STUDIES ON STRENGTH CHARACTERISTICS OF CONCRETE WITH "SODIUM NITRATE" AS AN ADMIXTURE

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ABSTRACT: Sodium nitrate is a chemical compound with the formula NaNO3. This alkali metal nitrate salt is also known as Chile saltpeter or Peru saltpeter (due to the large deposits found in the Atacama desert in these countries) to distinguish it from ordinary saltpeter, potassium nitrate. It is observed that sodium nitrate is as effective accelerating admixture used in concrete. The overall objective of the present study is to study the effect of adding sodium nitrate in concrete on its performance. It is decided to explore compressive strength, Split tensile strength, and Flexural strength of concrete on addition of different percentages of sodium nitrate. For this Mix proportions of OPC concrete for M30 by IS method (9103-1999) were determined. The mix proportion with partial addition such as 1%, 1.5%, 2%, 2.5% and 3% of sodium nitrate with OPC were calculated. The concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength with addition of different percentages of sodium nitrate with OPC for M30 grade concrete were prepared and cured the specimens for 7 days, and 28 days. The compressive strength of concrete, split tensile strength of concrete and flexural strength of concrete is found to be increased when the admixture is added. At sodium nitrate content of 2.5 % by weight of cement, the concrete attained maximum compressive strengths in terms of compressive, split tensile strength and flexural strength of concrete for M30 grade of concrete. Hence the accelerating effects and other benefits of sodium nitrate as an admixture to concrete can be tapped by limiting the admixture content up to 2.5% by weight of cement.
KEYWORDS: Sodium nitrate, Compressive strength, Split tensile strength, Flexural strength.

I. INTRODUCTION

1.1. GENERAL: The quest for the development of high strength and high performance concretes has increased considerably in recent times because of the compelling demands from the construction industry. In the last three decades, supplementary cementitious materials such as fly ash, silica fume and ground granulated blast furnace slag have been judiciously utilized as cement addition materials as these can significantly enhance the strength and durability characteristics of concrete in comparison with ordinary Portland cement (OPC) alone, provided there is adequate curing. Addition of sodium nitrate is one of the latest developments in this field. Winter has some peculiarities that affect construction in general and concreting in particular. Its duration is different in different parts of globe, but cold weather with white frosts may also happen in spring and autumn not just in winter only. In India certain regions experience sub-zero temperatures in winter. Concrete structures in such regions undergo cycles of freezing and thawing and their durability is affected due to frost action. Fresh concrete contains considerable quantity of fresh water which gets converted into ice lenses at freezing temperature. The ice formation in fresh concrete results in about 9% rise in volume and causes permanent damage to concrete and structural integrity cannot be recovered even if the concrete is made to harden later at high temperature. Thus, in winters, especially in Kashmir where the temperatures are below zero degree in winters some admixtures need to be added to nullify the effects of cold temperature on the strength of concrete. Sodium nitrate is a commonly used admixture in Kashmir during winter to accelerate the strength gain of concrete. On adding water to cement, paste is formed which gradually stiffens and then hardens. The stiffening of cement paste is called setting. Actually, setting is a process of transformation from an initial state, a scattered concentrated suspension, to a final state, a connected and strengthened system of particles. This transformation in the practice of cement and concrete is obtained by chemical reactions between cement particles and water (i.e. hydration of cement). Normal setting of cement is associated with the hydration of Alite (C3S) and formation of calcium silicate hydrate (C-S-H) phase. Cement paste / concrete sets gradually under the standard laboratory conditions (temperature ~ 23°C and relative humidity not less than 90%). But outside the laboratory concreting has to be done under the prevailing climatic conditions. In many countries or certain regions of countries, fresh concrete is subjected to cold weather. American Concrete Institute (ACI) defines cold weather when two conditions exist for three consecutive days: i) The average daily temperature falls below 5°C, and ii) Air temperature does not rise above 10°C for more than half a day in any 24 hour period. Cold weather leads to delay in setting and hardening of concrete, freezing of concrete at early age and thawing which leads to formation of ice needles in concrete and thus cavities are formed after thawing of ice needles which seriously impair the structural integrity of concrete and results in considerable loss of strength. In extreme cases, effects of cold weather may make the concrete an absolutely useless friable mass. On the other hand, if the concrete is sufficiently hardened when freezing conditions are likely to prevail, there will not be much harm to structural integrity of concrete. If the concrete has sufficiently hardened, the water that has been mixed for

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making concrete will have been utilized either being used up in hydration process or lost by evaporation. Due to the formation of cement gel, the capillary cavities also will have been very much reduced, with the result that there exists very little of free water in the body of concrete to freeze. Accelerating admixture is an admixture that accelerates the hardening or the development of early strength of concrete.

The rates of chemical reactions between clinker materials in cements and water may be altered by adding small amounts of chemical substances to the cement-water mix. Substances affecting these rates to give an overall increase in the hydration rate, i.e. an accelerating effect, are termed accelerating admixtures or simply accelerators. Hence, an accelerator is added to concrete for the purpose of shortening setting time and/or increasing early strength development. In the first case the main action of the accelerator occurs in the plastic state of the cement paste, while in the latter case the accelerator acts primarily in the hardened state. Some accelerators affect either setting or hardening, while several accelerate both setting and hardening. Accelerating admixtures are usually termed ‘chloride based’ or ‘chloride free’ and may be principally set or hardening accelerators. Care is needed to ensure that the correct one is selected for the required application. Most Concrete specifications restrict the use of calcium chloride or admixtures containing calcium chloride to plain unreinforced concrete and ban it for structural concrete that contains embedded metal. On adding water to cement, paste is formed which gradually stiffens and then hardens. The stiffening of cement paste is called setting . Actually, setting is a process of transformation from an initial state, a scattered concentrated suspension, to a final state, a connected and strengthened system of particles. This transformation in the practice of cement and concrete is obtained by chemical reactions between cement particles and water(i.e. hydration of cement) . Normal setting of cement is associated with the hydration of Alite (C3S) and formation of calcium silicate hydrate (C-S-H) phase. Cement paste / concrete sets gradually under the standard laboratory conditions (temperature ~ 23°C and relative humidity not less than 90%). But outside the laboratory concreting has to be done under the prevailing climatic conditions. In this research, sodium nitrite is used as accelerating admixture in the dosage range of 1% to 3% by weight of cement. The mechanism of function of accelerating admixture (sodium nitrite) is that it increases the rate of hydration of tricalcium silicate (C3S) and tricalcium aluminate (C3A) phases of cement, thereby providing earlier heat evolution and strength development. It acts as a catalyst in the hydration of tricalcium silicate (C3S) and tricalcium aluminate (C3A). Concrete specimens with varying percentage of sodium nitrite were tested for compressive strength, splitting tensile strength and flexural strength. The results obtained were compared with results of normal M-30 concrete mix. The results indicated the absolute possibility of using sodium nitrite as accelerating admixture in concrete subjected to cold weather.

1.2 SODIUM NITRATE

Sodium nitrate is the chemical compound with the formula $NaNO_3$. This alkali metal nitrate salt is also known as Chile saltpeter or Peru saltpeter (due to the large deposits found in the Atacama desert in these countries) to distinguish it from ordinary saltpeter, potassium nitrate. The mineral form is also known as nitratine, nitratite or soda niter.

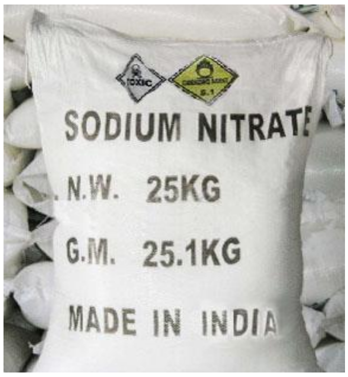

Figure1.1. Sodium nitrate

Sodium nitrate is a white solid very soluble in water. It is a readily available source of the nitrate anion (NO_3^-), which is useful in several reactions carried out on industrial scale.

1.3 MANUFACTURE OF SODIUM NITRATE

For our work we bought sodium nitrate from Vishnupriya chemical private limited, Bhaseerbagh, Hyderabad. The manufacture of anhydrous sodium nitrate in the form of fused sodium nitrate from aqueous solutions of sodium nitrate. It particularly provides a system for manufacturing solid anhydrous sodium nitrate in the form of prills or small pellets employing aqueous solutions of sodium nitrate as starting material. In this country sodium nitrate is commonly produced by neutralizing nitric acid with soda ash, sodium bicarbonate or caustic soda. Hence the material domestically produced is in aqueous solution and as an article of commerce must be reduced to a solid state by crystallization and separation or by some means oi dehydration. Probably the form of sodium nitrate of greatest commercial demand is the prilled product which is made by spraying molten sodium nitrate in a prilling tower where the sprayed droplets cool and solidify in falling and the resulting small pellets or prills are collected as the product. The reduction of aqueous solutions of sodium nitrate to anhydrous state so that the material can be fused for spraying or other handling without conventional evaporation, crystallization, filtration and drying presents a number of difficulties. Moreover, addition of an aqueous solution to a body of previously fused sodium nitrate with a view to flashing off the water must be avoided because of the danger of explosive generation of steam. In addition, contacting molten sodium nitrate With a relatively cool aqueous stream creates serious handling problems in the way of localized cooling results in troublesome solidification and plugging. Accordingly, the art has considered it necessary to obtain crystalline sodium nitrate from aqueous solutions by evaporation and cooling followed by separation of the crystals from the mother liquor. The crystal is are then dried in a separate operation before melting to produce the fused anhydrous sodium nitrate.

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1.4 PROPERTIES OF SODIUM NITRATE
Physical properties: Sodium nitrate is a white crystalline solid with a density of 2.26 g/mL and a melting point of 308 °C. It exists as either trigonal or rhombohedral crystals.
Chemical properties: Sodium nitrate is the salt of a strong acid and hence, dissociates completely in water into sodium and nitrate ions. It is a stable solid at room temperature, however upon prolonged heating, it can explode and release toxic fumes. It is a strong oxidizer and reacts violently with strong reducing agents and flammable materials.
Uses: Sodium nitrate is used as a food preservative and a salt substitute. It is also used in dental products, explosives, smoke bombs, fertilizers, wastewater treatment, energy storage materials, and solid rocket propellants.

1.5 STRENGTH PARAMETERS
Sodium nitrate is used as accelerating admixture in the dosage range of 1% to 3% by weight of cement. Concrete specimens with varying percentage of sodium nitrate were tested for compressive strength, splitting tensile strength and flexural strength.

1.6 ADVANTAGES OF SODIUM NITRATE
- Increased compressive and flexural strengths
- Reduced permeability.
- Increased resistance to chemical attack
- Increased durability
- Enhanced workability and finishing of concrete
- Reduced shrinkage, due to “particle packing” making concrete denser
- Improved color by lightening the color of concrete making it possible to tint lighter integral colour.

1.7 OBJECTIVE OF THE PRESENT WORK
The overall objective of the present study is to explore the effect of adding sodium nitrate in concrete and its performance; however the task is divided in to specific objectives to achieve step by step through experimental procedures. The main objectives of the present project work are listed below:
To prepare the concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength and also cubes for durability studies in laboratory with 1%, 1.5%, 2%, 2.5% and 3% addition of sodium nitrate with OPC for M30 grade concrete with water to cement ratio of 0.5. The main purpose of the project is
1. To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength.
2. To evaluate and compare the results.

II. METHODOLOGY

2.1. INVESTIGATION: In this section scope of the present investigation was presented and objectives identified in the similar lines were listed below. The properties of various materials used in the testing procedures were described. The IS code method used for mix design was described and the values obtained were presented. Addition of admixture sodium nitrate as a percentage of cement with was planned and testing of samples were explained.
The Experimental investigation is planned as under:
1. To find the properties of the materials such as cement, sand, coarse aggregate, water and sodium nitrate.
2. To obtain Mix proportions of OPC concrete for M30 by IS method (IS 9103:1999).
3. To prepare the concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength and also cubes for durability studies in laboratory with 0%, 1%, 1.5%, 2%, 2.5% and 3% addition of sodium nitrate with OPC for M30 grade concrete.
4. To cure the specimens for 7 days, 28 days.
5. To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength and compare the results.

2.2 MATERIAL PROPERTIES:
The materials used in the experimental work namely cement, fine aggregate and coarse aggregate (20mm, 10mm) have been tested in laboratory for use in mix designs. The details are presented below.
Cement
Ordinary Portland cement of 43 grade (Rasi-Cement) was used in this investigation. The details of tests conducted on cement are described below.
Specific gravity of cement
Specific gravity of the cement is calculated by using density bottle method.
Cement specific gravity: 3.15
Fineness test on cement
Fineness test on cement can be calculated by sieve test or air permeability method, in commercial cement it is suggested that there should be about 25 to 30 % of particles less than 7 microns in size.
Fineness of test cement: 92%
Initial and final setting time test on cement
Initial and final setting time test on cement is obtained by testing on vicat’s apparatus. For the initial setting time of the cement vicat’s needle should penetrate to a depth of 33 to 35mm from the top, for final setting time the vicat’s needle should pierce through the paste more than 0.5mm. We need to calculate the initial and final setting time as per IS: 4031 (Part 5) – 1988.
Initial setting time of test cement: 90 mins
Final setting time of test cement: 3 hrs 30 mins (210 mins)
Standard consistency test
The Standard consistency test of a cement paste is defined as that consistency which will permit vicat’s plunger having the 10mm diameter and 50mm length to penetrate to a depth of 33 to 35 from the top of the mould. The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988.
Standard consistency of test cement: 33%
Fine Aggregate
Aggregates smaller than 4.75mm and up to 0.075mm are

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considered as fine aggregate
The details of test conducted on fine aggregate are described below.
Specific Gravity
The specific gravity of fine aggregates is 2.6445
Fineness modulus
The standard definition of fineness modulus is as follows: "An empirical factor obtained by adding the total percentages of a sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100."
Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS: 2386 (Part I) – 1963.

- A set of IS Sieves of sizes – 80mm, 40mm, 20mm, 16mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm.
- Up to 80 mm to 4.75 mm IS sieves used for coarse aggregate analysis and from 4.75 mm to 150 µm IS sieves used for analyze fine aggregates.

The results of sieve analysis of fine aggregate are given in the Table 2.1 below.

Table 2.1 Sieve Analysis of Fine Aggregate

S.No	IS. Sieve Designation	%of Weight Retained	Cumulative % of weight Retained(C1)	%of Passing
1	10mm	-	-	
2	4.75mm	0.5	.5	99.5
3	2.36mm	1.5	2	98
4	1.18mm	8	10	90
5	600µ	24	34	66
6	300µ	46	80	20
7	150µ	18	98	2

Fineness Modulus of fine aggregate = 2.25
Coarse Aggregates
Aggregates greater than 4.75 mm are considered as coarse aggregates.
Specific gravity
The specific gravity of coarse aggregates is 2.6445
The results of sieve analysis of coarse aggregate are given in the Table 2.2 below.

Table 2.2 Sieve Analysis of Coarse Aggregate

IS Sieve Designation	%Weight Retained In kg	Cumulative Percentage Retained	Cumulative Percentage Passing
80mm	——	—	100
40mm	——	—	100
20mm	30.84	30.84	69.16
10mm	68.70	99.54	0.46
4.75mm	0	99.54	0
2.36mm	0	99.54	0
1.18mm	—	100	0
600µ	—	100	0
300µ	—	100	0
150µ	—	100	0

Fineness modulus of coarse aggregate =7.27

2.3 IS CODE METHOD OF MIX DESIGN (IS 9103:1999)
This method was developed as per IS 9103:1999. This Indian standard (First Revision) was adopted by the Bureau of Indian standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by Civil Engineering Division Council. Indian standard institution has brought out mix design procedure mainly based on work done in national laboratories. This method can be adapted to both medium strength and high strength concrete. The basic assumption made in the mix design is that the compressive strength of workable concrete is by and large, governed by the water-cement ratio. Another most convenient relationship applicable to normal concrete is that for a given type, shape, size and grading of aggregates, the amount determines its workability and the other factors which affecting the properties of concrete are quality of cement, water and aggregates, batching, transporting, placing, compacting and curing etc.
2.4 Design of M30 grade concrete
Stipulations for proportioning:
a) Grade designation: M30
b) Type of cement: OPC 43grade (IS: 12269)
c) Minimum Cement content: 300 kg/m³
d) Maximum nominal size of aggregate: 20 mm
e) Maximum water – cement ratio : 0.5
f) Workability : 100 mm (slump)
g) Exposure condition : Moderate
h) Method of concrete placing: Non Pumpable
i) Degree of supervision : Good
j) Type of aggregate : Crushed angular aggregate
Test data for materials:
a) Cement used : OPC 43 grade (IS: 12269)
b) Specific gravity of cement : 3.10
c) Mineral admixture : Sodium nitrate
d) Specific gravity of
1) Coarse aggregate : 2.69
2) Fine aggregate : 3.08
e) Water absorption
1) Coarse aggregate : 0.5%
2) Fine aggregate : 1.0%
f) Free (Surface) moisture
1) Coarse aggregate : NIL
2) Fine aggregate : NIL
g) Sieve analysis Fine aggregate : Confirming to grading Zone II of Table 4 of IS: 383
Target strength for mix proportioning:
Target strength = 31.60 N/mm²
Selection of water-cement ratio:
Maximum water cement ratio = 0.45
Selection of water content:
Estimated water content = 159 litre
Calculation of cement content:
Cement content = 378.57kg/m³
Proportion of volume of coarse aggregate and fine aggregate content:
Volume of Coarse aggregate for the water - cement ratio = 0.64

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Volume of fine aggregate = 0.36

Mix calculations:

The mix calculations per unit volume of concrete shall be as follows:= 0.122 m^3
c) Volume of water = = 0.159 m^3
d)Volume of all in aggregate= 0.719m^3
e) Mass of coarse aggregate= 1238 kg
f)Mass of fine aggregate = 797 kg

Mix proportions for trail:

Cement = 378 kg/ m^3
Water = 159litre
Fine aggregate: = 797kg
Coarse aggregate = 1238kg
Water Cement ratio = 0.42

2.5 CASTING AND CURING OF TEST SPECIMENS

The specimens of standard cubes of size (l50mmX150mmX150mm) 3No.s, Standard prisms (100mmx 100mm x 500mm) 3No.s and Standard cylinders of (150mm diameter 300mm height) 3Nos are cast for each cycle. In all 108 specimens were prepared with addition of sodium nitrate by 0%, 1%, 1.5%, 2%, 2.5% and 3% with M30 mix with 7 days and 28days curing.

Mixing

Measured quantities of coarse aggregate and fine aggregate were spread out over an impervious concrete floor. The dry ordinary Portland cement and sodium nitrate were spread out on the aggregate and mixed thoroughly in dry state until uniform colour is obtained. Water measured exactly by weight mixed the super plasticizer, is added to the dry mix and is mixed thoroughly to obtain homogeneous concrete.

Placing and Compacting

The cube mould of the standard size, the prism mould of standard size, the cylinder mould of standard size confirming to IS 10086-L982 are cleaned. All care is to be taken for any irregular dimensions. The joint between the sections of the mould, the inner side and the bottom of the mould are to be greased properly.

The mould are arrange on the vibrating platform for casting. The mix is placed in three layers; each layer is compacted using table vibrator to obtain dense concrete.

Curing

After 24 hours of casting the test specimens cubes, cylinders and prisms are de-moulded and immediately immersed in clean and fresh water tank and allow it for curing for 7 days and 28days.

2.6 TEST PROGRAMME

All the tests conducted were described here.

Tests for Workability

Slump Cone Test

Slump cone test is a very common test for determination of workability of concrete. This test was carried out for all the mixes M30, before casting the specimens.

Compaction Factor Test

This test is more accurate than slump cone test and this test is used to determine the workability of low water cement ratio concrete more accurately. This test is conducted as per IS 1199-1959.

Table 2.3 Slump and Compaction Factor Values for M30

S.NO	Description for M30	Compaction Factor	Slump (mm)
1	Plain Concrete	0.94	40
2	Sodium nitrate 1 %	0.89	35
3	Sodium nitrate1.5%	0.873	30
4	Sodium nitrate 2 %	0.87	26
5	Sodium nitrate 2.5%	0.86	25
6	Sodium nitrate 3 %	0.863	24

2.7 TEST FOR COMPRESSIVE STRENGTH OF CONCRETE

On the date of testing i.e., after for 7 days and 28days of using the cube specimens were removed from the water tank and placed on flat surface for 10 minutes to wipe off the surface water and grit, and also removes the projecting fines on the surface of the specimens. Before placing the specimen in the testing machine the bearing surfaces of the testing machine was wiped clean, and the cube specimen also cleaned. The cube specimen was placed in the machine, of 2000kN capacity. The load was applied at a rate of approximately 140 kg/cm /min until the resistance of the specimen to the increasing load can be sustained, The compressive strength of the specimen was calculated by dividing the maximum load applied on the specimen during the test by the cross sectional area of the specimen for which average of three values of three cubes and the individual variation is more than ±15% of the average was observed. The test results for compressive strength are presented in tables 3.1 for 1%, 1.5%, 2%, 2.5% and 3% of sodium nitrate concrete for M30 grades of concrete at room temperature for 7 days and 28days respectively

2.8 TEST FOR SPLIT TENSILE STRENGTH OF CONCRETE

Immediately after removal of cylinder specimens kept on the surface, water and grit shall be removed from the surfaces, which are to be in contact with the packing strips and the bearing surfaces of the testing machine was wiped clean.

The cylinder specimen was placed horizontally in the centering with packing skip (wooden strip)/or loading pieces carefully positioned along the top and bottom of the plane of loading of the specimen. The wooden pieces were placed on top of the cylinder and bottom of the cylinder, so that the specimen is located centrally, all these arrangements are shown in Plate 3.4 .The load was applied without shock and increased continuously at a nominal rate within the range 1.2 N/mm2/min to 2.4 N/mm2/min until failure of the specimen. The maximum load applied was recorded at failure. The test results for split tensile strength are presented in tables 3.2 for 0%, 1%, 1.5%, 2%, 2.5% and 3% of sodium nitrate concrete for M30 grades of concrete at room temperature for 7 days

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and 28days respectively. Then the split tensile strength fct of the specimen was calculated by using the following formula.

$$fct = \frac{2P}{(\Pi x L x d)}$$

Where P = Maximum load in Newton's applied to the specimen.
L = Length of the specimen in mm
d = Cross sectional dimension of the specimen in mm

2.9 TEST FOR FLEXURAL STRENGTH OF CONCRETE

The prism specimens were removed from the water tank on for 7 days and 28days placed for 10 minutes to wipe off the surface water. The dimensions of each specimen were noted before testing. Before placing the specimen in the testing machine the bearing surfaces of the supporting and loading rollers were wiped off clean and any loose sand or other material was removed from the surfaces of the specimen.

The specimen was placed in the machine in such a manner that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 13.33cm apart. The axis of the specimen was carefully aligned with the axis of the loading device. The load was applied through two similar steel rollers, 38mm in diameter, mounted at the third points of the supporting span that is spaced at 13.33cm center to centre. The load was applied without shock and increased continuously at a rate of 180 kg/min until the specimen failed. The maximum load applied to th specimen during the test was recorded. The appearance of the fractured faces of concrete and unused features in the type of failure was noted.

III. RESULTS & DISCUSSION

3.1 EFFECT OF SODIUM NITRATE: This part deals with the interpretation of the test results obtained from various tests conducted. The effect of addition of sodium nitrate at various percentages on, compressive strength, split tensile strength, and flexural strength has been discussed based on the results obtained.

3.2 EFFECT OF VARIATION OF SODIUM NITRATE ON COMPRESSIVE STRENGTH

The test was carried out to obtain compressive strength of M30 grade concrete. The compressive strength of concrete is tested for 1%, 1.5%, 2%, 2.5% and 3% addition of sodium nitrate and the values are presented in Table no 3.1and also graph plotted below in figure 3.1.

Table 3.1 Compressive Strength of concrete for M30 grade mix.

S.No	% of sodium nitrate	Compressive Strength(N/mm^2)	
		7 days	28 days
1	0%	21.58	33.20
2	1%	22.43	34.50
3	1.5%	22.72	34.96
4	2%	22.81	35.10
5	2.5%	23.78	36.59
6	3%	22.23	34.20

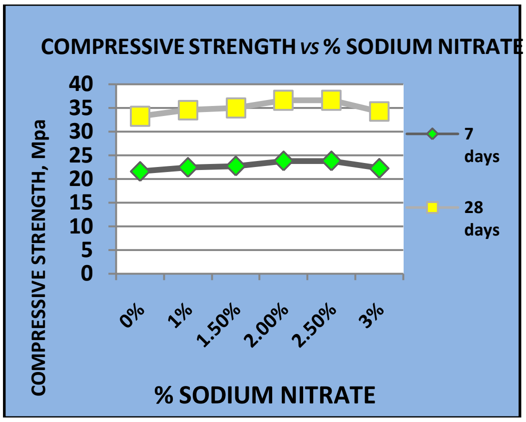

Figure 3.1 Graph showing Compressive Strength *vs* Sodium nitrate

From both table and graphs it is observed that at about 2.5% addition of cement with sodium nitrate, concrete attains its maximum compressive strength for M30 grade concretes, when the addition exceeds 2.5%, the compressive is found to be decreasing suddenly at 3% of sodium nitrate.

3.3 EFFECT OF VARIATION OF SODIUM NITRATE ON SPLIT TENSILE STRENGTH

The test was carried out to obtain split tensile strength of M30 concrete. The split tensile strength of concrete is tested for 7 days, 28 days for %, 1.5%, 2%, 2.5% and 3% addition of sodium nitrate and the values are presented in Table no 3.21and also graph plotted below in figure 3.2.

Table 3.2 Split tensile Strength of concrete for M30 grade mix.

S.No	% of Sodium nitrate	Split tensile Strength(N/mm^2)	
		7 days	28 days
1	0%	1.91	2.85
2	1%	2.1	2.95
3	1.5%	2.15	2.97
4	2%	2.18	3
5	2.5%	2.2	3.12
6	3	1.99	2.89

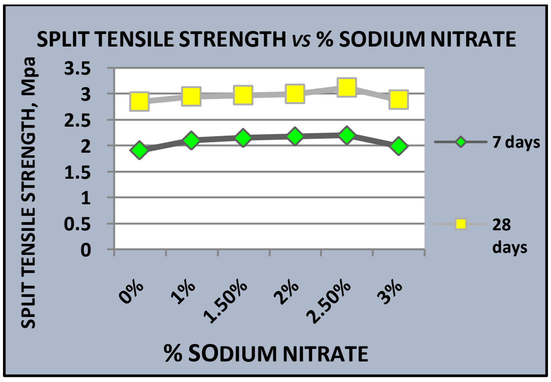

Figure 3.2 Spilt tensile strength VS % Sodium nitrate

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From both table and graph it is observed that at about 2.5 % addition of cement with sodium nitrate, concrete attains its maximum split tensile strength for M30 grade concretes, when the addition exceeds 2.5%, the split tensile strength is found to be decreased. At 3% addition it was clearly indicating the reduction of split tensile strength.

3.4 EFFECT OF VARIATION OF SODIUM NITRATE ON FLEXURAL STRENGTH

The test was carried out to obtain flexural strength of M30 grade concrete. The flexural strength of concrete is tested for 7 days, 28 days for 1%, 1.5%, 2%, 2.5% and 3% addition of sodium nitrate and the values are presented in Table no 3.3and also graph was plotted in below figure 3.3.

Table 3.3 Flexural Strength of concrete for M30 grade mix.

S.No	% of sodium nitrate	Flexural Strength(N/mm^2)	
		7 days	28 days
1	0%	2.06	2.81
2	1%	2.35	3.04
3	1.5%	2.38	3.14
4	2%	2.47	3.40
5	2.5%	2.59	3.69
6	3%	1.75	3.11

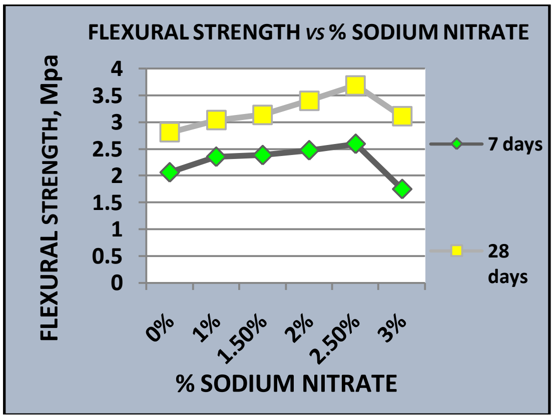

Figure 3.3 Graph showing Flexural Strength VS % sodium nitrate

From both table and graph it is observed that at about 2.5% addition of cement with sodium nitrate, concrete attains its maximum flexural strength for M30 grade concretes, when the addition exceeds 2.5%, the compressive is found to be decreasing suddenly beyond 3% of sodium nitrate.

IV. CONCLUSION

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn.

1. It was clearly understood from the above results that the addition of sodium nitrate is accelerating the strength development at smaller doses.
2. The compressive strength of concrete increased when cement is added with sodium nitrate for M30 grade of concrete. At 2.5% addition of sodium nitrate the concrete attained maximum compressive strength for 30 grade of concrete.
3. The split tensile strength of concrete is increased when cement is added with sodium nitrate .The split tensile strength is maximum at 2.5 % of addition.
4. The flexural strength of concrete is also increased when the cement is added with sodium nitrate. At 2.5% addition, the flexural strength is reached its maximum.
5. Workability of concrete decreases with the increase in sodium nitrate addition level.

SCOPE OF FURTHER STUDY

1. Studies on additions levels of high grade concrete can be carried out.
2. Combination of sodium nitrate with different other admixture can be carried out.
3. For use of sodium nitrate concrete as a structural material, it is necessary to investigate the behavior of reinforced concrete with sodium nitrate under flexure, shear, torsion and compression.
4.The study may further be extended to know the behavior of concrete whether it is suitable for pumping purpose or not as present day technology is involved in ready mix concrete where pumping of concrete is being done to larger heights.

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