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PREPARATION & ANALYSIS OF STRENGTH AND BEHAVIOR OF HIGH-PERFORMANCE CONCRETE USING FLY ASH

High performance concrete using fly Ash.

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Abstract: High performance concrete (HPC) has been defined as concrete that possesses high malleability, high strength, and high durability. High- performance concrete (HPC) is generally produced using high quality accoutrements. These ingredients drastically increase the original cost of HPC, therefore hindering its more wide operation. This exploration work intends to probe the possibility of producing low cost enhanced performance concrete or indeed low cost HPC, with 28 day strengths, using low- quality- as- entered accoutrements like cover ash and locally available crushed summations. In this way, a significant reduction in the use of Ordinary Portland cement, as well as that of scarce natural coffers, would be attained. The effect of the quantum of cover ash was estimated using 0, 10, 30 and 50 cement relief in fusions with different amounts. Plasticity, mechanical and continuity parcels of the produced concretes werestudied.The results attained indicate that it's possible to produce HPC by replacing up to 30 of cement by cover ash and using locally available crushed determinedness summations. Grounded on the results attained, it's possible to conclude that the use of cover ash in concrete is salutary in terms of the plasticity and continuity parcels but has some disadvantages because early strengths are reduced. The exploration work also indicates ways and means to ameliorate the performance of concretes without having its costs increased.

***Key words* - Mineral Admixture, Chemical Admixture, Fly Ash, Mechanical Properties, Durability Properties, HPC.**

I. INTRODUCTION

High performance concrete(HPC) has been most notorious in recent times. The world'seco-system is faced with the growing problem of global warming which is associated with the emigration of CO2 into the atmosphere. It's a well- known fact that for every ton of Portland cement produced, roughly one ton of CO2 is released. To reduce the CO2 emigrations related to cement product, the use of Portland cement needs to be reduced without compromising the performance of the concrete structures. The emigration of CO2 is only one of the numerous problems presently facing the construction assiduity. The increase in the volume of construction in the last many decades has redounded in a rage of our natural coffers. The natural coffers employed in concrete are finite, and so the sustainability of construction needs to be taken into consideration. likewise, the use of conventional concrete, indeed in common current constructions, has revealed itself to be technically and economically shy. The corroborated concrete structures deteriorate too fleetly, causing high conservation and repairing costs, in addition to the affiliated drop of the structures' service life.

II. AIM AND OBJECTIVES

AIM :- To Study & Analysis Of Strength And Behavior Of High Performance Concrete Using Fly Ash.

OBJECTIVES :-

- To study the concept of HPC and its behaviour's.
- To determine the mix proportion with fly ash and admixture to achieve desire mix.
- Evaluation of workability and strength of concrete.
- Compare conventional concrete and HPC, give discussion and suggestion for the above analysis.

III. METHODOLOGY

1. Study of properties of NSC and HPC like Workability, Bleeding, Segregation, Hydration Air Entrainment Durability & Strength.
2. Test conducted on HPC & NSC blocks on universal testing machine.
3. Number of blocks was casted by adding admixture HPC & NSC by varying percentage of materials as Fly ash.
4. All the blocks were tested under single point / two points leading after 7,14 ,28 days curing and eventhe cubes to determine the compressive strength of concrete. UTM test is carried out to check the quality of concrete mix.

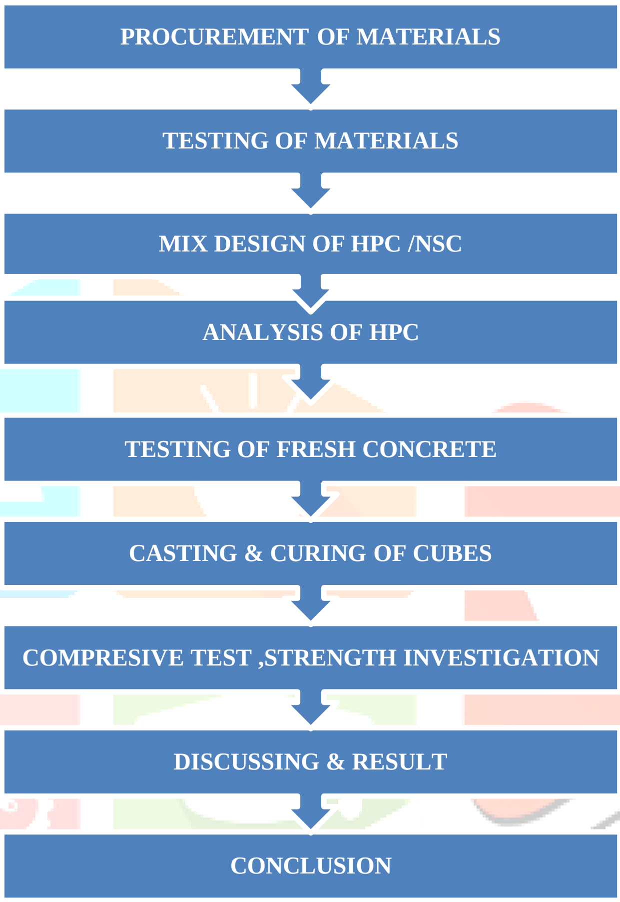


Fig: Flow Chart

IV. MIX DESIGN

- **Mix design for M20 Concrete as per IS method of concrete mix design: -**
  Design Steps

Characteristic cube compressive strength of concrete fck = 20 Mpa
Max size of aggregate used = 20mm
Specific gravity of cement = 3.15
Specific gravity of fine aggregate = 2.83
Specific gravity of coarse aggregate = 2.67

Step – 1
Calculation for Target Strength: -
F'ck = fck + 1.65 x S
From Table No.1 of IS code 10262-2009 Standard Deviation Value (S) for M20 grade is 4.
Fck' =20 + 1.65 x 4
=26.6 N/mm2
Where 1-65 from table no. 2 (IS: 10262-1982)

Step – 2

Selection of Water Cement Ratio: -

From fig no.1 IS:10262-1982, the water cement ratio required for target mean strength of 26.6N/mm2. W/C ratio is adopted = 0.5

Step – 3

Selection Of Water and Sand Content: -

From table no. 4 of IS:10262-1982, for 20mm Nominal Maximum size of aggregate and sand conforming to grading Zone 2, W/C 0.5,

Water Content per cube meter of concrete = 186 kg.

Estimated Water Content for75mm slump = 186 + 186 X 3/100 = 191.58 liters.

(3% increase for 25 mm slump over and above50mm slump)

Step- 4

Determination of Cement Content: -

Having known W/C ratio as 0.5 and water content 191.58 liters

= Water Content/(W /C Ratio)

Therefore, Cement = 191.58/0.5

= 383.2 Kg/M3

Step – 5

Estimation Of Coarse Aggregate Proportions: -

From table 3 of IS:10262-1982, for specified maximum size of aggregate of 20mm, the amount of entrapped air in the concrete is 2%

Zone of fine Aggregate = Zone II

And for w/c = 0.5

And for w/c = 0.5

Volume of coarse aggregate per unit volume of total aggregate = 0.62

Note- For pump able concrete the coarse aggregate proportion may be reduced up to 10% Hence,

Volume of coarse aggregate per unit volume of total aggregate = 0.62 × 90% = 0.558

Volume of fine aggregate = 1 – 0.558 = 0.442

Step -6

Estimation Of Mix Ingredients: -

Volume of concrete = 1m3

Volume of cement = (mass of cement / Specific gravity of cement) × (1 / 1000)

= (383.2 / 3.15) × (1 /1000)

= 0.122 m3

Volume of Water = (Mass of Water / Specific gravity of water) × (1 / 1000)

= (191.6 / 1) × (1 /1000)

= 0.1916 m3

Volume of Total Aggregates = volm. of concrete – (volm. of cement + volm of water)

= a – (b + c)

= 1 – (0.122 + 0.1916)

= 0.6864 m3

Mass of Coarse Aggregate = volm. of total aggregate x volm of coarse aggregate x volm of Sp. gravity of aggregate x1000

= 0.6864 × 0.558 × 2.84 × 1000

= 1087.75 kg

Mass of Fine Aggregate = volm of total aggregate x volm of fine aggregate x volm of Sp. gravity of aggregate x1000

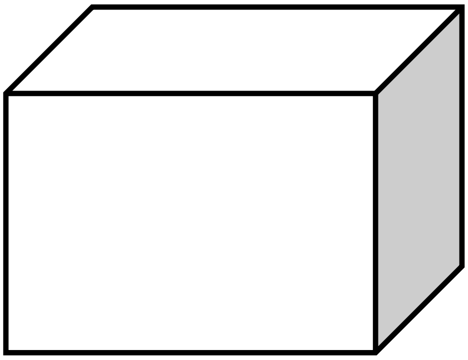
= 0.6864 × 0.442 × 2.84 × 1000

= 800.94 kg

V. QUANTITY OF MATERIALS

- **Calculation of materials for one cube (150mm×150mm ×150mm) for M20 grade of concrete.**

Density of Cement = 1440kg/M^3
Density of Sand = 1600kg/M^3
Density of Aggregate = 1800kg/M^3



Cube Dimension: -
L = 0.15M
B = 0.15M
H = 0.15M

Dry Volume of Cube: -
Volume = 0.15 x 0.15 x0.15
Dry Volume = 0.003375M^3

Wet volume: -
Wet Volume = 1.54 x Dry Volume
= 1.54 x 0.003375
Wet Volume = 0.00519 M^3

- **Use M20 grade of concrete (1: 1.5: 3) mix ratio: -**

CEMENT = wet volume / sum of ratio x 1
= 0.005197 / 1+1.5+3 x 1
= 0.0009449 M^3
= 0.0009449 x Density of cement
= 0.0009449 M^3 x 1440 kg / M^3
= 1.36 kg
SAND = wet volume / sum of ratio x 1.5
= 0.005197 / 1+1.5+3 x 1.5
= 0.001417 M^3
= 1.417 kg
AGGREGATE = wet volume / sum of ratio x 3
= 0.005197 / 1+1.5+3 x 3
= 0.00283 M^3
= 2.830 kg

- **TOTAL WEIGHT OF 9 CUBES OF NORMAL STRENGTH CONCRETE (NSC): -**

CEMENT = weight of cement one cube x 9 cubes of cement
=1.36 X 9
= 12.312Kg
SAND = weight of sand one cube x 9 cubes of sand
= 1.425 x 9
=12.825Kg
AGGREGATE = weight of aggregate one cube x 9 cubes of aggregate
= 2.25 x 9
= 25.65Kg
CHEMICAL ADMIXTURE = 0.35% of cement
= 12.312 X0.35%
= 0.0430Kg

- **TOTAL WEIGHT OF 9 CUBES OF HIGH-PERFORMANCE CONCRETE (HPC) USED OF FLY ASH 10%: -**

CEMENT = 12.312Kg (NSC)
SAND = 12.825Kg (NSC)
AGGREGATE = 25.65Kg (NSC)s
FLY ASH = 10% Cement (NSC)
= 12.312 x 10%
= 1.231Kg
USE OF CEMENT IN HPC = 12.312x 90%
= 11.080Kg (Use Cement)
CHEMICAL ADMIXTURE = 0.35% use of cement in HPC
=11.080 x 0.35%
= 3.878Kg

- **TOTAL WEIGHT OF 9 CUBES OF HIGH-PERFORMANCE CONCRETE (HPC) USED OF FLY ASH 30%: -**

CEMENT = 12.312Kg (NSC)
SAND = 12.825Kg (NSC)
AGGREGATE = 25.65Kg (NSC)
FLY ASH = 30% Cement (NSC)
= 12.312 x 30%
= 3.693Kg
USE OF CEMENT IN HPC = 12.312x 70%
= 8.618Kg (Use Cement)
CHEMICAL ADMIXTURE = 0.35% use of cement in HPC
=8.618 x 0.35%
= 0.030Kg

- **TOTAL WEIGHT OF 9 CUBES OF HIGH-PERFORMANCE CONCRETE (HPC) USED OF FLY ASH 50%: -**

CEMENT = 12.312Kg (NSC)
SAND = 12.825Kg (NSC)
AGGREGATE = 25.65Kg (NSC)
FLY ASH = 50% Cement (NSC)
= 12.312 x 50%
= 6.156Kg
USE OF CEMENT IN HPC = 12.312x 50%
= 6.156Kg (Use Cement)
CHEMICAL ADMIXTURE = 0.35% use of cement in HPC
=6.156x 0.35%
= 0.0215Kg

VI. PROCEDURE

- **PROCEDURE HAND MIXING OF NORMAL STRENGTH CONCRETE (NSC): -**

Used in material M_{20} grade of concrete (1:1.5:3).

Hand Mixing

- Mix the cement (OPC), sand and fine aggregate on a watertight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour.
- Add the 20mm sieve coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
- Add water and chemical admixture (super plasticizers 0.35% of cement) then mix it until the concrete appears to be homogeneous and of the desired consistency.

- **PROCEDURE HAND MIXING OF HIGH-PERFORMANCE CONCRETE USING FLY ASH (HPC): -**

Used in material M_{20} grade of concrete (1:1.5:3).

Hand Mixing

- Mix the cement (OPC) 90%,70%,50%, sand, fly ash 10%, 30%, 50% of cement and fine aggregate on a watertight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour.
- Add the 20mm sieve coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
- Add water and chemical admixture (super plasticizers 0.35% of used in HPC of cement) then mix it until the concrete appears to be homogeneous and of the desired consistency.

Fig: Hand Mixing of NSC

Fig: Hand Mixing of HPC

- **SAMPLING OF CUBES FOR TEST NSC & HPC**

- Clean the mounds and apply oil painting.
- Fill the concrete in the molds in layers roughly 5 cm thick.

- Compact each subcaste with not lower than 25 strokes per subcaste using a tamping rod(sword bar 16 mm periphery and 60 cm long, pellet- refocused at lower end).
- position the top face and smoothen it with a trowel.

Fig: Fill the concrete in mould & Compacting

CURING OF CUBES NSC & HPC

The test samples are stored in wettish air for 24 hours and after this period the samples are pronounced and removed from the molds and kept submerged in clear freshwater until taken out previous to the test.

Fig: Curing of Cubes

Fig: Curing of Cubes

Precautions For Tests NSC & HPC

The water for curing should be tested 7 days, 14 days, & 28 days and the temperature of the water must be at 27+-2oC.

PROCEDURE FOR CONCRETE CUBE TEST NSC & HPC

- Remove the instance from the water after specified curing time and wipe out redundant water from the face.
- Take the dimension.
- Clean the bearing face of the testing machine.
- Place the instance in the machine in such a manner that the cargo shall be applied to the contrary sides of the cell cast.
- Align the instance centrally on the base plate of the machine.
- Rotate the portable portion gently by hand so that it touches the top face of the instance.
- Apply the cargo gradationally without shock and continuously at the rate of 140 kg/ cm2/ nanosecond till the instance fails.
- Record the maximum cargo and note any unusual features in the type of failure.

NOTE: minimal three samples should be tested at each named age. The normal of three samples gives the crushing strength of concrete. The strength conditions of concrete.

Fig: UTM Testing in Cubes

Fig: Cube Testing

VII. CALCULATION AND ANALYSIS

- **COMPRESSIVE STRENGTH OF NARMAL STRENGTH CONCRETE (NSC): -**

SR. NO.	DAYS	SAMPLE	LOAD(KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
1	7days	1	355	15.67	15.590
		2	400	17.77	
		3	360	13.24	
2	14days	1	360	16.00	18.296
		2	380	16.89	
		3	445	22.00	
3	28days	1	580	25.78	23.000
		2	460	20.44	
		3	510	22.78	

CALCULATION OF 7DAYS SAMPLE NO.1: -

COMPRESSIVE STRENGTH = LOAD/CRASS SECTION AREA

= 355X103/ (150 X150) mm

=15.67 N/mm2

Similar calculation should be done for7day,14day, & 28-day compressive strength

- **CALCULATION OF 7DAYS AVERAGE COMPRESSIVE STRENGTH: -**

AVERAGE COMPRESSIVE STRENGTH = SAMPLE NO.1+SAMPLE NO.2+SAMPLE NO.3/3

=15.67+17.77+13.24/3

=15.59N/mm2

Similar calculation should be done for7day,14day, & 28-day average compressive strength

- **COMPRESSIVE STRENGTH OF HIGH-PERFORMANCE CONCRETE USING FLY ASH (HPC): -**

SR. NO.	DAYS	SAMPLE CUBES	USE OF FLY ASH %	LOAD (KN)	COMPRESSIVE STRENGTH (N/mm^2)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)
1	7day	1	10%	187.620	8.338	8.313
		2	10%	187.540	8.335	
		3	10%	186.000	8.266	
	7day	1	30%	165.120	7.338	7.343
		2	30%	170.000	7.556	
		3	30%	160.550	7.135	
	7day	1	50%	46.680	2.074	2.074
		2	50%	48.900	2.173	
		3	50%	44.500	1.977	
2	14day	1	10%	234.400	10.417	10.418
		2	10%	230.00	10.222	
		3	10%	238.900	10.617	

	14day	1	30%	225.900	10.040	10.042
		2	30%	230.956	10.264	
		3	30%	220.999	9.822	
	14day	1	50%	87.640	3.895	3.898
		2	50%	89.555	3.980	
		3	50%	85.945	3.819	
3	28day	1	10%	302.520	13.445	13.387
		2	10%	299.555	13.313	
		3	10%	301.594	13.404	
	28day	1	30%	286.680	12.741	12.714
		2	30%	285.990	12.701	
		3	30%	285.555	12.691	
	28day	1	50%	128.480	5.706	5.702
		2	50%	127.990	5.688	
		3	50%	128.555	5.718	

- **CALCULATION OF 7DAYS SAMPLE NO.1 USING FLY ASH10%: -**

COMPRESSIVE STRENGTH = LOAD/CRASS SECTION AREA

= $187.620X10^3/$ (150 X150) mm

$=8.338$ N/mm^2

Similar calculation should be done for7day,14day,& 28-day compressive strength of fly ash

- **CALCULATION OF 7DAYS AVERAGE COMPRESSIVE STRENGTH USING FLY ASH10% :-**

AVERAGE COMPRESSIVE STRENGTH = SAMPLE NO.1+SAMPLE NO.2+SAMPLE NO.3/3

=8.338+8.335+8.266/3

=8.313N/mm^2

Similar calculation should be done for7day,14day,& 28 day average compressive strength of fly ash

- **SLUMP CONE TEST: -**

Workability of fresh concrete was determined by using Slump Cone Test. Following were the obtained values of slump for various Grades.

SR.NO.	**TYPE OF CONCRETE (M_{20} GRADE OF CONCRETE)**	**USED IN FLY ASH %**	**MEASUREMENT OF SLUMP CONE TEST (mm)**	**TYPES OF SLUMPS**
1	NSC	-	160	COLLAPSE
2	HPC	10%	120	TRU SLUMP
3	HPC	30%	170	COLLAPSE
4	HPC	50%	170	COLLAPSE

Table: - Slump Cone Test

Fig: Collapse Slump Cone

Fig: Collapse Slump Cone

Fig: Tru Slump Cone

VIII. RESULT

- Total tests were conducted on 36 cubes, 9 cubes are NSC & 27 cubes are HPC used in fly ash 10, 30, & 50 curing period of 7days, 14days, and 28 days.
- According to the tests performed it's observed that there's remarkable proliferation in parcels of concrete according to the placement of in concrete.
- Number of layers placed in concrete also affects the strength of concrete.

- **COMPRESSIVE STRENGTH RESULT: -**

Compressive Strength Test of M_{20} Ordinary Portland Cement (OPC) And M_{20} HIGH-PERFORMANCE CONCRETE (HPC) FLY ASH (N/MM^2)

SR.NO.	TYPE OF CONCRETE (M_{20} GRADE OF CONCRETE)	USED IN FLY ASH %	7DAYS (N/mm^2)	14DAYS (N/mm^2)	28DAYS (N/mm^2)
1	NSC	0%	15.670	16.000	25.780
		0%	17.770	16.890	20.440
		0%	13.240	22.000	22.780
2	HPC	10%	8.338	10.417	13.445
		10%	8.335	10.222	13.313
		10%	8.266	10.6177	13.404
3	HPC	30%	7.338	10.04	12.741
		30%	7.556	10.264	12.701
		30%	7.135	9.822	12.691
4	HPC	50%	2.074	3.895	5.706
		50%	2.173	3.980	5.688
		50%	1.977	3.819	5.718

Table: Compressive Strength Test of M_{20} Grade of Concrete

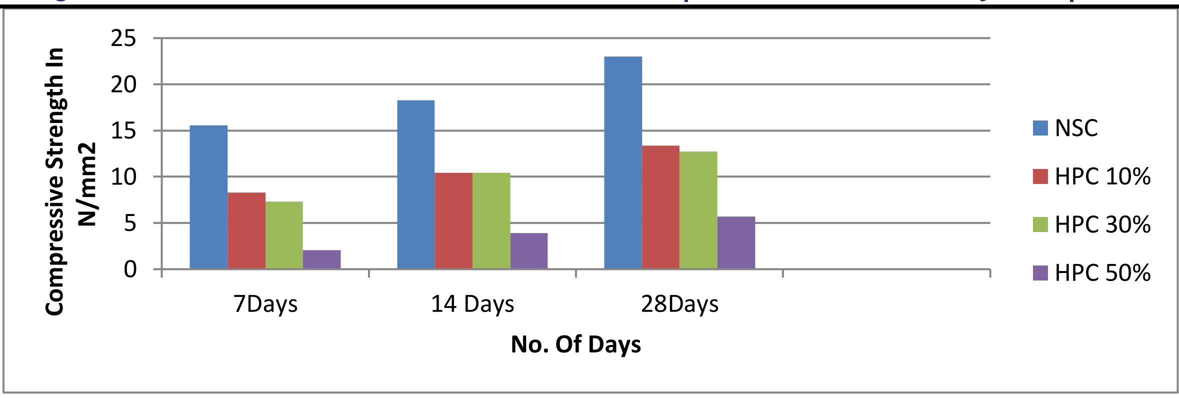


Fig: Compressive Strength test of Concrete M_{20}

IX. CONCLUSION

The compressive strength tests indicate that concrete with 15.590 N/mm^2 strength at 7 days, 18.296N/mm^2 at 14 days And 23.000 N/mm^2 at 28 days can be produced using Fly Ash 13.387N/mm^2 strength at 28 days with up to 10% cement replacement. Increasing the binder content, the compressive strength rises to about 12.714 N/mm^2 at 28 days with up to 30% cement replacement and 5.702N/mm^2 at 28 days with up to 50% cement replacement.

When evaluating the durability of concrete through the chloride ion diffusion coefficient, the electrical resistivity, the coefficient of capillary absorption and the water absorption by immersion, the addition of FA is seen to be beneficial, leading to more durable concrete. This effect is particularly noticeable with regard to the chloride-ion diffusion coefficient and electrical resistivity, indicating its special aptitude for environments that promote degradation of reinforced concrete due to chloride ion penetration.

Adding 50% FA renders concrete considerably weaker in terms of compressive strength, relative to other mixes studied here. However, both its workability and the durability were improved when compared to the control concrete mix. Thus, even in this case such mixtures can be rated as enhanced-performance concrete with regard to environmental and economic aspects. The research work demonstrates that it is possible to improve the concrete's performance, namely its durability, without having increased costs.

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