OBTAINING THE OPTIMAL PERCENTAGE OF ANTIFREEZING ADMIXTURES (SODIUM NITRITE AND POTASSIUM CARBONATE) EFFECTING THE STRENGTH PROPERTIES OF CONCRETE

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Abstract: Based on ACI 306R-10, the minimum temperature necessary for maintaining concrete hydration and strength gaining is 5 °C. If the temperature becomes lower than 5 °C, special measures should be taken in order to prevent decrease in the rate of hydration and to prevent fresh concrete from freezing. Concreting in winter conditions is very difficult. The reason is that concrete can harden and develop high strength in a relatively short time only within a certain range of above-zero temperatures. It is possible to create favorable conditions for concrete to harden when the ambient air temperature is below zero but that requires additional energy, materials and labour. During cold weather, preparations are made to protect the concrete; enclosures, windbreaks, portable heaters, insulated forms, and blankets are used to maintain the concrete temperature. As an alternative, antifreeze additives can be used in cold weather. These chemical additives suppress the freezing point of water under 0 °C degrees and accelerate the hydration of cement. However, the long term effects of these additives remain unknown. The selection of an antifreeze admixture will depend on the type of structure, the operating conditions and whether the admixture will be used with other protective methods of winter concreting. It is important therefore to determine through laboratory mix trials both the operating range and the particular dosage of the admixture required for the intended application. Cold-weather concreting with antifreeze admixtures does not exclude the use of other admixtures such as air-entraining agents, water reducers, retarders and super plasticizers. However, the dosage of the specific admixture to be used in combination with the antifreeze admixture should be established experimentally, because higher than normal amounts may be required. Concrete antifreeze additives are an indispensable component of concrete, particularly in winter and in areas with a cold climate. The overall effects of these additives, which are thought to have overall positive effects, should be determined and these effects should be taken into account in the design process. This study is conducted to study the effects of antifreeze (Sodium Nitrite plus Potassium Carbonate) on the strength properties of the concrete produced in cold weather.
The concrete samples will be prepared with different percentages of admixtures (0%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5% by weight of cement). Prepared concrete samples are to be placed in a formwork and exposed to the sub-zero temperatures (exterior winter conditions) and compressive strength & tensile strength of the concrete samples will be determined after the curing. In conclusion, the effect of antifreeze agents on the properties of concrete will be determined.

***IndexTerms* - Ant freezing Concrete, Sodium Nitrite, Potassium Carbonate.**

I. INTRODUCTION

Cold-weather conditions for construction is defined as a period when for more than 3 consecutive days, the following conditions exist: the average daily air temperature is less than 5°C (40°F) and the air temperature is not greater than 10°C (50°F) for more than one-half of any 24 h period. Under these conditions setting time and rate of strength gain of concrete is significantly delayed. Additionally, depending on the consistency of the mix, a reduced rate of hydration results in less water ingress into the cement particles, promoting bleeding and segregation. The time of setting of concrete increases by approximately one-third for every 6°C (10°F) drop in temperature (assuming that the concrete and ambient temperature are the same) down to 4°C (40°F). Retardation of setting increases the potential for freezing of the concrete before initial set. When the internal temperature of concrete falls to -2°C (28°F), free water in the pores begins to crystallize as ice. Freezing increases the volume by 9% generating stresses that incorporate defects within the concrete. When fresh concrete freezes, the strength of such concrete is lowered by 20–40%, its resistance to freeze-thaw cycling as given by the durability factor is lower by 40–60% and the bond between reinforcement and concrete is lowered by 70% compared with normally cured concrete. Thus, when concreting is done under cold weather conditions it is important to ensure that the concrete will not freeze while it is in the plastic state. Two options are available for cold weather concreting: (1) maintenance of near normal ambient and concrete temperatures through the heating of concrete ingredients and the provision of heated enclosures and (2) the use of chemical admixtures. Conventional non-chloride accelerating admixtures are used in cold weather concreting to offset the retarding effects of slow hydration on the rate of strength development. Such admixtures however do not permit concreting at or below freezing temperatures. When concreting is carried out under more drastic weather conditions, special admixtures, called antifreeze admixtures, which affect the physical condition of the mix water, are used. Antifreeze admixtures are capable of depressing the freezing point of water in concrete considerably and their use at temperatures as low as -30°C enables an extension of the period of construction activity. Selection of appropriate chemical admixtures enables the production of cold-weather concrete mixtures with both accelerated setting and early-age strength development characteristics, similar to that obtained with plain concrete mixtures at normal ambient and concrete temperatures (22°C). Although the use of antifreeze admixtures has been an acceptable practice in Russia for nearly three decades, their use in other countries has been more recent. The main non-chloride, noncorrosive accelerating admixtures available on the market are of two types: (1) accelerating admixtures which accelerate hydration but do not depress the freezing point of water; and (2) accelerating admixtures for use in sub-freezing ambient temperatures which depress the freezing point of water. The former contain salts of formates, nitrates and nitrites and are effective for set acceleration and strength development. However, their effectiveness is dependent on the ambient temperature at the time of placement. The latter contain components that depress the freezing point of water and accelerating ingredients and belong to the group of admixtures referred to as antifreeze admixtures. Chemicals used as antifreeze admixtures include Sodium and Calcium Chloride, Potash, Sodium Nitrite, Calcium Nitrate, Urea, and binary systems such as Calcium Nitrite Nitrate and Calcium Chloride-Nitrite-Nitrate. The effect of various antifreeze admixtures on the compressive strength has been previously investigated by researchers.

II. MATERIALS AND METHODS

2.1. The various materials used include

- Cement
- Sand
- Coarse aggregate
- Water
- Sodium nitrite
- Potassium carbonate

The test results of various materials are shown in the following tables 1and 2.

Table1. Properties of cement, sand and coarse aggregate

Material	Test property	Result	Specified limit	Specification
Cement	Consistency	31%	30-35%	IS 4031:1988
	Initial setting time	35 min	Not less than 30 min	
	Final setting time	445min	Not less than 10 hrs	
	Specific gravity	3.15	3.10-3.15	
Sand	Fineness modulus	2.9	Zone ii or iii	IS 2386:1963
	Specific gravity	2.65	2.6-2.8	
Coarse aggregate	Specific gravity	2.6	2.6-2.85	IS 2386:1963
	Fineness modulus	7.20	6.5-8.0	

Table2. Properties of sodium nitrite and sodium carbonate

Material	Property	Result
Sodium nitrite	Appearance	Whitish
	Density	2.168g/cm3
	Solubility	Soluble in water
Potassium carbonate	Appearance	Whitish
	Density	2.43g/cm

	Solubility	Soluble in water

Table 3: 7 day compressive strength

% of Admixture	Compressive Strength (N/mm^2)
0	10.74
0.5	11.08
1.0	13.12
1.5	14.14
2.0	12.42
2.5	11.50

2.2. Methodology

The anti-freezing admixtures (sodium nitrite and potassium carbonate) were added in mixture in different percentages as 0.5%. 1.0%, 1.5%, 2.0% and 2.5% to prepare M20 concrete.

III. RESULTS AND DISCUSSIONS

The main aim of the project was to obtain the optimal percentage of the mixture of sodium nitrite and potassium carbonate and to see their effect in the strength properties of concrete at 7 days and 28 days.

Different tests were performed and their results are shown in the following tables and figures:

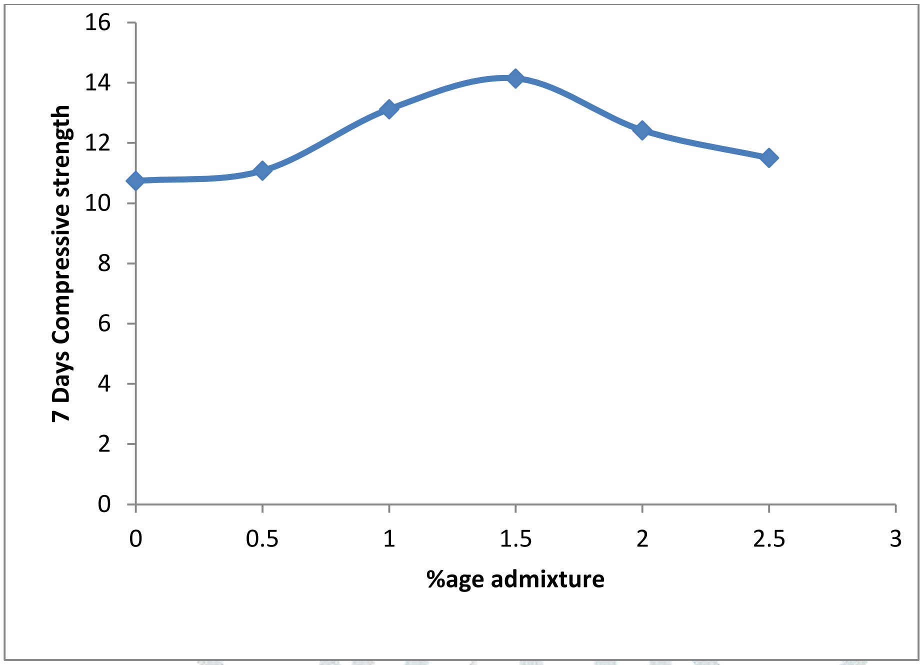

Figure1.Variation of 7 day compressive strength

Table 4: 7 Day Split Tensile Strength

% of Admixture	Split Tensile Strength (N/mm^2)
0	1.26
0.5	1.32
1.0	1.42
1.5	1.52
2.0	0.96
2.5	0.78

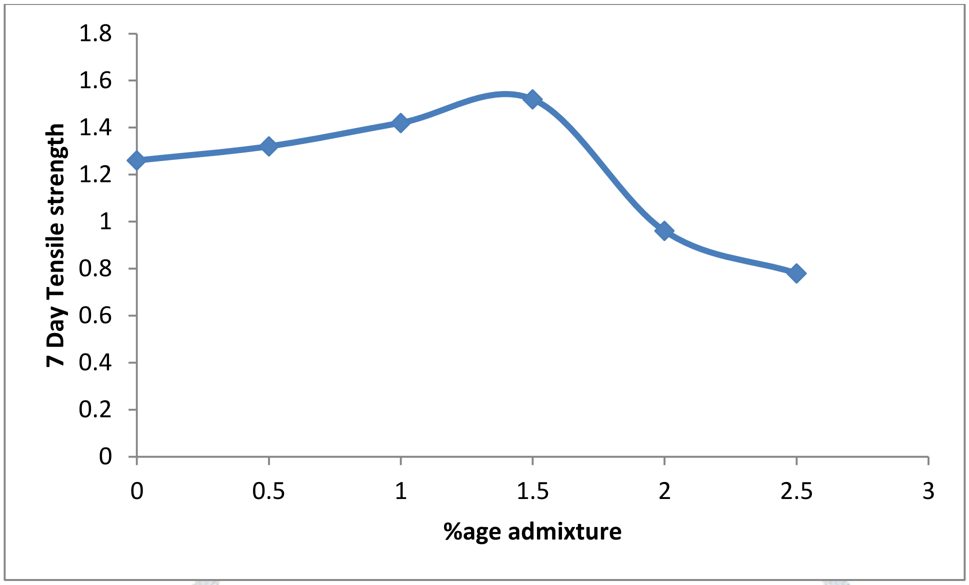

Figure2. Variation of 7 day tensile strength

Table 5. 28 Day Compressive Strength

% of Admixture	Compressive Strength (N/mm^2)
0	16
0.5	16.3
1.0	17.8
1.5	19.9
2.0	17.2
2.5	16.8

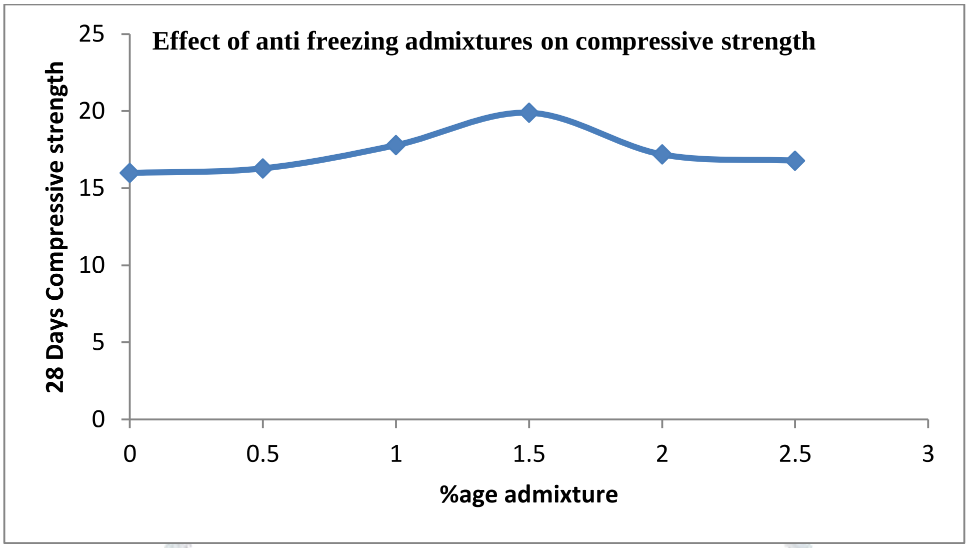

Figure3. Variation of 28 day compressive strength

Table6. 28 Day Split Tensile Strength

% of Admixture	Split Tensile Strength (N/mm^2)
0	1.72
0.5	1.80
1.0	1.98
1.5	2.20
2.0	1.62
2.5	1.52

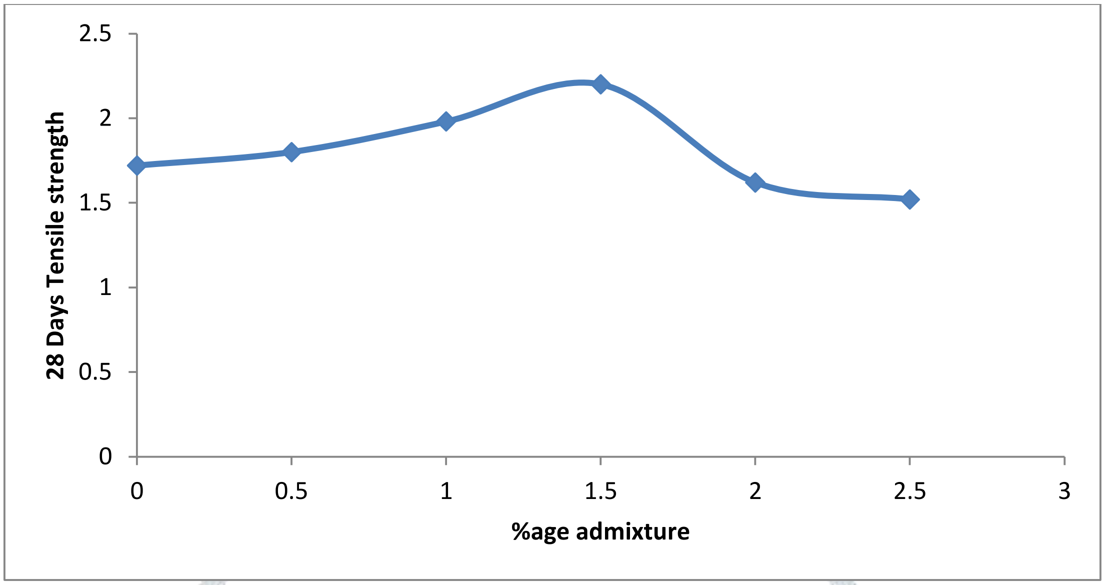

Figure 4.Variation of 28 day tensile strength

IV. CONCLUSION

The optimum percentage corresponding to which maximum increase in strength was obtained at 1.5% on using combination of Potassium Carbonate and Sodium Nitrite as an antifreeze admixture. The percentage increase in strength was found appreciable and encouraging. However on increasing the percentage by weight of antifreeze after optimum, there was decrease in percentage increase in strength. The results obtained will pave a way in future for using antifreeze in cold weather concrete constructions. Once code permits the use of antifreeze in concrete, it will become readily available as well as economical.

The use of Sodium Nitrite in combination with Potassium Carbonate as an anti-freezing admixture is therefore, recommended in optimum quantity (1.5% by weight of cement). As a thumb rule, it is recommended to use 0.75 kg of admixture material (Sodium Nitrite + Potassium Carbonate) per bag of cement.

V.

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