"EFFECT OF CALCIUM NITRATE, TRIETHANOLAMINE & CALCIUM CHLORIDE ON THE STRENGTH EVOLUTION OF CONCRETE AT EARLY AGES"

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Abstract:

Chemical admixtures are used in concrete for various purposes such as water reducing, plasticizing, air entraining, bonding, viscosity modifying, colouring, corrosion inhibiting, permeability reducing, accelerating or retarding the initial setting time, and shrinkage reducing. The use of chemical admixtures in concrete helps to improve workability of fresh concrete and durability properties of hardened concrete as well as reducing the total cost of concrete production. In this study, three different types of chemical raw materials (calcium nitrate, triethanolamine-TEA and calcium chloride) will be used in the production of chemical admixtures, which will be used in concrete with three-four different dosages. Day 1, 3 days, 7thday and 28thday, 56th day, 90th day compressive strengths of concrete will be determined and also fresh properties of concrete will be analysed. Effect of admixtures can reduce setting time when it is used along with different dosages. That's why its effect will be checked with different dosages of different admixtures.

Keywords – Accelerating admixtures, Triethanolamine, $Cacl_2$, $Cano_3$, Antifreezing Agent.

I. INTRODUCTION

Concrete is a well-known heterogeneous mixture of cement, water and aggregates. The mixture can be added to the concrete to modify some of the desired properties of the concrete by improving the overall strength and durability of the concrete. The simplest form of concrete is a mixture of pastes and agglomerates. Various materials such as fly ash and silica fume are added to the concrete to give the desired properties. Concrete properties are determined by the quality of the paste. The key to getting a strong, durable concrete is to carefully dispense, mix, and compress. The mixture can be added to the concrete to modify some of the important desired properties. Human activities such as rapid urbanization and industrialization have increased demand for high strength concrete. The present world must overcome the difficulties of building huge structures. Therefore, the goal of meeting the performance and strength requirements of concrete is emerging at an alarming rate.

General Portland Cement (OPC) was a cementitious material in the production of concrete since its creation in 1824. Packed concrete for the construction and repair of rigid pavement is usually produced using OPC. As demand for specific production increases globally, the natural resources for the raw materials needed for production of OPC increase, and these valuable resources can be depleted and ultimately destroyed. Therefore, environmentally benign alternative cement materials are being promoted in the construction industry. Grinded blast furnace slag (GGBS), a by-product of fly ash, thermal power plants and cast-iron plants, is useful in its nature as two materials used in concrete.

In recent decades, chemical and mineral mixtures have been used successfully in concrete structures. Proper use of the mixture provides some beneficial effect on the concrete including improved quality, accelerated or retarded cure time, improved frost and sulphate resistance, strength development control, improved workability and enhanced finishing ability. This approach has reduced construction costs and is universally accepted to reduce unexpected problems during construction. Depending on the expected ambient conditions and other construction procedures, various tests should be performed to determine the effect of specific working materials on the properties of the concrete. Chemical mixtures play an important role in modern concrete materials and technology. Chemical mixtures have not only improved the above properties of concrete, but also helped to develop new concrete technologies such as concrete pumping and self-levelling, underwater concrete and ejection.

The properties typically modified using the mixture are curing time, workability, air-release, dispersion and the like. The mixture is generally added in a relatively small amount ranging from 0.005% to 2% by weight of the cement. The use of an admixture adversely affects the physical properties of the concrete.

Admixtures are natural or manufactured chemicals added to concrete before or after mixing. They are used to relieve difficult construction conditions or to impart fresh and concrete properties. The admixture improves the workability, durability and strength of the concrete and can solve problems presented by high and low temperatures, initial strength requirements or low moisture-cement specifications. Some classifications of chemical mixtures: air infiltration, water loss, delay, accelerating and plasticizers, etc.

All concrete mixes contain today's concrete mixtures, which include concrete mixtures that help to increase productivity and lower costs. The cost of such a mixture depends on the amount and type of mixture used. All this adds to the cost of concrete cubic yards / meter.

Many materials are known to act as concrete accelerators. They include alkali hydroxides, silicates, fluoro-silicates, organic compounds, calcium formate, calcium nitrate, calcium thiosulphate, aluminium chloride, potassium carbonate, sodium chloride and calcium chloride. This calcium chloride is most widely used because of its ready availability, low cost, and predictable performance characteristics. Non-chloride mixtures are preferred because the chloride-containing material is believed to accelerate the corrosion of the stiffener.

II. LITERATURE SURVEY

1] Six alkanolamines were added separately to Portland cement as a chemical additive to investigate the effect on cement hardening and hydration for the first time. Six types of alkanolamine (ie, TEA, TIPA, DEIPA, EDIPA, THEED and THPED) were added to Portland cement as a chemical additive and the effect and mechanism of Portland cement on the physical properties and hydration were investigated. The results suggest that all alkanolamines can effectively improve the cement hydration of TEA. TEA delays the hydration of alites as the formation of TEA-Ca2 + complexes inhibits the growth of CH. TIPA accelerates hydration of C4AF in later stages, but reduces initial strength due to air influx. The lower dosage of DEIPA and EDIPA has the advantage of TEA and TIPA, which increases late strength as well as early strength. They not only promote hydration of both aluminum and ferrite phases, but also facilitate the conversion of AFt to AFm, leading to optimization of pore size distribution. The effect of THEED and THPED on the hydration of Portland cement is similar even though the molecular structure is different but improves later strength and has a larger suitable dosage range.

2] The amount of binder material and calcium nitrate used will affect the properties of the concrete mixture and the strength of the cured concrete. The initial and final bond hardening times 42.5 R at the curing temperatures (+ 20 ° C and + 5 ° C) of the pastes made from different cements (Portland cement CEM I 42.5 R and Portland limestone cement CEM II / A-LL) Of calcium nitrate from 1% to 3%. Effect of calcium nitrate on the technical properties of the concrete mixture (concentration of the mixture, density and air content of the mixture) on early concrete strength after 2 and 7 days and standard concrete strength after 28 days Other temperatures (+ 20 ° C and + 5 ° C) Were analyzed.

3] Calcium nitrates are used at 6% of cement usage in the mix. After casting, a group of concrete samples were cured in different bases for 7 minutes at -5 ° C, -10 ° C, -15 ° C and -200 ° C, after which the same samples were cured in water for 28 days. The compressive strength of concrete with the use of calcium nitrate in the mix was between 96-297% at -50 ° C, -100 ° C, -15 ° C and -200 ° C compared to the mixture without freezing agent, the freezer was cured for 7 days. The results showed that it is possible to use calcium nitrate as an antifreeze mixture in a concrete batch process in a cold climate concreting.

4] Chemical mixtures are used for concrete in concrete for a variety of purposes such as water reduction, plasticization, air entrainment, bonding, viscosity change, tinting, corrosion protection, reduced permeability, acceleration or retardation of initial curing time, and reduced shrinkage. The use of chemical mixtures in concrete helps to improve the workability of hardened concrete and the durability of hardened concrete as well as reducing the total cost of producing concrete. In this study, three types of chemical feedstocks (calcium nitrate, triethanolamine-TEA and trisopropanolamine-TIPA) were used in the production of chemical mixtures used in mortars with two types of cement admixtures. 7 and 28 days of mortar compression strength were determined and TIPA was found to have the greatest effect in increasing compressive strength in these three chemicals.

5] The purpose of this study is to improve the compressive strength of mortars made of fly ash (FA) and calcium carbide (CR) as binders. FA is a by-product of thermal power plants and CR is a byproduct of the acetylene gas industry. They have been used together to form new binder materials for concrete. Since the strength of the early age is low, several processes have been introduced to increase the compressive strength of new binders. In this study, the fineness, curing temperature and cement content of the binder were studied. The mortar moulded for 24 hours was oven-cured for 24 hours at temperatures of 30, 45, 60 and 75 ° C and cured to water at room temperature until the age of the test. The results showed that the precision of CR-FA binder is the most important factor to increase the compressive strength of CR-FA mortar. At 90 days, the compressive strength can increase from 15.6 MPa to 26.0 MPa as a result of the enhanced binder. Higher curing temperatures also improved the compressive strength of the mortar at early ages, but were less effective at later ages. Moreover, replacing some of the GCR-GFA binders with Portland cement can accelerate and increase mortar strength at varying rates. The mortar SC0T30 (without cement) has a compressive strength of 26.0 MPa at 90 days and can be increased to 30.3 and 31.2 MPa, respectively, with 5 and 10% cement in the binder.

6] Concrete is a common material used in the Nigerian construction industry. This is obtained by mixing the cementitious material, water, fine, coarse aggregates and sometimes the mixture at the required rate. The admixture is added to the concrete to modify the properties of the concrete to make it more suitable for any situation. The recent collapse of Nigeria's buildings has been a source of concern for people involved in the construction industry. It is necessary to inspect the mixture which affects the properties of the concrete. This study investigated the effect of calcium chloride (CaCl2) as a mixture of compressive strength of concrete produced in Nigerian cement of Dangote, Elephant and Burham brands.

7] Initial strength development of cement-fly ash cement material curing in a solution of water and nitrite corresponding to conventional antifreeze, i.e. sodium nitrite, was investigated. As a result, the addition of sodium nitrite results in an increase in the bulk of the sulfoaluminate in the composite adhesive material early, resulting in a decrease in the strength of the composite adhesive material cured at 5 °C. The addition of fly ash can contribute to the improvement of the late strength of the composite cement material cured at 5 °C.

8] The purpose of this study is to investigate the effect of using some mixtures such as calcium nitrate, triethanolamine and trispropanolamine in the curing and curing process of cement paste at 20 ° C. The tests were performed on specimens of various mixtures taking into account both types of cement. The results obtained indicate that the calcium nitrate used alone acts as a curing accelerator and has a relatively beneficial effect on the long-term development of mechanical resistance.

9] In this study, six alkanolamines such as TEA, TIPA, DEIPA, EDIPA, THEED, and THPED were added to Portland cement as a chemical additive to investigate the effect and mechanism of Portland cement on physical properties and hydration. The results show all alkanolamines. TEA can effectively improve cement hydration. TEA delays the hydration of alites as the formation of TEA-Ca2 + complexes inhibits the growth of CH. TIPA accelerates hydration of C4AF in later stages, but reduces initial strength due to air influx. The lower dosage of DEIPA and EDIPA has the advantage of TEA and TIPA, which increases late strength as well as early strength. They not only promote hydration of both aluminum and ferrite phases, but also facilitate the conversion of AFt to AFm, leading to optimization of pore size distribution.

10] The effects of chemical admixtures on the workability and strength development of calcium sulfamaluminate cement (CSA) at various temperatures were investigated, and the mechanisms of XRD and TG were analyzed. Cure time and early strength of CSA were greatly improved by sodium gluconate-borax (SG-B) sodium at 0C and lithium aluminum sulfate (LC-AS) at 40C. LCAS not only promoted ettringite formation, but also promoted Belite hydration, and the amount of ettringite was significantly increased at 0 ° C. However, the production of etrinzate is delayed by SG-B, and a decrease in the amount of etrinzate can be achieved at temperature 40·C.

In the present study, lithium carbonate (LC), aluminum sulfate (AS), calcium nitrate (CN), sodium gluconate (SG) and borax at 40 °C to improve the workability and strength of CSA at 10, The effects of special chemical mixtures at specific temperatures on curing time, flowability and strength development were examined in detail, and a suitable blend design was chosen at a specific temperature to enable a broader range of CSA applications.

11] This study investigates the effect of triethanolamine dosage on the effect of accelerated delay on initial curing time of hydrated cement. We conducted an atomic simulation to investigate the molecular interactions between triethanolamine and dissolved ions in hydrated cement and conducted an experiment to investigate the effect of triethanolamine on cement hydration. The accelerated delaying effect of triethanolamine over the initial set time was found to be due to the different intensities of the resulting ettringite, which is dependent on the triethanolamine dose. This discovery provides insight into the role of triethanolamine and ettringite formation at initial set-up time.

III. RESEARCH METHODOLOGY

This study includes test results of the experimental program conducted on hardened concrete such as compressive strength test, split tensile strength, and durability test (sulphate attack & chloride attack) prepared with and without various dosage of TEA, Cacl2 and Cano3 in replacement of cement for M30 grade of concrete.

1] Compressive strength:

For compressive strength test, cube specimens of 150mm x 150mm x 150mm size were casted for M30 grade of concrete. The various percentages of TEA content were taken as 0.4, 0.5 and 0.6%; Similarly, Cacl2 content were taken as 4, 5, and 6%; Similarly, Cano3 content were taken as 4, 5, and 6% by weight of cement for this research work. For compression test, 9 cubes of concrete without admixtures and 9 cubes of concrete with each proportion of were casted.

Tamping rod was used for compaction of concrete in the moulds. The top surface of the cube specimen was levelled and finished. After the period of 24 hours the cube specimens were demoulded and were transferred to curing tank. The cubes were tested at 1 day, 3 days, 7 days, 28 days, 56 days and 90 days as per IS 516-1959 and the load was noted at failure occurrence. For each mix three cubes were tested and their average value is reported. The compressive strength was calculated by following formula.

Compressive strength (MPa) = (Failure load) / (c/s area of cube specimen)

2] Split Tensile Strength Test:

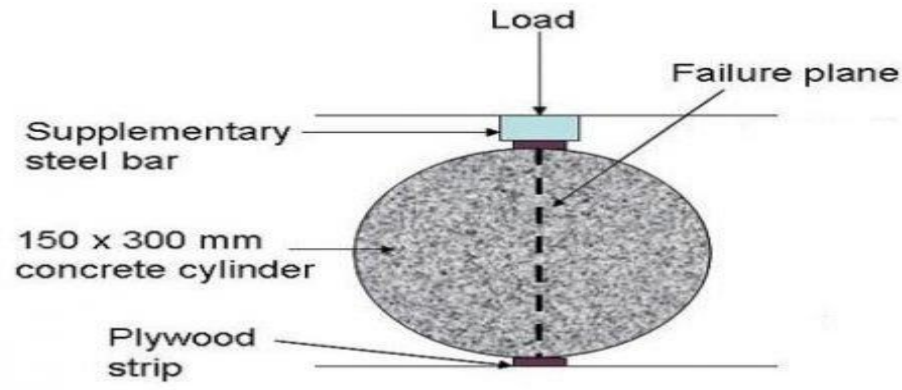
For split tensile strength test, cylinder specimens of size 150 mm diameter and 300 mm length were casted for M30 grade of concrete. The various percentages of TEA content i.e. 0.4, 0.5 and 0.6%; Cacl2 4, 5 and 6%; Cano3 4,5 and 6% were taken for this research work. For split tensile strength test, 3 cylinders of concrete without admixtures and 3 cylinders of concrete with each proportion of admixtures were casted.

After the period of 24 hours the cylindrical specimens were demoulded and were transferred to curing tank. These cylindrical specimens were tested under compression testing machine at 28 days as per IS 5816-1999 and the load was noted at failure occurrence. For each mix three cylinders were tested and their average value is reported.

The Split tensile strength was calculated by following formula :

Split tensile strength (MPa) = (2 x P) / (π x D x L)

Where, P = failure load D = diameter of the cylinder = 150 mm L = length of the cylinder = 300 mm



3] Resistance to sulphate attack:

For this test, 3 cubes of 150 x 150 x 150 mm size concrete without TEA, Cacl2 and Cano3 and 3 cubes of concrete with TEA, Cacl2 and Cano3 for each proportion 28 days of water curing and dried for one day were immersed in 5 % magnesium sulphate (MgSO4) added water for 90 days. concentration of sulphate water was maintained throughout the period. After 90 days immersion period, the concrete cubes were removed from the sulphate waters and after wiping out the water and girt from the surface of cubes tested for compressive strength following the procedure prescribed in IS: 516- 1959.

4] Resistance to chloride attack:

For this test, 3 cubes of 150 x 150 x 150 mm size concrete without TEA, Cacl2 and Cano3 and 3 cubes of concrete with TEA, Cacl2 and Cano3 for each proportion after 28 days of water curing and dried for one day were immersed in 5 % Sodium Chloride (NaCl) added water for 90 days. concentration of chloride water was maintained throughout the period. After 90 days immersion period, the concrete cubes were removed from the chloride water and after wiping out the water and girt from the surface of cubes tested for compressive strength following the procedure prescribed in IS: 516- 1959.

5] RCPT Test:

UTC-1200 Rapid Chloride Permeability Test Equipment (RCPT) is used to evaluate the resistance of a concrete sample to the penetration of chloride ions. Test is performed by placing a 100 mm diameter concrete cylinder into the sample cells that contain 3.0 % salt solution and 0.3 N sodium hydroxide solution. A voltage of 60 V DC is maintained across the ends of the sample throughout the test and the charge that passes through the sample is recorded. Based on the charge, a qualitative rating can be made of concrete's permeability.

Rapid Chloride Permeability Test Equipment contains four standard cells, four PT-100 sensors for temperature monitoring during the test and a 190x64 resolution lcd screen. Utest provides two types of sample cells for RCPT. UTC-1210 is the standard cell for performing chloride resistance test. UTC-1220 has additional cooling fins and can be used when the temperature should be kept constant.

Utest Rapid Chloride Permeability Testing Equipment is supplied with Usoft-1200, Utest Software for RCPT tests. Using Usoft-1200 temperature and current measurements on each of the four cells can be displayed and final charge passed (Q) can be reported.

Equipment info:

Technical Specifications	
Measurement Channels	4
Temperature Measurement Range	0-100°C
Dimensions	500x300x200 mm
Weight (approx.)	15 kg

IV. MIX DESIGN AND MATERIAL TEST RESULTS

This section includes results of various tests and their acceptance criteria as per IS codes for the materials which were used for the experimental work. In this section design calculations are also done for M-30 grade concrete as per IS 10262:2009.

1] Cement test results:

The physical properties of cement used for the experimental work was satisfying all the criteria of IS: Physical property of cement Table 4.1 12269 and IS: 4031 are as shown in table:

Physical Requirements			
Sr. No	**Parameters**	**Result**	**Req as per IS:12269**
1	Fineness-Specific Surface(m^2/Kg.)	298	Minimum -225.0(m^2/Kg.)
2	Standard consistency in (%)	29.4	
3	Setting time in Min.		
	(a) Initial setting time(Min.)	49	Minimum - 30 Minute
	(b) Final setting time(Min.)	280	Maximum- 600 Minute
4	Soundness		
	By Le-chat Expansion in (mm)	3.14	Maximum-10.00 mm
5	Compressive Strength in (Mpa)		
	3 Days	31.8	Minimum- 27.00 Mpa
	7 Days	43.7	Minimum- 37.00 Mpa
	28 Days	56.8	Minimum- 53.00 Mpa

2] 20mm aggregate:

The results of the aggregates are following. The sand used for the experimental work was satisfying the criteria as shown in table:

Grain Size Analysis of 20 mm Aggregate						
Sr. No.	IS Sieve Size (mm)	Wt.Retained (gm)	Cumm. Wt. Retained (gm)	Cumulative Wt.		Requirement as per IS : 383
				Retained (%)	Passing (%)	
1	40	0.0	0.0	0.0	100.0	100
2	20	375.0	375.0	12.5	87.5	85-100
3	10	2566.0	2941.0	98.0	2.0	0-20
4	4.75	59.0	3000.0	100.0	0.0	0-5
---	---	3000.0	---	210.5	---	---
Sr. No	Other Parameters				Result	Req.
1	Water Absorption in (%)				0.97	Max. - 2.0 %
2	Sp.Gravity of Agg.				2.81	2.6 - 2.9
3	Elongation Index in (%)				12.34	--
4	Flakiness Index in (%)				10.70	--
5	Aggregate Impact value (%)				14.35	Max.-45.0 %
6	Aggregate Crushing Value (%)				17.37	Max. - 45.0 %
7	Aggregate Abrasion Value (%)				17.40	Max. - 45.0 %

3] Grit 10mm:

Grain Size Analysis of 10 mm Grit						
Sr.No.	IS Sieve Size	Wt.Retained (gm)	Cumm. Wt. Retained (gm)	Cumulative Wt.		Requirement as per IS : 383
				Retained (%)	Passing (%)	
1	12.5 mm	0.0	0.0	0.0	100.0	100
2	10 mm	260.9	260.9	13.0	87.0	85-100
3	4.75 mm	1507.6	1768.5	88.4	11.6	0-20
4	2.36 mm	209.7	1978.2	98.9	1.1	0-5
--	Pan	20.9	1999.1	100.0	--	--
--	--	1999.1	--	200.4	--	--
Sr. No	Other Parameters				Result	Req.
1	Water Absorption in (%)				0.86	Max. - 2.0 %
2	Sp.Gravity of Agg.				2.83	2.6 - 2.9
3	Elongation Index in (%)				11.96	--
4	Flakiness Index in (%)				12.74	--
5	Aggregate Impact value (%)				9.78	Max.-45.0 %
6	Aggregate Crushing Value (%)				17.05	Max. - 45.0 %
7	Aggregate Abrasion Value (%)				16.90	Max. - 45.0 %

4] Results of sand:

Particle Size Analysis of Sand						
Sr.No.	IS Sieve Size	Wt. Retained (gm)	Cumm. Wt. Retained (gm)	Cummulative Wt.		Requirment as per IS : 383
				Retained (%)	Passing (%)	
1	10 mm	0.0	0.0	0.0	100.0	100
2	4.75 mm	32.6	32.6	3.26	96.7	90-100
3	2.36 mm	166.8	199.4	19.94	80.1	75-100
4	1.18mm	178.5	377.9	37.79	62.2	55-90
5	600 µm	184.7	562.6	56.26	43.7	35-59
6	300 µm	189.7	752.3	75.23	24.8	08-30
7	150 µm	172.8	925.1	92.51	7.5	0-10
8	Pan	74.9	1000.0	100.00	0.0	
	Total	1000.0	--	285.0	---	---

Sr. No.	Parameters	Observation	Req.
1	Sand Falls in Zone	II	--
2	Finess Modulus of sand	2.85	
3	Water Absorbption (%)	1.13	Max - 2 %
4	Sp.Gravity of Sand	2.68	2.6 - 2.7
5	Silt Content (finer than 75 mic. (%)	2.72	max.- 3 %

5] Water:

Thus, water is the most important factor for the making concrete. Due to the addition of water to cement, the cement paste occurs which is very helpful to bond the various coarse aggregate and fine aggregate particles with each other. Thus, the water plays an important role and hence, the quality and quantity of water should also be taken in to consideration while making concrete because it directly affects the strength of concrete.

Physical & Chemical Test of Water			
Sr No	Test	Result	Specification As Per Is:456
1	PH Value	7.30	Not Less Then 6

6] Mix design for M30:

1) Design Stipulation	
Grade of Concrete	M-30
Characteristic Compressive Strength (Mpa)	30
Maximum size of coarse aggregate (in mm)	20
Degree of workability (slump in mm)	75-100
Degree of Quality Control	Good
Type of Exposure (IS-456, Table - 5)	Mild

Maximum water cement ratio (IS-456 -2000, Table -5)			0.5
Minimum cement content in kg (IS-456-2000, Table - 5)			250
Mode of placement			
Type of Admixture			---
2) Test Data of Materials			
(a). Cement:			
Sr. No	Parameters	Result Obtained	Req as per IS:12269
1	Fineness-Specific Surface(m^2/Kg.)	285	Minimum -225.0(m^2/Kg.)
2	Standard consistency in (%)	30	---
3	Setting time in Min.		---
	(a) Initial setting time (Min.)	47	Minimum - 30 Minute
	(b) Final setting time (Min.)	260	Maximum- 600 Minute
4	Soundness		---
	By Le-chat Expansion in (mm)	3.42	Maximum-10.00 mm
5	Compressive Strength in (Mpa)		---
	3 Days	30.56	Minimum- 27.00 Mpa
	7 Days	39.81	Minimum- 37.00 Mpa
	28 Days	56.14	Minimum- 53.00 Mpa

(b) Fine Aggregates

Sr.No.	IS Sieve Size	Wt. Retained (gm)	Cumm. Wt. Retained (gm)	Cumulative Wt.		Requirement as per IS : 383		
				Retained (%)	Passing (%)			
1	10 mm	0.0	0.0	0.0	100.0	100		
2	4.75 mm	45.8	45.8	4.58	95.4	90-100		
3	2.36 mm	128.8	174.6	17.46	82.5	75-100		
4	1.18mm	188.7	363.3	36.33	63.7	55-90		
5	600 µm	254.3	617.6	61.76	38.2	35-59	35-59	35-59
6	300 µm	215.4	833.0	83.30	16.7	08-30		
7	150 µm	149.2	982.2	98.22	1.8	0-10		
8	Pan	17.7	999.9	99.99	0.0			
	Total	999.9	--	301.7	---	---		

Sr.No.	Parameters	Observation	Req.
1	Sand Falls in Zone	II	--
2	Fineness Modulus of sand	3.0	---
3	Water Absorption (%)	1.1	Max - 2 %
4	Sp.Gravity of Sand	2.7	2.6 - 2.7
5	Silt Content (finer than 75 mic. (%))	2.2	max.- 3 %

(c) Coarse Aggregates (10mm)

Sr.No.	IS Sieve Size	Wt. Retained (gm)	Cumm. Wt. Retained (gm)	Cummulative Wt.		Requirment as per IS : 383
				Retained (%)	Passing (%)	
1	12.5 mm	0.0	0.0	0.0	100.0	100.0
2	10 mm	296.3	296.3	14.82	85.2	85-100
3	4.75 mm	1545.0	1841.3	92.07	7.9	0-20
4	2.36 mm	139.0	1980.3	99.02	1.0	0-5
5	Pan	19.6	1999.9	100.00		
6		1999.9		205.90		

Sr.No.	Parameters	Observation	Req.
1	Water Absorption in (%)	0.91	Max. - 2.0 %
2	Sp.Gravity of Agg.	2.78	2.6 - 2.9
3	Elongation Index in (%)	11.96	--
4	Flakiness Index in (%)	12.74	--
5	Aggregate Impact value (%)	11.19	Max.-45.0 %
6	Aggregate Crushing Value (%)	12.81	Max. - 45.0 %
7	Aggregate Abrasion Value (%)	13.36	Max. - 45.0 %

(d) Coarse Aggregates (20mm)

Sr.No.	IS Sieve Size	Wt. Retained (gm)	Cumm. Wt. Retained (gm)	Cummulative Wt.		Requirment as per IS : 383
				Retained (%)	Passing (%)	
1	40 mm	0.0	0.0	0.0	100.0	100.0
2	20 mm	375.0	375.0	12.50	87.5	85-100
3	10 mm	2566.0	2941.0	98.03	2.0	0-20
4	4.75	59.0	3000.0	100.00	0.0	0-5

	mm							
5		3000.0		210.53				
Sr.No.	Parameters				Observation		Req.	
1	Water Absorption in (%)				0.97		Max. - 2.0 %	
2	Sp.Gravity of Agg.				2.81		2.6 - 2.9	
3	Elongation Index in (%)				12.34		--	
4	Flakiness Index in (%)				10.70		--	--
5	Aggregate Impact value (%)				14.35		Max.- 45.0 %	Max.- 45.0 %
6	Aggregate Crushing Value (%)				17.37		Max. - 45.0 %	Max. - 45.0 %
7	Aggregate Abrasion Value (%)				17.40		Max. - 45.0 %	Max. - 45.0 %
3) Concrete Mix Design Calculations as per IS:10262-2009								
(a) Target Mean Strength of Concrete in Mpa								
fck' =	fck + 1.65 S							
S = Std deviation				5		(Refer table 2)		
fck = Characteristic strength of Concrete				30				
fck' = Target strength in Mpa				38.25				
(b) Selection of Water Content								
Maximum water content (kg) for 25-50 mm slump					186		(Refer table 3)	
Estimate water content for slump of					75	to 100 mm	197.16	
Water content reduction					0.95		(if plasticizer used, otherwise 1)	
water content in kg					187.302			
(d) Estimation of Cement Content								
Maximum Water cement ratio				0.5				
Water cement ratio desired				0.45				
Cement Content (kg)				416.2266667				
Minimum Cement content (kg)				250				
Final cement content (kg)				416.2266667		(maximum from above two)		
Final water content (kg)				187.302				
(e) Proportion of Volume Of Fine And Coarse Aggregate								

Zone of fine aggregates	II	
Change in w/c ratio with reference to 0.5	-0.05	
Maximum size or coarse aggregate (mm)	20	
Volume of coarse aggregate	0.62	(Refer table 4)
Correction in volume of coarse aggregate	-0.01	
Corrected volume of coarse Aggregate	0.63	
Reduction in coarse aggregate	0%	(note for pumpable concrete reduce this value upto 10 percent)
Final volume of coarse aggregate	0.62	
Final volume of fine aggregate	0.38	
Proportion of Kapachi / Grit	0.4	
(f) Mix Calculation		
Volume of concrete (in cu.m)	1	
Volume of cement (in cu.m)	0.13213545	
Volume of water (in cu.m)	0.187302	
Volume of chemical admixture (in cu.m)	0	
Volume of all in aggregate (in cu.m)	0.68056255	
Mass of coarse aggregate (kg)	1185.676075	
Mass of fine aggregate (kg)	690.4987635	
7) Mix Proportion Of trial 1 for 1m^3 Concrete		
Vol of Concrete (cu.m.)	1	
Cement Content (kg)	416.2266667	
Water Content (kg)	187.302	
Fine aggregate (kg)	690.4987635	
10 mm Grit (kg)	474.27043	
20 mm Kapachi (kg)	711.405645	
Admixture (kg)	0	
Weight (kg)	2479.703505	
w/c ratio	0.45	

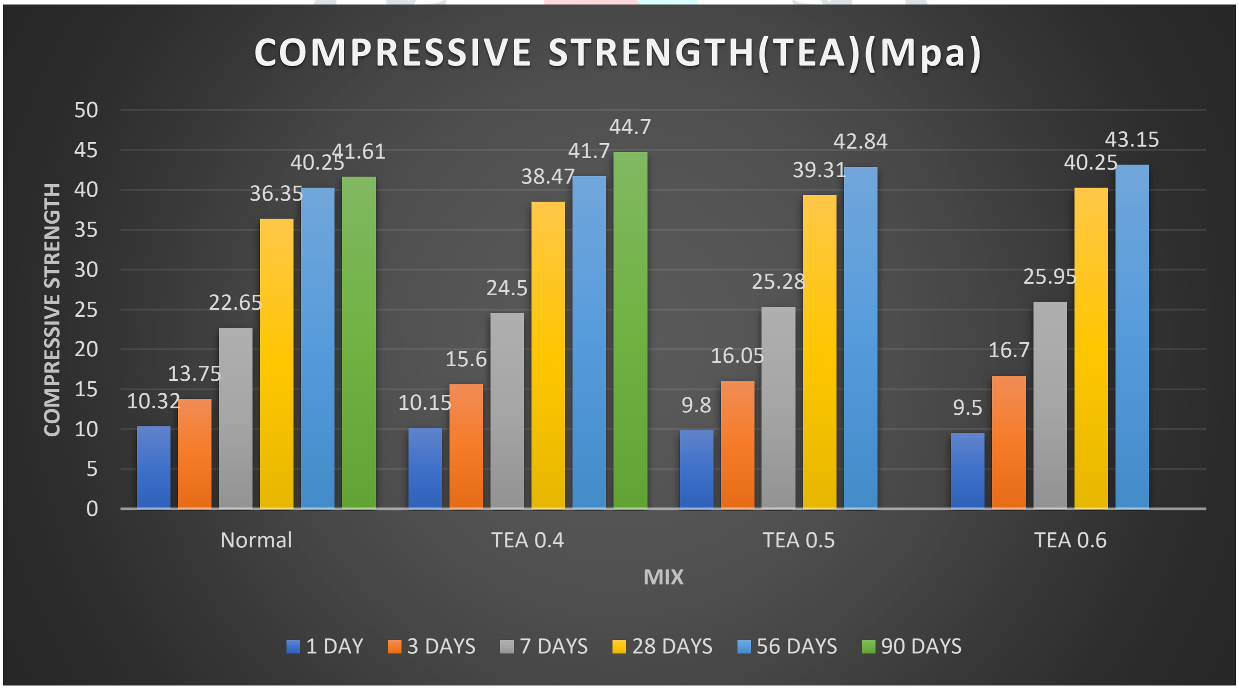
7] Compressive strength of M30 grade concrete using TEA (Triethanolamine):

Compressive strength (MPa) = (Failure load) / (c/s area of cube specimen)

The results of the experimental study of compressive strength at 1 day, 3 days, 7 days, 28 days, 56 days and for 90 days are followings:

Mix	1 DAY	3 DAYS	7 DAYS	28 DAYS	56 DAYS	90 DAYS
Normal	10.32	13.75	22.65	36.35	40.25	41.61
TEA 0.4	10.15	15.60	24.50	38.47	41.70	42.52
TEA 0.5	9.80	16.05	25.28	39.31	42.84	43.45
TEA 0.6	9.50	16.70	25.95	40.25	43.15	43.91

Graphical presentation

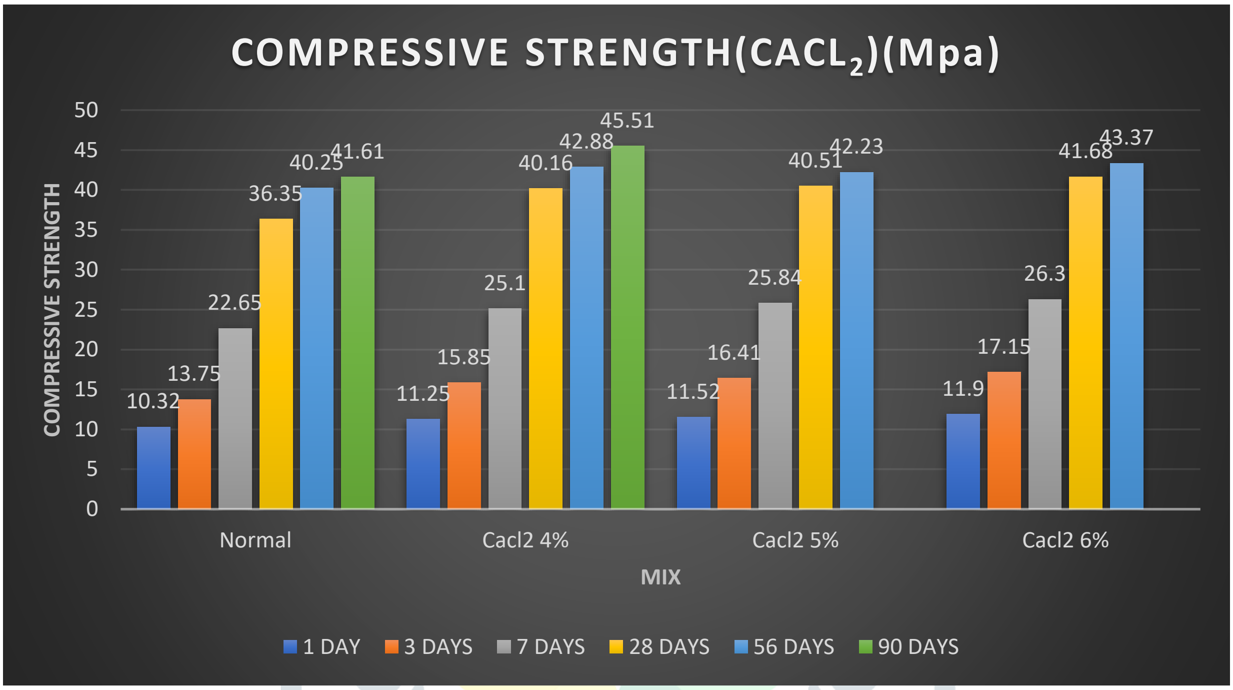


8] Compressive strength of M30 grade concrete using Cacl2:

Mix	1 DAY	3 DAYS	7 DAYS	28 DAYS	56 DAYS	90 DAYS
Normal	10.32	13.75	22.65	36.35	40.25	41.61

$Cacl_2$ 4%	11.25	15.85	25.10	40.16	42.88	43.32
$Cacl_2$ 5%	11.52	16.41	25.84	40.51	42.23	43.59
$Cacl_2$ 6%	11.90	17.15	26.30	41.68	43.37	44.12

Graphical Presentation

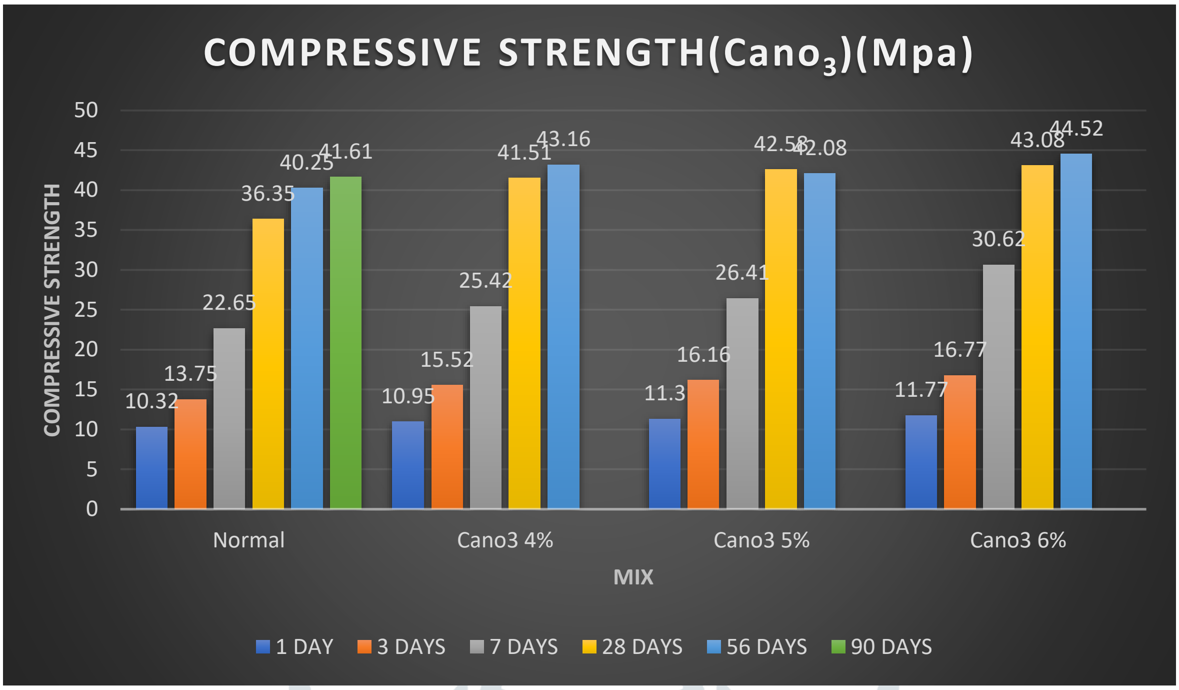


9] Compressive strength of M30 grade concrete using Cano3:

Mix	1 DAY	3 DAYS	7 DAYS	28 DAYS	56 DAYS	90 DAYS
Normal	10.32	13.75	22.65	36.35	40.25	41.61
$CaNo_3$ 4%	10.95	15.52	25.42	41.51	43.16	44.20
$CaNo_3$ 5%	11.30	16.16	26.41	42.58	44.08	42.89
$CaNo_3$ 6%	11.77	16.77	30.62	43.08	44.52	44.84

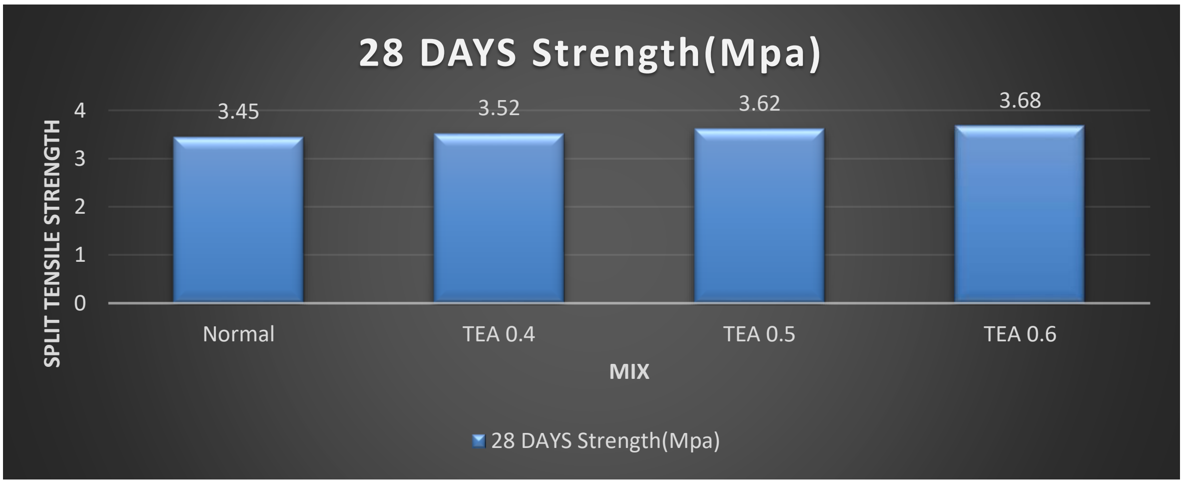
Graphical Presentation

The results showed that it is possible to use calcium nitrate as an antifreeze admixture in concrete placing process in cold weather concreting. Calcium nitrate improved the workability of concrete. Therefore, It can be said that calcium nitrate can be used as an antifreeze admixture in concrete, according to test results.



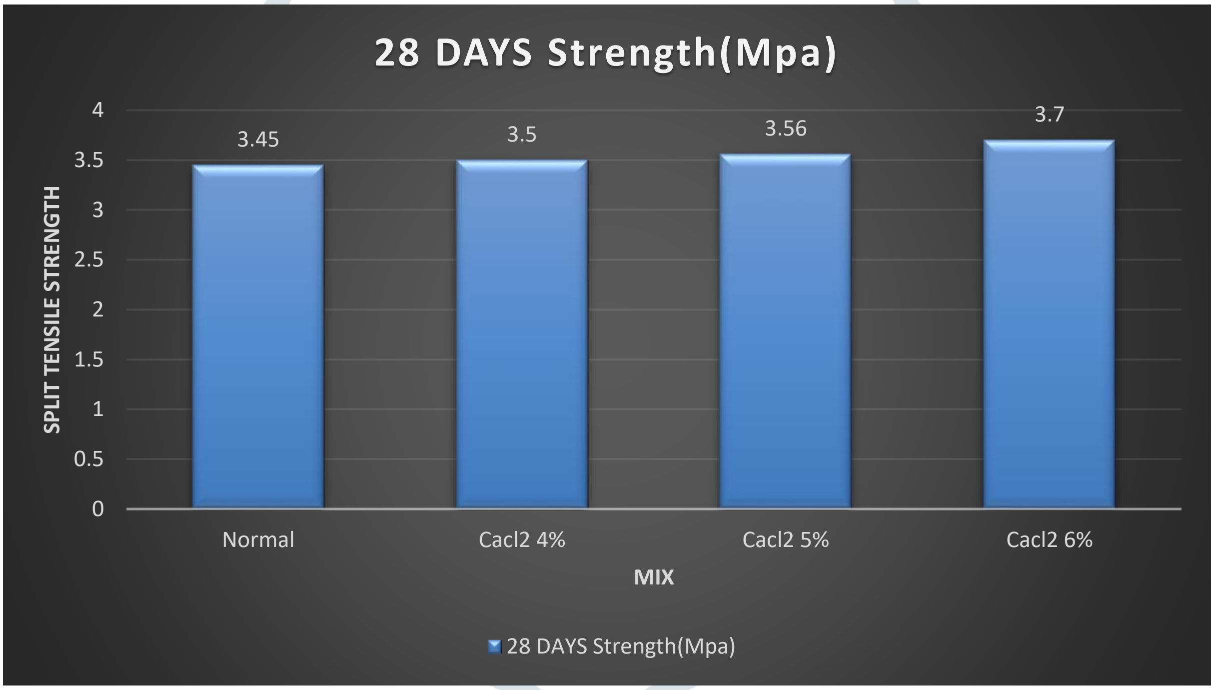
10] Split tensile strength of M30 grade concrete using TEA at 28 days (Mpa):

Mix	28 DAYS
Normal	**3.45**
TEA (0.4%)	**3.52**
TEA (0.5%)	**3.62**
TEA (0.6%)	**3.68**



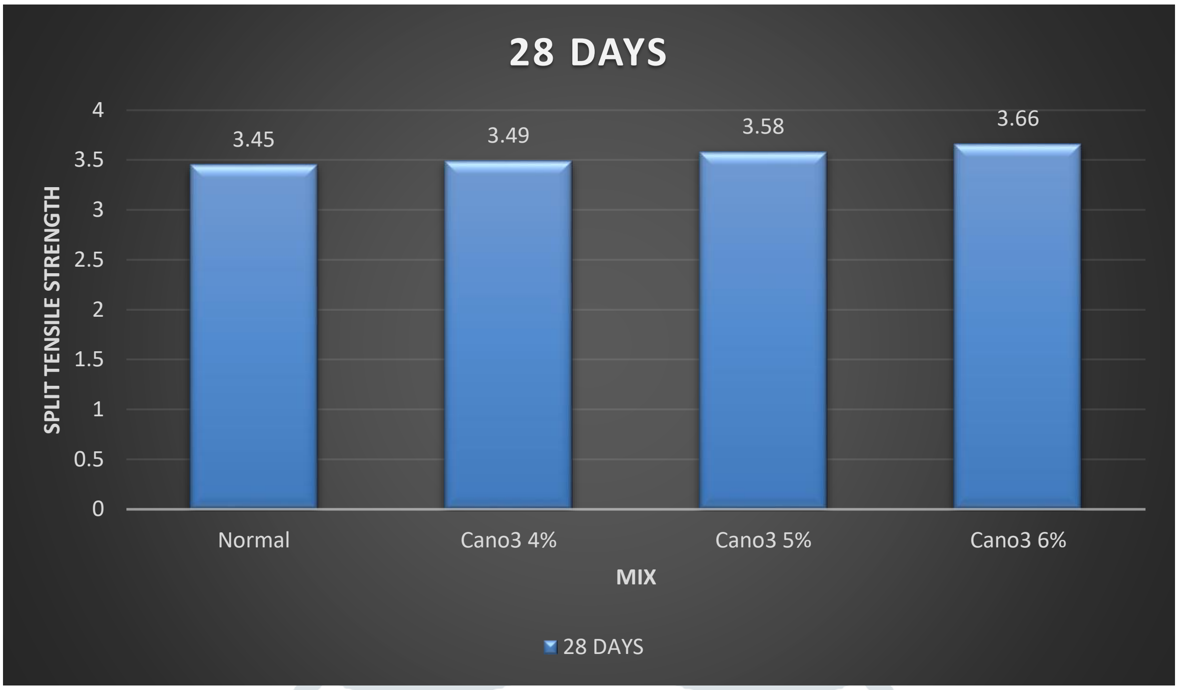
11] Split tensile strength of M30 grade concrete using Cacl2 at 28 days (Mpa):

Mix	28 DAYS
Normal	3.45
$Cacl_2$ (4%)	3.50
$Cacl_2$ (5%)	3.56
$Cacl_2$ (6%)	3.70



12] Split tensile strength of M30 grade concrete using Cano3 at 28 days (Mpa):

Mix	28 DAYS
Normal	3.45
$Cano_3$ (4%)	3.49
$Cano_3$ (5%)	3.58
$Cano_3$ (6%)	3.66



13] Results of sulphate attack for M30 grade concrete:

Proportions	Sulphate attack (28 + 90 days)	% Strength loss
Normal concrete	33.72	7.22
TEA (0.6% by weight of cement)	38.18	5.16
$Cacl_2$ (6% by weight of cement)	39.56	5.09
$Cano_3$ (6% by weight of cement)	40.9	5.07

14] Results of chloride attack for M30 grade concrete:

Proportions	Chloride attack (28 + 90 days)	% Strength loss
Normal concrete	33.64	7.47
TEA (0.6% by weight of cement)	37.97	5.67
$Cacl_2$ (6% by weight of cement)	39.49	5.27
$Cano_3$ (6% by weight of cement)	40.85	5.18

15] Rapid chloride permeability test result:

Proportions	RCPT Test Coulomb Passed
Normal concrete	2634
TEA (0.6% by weight of cement)	2484
$Cacl_2$ (6% by weight of cement)	2152
$Cano_3$ (6% by weight of cement)	1815

V. CONCLUSION & FUTURE SCOPE

1] Conclusions:

In this chapter conclusions related to present experimental work is illustrated by analysis of results obtained. Some important topics which can be useful for future study based on this experimental work are also described at the end.

1. The compressive strength of concrete with TEA is higher than concrete without TEA at 3 days, 28 days and 90 days.
2. TEA decreases initial compressive strength of concrete and increase compressive strength at 3 days onwards.
3. Compressive strength for M30 grade concrete increased by 13% compared to normal concrete respectively after 3 days using TEA 0.6%.
4. Compressive strength for M30 grade concrete increased by 10% compared to normal concrete respectively after 28 days using TEA 0.6%.
5. Compressive strength for M30 grade concrete increased by 5% compared to normal concrete respectively after 90 days using TEA 0.6%.
6. The compressive strength of concrete with $Cacl_2$ is higher than concrete without cacl2 at 1 day, 3 days, 28 days and 90 days.
7. Compressive strength for M30 grade concrete increased by 15% compared to normal concrete respectively after 1 day using $Cacl_2$ 6%.
8. Compressive strength for M30 grade concrete increased by 20% compared to normal concrete respectively after 3 days using $Cacl_2$ 6%.
9. Compressive strength for M30 grade concrete increased by 14% compared to normal concrete respectively after 28 days using $Cacl_2$ 6%.
10. Compressive strength for M30 grade concrete increased by 6% compared to normal concrete respectively after 90 days using $Cacl_2$ 6%.
11. The compressive strength of concrete with $Cano_3$ is higher than concrete without cano3 at 1 day, 3 days, 28 days and 90 days.
12. Compressive strength for M30 grade concrete increased by 14% compared to normal concrete respectively after 1 day using $Cano_3$ 6%.
13. Compressive strength for M30 grade concrete increased by 21% compared to normal concrete respectively after 3 days using $Cano_3$ 6%.
14. Compressive strength for M30 grade concrete increased by 18% compared to normal concrete respectively after 28 days using $Cano_3$ 6%.
15. Compressive strength for M30 grade concrete increased by 7% compared to normal concrete respectively after 90 days using $Cano_3$ 6%.
16. Optimum % of TEA to achieve maximum compressive strength of M30 grade of concrete is 0.6% after 90 days.
17. Optimum % of $Cacl_2$ to achieve maximum compressive strength of M30 grade of concrete is 6% after 90 days.
18. Optimum % of $Cano_3$ to achieve maximum compressive strength of M30 grade of concrete is 6% after 90 days.

2] Future Scope:

1. One can try with fly ash and GGBS with TEA and test the compressive strength of concrete at early and later ages.
2. One can try with varying dosages of TEA, $Cacl_2$ and $Cano_3$.
3. Further study can be carried out by trying with different grade of concrete.

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