COMPARATIVE STUDY OF ACCELERATING ADMIXTURES ON PROPERTIES OF CONCRETE

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Abstract

Accelerating admixtures affect the rates of reactions between cement and water to give an overall increase in the hydration rate. Thus, the use of accelerators in concrete provides a shortening of setting time and/or an increase in early strength development. In this paper the issue of slow down setting and hardening of concrete or addressed by the use of accelerating admixture are (sodium nitrite and calcium nitrite) in concrete. Sodium nitrite and Calcium nitrite was added in four samples having the quantity of 1%, 1.5 %, 2%, 2.5% and 3% by weight of cement was taken as mix -1 and mix -2. The concrete samples were tested 7, 14 and 28 days of Compressive strength, Split tensile strength and Flexural strength. The concrete specimens were laid for M25 grade of concrete.

Keywords: *Admixture, Sodium nitrite, Calcium nitrite, Compressive strength, Split tensile strength and Flexural strength.*

Introduction

The rates of chemical reactions between clinker materials in cements and water, often referred to as cement hydration reactions, 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.

The aim of this report is to provide an overview of chemical admixtures reported to accelerate setting and/or hardening of Ordinary Portland Cement (OPC) and OPC based concrete. Both accelerators for normal concrete.

As almost 100 % of concrete accelerators on the market are in liquid form (a few are sold as readily soluble powders), and the fact that most operators at concrete mixing plants prefer to handle accelerators in liquid form, this report does not treat powder accelerators insoluble in water.Accelerating admixtures can be used to increase either the rate of stiffening or setting of the concrete or the rate of hardening and early strength gain to allow earlier formwork striking and demoulding. Most accelerators achieve one rather than both of these functions.

Calcium Nitrite has a great variety of uses. It can be use as antifreeze due to its high solubility, either in solution or powder. It can promote the hydration of minerals in cement using this antifreeze at sub freezing temperature; the operative temperature can be reduced to −20 °C. It also works as metal corrosion inhibitor, so it can protect steel in concrete buildings and structures from rust, to extend life of specific buildings.

Sodium nitrite is an effective corrosion inhibitor and is used as an additive in industrial greases as an aqueous solution in closed loop cooling systems and in a molten state as a heat transfer medium.

In this research sodium nitrite and calcium nitrite is used as accelerating admixtures in the quantity range of 1% to 2.5% by weight of cement. So it can be arising the heat evolution and strength development. It behaves as a stimulant in the hydration of tricalcium silicate (C_3S) and tricalcium aluminate (C_3A).

Concrete sample with various percentages of sodium nitrite and calcium nitrite were tested for

- Compressive strength,
- Split tensile strength and
- Flexural strength.

Material Used

Cement

Cement is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. The project deals with ordinary Portland cement 43 grade confirming to IS 8112 was used throughout the work.

Fine Aggregate

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

- Natural Sand– it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies
- Crushed Stone Sand– it is the fine aggregate produced by crushing hard stone.
- Crushed Gravel Sand– it is the fine aggregate produced by crushing natural gravel.

According to size the fine aggregate may be described as coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grading Zone-1 to grading Zone-4. The four grading zones become progressively finer from grading Zone-1 to grading Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depending upon its grading zone.

Coarse Aggregate

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification. According to source, coarse aggregate may be described as:

- Uncrushed Gravel or Stone– it results from natural disintegration of rock
- Crushed Gravel or Stone– it results from crushing of gravel or hard stone.
- Partially Crushed Gravel or Stone– it is a product of the blending of the above two aggregate.

According to size coarse aggregate is described as graded aggregate of its nominal size i.e. 40 mm, 20 mm, 16 mm and 12.5 mm etc. for example a graded aggregate of nominal size 20 mm means an aggregate most of which passes 20 mm IS sieve.

A coarse aggregate which has the sizes of particles mainly belonging to a single sieve size is known as single size aggregate. For example 20 mm single size aggregate mean an aggregate most of which passes 20 mm IS sieve and its major portion is retained on 10 mm IS sieve.

Sodium Nitrite

Sodium nitrite is the inorganic compound with the chemical formula $NaNO_2$. It is a white to slightly yellowish crystalline powder that is very soluble in water and is hygroscopic. It is in the form of fine powder so it was easily added in the mix for purpose of increasing the properties of concrete. Fig -1 shows sodium nitrite and Fig -2 shows mixed ingredients of concrete for mix proportion.

Calcium Nitrite

Calcium nitrite can be produced by different synthesis processes. One is by reacting hydrated lime with NOX gas, which typically comes from a nitric acid plant. . It is in the form of fine powder so it was easily added in the mix for purpose of increasing the properties of concrete.
phosphate from

Sodium Nitrite

Calcium Nitrite

Table 1 Physical Properties of Materials

S.NO	PROPERTY	TEST RESULTS	IS– SPECIFICATION
1	**Cement : 43 grade OPC cement**		IS 8112: 1988
	Specific gravity	3.18	
	Initial setting time	30 min	
	Final setting time	5 hrs 10 min	
2	**Physical properties of fine aggregate**		IS 383: 1970
	Specific gravity	2.78	
	Fineness modulus	2.48	
	Bulk density	17KN/m^3	
	Grading	Zone – 2	
3	**Physical properties of coarse aggregate (20mm)**		IS 383: 1970
	Specific gravity	2.78	
	Fineness modulus	6.02	

Experimental Investigation

Mix proportions

The concrete mix design was proposed by using IS 10262. The grade of concrete has been laid M-25 with water cement ratio 0.50

Table 2 Mix Proportion – 1

S. No.	Sodium Nitrite	Water to cement ratio	Water (kg/m3)	Cement (kg/m3)	Sodium Nitrite (kg/m3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)	Slump value (mm)
1	0%	0.50	192	383	0.0	834	1062	30.5
2	1%	0.50	192	383	3.83	834	1062	32
3	1.5%	0.50	192	383	5.74	834	1062	33.5
4	2%	0.50	192	383	7.66	834	1062	34
5	2.5%	0.50	192	383	9.57	834	1062	36
6	3%	0.50	192	383	11.49	834	1062	30

Table 3 Mix Proportion – 2

S. No.	Calcium Nitrite	Water to cement ratio	Water (kg/m3)	Cement (kg/m3)	Calcium Nitrite (kg/m3)	Fine Aggregate (kg/m3)	Coarse Aggregate (kg/m3)	Slump value (mm)
1	0%	0.50	192	383	0.0	834	1062	30.5
2	1%	0.50	192	383	3.83	834	1062	31.7
3	1.5%	0.50	192	383	5.74	834	1062	33.0

4	2%	0.50	192	383	7.66	834	1062	34.6
5	2.5%	0.50	192	383	9.57	834	1062	36.0
6	3%	0.50	192	383	11.49	834	1062	29.0

Test on fresh concrete

Slump cone test used extensively in site work all over the world. Very useful in detecting variations in the uniformity of a mix of given nominal proportions. Rich mixes behave satisfactorily, their slump being sensitive to variations in workability. The slump test were performed according to IS 1199- 1959.

Test on hardened concrete

The main destructive tests on hardened concrete are as follows.

- Cube test: Compressive strength of hardened concrete is done by cube test. More details about Cube. the size of the concrete cube size as 150mm × 150mm × 150mm.
- Tensile splitting test on concrete cylinders as a size of 150mm × 300mm.
- Flexure test on concrete as a size of 500mm × 100mm × 100mm.

Results and Discussion

Compressive Strength

Compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analysed independently. These tests were carried out for 7, 14 and 28 days. An increasing compressive strength was observed up to 2.5% of sodium nitrite as an admixture has been decreased in compressive strength and 2.5% of calcium nitrite has been slightly increased.

Table 4 Compressive Strength Test Results

S. No.	% of Accelerating admixture	Strength attained by Sodium nitrite (N/mm^2)			Strength attained by Calcium nitrite (N/mm^2)		
		7 days	14 days	28 days	7 days	14 days	28 days
1	0	13.90	16.00	26.10	13.90	16.00	26.10
2	1	16.20	17.30	27.80	16.00	17.15	27.85
3	1.5	16.70	17.70	27.90	16.50	17.80	27.95
4	2	17.30	18.50	28.00	17.00	18.90	28.15
5	2.5	19.50	22.00	28.50	17.50	19.50	28.60
6	3	14.10	13.60	24.90	14.00	16.00	24.00

Figure 1 Compressive Strength Test

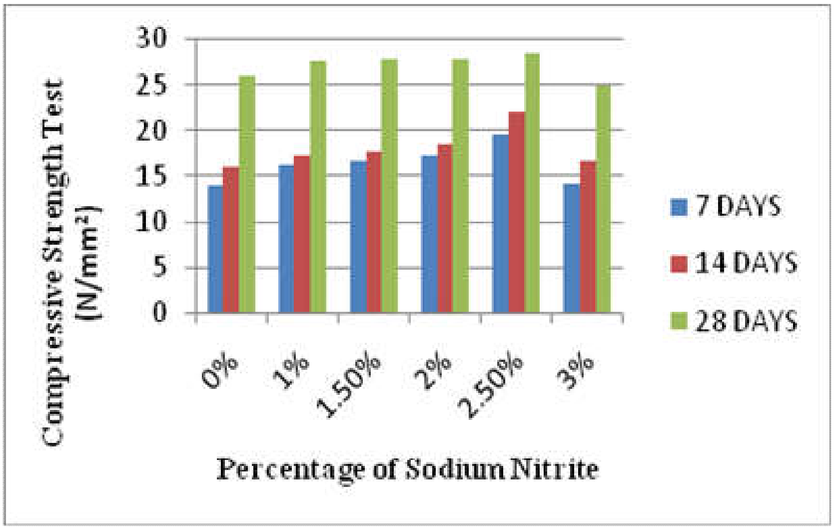

Figure 2 Compressive Strength Results for Sodium Nitrite

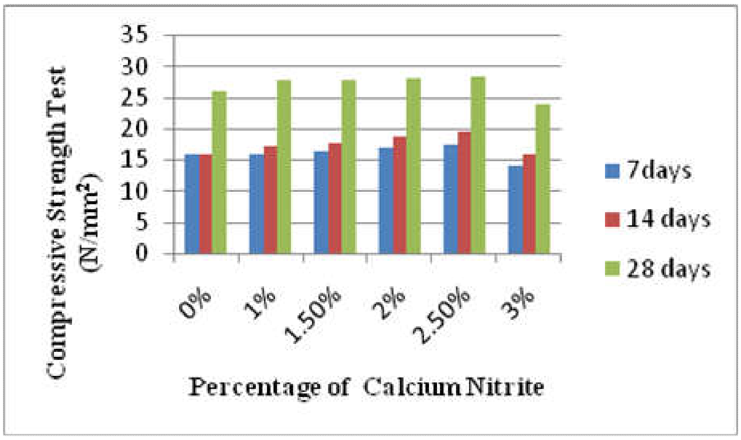

Figure 3 Compressive Strength Results for Calcium Nitrite

Split Tensile Strength

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

Table 2 Split Tensile Strength Test Results

S. No.	Percentage of accelerating admixture	Strength attained by Sodium nitrite (N/mm^2)			Strength attained by Calcium nitrite (N/mm^2)		
		7 days	14 days	28 days	7 days	14 days	28 days
1	0	2.01	3	3.2	2.01	3	3.2
2	1	2.5	3.8	3.31	2.2	2.6	2.8
3	1.5	2.51	3.80	3.36	2.23	2.72	2.81
4	2	2.66	3.82	3.8	2.5	2.8	3
5	2.5	2.67	3.4	3.6	2.8	2.81	3.33
6	3	1.77	2.39	2.84	1.45	2.01	2.15

Figure 4 Split Tensile Strength Test

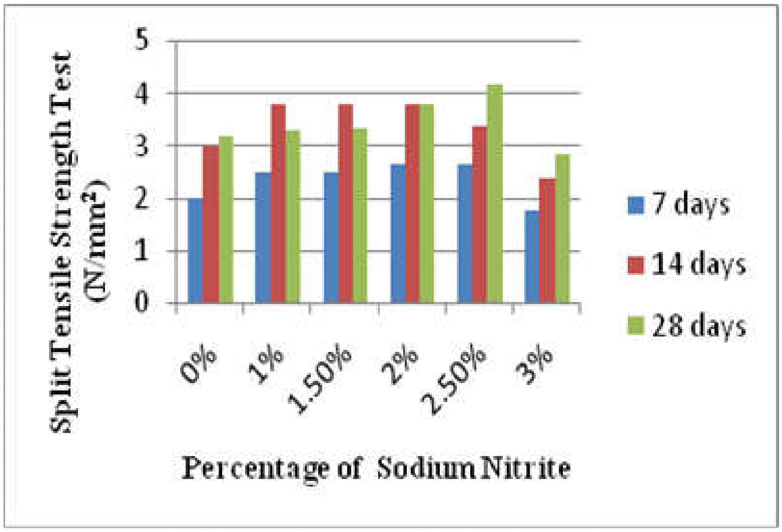

Figure 5 Split Tensile Strength Results for Sodium Nitrite

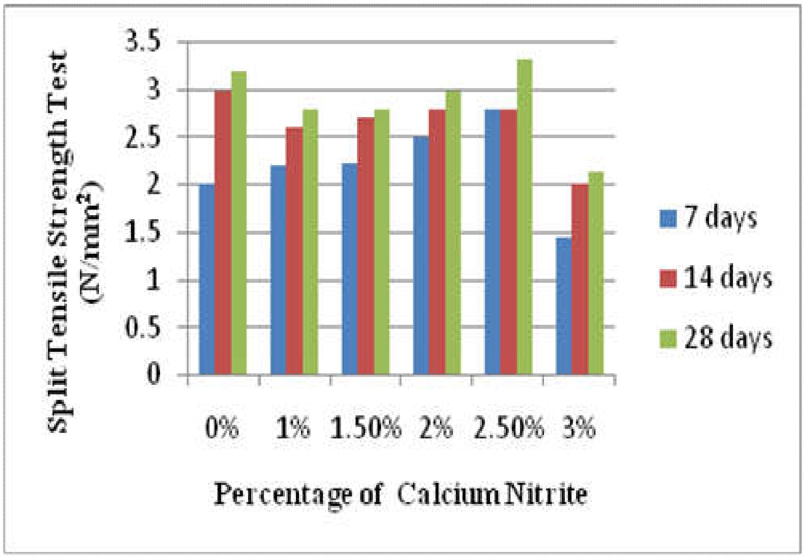

Figure 6 Split Tensile Strength Results for Calcium Nitrite

Flexural Strength Test

The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'Fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fibre reaches its limiting tensile stress.

Figure 7 Flexural Strength

Table 3 Flexural Strength Test Results

S. No.	% of Accelerating admixture	Strength attained by Sodium nitrite (N/mm^2)			Strength attained by Calcium nitrite (N/mm^2)		
		7 days	14 days	28 days	7 days	14 days	28 days
1	0	1.34	2.36	3.33	1.34	2.36	3.33
2	1	1.36	2.45	3.45	1.4	2.46	2.85
3	1.5	1.42	2.49	3.6	1.56	2.53	3.46
4	2	1.54	2.51	3.64	1.7	2.55	3.51
5	2.5	1.59	2.9	4.1	1.78	2.61	3.55
6	3	1.23	2.1	3	1.1	2.14	2.07

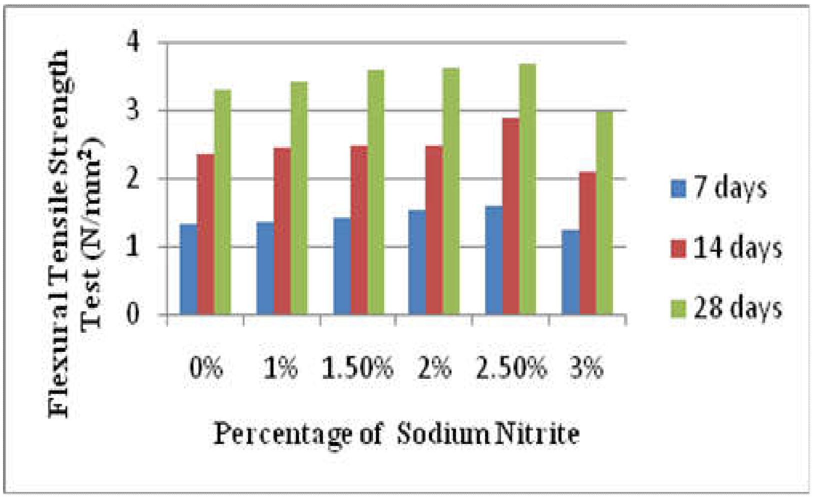

Figure 8 Flexural Strength Results for Sodium Nitrite

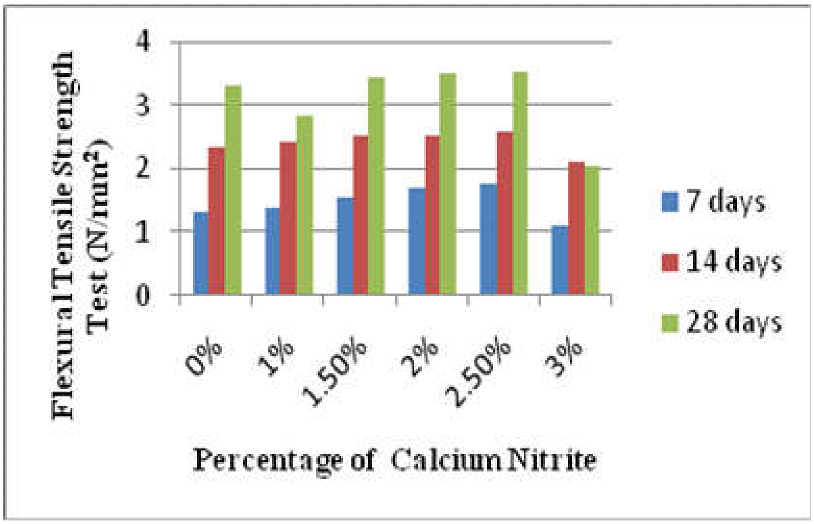

Figure 9 Flexural Strength Results for Calcium Nitrite

Conclusion

On the basis of results obtained, following conclusions are

- For the normal mix of concrete the compressive strength of the concrete was gained as 13.9, 16.01, 26.10 N/mm^2 has been achieved at 7, 14 &28 days.
- For the 2.5% of sodium nitrite added in the concrete & achieved the strength as 40.28%, 37.5% & 9.19% increase in compressive strength of concrete with respect to the reference mix at 7, 14 &28 days.
- For the 2.5% of calcium nitrite added in the concrete & achieved the strength as 10.6%, 21.8% & 9.5% increase in compressive strength of concrete with respect to the reference mix at 7, 14 &28 days.
- By the comparison of both the accelerating admixtures the greater compressive strength is achieved in the concrete by the addition of optimum dosage level (i.e.2.5%) of sodium nitrite.
- For the normal mix of concrete the split tensile strength of the concrete was gained as 2.01, 3, 3.2 N/mm^2 has been achieved at 7, 14 &28 days.
- For the 2.5% of sodium nitrite added in the concrete & achieved the strength as 32.8%, 13.33% & 12.5% increase in split tensile strength of concrete with respect to the reference mix at 7, 14 &28 days.
- For the 2.5% of calcium nitrite added in the concrete & achieved the strength as 39.3%, 6.33% & 4% increase in split tensile strength of concrete with respect to the reference mix at 7, 14 &28 days.
- By the comparison of both the accelerating admixtures the greater split tensile strength is achieved in the concrete by the addition of optimum dosage level (i.e.2.5%) of sodium nitrite.
- For the normal mix of concrete the flexural strength of the concrete was gained as 1.34, 2.36, 3.33 N/mm^2 has been achieved at 7, 14 &28 days.

- For the 2.5% of sodium nitrite added in the concrete & achieved the strength as 18.65%, 22.88% & 23.12% increase in flexural strength of concrete with respect to the reference mix at 7, 14 &28 days.
- For the 2.5% of calcium nitrite added in the concrete & achieved the strength as 32.8%,10.59% & 6% increase in flexural strength of concrete with respect to the reference mix at 7, 14 &28 days.
- By the comparison of both the accelerating admixtures the greater flexural strength is achieved in the concrete by the addition of optimum dosage level (i.e.2.5%) of sodium nitrite.
- An increase of compressive strength, split tensile strength and flexural strength at 7,14 and 28 days corresponding to 2.5% sodium nitrite addition notifies its absolute possibility of usage as accelerating admixture.
- Sodium nitrite can be used as accelerating admixture particularly in cold climate at 2.5% dosage by weight of cement without any harmful effects.
- Calcium nitrite can also be used as accelerating admixture but sufficient strength is not attained when compared to the sodium nitrite.

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