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Influence of Non Chloride Accelerator in Cement Concrete

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Abstract:- The present experimental work explains the combined effect of a commercial non-chloride hardening accelerator and method of curing in the strength development of concrete. Ordinary Portland cement (OPC) was used to produce concrete mixtures. Concrete mixtures were designed as per the guidelines of IS 10262:2009. Compressive strength of standard cube specimens (150 mm) at early and later- age, cured with water were studied. Performance of accelerator at a given age of concrete was assessed based on the maximum percentage increase in the compressive strength. The strength of control mix cured with water is taken as reference. Among various types of chemical admixtures, Non Chloride Accelerator Admixture (NCA) is chosen. The non chloride accelerator admixture is added with normal mix of the concrete in the nominal dosage and the effects are studied. 0.8%, 1.0%, 1.2% of non chloride accelerators were mixed with various grades of concrete such as M20& M25. The optimum level of high early development strength was analyzed. Average efficiency of the curing compound for the given age was calculated as the ratio of average compressive strength of concrete cured with NCA to that cured with water. The test results revealed that, the type of curing affected the optimum performance of accelerator in concrete mixtures. Average efficiency of the curing compound was found to be more at early- age of the concrete mixtures.

Keywords:- Accelerator, OPC**,** Compressive, Flexural and Split Tensile Strength of Concrete**.**

I. INTRODUCTION

Concrete is a composite construction material composed primarily of aggregate, cement, and water. In general the coarse aggregate used is broken granite stone and the fine aggregate used is river sand. The common Portland cement and other cementitious materials such as fly ash and slag cement, serve as a binder for the aggregate. Various chemical admixtures are also added to achieve varied properties. Water is then mixed with this dry composite, which enables it to be shaped and then solidified and hardened through a chemical process called hydration. The water reacts with the cement, which bonds the other components together, eventually creating a robust stone-like material. Concrete has relatively high compressive strength, but much lower tensile strength

Additives are shortly named as Admixtures. Admixtures interact chemically with the ingredients of the concrete and change its performance in the fresh and hardened state. They confirm special beneficial effect to concrete. They can enhance the workability of the fresh concrete. The dosage of mixing will be 0.8% to 1.5% by weight of cement. Research on the use of supplementary cementitious materials in cement concrete hints at the limitation of their blending with OPC at site due to lack of testing facility to check their pozzolanic characteristics and due to other practical reasons. Hence blending of cementitious materials during the production of cement under strict quality control is prudent to reap the benefits.

1.1 Accelerator

Non-chloride accelerators are now being tried in place of calcium chloride in order to minimize potential of steel corrosion. Accelerators primarily target acuminate phase resulting in rapid workability loss. Limited Experimental study on the accelerators shows that they not only enhance rate of hydration but help in providing better paste quality and surface characteristics. It is also experimentally proven that as the curing age is increased from opening time to maturity, concrete with accelerating admixture showed better resistance to abrasion which is a desirable property for pavement concrete.

1.1.1 Reasons for Using Accelerating Admixture

The major reasons for using accelerating admixtures are

- To reduce the cost of concrete construction
- To achieve certain properties in concrete more effectively than by other means
- To maintain the quality of concrete during the stages of mixing, transporting, placing and curing in adverse weather condition.
- To reduce shrinkage cracks in concrete.

1.1.2 Types of Accelerating Admixture
The two types of accelerating admixture are
- Chloride accelerating admixture
- Non-Chloride accelerating admixture

1.1.2.1 Chloride Accelerating Admixture
Calcium chloride is the most common accelerator used in concrete. Most of the available literature treats calcium chloride as the main accelerator. Calcium chloride (CaCl2) is a by product of the Solvay process for sodium carbonate manufacture.
$CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$ (Limestone Brine Solution)
Calcium chloride in reinforced concrete can promote corrosion activity of steel reinforcement, especially in moist environments. This corrosion can be prevented by using Limestone Brine Solution

1.1.2.2 Non-Chloride Accelerating Admixture
A non-chloride admixture does not contain chlorides. It results in anti corrosive admixture. It easily disperses in concrete and masonry mixes and accelerates the setting time. This accelerator is typically suited for cold weather concreting. It is safe for use in pre-stressed and reinforced concrete. It also increases early strength and ultimate strength of concrete. Table-1shows comparison of chloride based and non-chloride based accelerator

Fig.1. Non-Chloride Accelerating Admixture

Table -1 Comparison Of Chloride Based And Non-Chloride

CHLORIDE BASED	NON-CHLORIDE BASED
Corrosion is possible in reinforcement of concrete	**No possibility of corrosion in reinforcement of concrete**
The properties were achieved by American code of provisions	**The properties were achieved by Indian code of provisions**
This may results in high heat of hydration in concrete	**Easily disperses in concrete results proper heat of hydration.**
This may creates shrinkage cracks	**This may avoid shrinkage cracks**

II. MATERIALS AND METHOD
Ordinary Portland Cement (OPC), conforming to Indian Standards IS 8112 was used to prepare concrete mixtures, whose physical characteristics are given in Tables 2 respectively. Oven dried river sand conforming to grading zone IV of Indian Standards (IS 383:1970) was used as fine aggregate. Saturated surface dry angular aggregates of size 20 mm and 10 mm used as coarse aggregates such that the combined gradation conformed to Indian Standards (IS 383:1970) grading limits for graded coarse aggregates. Table 2 shows the physical properties of aggregates. Ordinary tap water was used for mixing the concrete mixtures of the experimental study. Commercial non-chloride hardening accelerator conforming to ASTM C-494 Type C and IS 9103: 1999 standards. The properties of non chloride accelerator using for our investigation are given below:
Type of admixture - Non-Chloride accelerator
Name of the Material- Techmix 460
Physical State = Light Straw Colored Liquid
Specific Gravity = 1.20 ± 0.02 @ 30º C
Chloride Content = Nil
Dosage = 0.8% to 1.5% by weight of cement was used to hasten the hardening process of the concrete mixtures.

TABLE 2 PHYSICAL PROPERTIES OF AGGREGATES

Cement	Fineness %	Setting Time (Min.)		Strength-28 day Compressive (MPa)	Specific Gravity
		Initial	Final		
OPC	3	33	150	45.2	3.15

2.1 Concrete mix proportioning

Concrete mixtures of grade M20, M25 were designed for pavement concrete using revised guidelines of Indian Standards (IS 10262:2009). Table 3& Table 4 shows the ingredients of control mixture produced with OPC.

TABLE 3 MIX PROPORTION BY WEIGHT

Mix	Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water lit/ m^3
M20	348.32	569.41	1226.16	185.07
M25	372	547.16	1217.68	185.07

TABLE 4 MIX PROPORTION

Mix	Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3	Water lit/ m^3
M20	1	1.63	3.52	0.53
M25	1	1.47	3.27	0.49

The control mixture was modified with accelerator dosage from 2 liters to 5 liters per cubic meter of concrete as per the instructions of the manufacturer, i.e. 0.8 to 1. 5 percent by weight of cement.

2.2 Curing and Tests

Cast concrete cube specimens (150 mm) were cured with water by immersing specimens in water tank at room temperature. Fig 1 shows curing the specimen

Fig. 2. Curing the specimen

2.3 Experimental tactic

2.3.1Compressive strength test:

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M20and M25 grade of concrete. NCA (0.8%,1% &1.2% by weight of cement) was added . Vibration was given to the moulds using table vibrator. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where in they are allowed to cure for 28 days. 54 cube specimens were casted. 3 Specimens were tested at each different age of curing for compressive strength test in accordance to evaluate the interaction of accelerator with type of cement and method of curing in the compressive strength development of concrete, as often compressive strength of concrete is deemed as the sole criterion to approve any concrete mixture and moreover it is possible to relate compressive strength to other strength and durability parameters using customary empirical equations.

The maximum load at the breakage of concrete block was noted. In each category three cubes were tested and their average value is reported. From the noted values, the compressive strength was calculated by using expression. The compressive strength was calculated as follows. Compressive strength (MPa) = Failure load / cross sectional area

Fig.3. Testing the compressive strength of specimen

2.3.2 Flexural strength Test:

For the determination of flexural strength of concrete, Beam specimen of size 1000mm x 150mm x 150mm were used. Specimens were dried in open air after 28 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. The flexural strength (R) was obtained using the formula

$$R=1.5Pl/bd^2 \ (N/mm^2)$$

Where,

R	=	Modulus of rupture (N/mm^2)
P	=	Maximum applied load (N)
l	=	Effective Span length (mm)
b	=	Width of specimen (mm)
d	=	depth of specimen (mm)

Fig.4. Testing the flexural strength of specimen

2.3.3 Split Tensile strength test:

For the determination of Split tensile strength of concrete, cylinder specimens of diameter to length ratio 1:2 was selected, with diameter as 150 mm and length as 300 mm. Specimens were dried in open air after 7, 14 & 28 days of curing and subjected to splitting tensile test under compression testing machine. The rate of loading was 0.5 kN/s as per ASTM C 490-96. While testing the specimens, plywood pieces are placed one at top and other at the bottom. The split tensile strength (fsp) was obtained using the formula

fsp = 2P/ πdl (N/mm2)

Where,

P = Load at failure (N)

d = Diameter of specimen (mm)

l = Length of specimen (mm)

Fig. 5 .Testing the Split tensile strength of specimen

III. RESULTS AND DISCUSSION

3.1Hardened Concrete Properties

Hardened concrete properties were assessed by compression test. It is not only the compressive strength at full maturity, but the compressive strength at early age is equally important in construction and rehabilitation. Hence, compressive strength was recorded at, seven, fourteen and twenty-eight day of curing with water .The values are shown in tables 5 and 6. Percentage gain in strength of mixtures with varied dosage of accelerator, in comparison to the strength of control mixture was calculated. Efficiency of curing compound at a given age of concrete and for a given dosage of accelerator, defined as the ratio of compressive strength of mixture cured with it to the compressive strength of mixture cured with water, expressed as percentage was also assessed for all the mixtures. Table 5 and 6 shows compressive strength for M20 & M25 grade

TABLE 5 COMPRESSIVE STRENGTH IN N/mm2 FOR M25GRADE

Accelerator content (%)	Compressive Strength for M 20grade concrete in N/mm^2		
	7 days	14 days	28 days
0	18.9	21.4	26.2
0.80	19.8	22.4	27.2
1	21.5	30.2	34.3
1.20	23.1	32.4	35.6

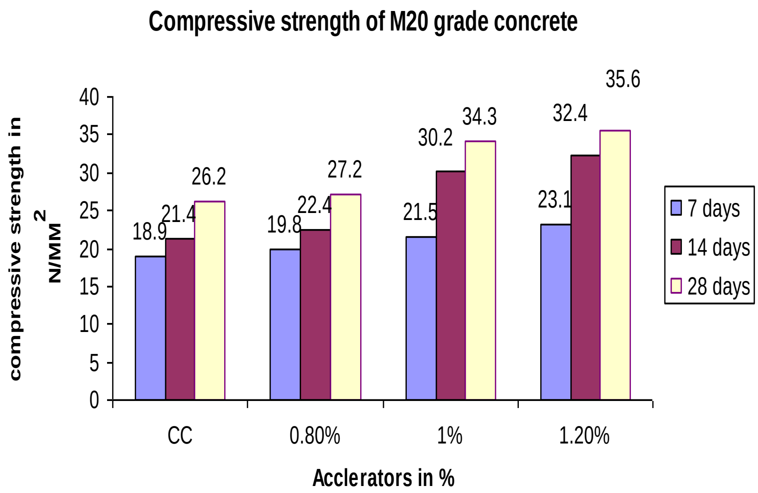

Fig. 6. Comparison of Compressive Strength of M20 Grade Concrete for 7, 14, 28 days

TABLE 6 COMPRESSIVE STRENGTH IN N/mm2 FOR M25GRADE

Accelerator content (%)	Compressive Strength for M 25 grade concrete in N/mm^2		
	7 days	14 days	28 days
0	22	26	32
0.80	22	27	32
1	24	29	36
1.20	30	33	37

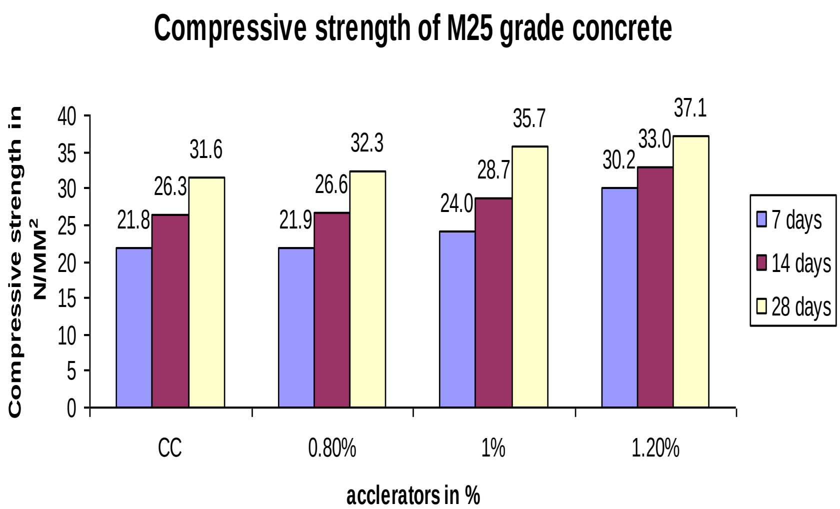

Fig. 7 Comparison of Compressive Strength of M25 Grade Concrete 7, 14, 28 days

TABLE 7 FLEXURAL STRENGTH IN N/mm^2 FOR M20GRADE

Accelerator content (%)	Flexural strength for M 20 grade concrete in N/mm^2		
	7 days	14 days	28 days
0	12.00	12.67	13.17
0.80	12.63	13.46	13.63
1	12.92	13.58	13.83
1.20	13.08	14.04	14.21

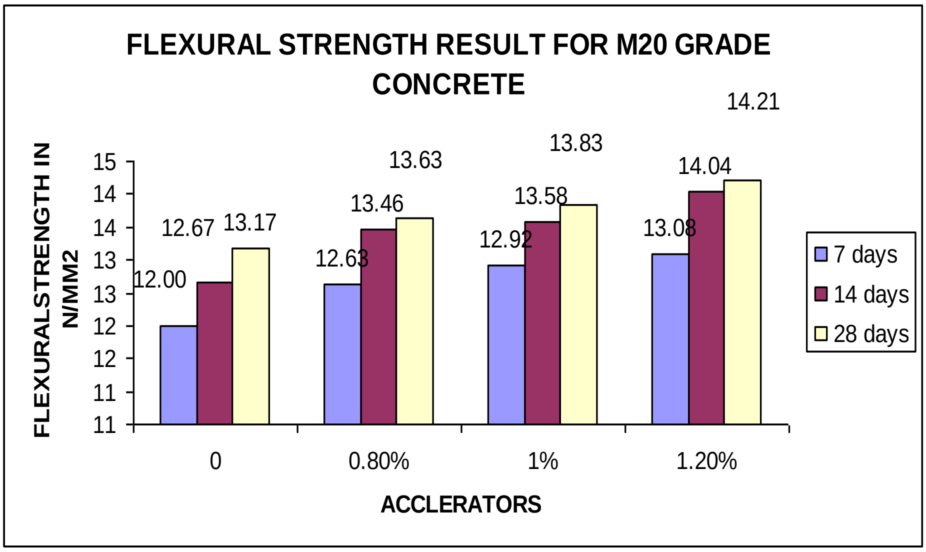

Fig. 8 Comparison of Flexural Strength of M20 Grade Concrete for 7, 14, 28 days

Table 8 Flexural Strength In N/Mm^2 For M25grade

Accelerator content (%)	Flexural strength for M 25 grade concrete in N/MM^2		
	7 days	14 days	28 days
0	12.13	12.79	13.42
0.80	12.29	13.17	13.63
1	12.92	13.50	14.08
1.20	13.00	13.75	14.29

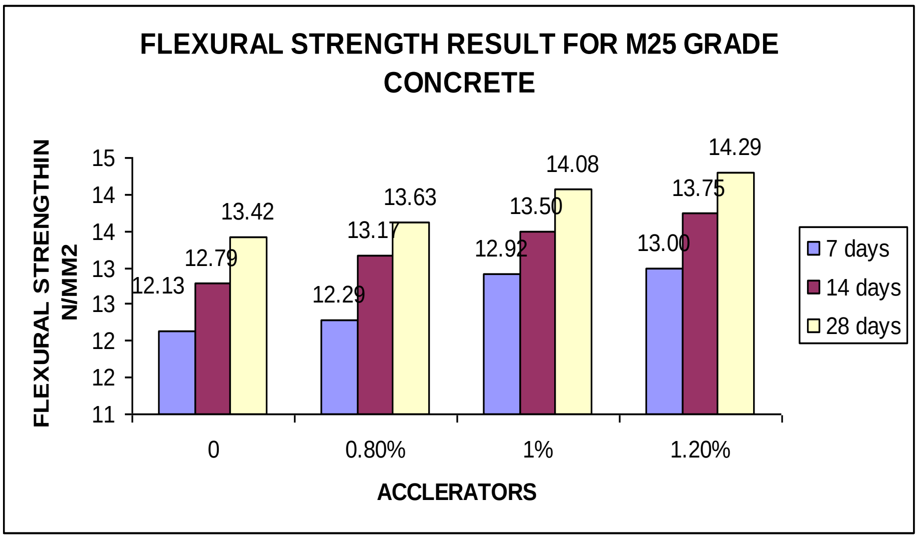

Fig. 9 Comparison of Flexural Strength of M25 Grade Concrete for 7, 14, 28 days

TABLE 9 SPLIT TENSILE STRENGTH IN N/MM2 FOR M20GRADE

Accelerator content (%)	Split tensile strength for M 20 grade concrete in N/mm^2		
	7 DAYS	14 DAYS	28 DAYS
0	1.56	2.54	3.25
0.80	1.62	2.57	3.52
1	2.17	3.53	3.14
1.20	3.13	5.15	5.50

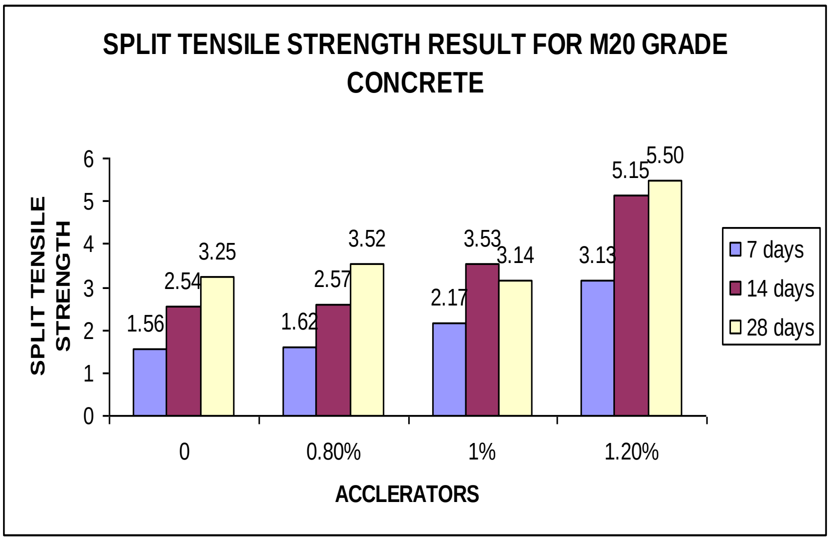

Fig. 10 Comparison of Split Tensile Strength of M20 Grade Concrete for 7, 14, 28 days

TABLE 10 SPLIT TENSILE STRENGTH IN N/mm^2 FOR M25GRADE

Accelerator content (%)	Split tensile strength for M 25 grade concrete in N/mm^2		
	7 days	14 days	28 days
0	2.56	3.54	4.83
0.80	2.60	3.58	4.93
1	2.92	3.99	5.13
1.20	4.11	4.64	6.83

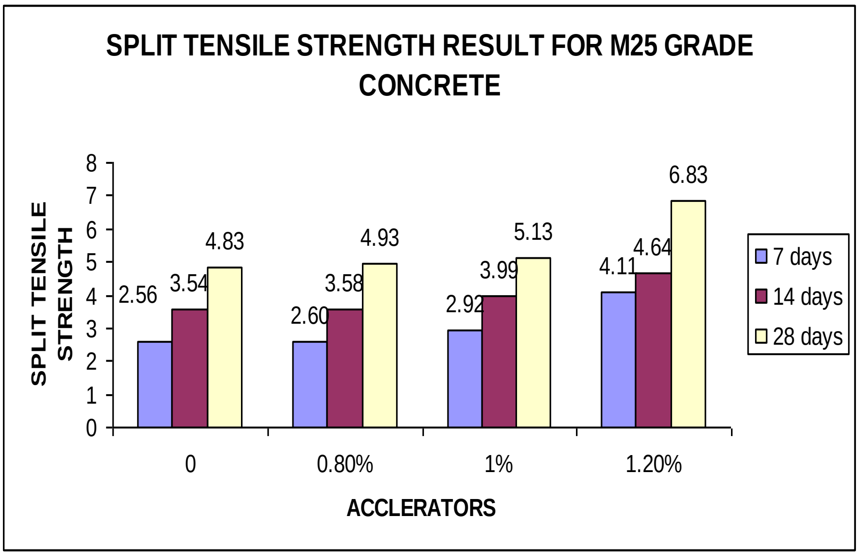

Fig. 11 Comparison of Split Tensile Strength of M25 Grade Concrete for 7, 14, 28 days

IV. CONCLUSION

Accelerator was effective in increasing the compressive strength of all the concrete mixtures. Performance of accelerator at a given age of concrete was assessed based on the maximum percentage increase in the compressive strength, measured with reference to the strength of the control mixture at the corresponding age. Interaction of the accelerator was better at three and five day of mixtures cured with water. The optimum performance of accelerator was found to be affected by method of curing. Average efficiency of the curing compound was found to be higher at early- age than at later- age. The correlation between early- age and later -age compressive strength was found to be affected by the method of curing.

The compressive, Flexural, Split tensile strength test conducted on various mixtures has revealed the following observation.

- When 0.8% added, the strength may slightly increases for both M20 and M25.
- When 1.0% added, the strength variation is started.
- When adding 1.2%, the strength reaches the maximum level.
- Thus, the experimental work concludes that “to achieve the maximum strength in earlier days, the minimum level of non chloride accelerator can be used with other ingredients of the concrete”
- From this study it is understood that the addition of non chloride accelerator has played an important role in the achievement of early concrete strength.

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