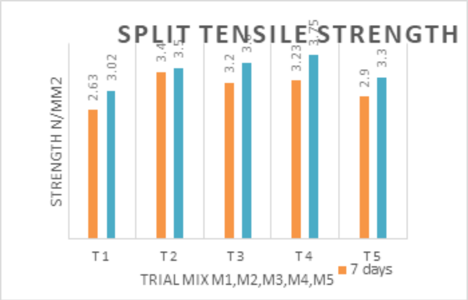
3.2. SPLIT TENSILE STRENTH TEST

The split tensile strength of concrete for 7 and 28 days after casting is shown in the table below M1,M2,M3,M4 and M5.



Tensile strength of concrete N/mm²					
Test Specimen	M1	M2	M3	M4	M5
7 days	2.63	3.4	3.2	3.23	2.9
28 days	3.02	3.5	3.6	3.75	3.3

Table 3.4: Tensile strength of concrete

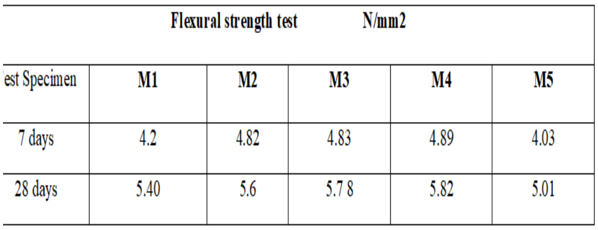


Graph 3.2 : Split Tensile Strength of Concrete at 7 and 28 day

Table 3.4 and Graph 2 show that the Split Tensile Strength of M4 at the 28th day increased by 7% when compared to M2 and by 24% when compared to M1. When compared to M4, M5 strength has been reduced by 13%.

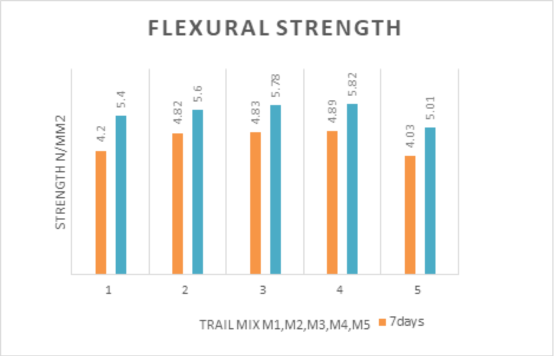
3.3.FLEXTURAL STRENGTH TEST

The split tensile strength of concrete for 7 and 28 days after casting is shown in the table below M1,M2,M3,M4 and M5.



Flexural strength test N/mm2					
est Specimen	M1	M2	M3	M4	M5
7 days	4.2	4.82	4.83	4.89	4.03
28 days	5.40	5.6	5.7 8	5.82	5.01

Table 3.5: Flexural Strength of Concrete



Graph 3.3 : Flexural Strength of Concrete at 7 and 28 day

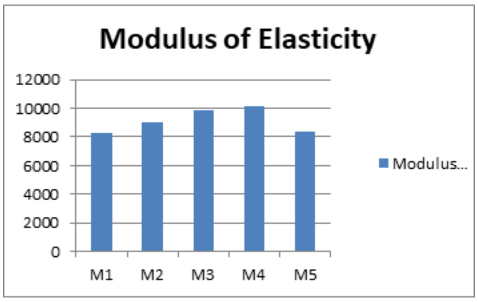
According to Table 3.5 and Graph 3.3, the Flexural Strength of M4 at the 28th day rose by 3.9 percent when compared to M2 and 7.7% when compared to M1. When compared to M4, M5 strength has been reduced by 16%.

IV. MODULUS OF SPECIMENS:

The values for modulus of elasticity of specimen are tabulated in Below Table

Test Specimen No.	Modulus of Elasticity E (N/mm2)
M1	8295.075
M2	8976.702
M3	9865.21
M4	10138.37
M5	8373.526

Table 3.6: Modulus of Elasticity of Specimens



Graph 3.4: Initial Tangent Modulus Elasticity of Specimen

According to Table 3.6 and Graph 3.4, the Flexural Strength of M4 at the 28th day rose by 12% compared to M2 and 21% compared to M1. When compared to M4, M5 strength has been reduced by 19%.

V. CONCLUSIONS

Cement production uses a lot of energy and produces a lot of CO2. By serving as a substitute for cement, waste materials such as FA may reduce the amount of cement utilized, which has positive effects on the environment and the economy. The encouraging outcomes of replacing a little portion of FA with cement raise the bar for HVFAC research. Furthermore, as waste resources may be used as effectively as possible, a high FA utilization rate is essential for sustainable growth.

The FA improves the workability of the concrete. Because of their spherical form, smooth FA particles operate in the concrete like tiny ball bearings, providing a lubricating effect and lowering the viscosity of the mixture.

Additionally, this reduces frictional losses while pumping concrete.

In order to stop the oppositely charged cement particles from flocculating, FA particles adsorb on their surfaces. Large volumes of water are thus discharged, which reduces the water need for specific workability. As a result, adding more FA to concrete decreases the amount of water needed for the same slump, and because more FA may also reduce the amount of water needed, the amount of SP needed may be reduced when FA is present.

When FA combines with CH generated by cement hydration, it creates CSH gel, the primary binder in cement and concrete and the source of their strength. FA is a pozzolanic material. Moreover, adding FA to the lime created during cement hydration results in increased strength. Consequently, compared to cement-only concrete, FA concrete will be stronger at later curing ages and weaker at earlier curing ages. The amount of FA, its chemical makeup, the size and surface area of the FA particles, the ratio of water to binder, and the temperature all affect how strong the concrete is.

Because the ideal dosage of FA is required to fully fill the pores existing in the concrete, the increase in compressive strength at a given FA dose may be explained. The pozzolanic reaction with CH is accelerated by the inclusion of finer cementitious particles. Therefore, adding SF or GGBS to FA-admixed concrete may enhance its strength characteristics.

High FA levels may be used to make concrete with conventional design strengths, and low energy clinker or quick hardening cement can be used to mitigate the early strength problems that come with such HVFC.

FA accelerates the hydration process, which improves the ITZ density and microstructure over time as the pore structure becomes more fine-tuned with curing time. While the refined pore structure's reduction in pore network connection may limit transport processes and enhance concrete durability, the increased density may also contribute to an increase in strength.

The sorptivity, water permeability, water-permeable voids, and water absorption of the concrete are all impacted by the quantity of FA present in the material. These qualities increased with larger levels of FA content, but decreased when the FA content rose to a certain point. The concrete pores were filled with the extra CSH gel that developed as a consequence of the FA particles' pozzolanic activity. The result was a decrease in the permeability coefficient as the concrete became more compact and dense.

The concrete's compressive strength, the concentration of FA, and, to a lesser extent, the moist-curing duration are the primary determinants of carbonation resistance, which declines as the FA content rises. Conversely, when using RCA concrete, the combination of RCA and FA works better to stop the carbonation of the concrete.

Since the pozzolanic processes decrease CH levels and raise CSH gel, which refines ITZ and matrix pores and decreases permeability, FA concrete may withstand attacks from chloride, sulfate, and acid better. FA concrete resists corrosion better because to its lower permeability to chloride ions.

Because the FA reaction consumes alkali, lowering them available for extensive interactions with reactive particles, adding FA to concrete increases its resistance to ASR. The particle size and chemical makeup of FA determine its capacity to decrease the availability of hydroxyl and alkali ions in the solution. FAs range in their safe replacement amounts as a result.

Compared to ordinary concrete, FA concrete could perform noticeably better at higher temperatures. This is because all of the unreacted FA particles react with CH to form additional CSH at higher temperatures. FA concrete may also prevent concrete

ISSN 2319-5991 www.ijerst.com

Vol. 11, Issue 4, 2018

from losing weight at high temperatures, suggesting that it is an efficient way to prevent concrete from losing strength when exposed to high temperatures.

The unreacted FA particles in the paste may function as micro-aggregates with a greater modulus of elasticity, increasing the resistance to fracture propagation, in accordance with Zhang's hypothesis. An increased amount of energy is released prior to failure as a consequence of the cracking surrounding the FA particles. These characteristics make HVFA concrete more durable and less linear in its fracture process.

In FA concrete, a declining trend in hydration heat is seen.

An increase in FA dose results in a reduction in the heat of hydration. The decreasing solubility index of FA in blended paste and the decreased availability of C3S as FA concentration rises are most likely the causes of the low hydration heat. Sluggish pozzolanic response at an early age is caused by insufficient CH interacting with the silica from the FA. Because the minuscule LS particles may provide an additional surface for the nucleation and formation of hydration products, FA in combination with limestone may accelerate the rate of hydration. Hydration kinetics and the development of compressive strength are intimately related to the blaine fineness, reactive silica content, and alumina content of FA.

The pozzolanic reaction caused by the hostile environment breaks down the FA spherical particles, replacing them with ettringite needles in the empty area between the aggregate to create a denser binder mix than regular concrete. Because to tight FA particle packing and the production of tobermorite, a potent hydration product at high pressure and temperature, FA concrete has a comparatively low microcrack at the ITZ.

Fly ashes exhibit significant heterogeneity in both their chemical composition and particle size. Numerous previous research have shown that the kind, fineness, and chemical makeup of the fly ashes affect the qualities of the concrete that contains them. Consequently, it is challenging to draw firm conclusions on fly ash's impact on concrete. Nonetheless, the outcomes of the large-scale research may serve as a basis for future investigation, and the variability of fly ash leaves room for more study on fly ash concrete.

REFERENCES

1. “The Future is Now: Science for Achieving Sustainable Development, Global Sustainable Development Report.,” 2017.
2. Abhilash, P.P., Nayak, D.K., Sangoju, B., Kumar, R., Kumar, V., 2021. Effect of nano-silica in concrete; a review. Constr. Build. Mater. 278, 122347 https://doi.org/10.1016/j. conbuildmat.2021.122347.
3. Adams, T.H., 2019. Fly ash use in concrete increases slightly as overall coal ash recycling rate declines december. Am. Coal Ash Assoc. d, 1–5 [Online]. Available: www.acaausa.org.
4. Ali, M.B., Saidur, R., Hossain, M.S., 2011. A review on emission analysis in cement industries. Renew. Sustain. Energy Rev. 15 (5), 2252–2261. https://doi.org/ 10.1016/j.rser.2011.02.014.
5. Al-Yousuf, A., Pokharel, T., Lee, J., Gad, E., Abdouka, K., Sanjayan, J., 2021. Effect of fly ash and slag on properties of normal and high strength concrete including fracture energy by wedge splitting test: Experimental and numerical investigations. Constr. Build. Mater. 271, 121553 https://doi.org/10.1016/j.conbuildmat.2020.121553.
6. Amnadnua, K., Tangchirapat, W., Jaturapitakkul, C., 2013. Strength, water permeability,and heat evolution of high strength concrete made from the mixture of calcium carbide residue and fly ash. Mater. Des. 51, 894–901. https://doi.org/10.1016/j.matdes.2013.04.099.
7. Antoni, L.C., Hardjito, D., 2015. The impact of using fly ash, silica fume and calcium carbonate on the workability and compressive strength of mortar. Procedia Eng. 125, 773–779.https://doi.org/10.1016/j.proeng.2015.11.132.
8. Ardoga, ˘ M.K., Erdogan, ˘ S.T., Tokyay, M., 2019. Effect of particle size on early heat evolution of interground natural pozzolan blended cements. Constr. Build. Mater. 206, 210–218. https://doi.org/10.1016/j.conbuildmat.2019.02.055.

ISSN 2319-5991 www.ijerst.com

Vol. 11, Issue 4, 2018

9. Astm, 2016. C187, “Standard Test Method for Amount of Water Required for Normal Consistency of Hydraulic Cement Paste”. ASTM Int. 1–3. https://doi.org/10.1520/C0187-16.2.
10. ASTM C1202, “Standard Test Method for Electrical Indication of Concrete’s Ability to Resist Chloride Ion Penetration,” Am. Soc. Test. Mater., no. C, pp. 1–8, 2012,10.1520/C1202-19.2.
11. Atis¸, C.D., 2003. High-Volume Fly Ash Concrete with High Strength and Low DryingShrinkage. J. Mater. Civ. Eng. 15 (2), 153–156. https://doi.org/10.1061/(asce)0899-1561(2003)15:2(153).
12. Atis¸, C.D., Kiliç, A., Sevim, U.K., 2004. Strength and shrinkage properties of mortar containing a nonstandard high-calcium fly ash. Cem. Concr. Res. 34 (1), 99–102.
13. Aydin, S., Yazici, H., Yiğiter, H., Baradan, B., 2007. Sulfuric acid resistance of highvolume fly ash concrete. Build. Environ. 42 (2), 717–721. https://doi.org/10.1016/j.buildenv.2005.10.024.
14. Baert, G., Poppe, A., De Belie, N., 2008. Strength and durability of high-volume fly ash concrete. Struct. Concr. 9 (2) https://doi.org/10.1680/stco.2008.9.2.101.
15. Baghabra Al-Amoudi, O.S., 2002. Attack on plain and blended cements exposed to aggressive sulfate environments. Cem. Concr. Compos. 24 (3–4), 305–316. https://doi.org/10.1016/S0958-9465(01)00082-8.