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Mechanical Properties of Class F Fly Ash Blended Concrete Incorporation with Natural Admixture

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Abstract : This research work reveled that effect of Natural admixture (NAD) on Conventional Concrete (CC) and low calcium fly ash (Class F Fly Ash) blended concrete. Broiler hen egg white albumen and yellow yolk was used as Natural Admixture. Cement was replaced by Class F fly ash at various levels of 0% to 45% by its mass and NAD was added to concrete at different replacement dosages of 0%, 0.25%, 0.5%, 0.75% and 1.00% by its volume to water content and liquid to binder ratio was maintained at 0.5. For all replacement levels of FA and NAD, the mechanical properties viz unit weight, compressive strength, splitting tensile strength and modulus of elasticity of CC and Class F fly ash (FA) were studied at 7, 28, 56 and 112 days. From the results, it was concluded that 0.25% of NAD dosage was considered as optimum dosage for both CC and Class F fly ash blended concrete. The studies revealed that 35% Class F fly ash blended concrete mix is concluded as optimum mix.
Keywords : Natural Admixture; Class F fly ash, Unit weight, Compressive Strength, Splitting tensile and Modulus of Elasticity.

1. Introduction

The rapid development of construction industry led to hug utilization of cement, this leads to emission of greenhouse gas (CO_2) into environment and that causes the global warming. To reduce the emission of CO_2, the supplementary cementious material was introduced and vast investigation is going on over those materials. The most of the research was concluded that the 25% fly ash can be replaced to cement the get the designed strength, that reduce few percentage of CO_2. So that there is necessity again reduce utilization of cement again by increasing the supplementary and pozzolanic materials by adding additives or admixtures.

Ravina Dan and Mehta [1] was concluded that 40 to 50% Class F or Class C fly ashes can be replaced to cement, but it requires 180 days of curing. They were proposed the high volume fly ash concrete by replacement level greater than 50% to cement. But practically curing of concrete for 180 days is not possible. So that the curing period has to reduce, and there by mix should get design strength within 28 days curing period by adding accelerators to enhance the hydration and pozzolanic action. Ramesh Babu and Neeraja [2] have concluded that NAD is acting as accelerator when it added to binder at optimum dosage. Malhotra and Painter [3] concluded that high volume FA concrete having high resistance to freezing and thawing effect.

This research is focused on study of mechanical properties viz unit weight, compressive strength, splitting tensile strength and modulus of elasticity of CC and FA blended concrete incorpation with NAD. And also identify optimum mix to get higher strength and economical mix which gives the designed strength with less cement content and high volume FA.

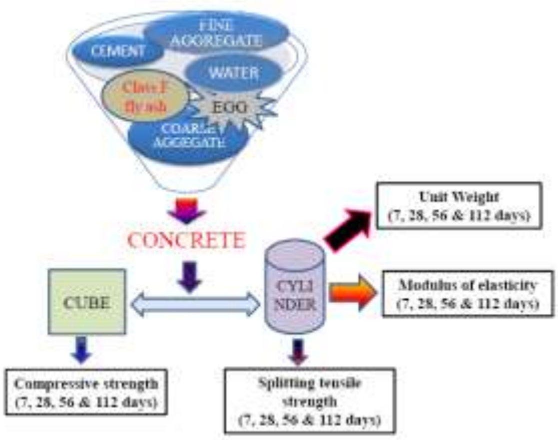


Figure 1. Graphical abstract

2. Literature Review

Hanifi Binici et al. [4] reported that replacement of egg shell powder in sand that leads to reduction in the compressive strength and flexural strength of cement mortar. Butit has high resistance to radiation effect.

Ramesh Babu and Neeraja [2] revealed that when NAD added to binder, it acts as accelerator. The optimum dosage of NAD was determined by the fresh properties of binder and compressive strength CC and Class C fly ash concrete and concluded as 0.25% NAD replacement dosage as optimum dosage for CC and Class C fly ash blended concrete. Due to high viscous nature of NAD and rapid setting of concrete and the workability of concrete was decreased. Ramesh Babu et al [5] reported that the mechanical properties of CC and Class C fly ash blended concrete will increases at optimum dosage 0.25% NAD replacement. But 25% replacement of Class C fly ash with optimum dosage had attained M25 designed strength with optimum NAD dosage, and there after decreasing of compressive strength was observed with increasing FA. They were concluded that maximum replacement of Class C fly ash was 25%

3. Experimental Study

3.1 Materials

The aim of this research is to study the effect of NAD on mechanical properties of CC and low calcium fly ash (FA) blended concrete. FAwas replaced to cement by its weight at various replacement levels of 0%, 25%, 35% and 45%. NAD was replaced to water at various dosages levels of 0%, 0.25%, 0.50%, 0.75% and 1.00% to the weight of cementitious material, by maintaining the liquid to binder ratio at 0.5. The mechanical properties viz unit weight, compressive strength, splitting tensile strength and modulus of elasticity of convention concrete (CC) and FAblended concrete were determined. The optimum replacement level of FAand NAD to get high strength was determined.

3. 2. Material properties

This section describes the proprieties of ingredients used in this study as per Bureau of Indian Standards (BIS) and American Society for Testing and Materials (ASTM)

3.2.1 Cement

Ultra tech 53 grade ordinary Portland cement was used corresponding to IS 12269:1987 [6]. The chemical and physical properties of cement are shown in Tables 1and 2.

Table 1: Chemical properties of cement

Particulars	Test result	Requirement as per IS:12269-1987
Chemical composition		
% Silica (SiO_2)	19.29	
% Alumina (Al_2O_3)	5.75	
% Iron oxide (Fe_2O_3)	4.78	
% Lime (CaO)	62.81	
% Magnesia (MgO)	0.84	Not more than 6.0%
% Sulphuric anhydride (SO_3)	2.48	Max. 3.0% when C_3A>5.0
		Max. 2.5% when C3A<5.0
% Chloride content	0.003	Max. 0.1%
Lime saturation factor CaO $0.7SO_3/ 2.8SiO_2+1.2Al_2O_3+0.65Fe_2O_3$	0.92	0.80 to 1.02
Ratio of Alumina/Iron Oxide	1.21	Min. 0.66

Table 2: Physical properties of cement

Particulars	Test result	Requirement as per IS:12269-1987
Physical properties		
Specific gravity	3.15	
Fineness (m^2/kg)	315.4	Min. 225 m^2/kg
Soundness		
Lechatlier expansion (mm)	0.8	Max. 10mm
Auto Clave expansion (%)	0.01	Max. 0.08%
Setting time (Minutes)		
Initial	45	Min 30 mints
Final	230	Max. 600 mints

3.2.2 NAD

Broiler hen egg was used as NAD, both egg white albumen and yellow yolk was thoroughly mixed and added to concrete. The NAD was replaced to water as 0%, 0.25%, 0.5%, 0.75% and 1.00% of cementitious material weight by maintaining the liquid to binder ratio (0.5).

3.2.3 Mineral admixture

FAwas used as an additive according to ASTM Class F 618. Table 3 shows the properties FA.

Table 3: Properties of fly ash

Physical properties	**Test results**
Specific gravity	2.13
pH	11.52
Moisture content	0.80%
Chemical properties	
Element	**Weight %**
CaO	5.98
SiO_2	62.00
Al_2O_3	18.90
Fe_2O_3	4.90

Physical properties	Test results
MgO	1.99
Na_2O	2.47
K_2O	1.14
TiO_2	1.09
Loss on ignition	1.56

3.2.4 Coarse aggregate

20 mm and 10 mm crushed granite stones were used as coarse aggregate. The specific gravity was 2.62 and water absorption of the coarse aggregate was 0.29%. Sieve analysis was conducted as per IS: 383-1970 [7]. The Fig 2 & 3 shows the gradation curves of 20mm and 10mm aggregates. The coarse aggregate was blended with 20mm (60%) and 10mm (40%) to its total weight of coarse aggregate.

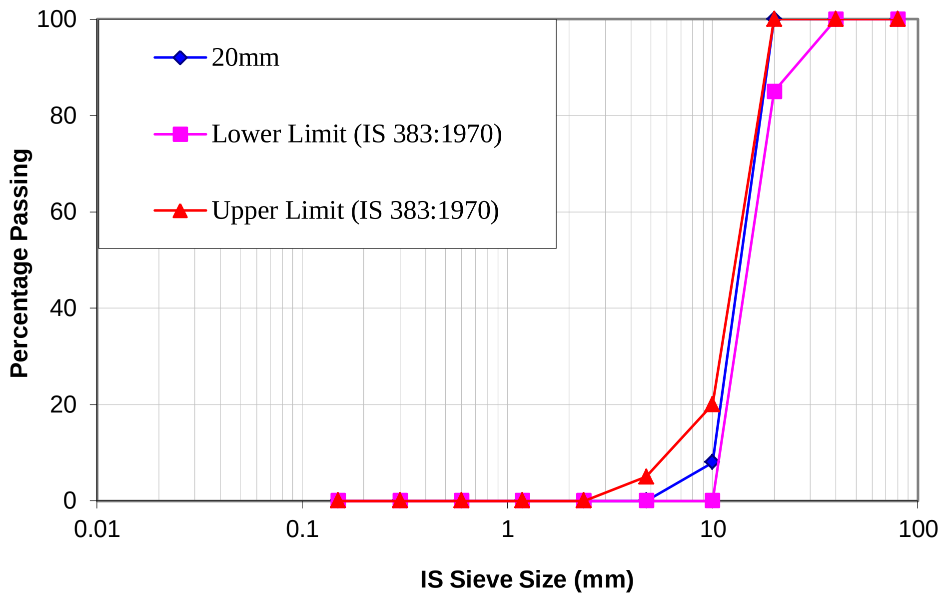


Figure 2.Grading curve of 20 mm coarse aggregate

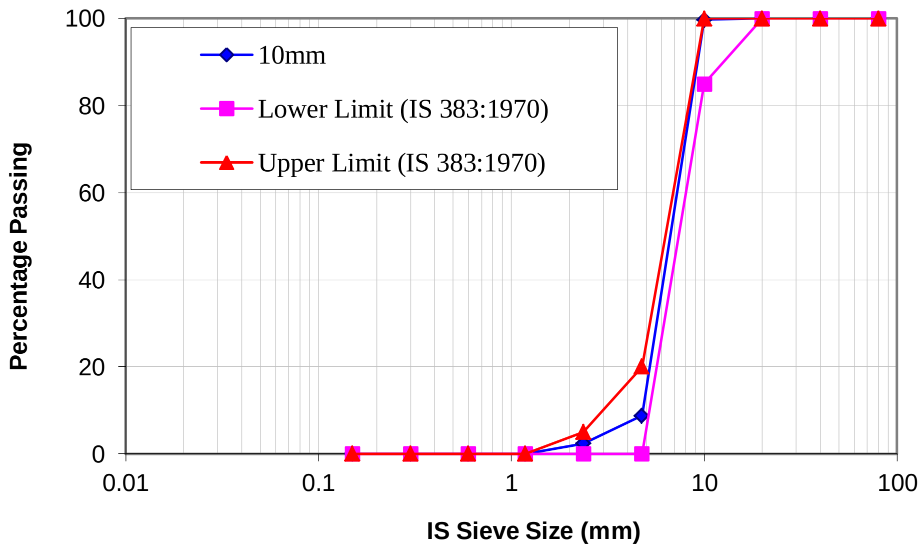


Figure 3.Grading curve of 10 mm coarse aggregate

3.2.5 Fine aggregate

The river sand was used as fine aggregate. The specific gravity was 2.6 and water absorption of the fine aggregate was 0.31%. Sieve analysis was conducted as per IS 383:1970 [7]. The Fig 4.Shows the gradation curves of fine aggregate. Based on particle distribution fine aggregate is concluded as zone –II.

3.2.6 Water

The ordinary tap water was used in present study which satisfies water standards as per IS 456 – 2000 [8].

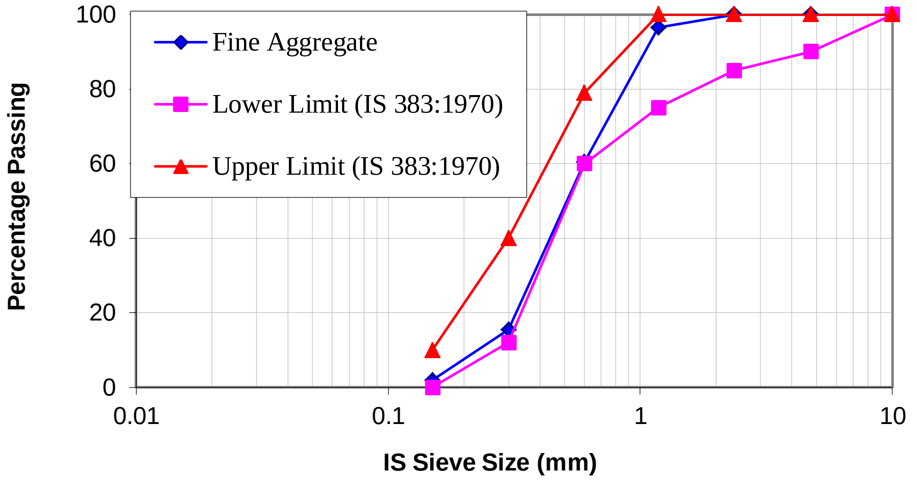


Figure 4.Grading curve of fine aggregate

4. Experimental Procedure

4.1 Mix design

CC M 25 was designed as per IS 10262-2009 [9] and IS 456-2000 [8] and the designed target strength was fixed as 32Mpa after 28 days of curing. The designed M25 CC mix was used to prepare FAblended mixes by replacing the FA at various levels of 0%, 25%, 35% and 45% of CC cement weight. The NAD was replaced in water at various replacement dosages of 0.00%, 0.25%, 0.50%, 0.75 and 1.00% of cementitious material weight by maintaining constant liquid – binder ratio (0.5) which affects the compressive strength [8]. Here, liquid refers to water content with or without egg replacement and binder refers to cementitious content the mixing process was showed in Fig 5. The design mix proportions are shown in Table 4.

Table 4: Mix proportions of constituent materials

Sample Notation	Cement (Kg)	Fly Ash (Kg)	Fine aggregate (Kg)	Course aggregate (Kg)	Water (Lts)	% of NAD	Quantity of NAD (Lts)
C-100_FA-0	360 (100%)	0.00 (0%)	745	1150	180.00	0.00	0.00
					179.10	0.25	0.90
					178.20	0.50	1.80
					177.30	0.75	2.70
					176.40	1.00	3.60
C-75_FA-25	270 (75%)	90 (25%)	745	1150	180.00	0.00	0.00
					179.10	0.25	0.90
					178.20	0.50	1.80
					177.30	0.75	2.70

Sample Notation	Cement (Kg)	Fly Ash (Kg)	Fine aggregate (Kg)	Course aggregate (Kg)	Water (Lts)	% of NAD	Quantity of NAD (Lts)
					176.40	1.00	3.60
C-65_FA-35	234 (65%)	126 (35%)	745	1150	180.00	0.00	0.00
					179.10	0.25	0.90
					178.20	0.50	1.80
					177.30	0.75	2.70
					176.40	1.00	3.60
C-55_FA-45	198 (55%)	162 (45%)	745	1150	180.00	0.00	0.00
					179.10	0.25	0.90
					178.20	0.50	1.80
					177.30	0.75	2.70
					176.40	1.00	3.60

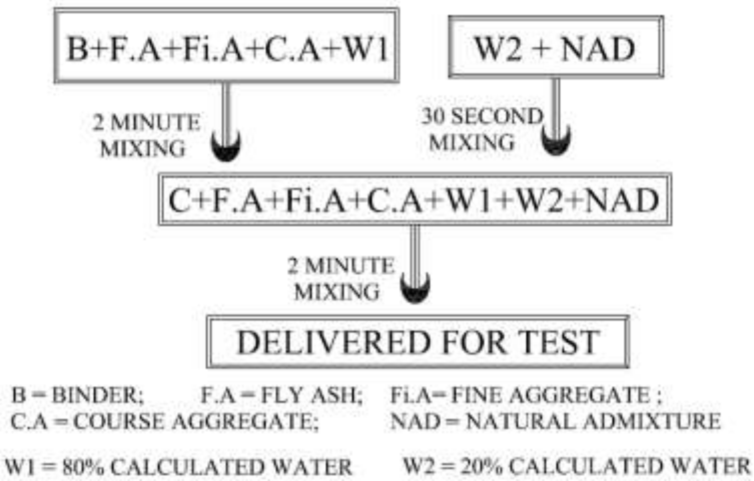


Figure5. Mixing process of concrete ingredients

4.2 Testing hardened mechanical properties

This research concentrates on mechanical properties of hardened concrete for designed mixes. The mechanical properties are unit weight, compressive strength [10], Splitting Tensile Strength (STS) [11] and Modulus of Elasticity (MOE) [10]. Three cubes of size 150 mm were cast and tested for compressive strength for each age and for each mix. Three cylindrical specimens of size 100 mm × 200 mm were cast and tested for each test, and those were unit weight, STS and MOE for each age and for each mix. The mechanical properties were concluded by considering the average of three samples. The Fig 6 and 7 shows the failure sample of compression and STS. The unit weight of mixes was determined by measuring weight and volume of cylindrical specimens prior to STS and MOE tests. The unit weight of hardened concrete (γ_c) was determined after 7, 28, 56 and 112 days of curing for all the mixes.

Figure 6.Compression Failure of cube

Figure 7. Splitting tensile failure of cylinder

5. Results and Discussion

5.1. Unit weight of hardened concrete

The average of three cylindrical specimens unit weight of hardened concrete was showed in Fig 8.A to 8.D for all the mixes. From the results it is observed that, the unit weight of CC and FA mixes have been increased significantly at 0.25% NAD replacement at all curing periods than that of 0% NAD mixes of CC. The increase in unit weight is due to improvement of strength. The same trend was observed in remaining all mechanical properties of CC. There by increasing the percentage of NAD the decreasing of unit weight was observed in both CC and FA mixes. The unit weight of concrete decreases with increasing of fly ash percentage replacement level was observed. The low specific gravity of fly ash leads to decreasing the unit weight of concrete. Siddique [12], [13] reported that the unit weight of FAblended concrete decreases with increasing replacement level of FA.

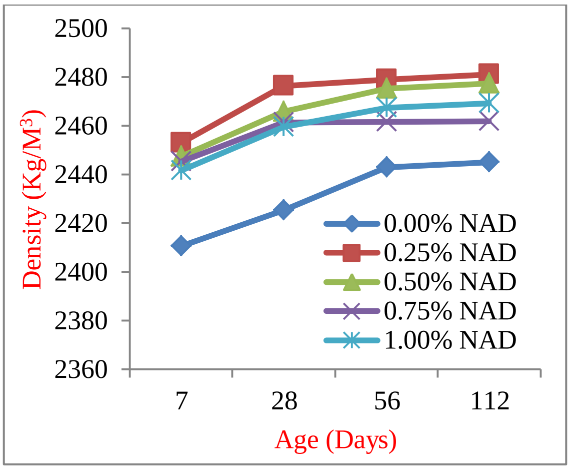


Figure 8.A. Unit weight of C-100_FA-0

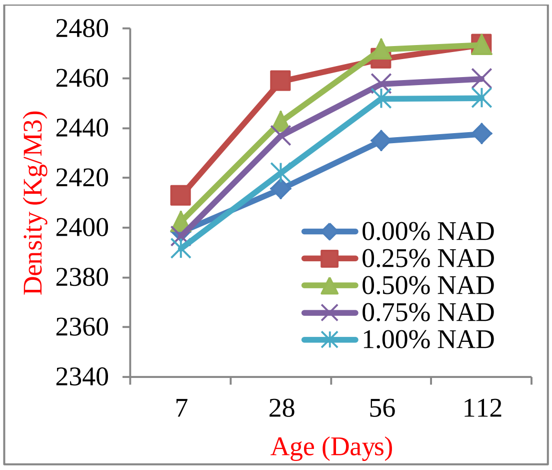


Figure 8.B. Unit weight of C-75_FA-25

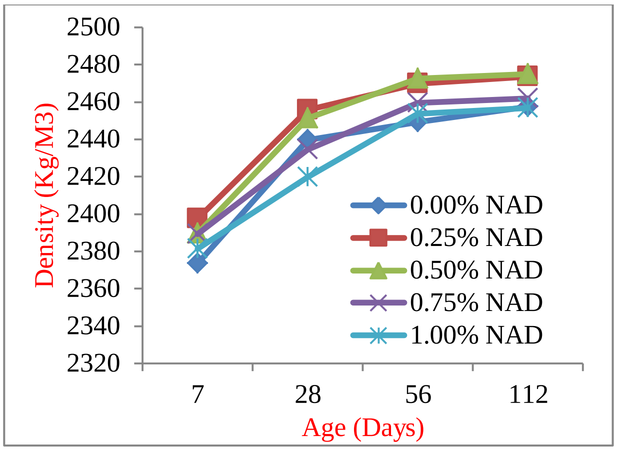


Figure 8.C. Unit weight of C-65_FA-35

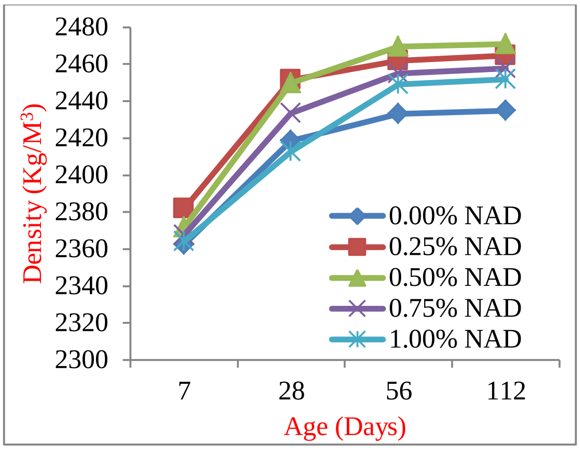


Figure 8.D. Unit weight of C-55_FA-45

5.2. Compressive strength

The cube average compressive strength of all mixes were showed in Table 5 and Fig 9.A to 9.D. From the results, it is observed that compressive strength of concrete was decreased with increasing FA replacement level at 7 days at 0% NAD. It is due to FAwill have low strength at early ages [14]. The CC (C-100_FA-0) mix having higher compressive strength at 7 days of curing than that of FA blended concrete. Siddique [13] reported that the compressive strength of FAblended concrete was decreased with increasing the FA replacement at early ages. But at 0.25% of NAD dosage the compressive strength of CC and FA mixes were increased when compared to without NAD dosage mixes. Ramesh Babu [3] revealed that the NAD dosage of 0.25 % is considered as optimum dosage and at this dosage the compressive strength of CC mixes were increases and that is higher than that of without NAD mixes. The 28 days designed compressive strength of M25 grade CC mix was achieved with 0.25% NAD at 7 days of curing. This shows that NAD had very much significant effect to develop the strength in CC and FA blended mixes. The C-100-FA-0 mixes with 0.25% NAD achieved 72% higher strength than that of same mix without NAD at 7 days hydration.

Table 5: Compressive strength of concrete cubes

NAD Quantity	0.00%	0.25%	0.50%	0.75%	1.00%
C-100 _ FA-0					
7 Days	20.67	35.56	34.67	33.64	25.78
28Days	32.44	42.44	41.56	38.89	36.25
56Days	37.63	46.15	43.15	40.76	38.64
112Days	41.27	48.47	44.58	43.36	42.14
C-75 _ FA-25					
7 Days	19.78	22.22	23.56	22.49	18.80
28Days	31.13	36.22	35.67	33.78	30.67
56Days	38.97	44.36	41.06	38.47	36.85
112Days	45.32	49.32	45.25	42.07	38.89
C-65_ FA-35					
7 Days	17.89	20.89	20.09	18.98	14.67
28Days	29.65	35.45	34.89	31.78	28.11
56Days	40.32	46.52	42.49	39.72	38.07
112Days	49.07	56.07	47.69	44.89	41.56
C-55_ FA-45					
7 Days	16.67	20.44	18.22	15.56	14.67
28Days	27.12	34.22	31.56	30.89	27.33
56Days	37.05	44.32	41.32	38.49	36.12

NAD Quantity	0.00%	0.25%	0.50%	0.75%	1.00%
112Days	44.23	52.22	48.44	44.22	39.56

After 28 days of curing the mix with 25% fly ash replaced mixes achieved 28 days designed strength without NAD. The 25% FA replacement mix having 4% less strength than that of CC without NAD. But whereas, 0.25% NAD dosage all the mixes have achieved designed strength. The compressive strength of concrete is decreased by 14%, 16% and 19% with the replacement of FA with replacement levels of 25%, 35% and 45% of fly ash respectively at 0.25% NAD when compared to those with 0% fly ash mix. Whereas compared to designed strength (32MPa), the strength of mixes was higher as 32%, 13%, 11% and 7% for 0%, 25%, 35% and 45% respectively at 0.25% NAD dosage. There by increasing the NAD dosage greater than 0.25% the reduction in strength was observed. It was observed that from this experimental work, the liquid form of Calcium present in NAD is effectively involved to enhance the hydration and to get the higher strengths. The increased compressive strengths from 0% to 0.25% NAD was 31%, 16%, 19% and 26% for 0%, 25%, 35% and 45% FA replacement respectively.

After 56 days of curing the strength increment was observed in all the mixes. At 0%NAD all the mixes achieved designed strength, but 35% FA replaced concrete mix achieved higher strength amount all the mixes after 56 days of curing. The increasing trend was observed from 0% to 35% FA replaced mixes and there after falling trend was observed at 0% NAD dosage. It shows that the optimum replacement level of fly ash to get higher strength at lateral ages is 35%. The compressive strength of 35% FA replacement mix is 7% higher than that of CC mix at 0% NAD. It is evident that the FA blended mix gets higher strength at later ages due to its pozzolanic action. The trend was observed at optimum NAD of all the mixes. The strength increments from 28 to 56 days was 8%, 22%, 31% and 30% for 0% to 45% FA replacement levels at 0.25% NAD dosage. There by increasing NAD dosage greater than 0.25% the strength was reduced. The strength increments are very much significant at 35%. Ravina [15] had concluded that FAconcrete has higher strength at later ages.

After 112 days of curing, the same trend of strength was observed. The compressive strength was increased for up to 35% FA replacement and thereby increasing the FA replacement decreasing the strength was observed. The 35% FA replacement mix achieved higher strength among all the mixes at 0% NAD dosage. At 0.25% NAD all the FA replaced mixes achieved higher strength than that of CC mix. This shows that the NAD effect is continues in FA blended mixes after 112 days to enhance it strength. The strength increments from 56 to 112 days were 5%, 11%, 20% and 18% for 0% to 45% replacement levels of FA respectively. It can be concluded that NAD is effectively involved to enhance the pozzolanic action also [5].

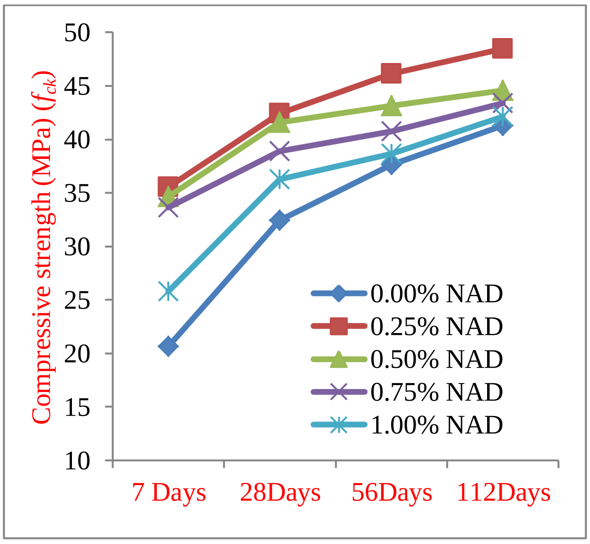


Figure 9.A. Compressive strength of C-100_FA-0

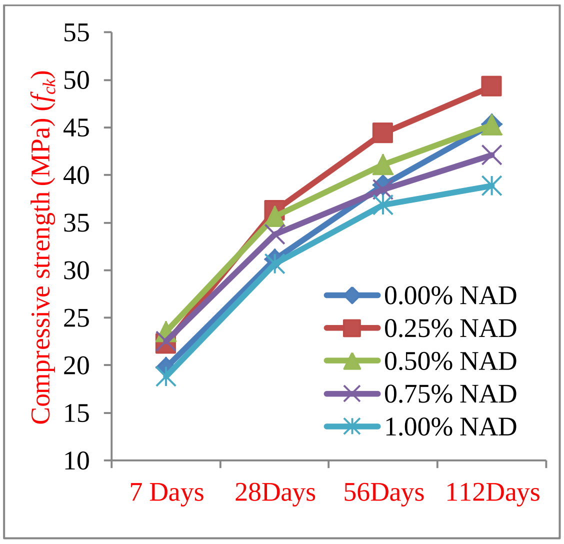


Figure 9.B. Compressive strength of C-75_FA-25

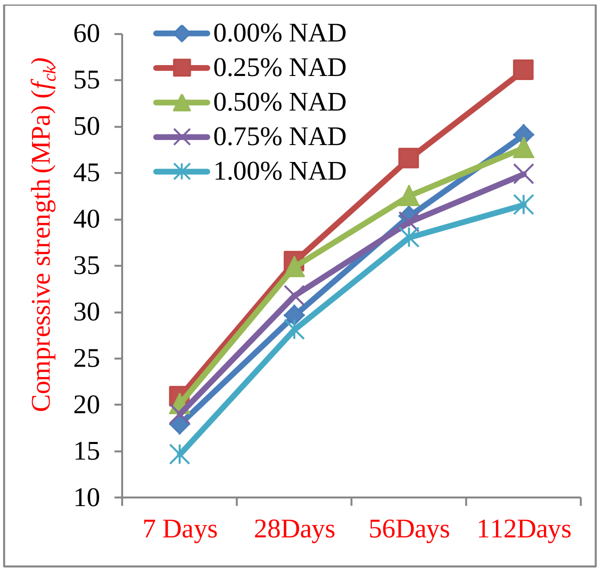


Figure 9.C. Compressive strength of C-65_FA-35

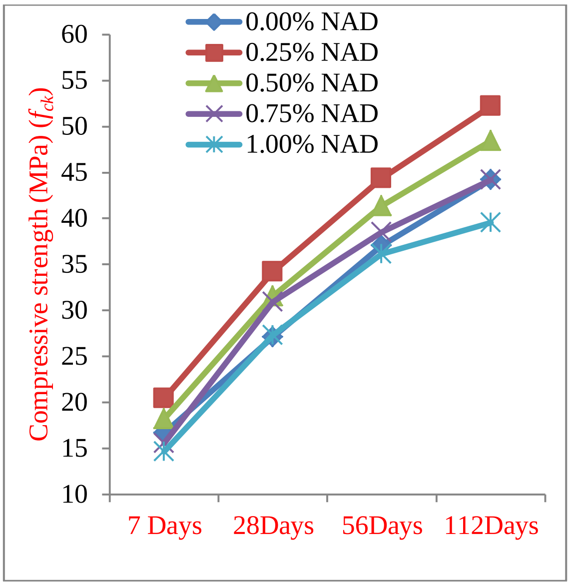


Figure 9.D. Compressive strength of C-55_FA-45

5.3 Splitting tensile strength

The Splitting Tensile Strength (STS) of concrete mixes are shown in Table 6 and Fig 10.A. to 10.D. From the results, it is observed that STS values of CC is higher than that of FA blended mixes at 0% NAD replacement level at 7days. It shows the same trend of compressive strength. The CC mix with 0.25% NAD had achieved 31% higher STS than that of same mix without NAD after 7 days of curing. The same significant effect also observed in FA blended mixes at 0.25% NAD replacement level. The same incremental trend was observed in FA blended mixes at 0.25% NAD replacement level, but the percentage of increments were decreasing with increasing the FA replacement level. The STS increments were 31%, 12%, 7% and 5% for 0% to 45% FA replacements. This is due to slower pozzolanic action of FA at early days. Siddique [13] concluded that the compressive strength and STS of FA blended concrete was decreases with increase in FA replacement. There by increasing of NAD dosage the decreasing of STS were observed. So that 0.25% NAD can be concluded as optimum dosage for all the CC and FAmixes for STS.

Table 6: Splitting tensile strength of concrete (MPa)

NAD Quantity	7 DAYS	28 DAYS	56 DAYS	112 DAYS
C-100 _ FA-0				
0.00%	2.52	3.34	3.41	3.54
0.25%	3.31	3.78	4.07	4.17
0.50%	3.01	3.26	3.76	3.84
0.75%	2.59	3.11	3.65	3.79
1.00%	2.54	3.06	3.45	3.62
C-75 _ FA-25				
0.00%	2.12	2.93	3.43	3.68
0.25%	2.37	3.47	3.74	4.21
0.50%	2.31	3.22	3.59	3.94
0.75%	2.21	3.14	3.47	3.64
1.00%	2.01	3.03	3.31	3.51
C-65 _ FA-35				
0.00%	2.07	2.91	3.48	3.58
0.25%	2.22	3.41	4.14	4.37
0.50%	2.26	3.16	3.93	4.21

NAD Quantity	7 DAYS	28 DAYS	56 DAYS	112 DAYS
0.75%	2.14	3.11	3.82	3.98
1.00%	1.91	3.04	3.73	3.83
C-55 _ FA-45				
0.00%	1.94	2.71	3.49	3.69
0.25%	2.05	3.17	4.09	4.24
0.50%	1.98	3.05	3.79	4.11
0.75%	1.87	2.89	3.61	3.88
1.00%	1.77	2.76	3.49	3.66

After 28 days of curing, STS of CC was 3.34Mpa at 0% NAD, that is higher than 7 days STS. At 0.25% NAD all the mixes achieved higher STS than that of 0% NAD, the STS increments from 7 to 28 days was 14%, 46%, 55% and 53% with 0% to 45% FAreplacement level. It is observed that the STS increments were high in FA blended mixes than that of CC up to 35% FA, thereby increasing the FA decreasing STS was observed. So it can be concluded that the NAD effect is very much significant in FAthan that of CC mix at 0.25% of NAD. There by increasing the NAD dosage the STS were decreases.

After 56 days of curing, same STS increment trend was observed at 0% NAD dosage, but it is less than 0.25% NAD dosage for all the mixes. The mix C-65_FA-35 mix achieved 4.14 Mpa, it higher amount all the mixes at 0.25% NAD. The STS increments at 0.25% NAD dosage for 28 days to 56 days was 7%, 8%, 29% and 21% with 0% to 45% FA replacement levels. The rate of increment of STS was reducing from 28 days to 56 days when compared to 7 days to 28 days. It indicates the strength gaining capacity of mixes gradually reduces. The same trend observed after 112 days also. The increasing the FA replacement increase in STS was observed up to 35% FA replacement. There by Increasing FA replacement higher than 35% decreasing in STS was observed. So that, the C-65_FA-35 mix achieved higher STS than that of all mixes at 56 days and later.

Previous studies reveled that higher fines (or) admixtures have more influence on tensile strength of concrete [16]. The mix C-65_FA-35 achieved higher STS at 0.25% NAD dosage, it shows that the NAD is effectively involved to enhance the strength and improves the pozzolanic action. Whereas all FA blended mixes at 0.25% NAD attained higher STS than that of CC. It is evident that pozzolanic action of FA at later ages [12] – [19] and improvement of interfacial transition zone (ITZ) between paste and aggregate [16] with incorporation of 0.25% NAD dosage.

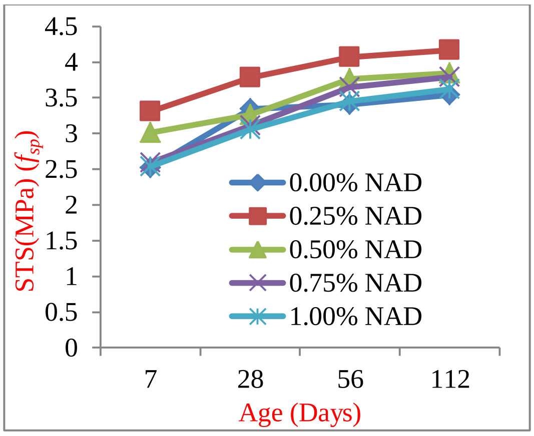


Figure 10.A. Splitting tensile strength of C-100_FA-0

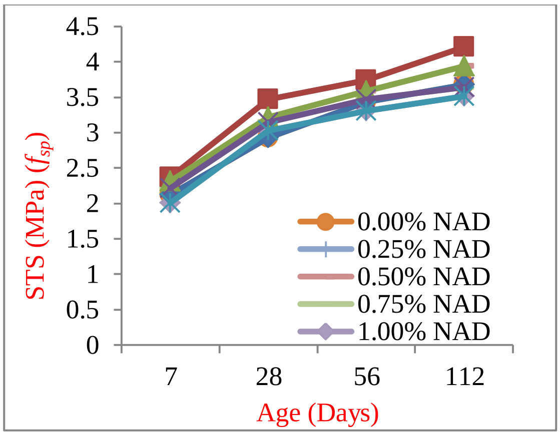


Figure 10.B. Splitting tensile strength of C-75_FA-25

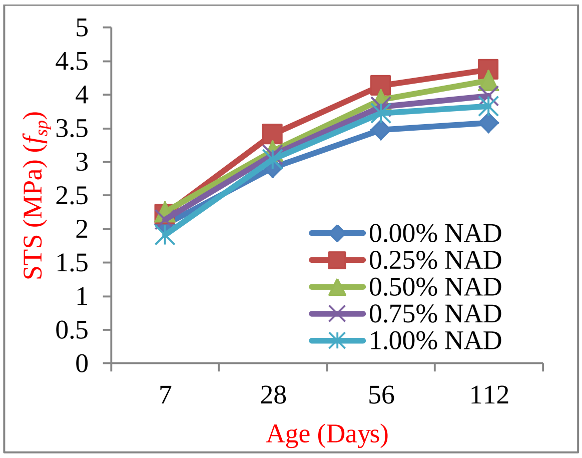


Figure 10.C. Splitting tensile strength of C-65_FA-35

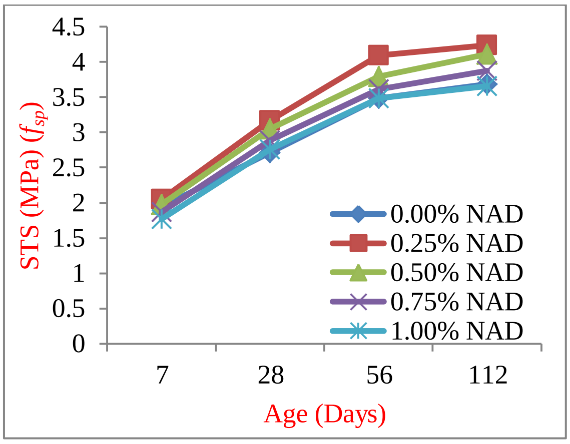


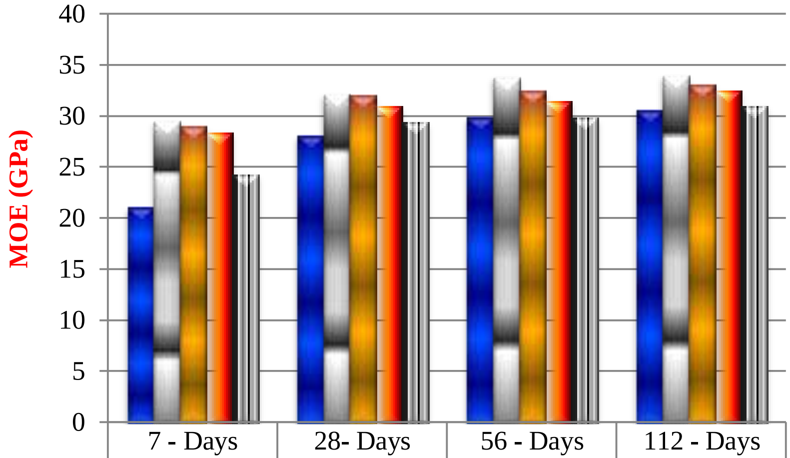
Figure 10.D. Splitting tensile strength of C-55_FA-45

5.4. Modulus of elasticity

The Modulus of Elasticity (MOE) of CC and FAblended mixes were shown in Fig 11.A. to 11.D. From the results, it is observed that the MOE of CC was increases with increase in curing period at 0% NAD dosage. After 7 days of curing, increasing the FA replacement level the decrease in MOE was observed. At 0.25% NAD the MOE of CC was 29.54Gpa and that is 40% higher than 0% NAD dosage of same mix. It shows that the NAD was also having very much significant effect to enhance the MOE at 0.25% NAD. There by increasing NAD the reduction of MOE was observed. The same increasing trend was observed in FA blended mixes, but the rate of increments was less in FA blended mixes than that of CC. It can be also consider as slower pozzolanic action.

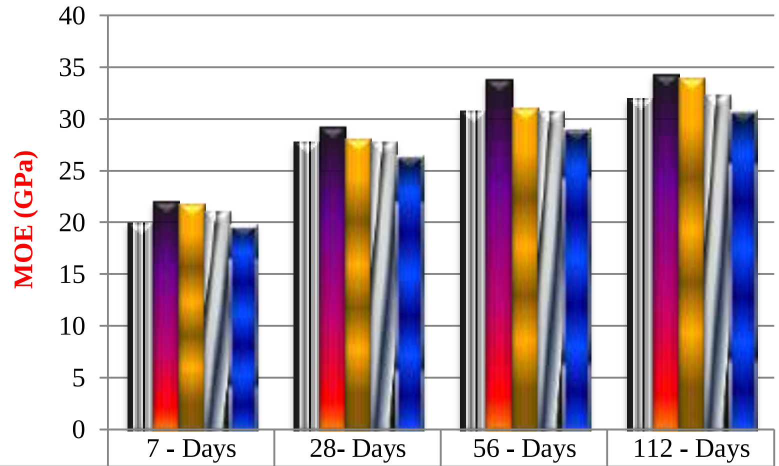
After 28 days, the MOE was increased with age for all the mixes with and without NAD. The MOE of CC after 28 days of curing was 32.21Gpa, which is greater than amount all the FA blended mixes. The rate of increment of MOE from 7 days to 28 days was 14%. The same increment trend was followed by remaining FA blended mixes, but rate of increment is less. This is due to lower strength of FA blended concrete at early ages. All the mixes follow same trend pattern of compressive strength. [16] – [21].

After 56 days, MOE increment was continues in all the mixes with and without NAD with different rate of increments. The mix C-65_FA-35 (35% FA replacement) has achieved 31.97GPa, 34.16GPa at 0% and 0.25% NAD, which is higher than among all mixes. The MOE was increased by 7% with 0.25% NAD dosage. So it can be consider NAD effect was continues after 56 days also. [5] Concluded that the MOE of FA blended mixes would be high at later ages. The MOE increments were observed with increase in FA replacement up to 35%. The decrease in MOE was observed in mixes greater than 35% FA replacements. After 112 days of curing, MOE of 35% FA replacement mix is higher than the amount all which is same as at 56 days curing. The rate of increment of MOE from 56 days to 112 days was 4%, but from 28 days to 56 days was 19%. It shows that the increment rate is gradually reducing.



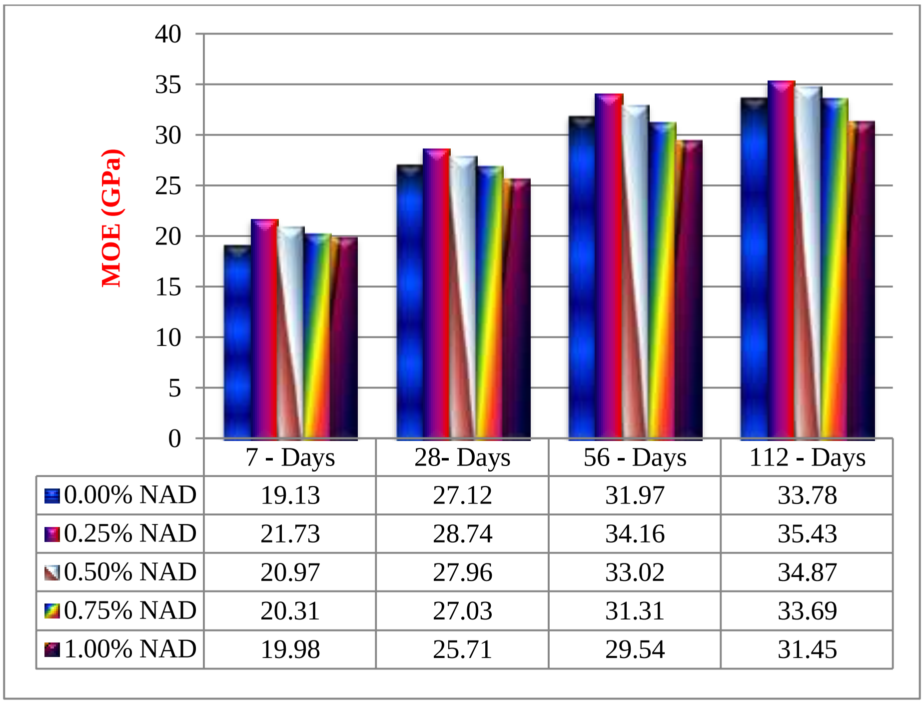
	7 - Days	28- Days	56 - Days	112 - Days
0.00% NAD	21.09	28.14	29.94	30.66
0.25% NAD	29.54	32.21	33.86	34.03
0.50% NAD	29.09	32.07	32.52	33.16
0.75% NAD	28.47	31.04	31.49	32.54
1.00% NAD	24.31	29.45	29.86	31.03

Figure 11.A. Modulus of Elasticity of C-100_FA-0



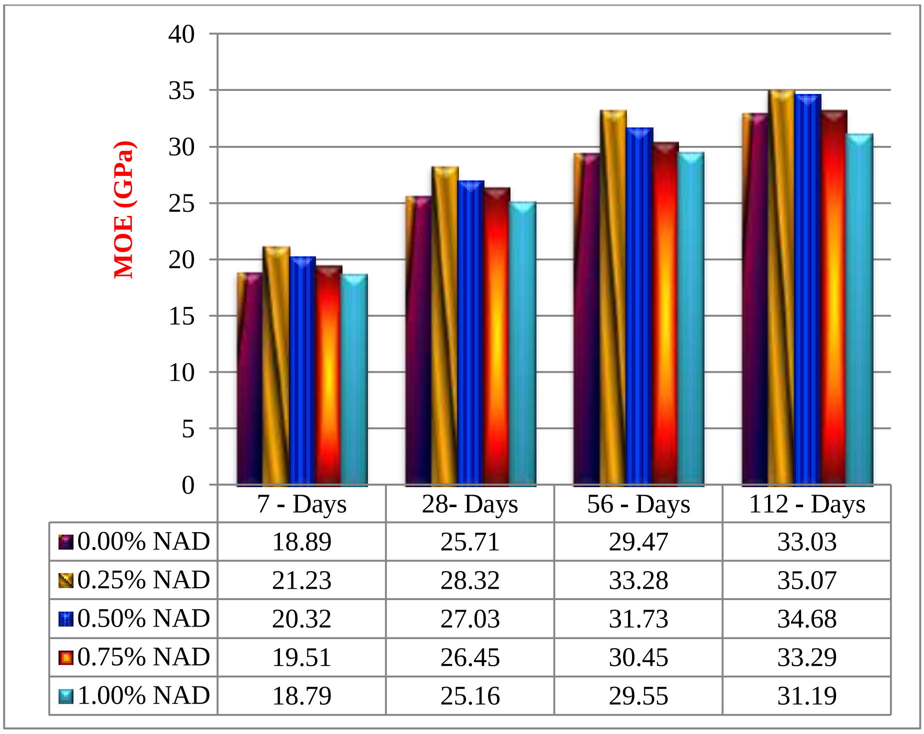
	7 - Days	28- Days	56 - Days	112 - Days
0.00% NAD	20.05	27.84	30.87	32.03
0.25% NAD	22.08	29.32	33.91	34.42
0.50% NAD	21.86	28.14	31.13	34.05
0.75% NAD	21.17	27.82	30.79	32.41
1.00% NAD	19.76	26.45	29.07	30.83

Figure 11.B. Modulus of Elasticity of C-75_FA-25



	7 - Days	28- Days	56 - Days	112 - Days
0.00% NAD	19.13	27.12	31.97	33.78
0.25% NAD	21.73	28.74	34.16	35.43
0.50% NAD	20.97	27.96	33.02	34.87
0.75% NAD	20.31	27.03	31.31	33.69
1.00% NAD	19.98	25.71	29.54	31.45

Figure 11.C. Modulus of Elasticity of C-65_FA-35



	7 - Days	28- Days	56 - Days	112 - Days
0.00% NAD	18.89	25.71	29.47	33.03
0.25% NAD	21.23	28.32	33.28	35.07
0.50% NAD	20.32	27.03	31.73	34.68
0.75% NAD	19.51	26.45	30.45	33.29
1.00% NAD	18.79	25.16	29.55	31.19

Figure 11.D. Modulus of Elasticity of C-55_FA-45

5. Conclusions

1. The following conclusions have been drawn based on the investigation studied on the effect of NAD(broiler hen egg) on mechanical properties of CC and FA blended concrete:
2. The mechanical properties of CC and FA blended mixes were very much significantly increased at 0.25% NAD dosage. So that it can be concluded as 0.25% NAD is optimum dosage for CC and FA blended mixes.
3. The design M25 grade concrete strength was obtained in CC at 7 days with optimum dosage of NAD
4. The mechanical properties of CC are rapidly increased at early ages with incorporation of optimum dosage

of NAD.

5. The compressive strength of 35% FA replacement mix achieved higher than designed strength of M25 grade concrete with 0.25% NAD dosage and it achieved higher strength than that of CC after 56 days.
6. The 35% FA replacement mix is concluded as optimum mix, because it achieved higher strength amount all the remaining FA blended mixes with incorporation of 0.25% NAD.
7. The NAD was very much actively increasing the hydration and pozzolanic action.
8. The splitting tensile strength and modulus of elasticity of all mixes follows the same trend as like compressive strength.
9. The mechanical properties of concrete is depends on compressive strength of concrete for both CC and FA blended mixes incorporation with NAD.
10. The effect of NAD on FAis very much significant effect than that of CC at later ages.
11. The broiler hen egg can be recommended Natural admixture to reduce the usage of chemical admixture to reduce the environmental problems.
12. The 35 % FA replacement with 0.25% NAD reduces the production cost of concrete and also consider as sustainable materials.

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