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ANALYSIS ON CONCRETE STRENGTH USING VARYING FLY ASH

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Abstract: Concrete plays vital role in present and also greater demand in its ingredient materials. With the increase of demand, manufactures of fresh minerals also rise. It leads to ecology imbalance due to depletion of natural resources. In order to negotiate the main raw materials, geopolymer i.e. Fly Ash with certain ratio is used as replacement of cement in concrete. In this study, it shows that fly ash play major role in concrete. Geopolymer concrete is racing forward for sustainable construction and eco-friendly to present environment. During this experimental study, certain test i.e. water absorption, sorptivity, compressive strength and split tensile test were conducted at M20 and M25 mix design where 15%, 18%, 20%, 25% and 28% fly ash as a replacement of cement. The results were compared between M20 and M25 geopolymer concrete and its benefit as compared with normal concrete. It was concluded through the experimental study that geopolymer fly ash is more advantageous and give better impact to the concrete as compared to normal concrete. Fly ash can be reused from industrial wastes product like ashes into construction purposes and helps in saving natural resources. This process will make great liable safe, economy as well as clean environment**.**

Keyword: Fly ash, Water absorption, Sorptivity, Compressive strength, Split tensile, Eco-friendly.

I. Introduction

Cement plays important role in concrete which also act as binder in concrete. Concrete is a widely used construction materials for various types of structures due to its structural ability and strength [10]. Because of rapid urbanization and fast growth in industrialization, the demand of cement increases where quarrying of raw materials for cements also at high rate. The world wide production of cement is high as 2.6 billion tons per year and generates nearly 7% of carbon-di-oxide [1] which largely contributes to environmental pollution and global warming [9]. It is important to reduce CO_2 emission through the greater use of substitute to ordinary Portland cement (OPC) such as fly ash, clay and other geo-bases materials [7]. Due to this, civil engineering researchers search replacement materials for cements and found out fly ash as one of them. From the point of energy saving and conversation of natural resources, the use of alternative constituents in construction materials are now a global concern [4].

Fly ash is the waste by-product from the combustion of coals and disposed off in rivers, landfill, etc. which make pollute the river water as well as surface source of water and increase the particulate matters present in the air. Every year fly ash produce is estimated about 780 million tons in World but out of which only 17-20% are used [2]. Coal Combustion products are produced with the production of electricity in coal-fired power plants [5]. This makes the environment pollute for openly disposed the fly ash and makes hazardous to the human health also. In order to decrease such havoc and save the natural resources, fly ash were used at certain ratio as a replacement of cements and make a concrete which might be called as geopolymer concrete.

Geopolymer is an alternate cementitious material which has ceramic like properties. The production of geopolymer materials were accompanied by much lower carbon dioxide emission compared to ordinary Portland cement [8]. As oppose to OPC, the manufacture of fly ash-slag does not consume high levels of energy. Those materials of geopolymer are mainly by-products from the industries. There are two main constituents of geopolymer, namely the source materials and alkaline liquids [6]. To use alternate pozzolana materials which will utilize waste produced as well as reduce the adverse effect of construction of environment and also improve the performance of concrete. The durability of concrete largely depends on the ease with which fluids enter and move through the matrix [11]. Thus, geopolymer concrete makes present environment eco-friendly and plays vital role to decrease the waste products like ashes from the various industries. But in this study only fly ash were considered as supplementary materials instead of cements.

II. MATERIALS AND METHODS

Materials

- **A.** ***Fly Ash*: ** Class F of low calcium is used.
- **B.** ***Coarse Aggregates:*** Local available stone crush chips were used. As per IS: 383-1970, Table 2, (Clause 4.1 and 4.2) the sizes of the aggregate were combinations of 12.5mm and 16mm w.r.t percentage of passing as per code and adopted under SSD condition.
- **C.** ***Fine Aggregate:*** Local available river sand (Serou sand) and As per IS: 383-1970, Table 4, (Clause 4.3), the fine aggregate is Grading Zone I.
- **D.** ***Water:*** Water: Clean portable water was used in this study.

Methods

As per IS: 10262-2009, concrete were casted as M20 and M25 mix design and replaced 15%, 18%, 20%, 25% and 28% cement by fly ash. Adopted methods are as follows:

- **A.** ***Water absorption:*** It is the amount of water absorb from all the 4-directions. As per IS: 383 -1970, where, $\frac{w1-w2}{w2}$ x 100%; w1= wt. of saturated dry, w2= wt. of oven dry aggregate. For each sample 3 specimens were prepared of 150x150x150mm cubes sizes for 28 days curing. Then specimens were oven dried at 100°C for 1 day, after that specimens were immersed in water for 1 day and weighing were performed.
- **B.** ***Sorptivity:*** Sorptivity is materials property which transport of liquid in porous solid by capillary action. It is simple and rapid test to determine the tendency of concrete to absorb water by capillary suction [3]. It is a unidirectional absorb of water inside the specimens. For each test, 3 specimens were prepared of 100x100x100mm cubes sizes for 28 days curing. Then four sides of the cubes were painted water repellent and placed at water 1/4th height of the cube for 30 minutes and values were noted.

  Where, $S= I/ t^{0.5}$, mm/min$^{0.5}$
  S= Sorptivity in mm,
  t= elapsed time in min., $I = (w2 - w1)/ A. \varrho$,
  w1= dry weight of cube in grams,
  w2= weight of cube after 60min capillary suction in water in grams,
  A= surface area which water penetrated in mm^2,
  ϱ= density of water in gm/cm^3
- **C.** ***Compressive strength:*** It is given as compression load by surface area in a concrete cube. Its unit is N/mm^2. For each sample 3 specimens were prepared of 150x150x150mm cubes sizes for 28 days curing and test were performed under Compression Testing Machine of 2000KN capacity.
- **D.** ***Split tensile:*** It is ratio of load by surface area in a cylindrical concrete cube. Its unit is N/mm^2. For each sample 3 specimens were prepared of 150mm x 300mm cylindrical cubes sizes for 28 days curing and test were performed under Compression Testing Machine of 2000KN capacity.

III. RESULTS AND DISCUSSION

3.1 Results of data for M20 and M25mix design with and without Fly ash

Table 3.1: Data for M20 and M25 mix design without Fly ash

Mix Design	Fly Ash (%)	Weight of Saturated Dry, w1(gm)	Weight of Oven dry Cube, (gm)	Weight of cube after 30min, applied water proofer, (gm)	Load (KN)	Area (mm^2)	Results	Units	Method
M20	0.0	2332.0	2286.1	-------	-------	------	2.01	%	W/Absorption
	0.0	2350.1	--------	2353.6	-------	150x150	0.452x10^{-4}	mm/min$^{0.5}$	Sorptivity
	0.0	---------	--------	--------	664.5	150x150	29.5	N/mm^2	C/St
	0.0	---------	--------	--------	205.0	35343.0	5.79	N/mm^2	S/tensile
M25	0.0	2355.3	2310.7	--------	-------	--------	1.93	%	W/Absorption
	0.0	2298.3		2300.1			0.232x10^{-4}	mm/min$^{0.5}$	Sorptivity
	0.0	---------	--------	--------	799.0	150x150	35.5	N/mm^2	C/St
	0.0	---------	---------	--------	226.0	35343.0	6.40	N/mm^2	S/tensile

Table 3.2: Water Absorption Value Mix Design for M20 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Weight of Saturated Dry, w1(gm)	Weight of Oven dry Cube, w2 (gm)	Water Absorption (%)
M20 water: cement is 0.51	15.00	2283.7	2224.1	2.68
	18.00	2166.3	2109.2	2.71
	20.00	2204.4	2144.8	2.78
	25.00	2215.2	2155.2	2.80
	28.00	2192.2	2129.4	2.95

Table 3.3: Sorptivity Value at 30min for Mix Design M20 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Dry weight of cube, w1(gm)	Weight of cube after 30min, applied water proofer, w2 (gm)	Sorptivity Value in 10^{-4}, mm/min$^{0.5}$
M20 water: cement is 0.51	15.00	2200.5	2217.8	1.40
	18.00	2155.8	2177.4	1.75
	20.00	2120.8	2143.3	1.82
	25.00	2185.9	2207.7	1.77
	28.00	2210.5	2233.3	1.85

Table3.4: Compression Strength Test Mix Design for M20 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Compressive Load (KN)	Area (mm^2)	Compression Strength (N/mm^2)
M20 ,water: cement is 0.51	15.00	660.00	150 x 150	29.3
	18.00	650.00	150 x 150	28.9
	20.00	680.00	150 x 150	30.2
	25.00	650.00	150 x 150	28.9
	28.00	655.00	150 x 150	29.1

Table 3.5: Split Tensile Test Mix Design for M20 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Compressive Load (KN)	Area (mm^2)	Split Tensile Strength (N/mm^2)
M20 ,water: cement is 0.51	15.00	210.00	35343.0	5.65
	18.00	215.00	35343.0	6.08
	20.00	215.00	35343.0	6.08
	25.00	185.00	35343.0	5.23
	28.00	180.00	35343.0	5.09

Table 3.6: Water Absorption Value Mix Design for M25 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Weight of Saturated Dry, w1(gm)	Weight of Oven dry Cube, w2 (gm)	Water Absorption (%)
M25 water: cement is 0.46	15.00	2199.05	2151.5	2.21
	18.00	2244.49	2195.1	2.25
	20.00	2235.66	2185.4	2.30
	25.00	2202.89	2150.2	2.45
	28.00	2235.02	2180.5	2.50

Table 3.7: Sorptivity Value at 30min for Mix Design M25 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Dry weight of cube, w1(gm)	Weight of cube after 30min, applied water proofer, w2 (gm)	Sorptivity Value in 10^{-4}, mm/min$^{0.5}$
M25 water: cement is 0.46	15.00	2211.6	2217.8	0.51
	18.00	2170.6	2177.4	0.55
	20.00	2136.3	2143.3	0.57
	25.00	2193.8	2207.7	1.13
	28.00	2218.3	2233.3	1.22

Table 3.8: Compression Strength Test Mix Design for M25 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Compressive Load (KN)	Area (mm^2)	Compression Strength (N/mm^2)
M25 water: cement is 0.46	15.00	750.00	150 x 150	33.33
	18.00	755.50	150 x 150	33.55
	20.00	740.00	150 x 150	32.89
	25.00	735.00	150 x 150	32.67
	28.00	700.50	150 x 150	31.13

Table 3.9: Split Tensile Test Mix Design for M25 grade concretes using Fly Ash

Mix Design	Fly Ash (%)	Compressive Load (KN)	Area (mm^2)	Split Tensile Strength (N/mm^2)
M25 water: cement is 0.46	15.00	250.0	35343.0	7.07
	18.00	250.0	35343.0	7.07
	20.00	245.0	35343.0	6.93
	25.00	220.0	35343.0	6.23
	28.00	210.0	35343.0	5.94

Fig 1: Graph comparison between M20 and M25 Water Absorption using Fly Ash

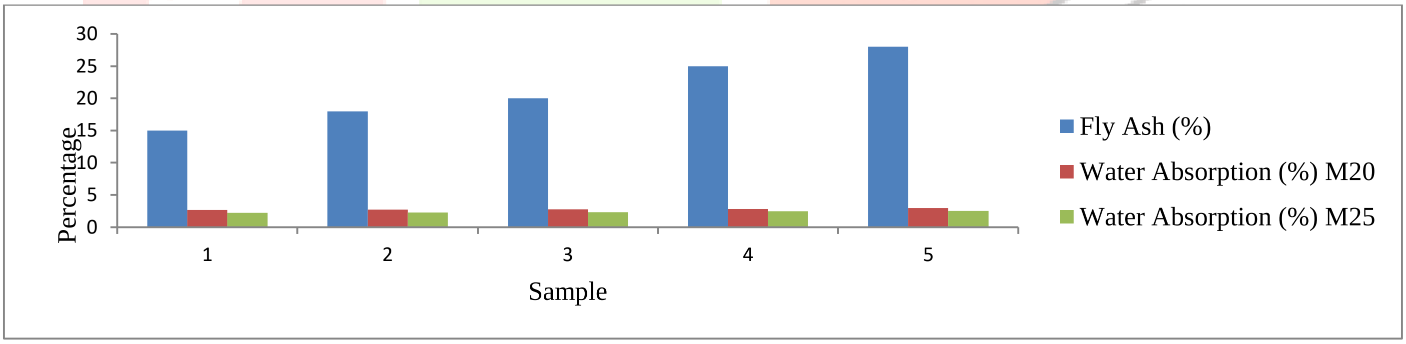


Fig 2: Graph comparison between M20 and M25 Sorptivity using Fly Ash

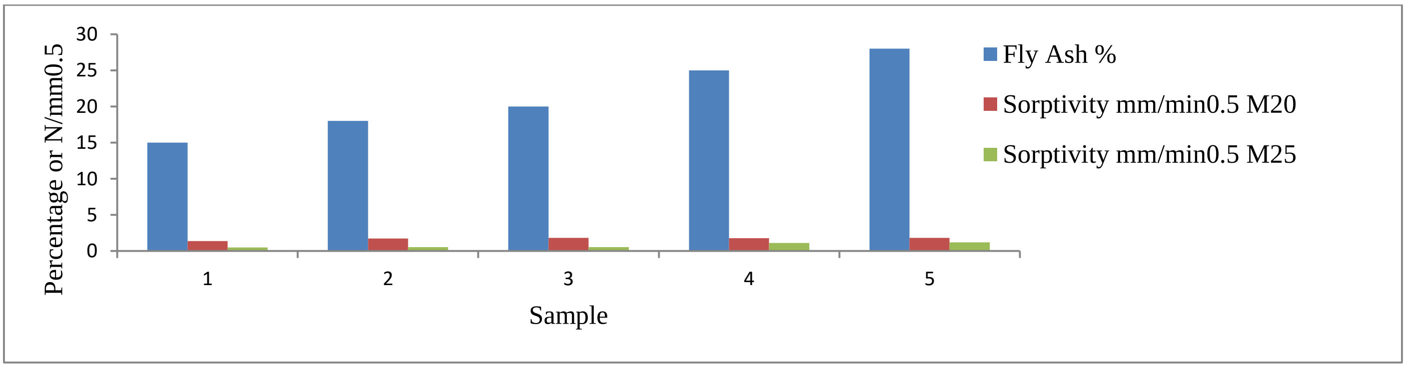


Fig 3: Graph comparison between M20 and M25 Compressive Strength using Fly Ash

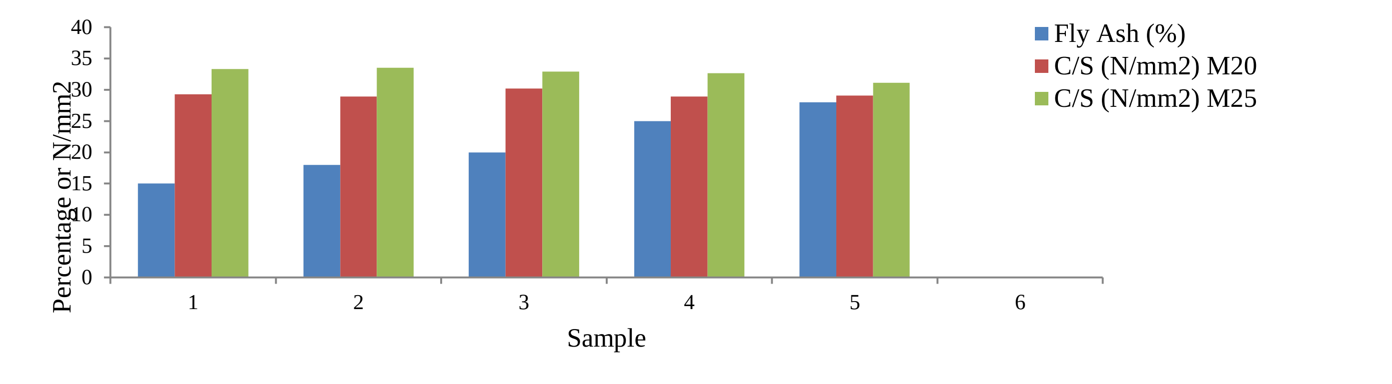
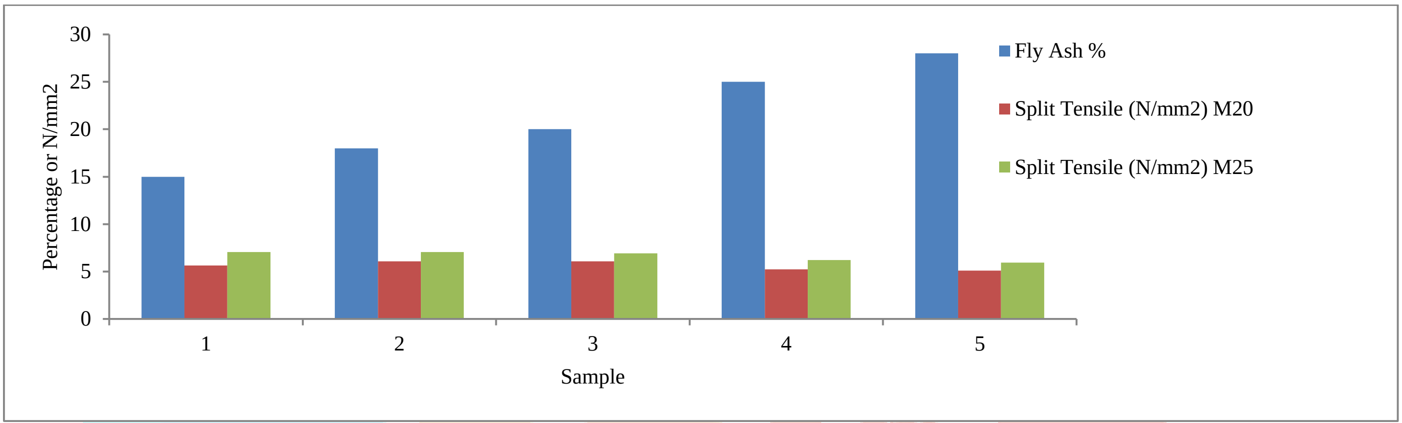


Fig 4: Graph comparison between M20 and M25 Split Tensile test using Fly Ash



IV. CONCLUSION

i. Comparing to normal concrete M20 and M25, geopolymer concrete M20 and M25 has more water absorption; where with the increase in fly ash %, water absorption value also increases. This can be control by using water proofer material.

ii. Comparing to normal concrete M20 and M25, geopolymer concrete M20 and M25 has more sorptivity values. With the increase in fly ash %, sorptivity value also increases. This is also can be reduced by using water proofer materials.

iii. Comparing to normal concrete M20 and M25, geopolymer concrete M20 and M25 also reach target strength. But using 20% and 18% fly ash has more compressive strength than in M20 and M25 respectively.

iv. Comparing to normal concrete M20 and M25, geopolymer concrete using 18% , 20% fly ash in M20 and using 15%, 18%, 20% fly ash in M25 were more split tensile than normal concrete M20 and M25.

From the observations and results obtained it can conclude that using fly ash upto 18% in average for M20 and M25 concrete which might safe in constructions purposes and helps in reduces the waste by-products. This helps in controlled the environment pollution and better eco-friendly.

V. ACKNOWLEDGMENT

Leishangthem Yaiphaba Meitei is presently Research Scholar with the Department of Civil Engineering, Manipur Institute of Technology (A Constituents College of Manipur University). He was completed B.Tech Civil Engineering from ICFAI University Tripura and M.Tech Structural Engineering from MIT, Manipur. He is authorized to use the style and title of Chartered Engineers by the Institute of Engineers India (**IEI**). He became a Associate Member of IEI in 2021. He presented International conference, National conferences and poster presentation regarding Recycled Aggregate Concrete and Dampness issue. He has published 1 International Journal, 2 International conference papers, 1 posture presentation in conferences. He is Associate member of IEI, India and also holding Chartered Engineer licenses. His goal is as a Civil Engineering student, to give useful idea about damp free structural buildings, climate saving theme and for preserve nature resources for sustainable development.

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