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Effect of Strong Alkaline Substances Present in Mixing Water on the Properties of Cement Mortar

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Abstract: The quality of water plays a vital role on setting, strength development and durability of cement mortar or concrete. In the present study, the effect of strong alkaline substances like sodium carbonate (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$) on setting time, compressive strength, pH and durability of cement mortar is assessed under laboratory conditions. The results indicate that sodium carbonate (Na_2CO_3) in mixing water accelerated the setting times of cement mortar and sodium bicarbonate ($NaHCO_3$) retarded the setting times. The presence of Na_2CO_3 and $NaHCO_3$ in mixing water decreases the compressive strength, acid resistance and alkaline resistance of cement mortar. The rate of decrease in these continuous with increase in concentration of alkaline substances (Na_2CO_3 and $NaHCO_3$) present in mixing water. The pH of cement mortar increases with increase of alkaline substances in mixing water. The present work analyses the hydration characteristics of cement mortar using SEM analysis.
Keywords: Cement mortar, Setting Time, Compressive Strength, pH, Durability, Alkaline Substances

I. INTRODUCTION

Since water actively reacts with cement, the quality of water plays an important role in the preparation of concrete or cement mortar. Thus water used for mixing in concrete or mortar should not contain any substance which affect the strength of cement mortar or concrete.Potable water is generally considered satisfactory for mixing concrete. The pH value of mixing water shall be not less than 6.The chemical substances present in water are generally classified into neutral salts, strong alkaline substances, slightly acidic substances and strong acids. The effects of strong alkaline substances on setting, hardening, strength, pH and durability of cement mortar or concrete are not known much. Hence, an investigation is carried out in order to study the effect of strong alkaline substances on setting times, strength, pH and durability of cement mortar under laboratory conditions.

II. OBJECTIVE

The aim of this experimental investigation is to study the Setting properties of cement, Compressive strength, pH and Durability studies like acid resistance and alkaline resistance of cement mortar prepared with various concentrations of strong alkaline substances like sodium carbonate and sodium bicarbonate in mixing water. The various concentrations of sodium carbonate (Na_2CO_3) and sodium bicarbonate ($NaHCO_3$) used in De Ionized water are 0 g/l, 1.0 g/l, 1.5g/l, 2.0 g/l, 3.0 g/l, 4.0 g/l and 5.0 g/l.

III. MATERIALS AND METHODS

A. Cement

Cement used in the present investigation is 53 Grade Ordinary Portland cement conforming to IS 12269-1987 specifications.

B. Fine Aggregate

Fine Aggregate used in the present investigation is Ennore sand obtained from Tamil Nadu minerals, Chennai, which satisfies the criteria for standard sand as specified in IS 650-1991.

C. Water

De-ionized water is used as mixing water with different concentrations of strong alkaline substances like sodium carbonate and sodium bicarbonate.

D. Cement Mortar Mix Proportion

Cement and sand proportion used in the present work is 1:3. The mix proportion of cement mortar is shown in Table1.

TABLE1: MIX PROPORTION

Cement	Fine Aggregate		
	Grade I (2mm to 1mm)	Grade II (1mm to 0.5mm)	Grade III (0.5mm to 90μ)
1	1	1	1
1	3		

Quantity of water to be mixed in the preparation of cubes is calculated according to IS 269-1976, which is varying with respect to the concentration of test solution. It is given by $(\frac{P}{4} + 3)$ percent of combined weight of cement and sand, where 'P' being percentage of water required to produce a paste of normal consistency.

E. Experimental Tests

1) Normal Consistency &Setting Times: Vicat's apparatus conforming to IS-4031 (part5) 1988 is used to find the normal consistency and setting times.

2) Compressive Strength: Mortar cubes of size 70.7mm × 70.7mm × 70.7mm were cast to test the compressive strength of cement mortar at the age of 3, 7, 28, 56 and 90days.Compressive strength is determined by using Universal Testing Machine by applying load gradually till the specimen fails.

3) pH: To measure the pH of hardened cement mortar, an aqueous solution of the powdered material is created. This dilutes the concentration of the solid material. The tests were conducted using 5 g samples with dilution ratios of 1:10, 1:5 and 1:2. The pH readings were obtained using a pH meter.

4) Durability

a) Acid Resistance Test: The resistance of mortar to acid attack was found by the % loss of weight of specimen and the % loss of compressive strength on immersing mortar cubes in acidic water. Hydrochloric acid (HCL) and Sulphuric acid (H_2SO_4) with pH of 1 at 2.5% weight of water added to water in which the mortar cubes were stored.

b) Alkaline Resistance Test: To determine the resistance of cement mortar to alkaline attack, water having 2.5% of sodium hydroxide (NaOH) by weight of water was used. The % loss of weight of specimen and the % loss of compressive strength of specimen on immersing mortar cubes in alkaline substance were found.

IV. RESULTS AND DISCUSSION

A. General

In assessing the performance of any parameter, it is considered that if the change in percentage of that particular parameter is more than 10%, it is considered significant, otherwise insignificant.

B. Setting Times

Fig.1 shows the variation of setting times of cement with increase in concentrations of Sodium carbonate.Fig.2 shows the variation of setting times of cement with increase in concentrations of Sodium bicarbonate.

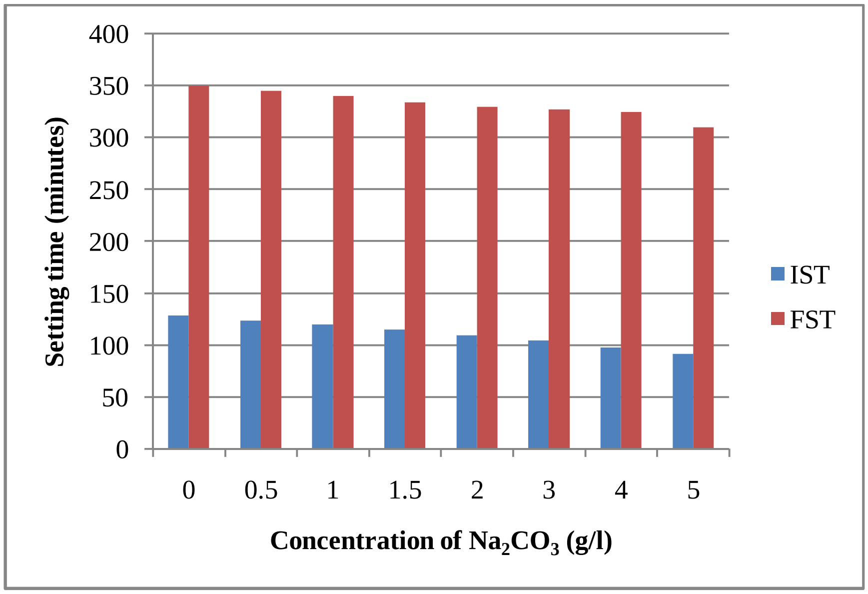

Fig.1 Variation of Setting Times of Cement with different concentrations of Na_2CO_3

It is observed from fig.1that initial and final setting times of cement got accelerated as the concentration of Na_2CO_3 increases in mixing water. At lower concentrations up to 3g/l, the change in initial setting time is insignificant. The significant change in initial setting time is noticed at concentrations of 4g/l and 5g/l. The significant change in final setting time is noticed at the concentration of 5g/l. It is also observed that at lower concentrations of Na_2CO_3, the change in final setting time is insignificant. The acceleration of setting of cement is attributed to the formation of Gyrolite upon the hydration of cement with mixing water containing Na_2CO_3.

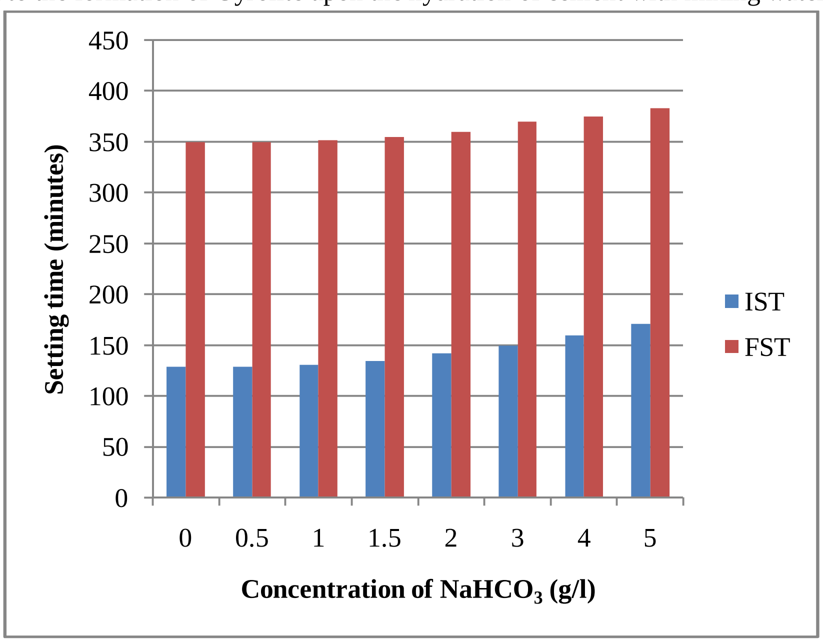

Fig.2 Variation of Setting Times of Cement with different concentrations of $NaHCO_3$

It is observed from fig.2that initial and final setting times of cement got retarded as the concentration of $NaHCO_3$ increase in mixing water. At lower concentrations up to 3g/l, the change in initial setting time is insignificant. The significant change in initial setting time is noticed at concentrations of 4g/l and 5g/l. The significant change in final setting time is noticed at the concentration of 5g/l. It is also observed that at lower concentrations of $NaHCO_3$, the change in final setting time is insignificant. The probable reason for the retardation of setting times of cement could be the formation of tetra calcium aluminates carbonate 12-hydrate by the hydration of cement with mixing water containing $NaHCO_3$.

C. Compressive Strength

Fig.3& Fig.5 show the variations of compressive strength of cement with increase in concentrations of Sodium carbonate and Sodium bicarbonate respectively at different ages. Fig.4 & Fig.6 show the percentage variations of compressive strength of cement with increase in concentrations of Sodium carbonate and Sodium bicarbonate respectively at different ages.

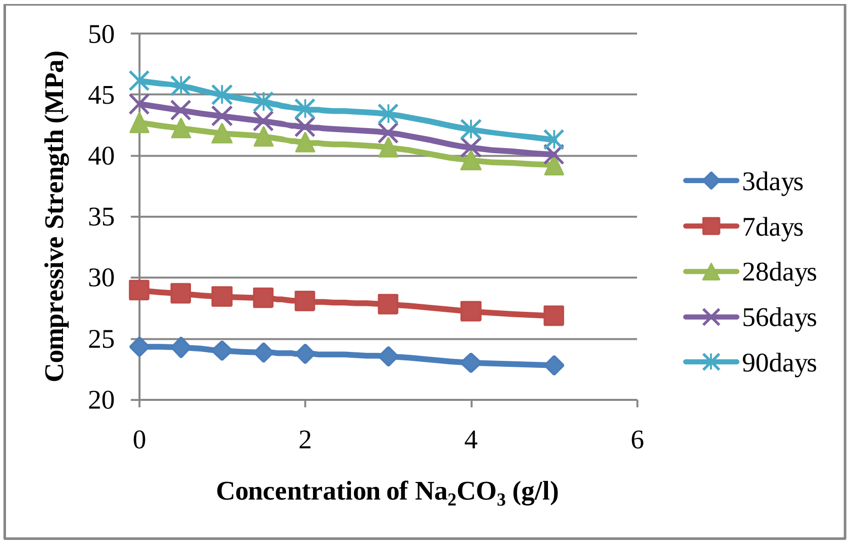

Fig.3 Variation of Compressive strength of Cement of different age with different concentrations of Na_2CO_3

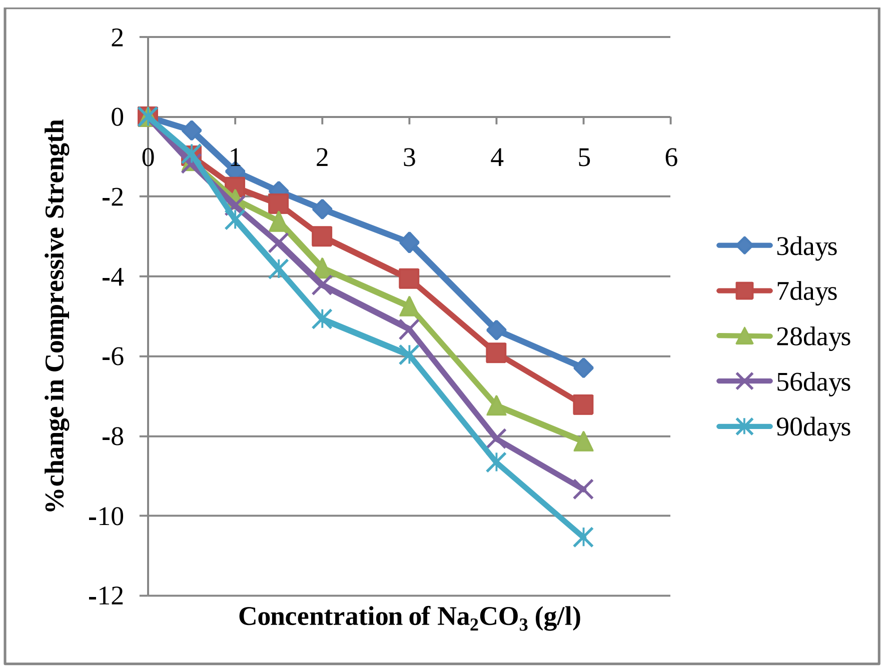

Fig.4 Percentage reduction in compressive strength of cement of different age with various concentrations of Na_2CO_3

From the graph shown, in fig.3 it is observed that there is less reduction in the compressive strength at early ages. It is observed that the rate of decrease in compressive strength is more for higher concentrations. From Fig.4,it is observed that percentage reduction in compressive strength is more at 5.0g/l at all testing ages. Its variation observed is significant only at 90 days and insignificant at all other ages lesser than 90 days. Continuous decrease in the compressive strength for all samples could be due to the formation of Gyrolite. When Gyrolite gel comes in contact with water, it swells by imbibing a large amount of water through osmotic process. The hydraulic pressure so developed leads to expansion and cracking of the cement paste matrix surrounding the aggregate, thus leading to the decrease in compressive strength.

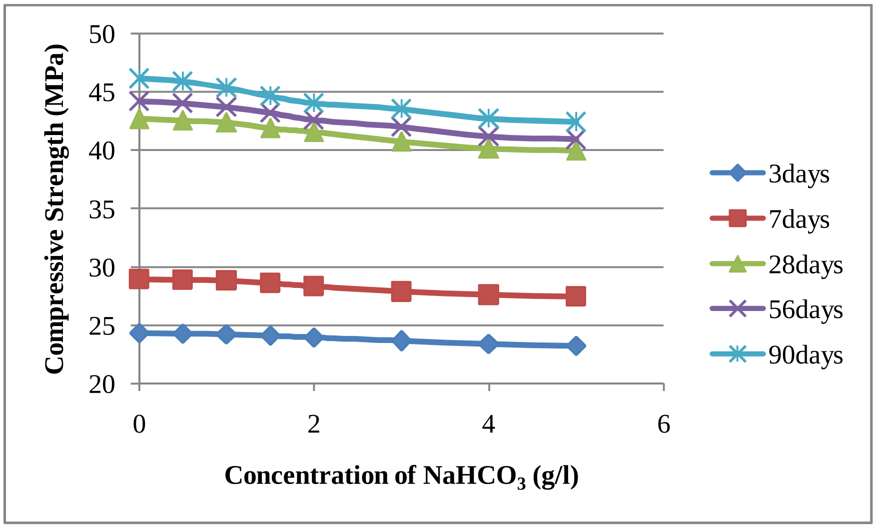

Fig.5 Variation of compressive strength of Cement of different age with different concentrations of $NaHCO_3$

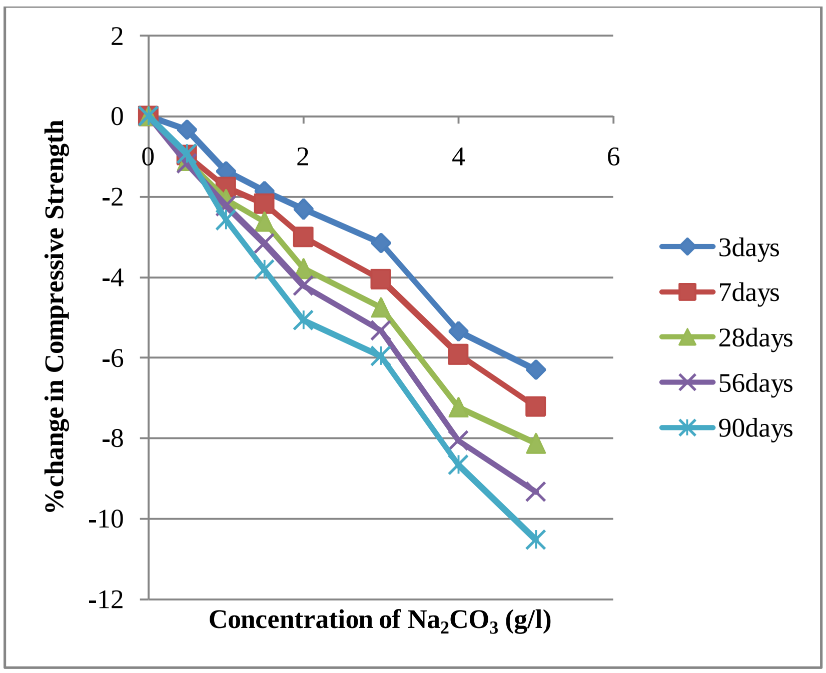

Fig.6 Percentage reduction in compressive strength of Cement of different ages with various concentrations of $NaHCO_3$

From fig.5, it is observed that almost there is no reduction in the compressive strength at the early ages. The rate of decrease is observed to be more for higher concentrations. The Fig.6 shows that percentage reduction in compressive strength is more at 5.0g/l at all testing ages but its variation is not significant. Continuous decrease in compressive strength could be due to the formation of tetracalcium aluminate carbonate 12- hydrate. Tetracalcium aluminate carbonate 12-hydrate gel comes in contact with water and swells by imbibing a large amount of water through osmotic process. The hydraulic pressure so developed may lead to expansion and cracking of the cement paste matrix surrounding the aggregate and thus leading to the decrease compressive strength.

D. pH

The Fig.7 shows that pH of cement mortar increases with the concentration of Na_2CO_3. The pH of cement mortar is more at the concentration of 5 g/l. The pH of cement mortar increases with the dilution ratio but the rate of increase is retarded gradually.

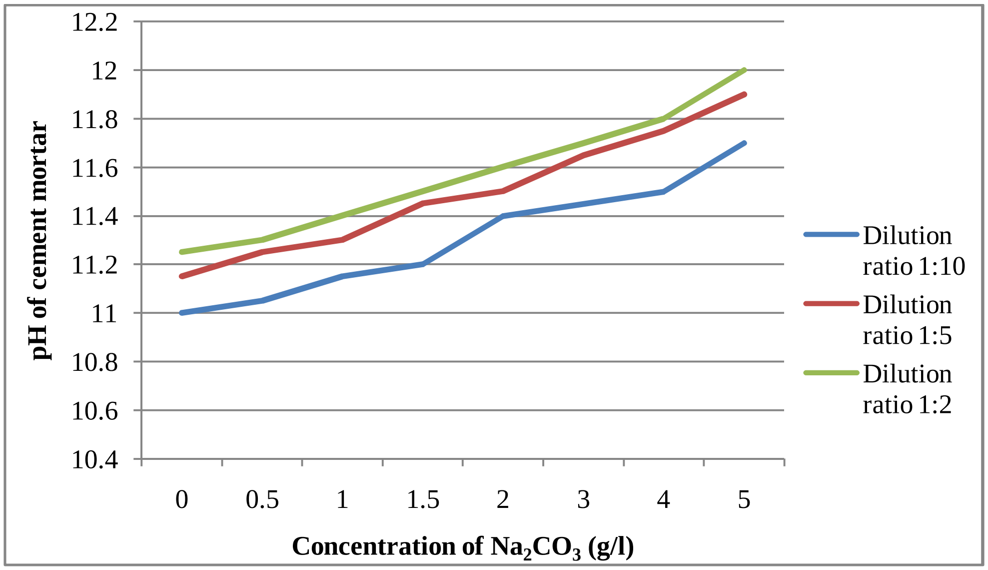

Fig.7 Variation of pH of cement mortar with varying concentrations ofNa_2CO_3

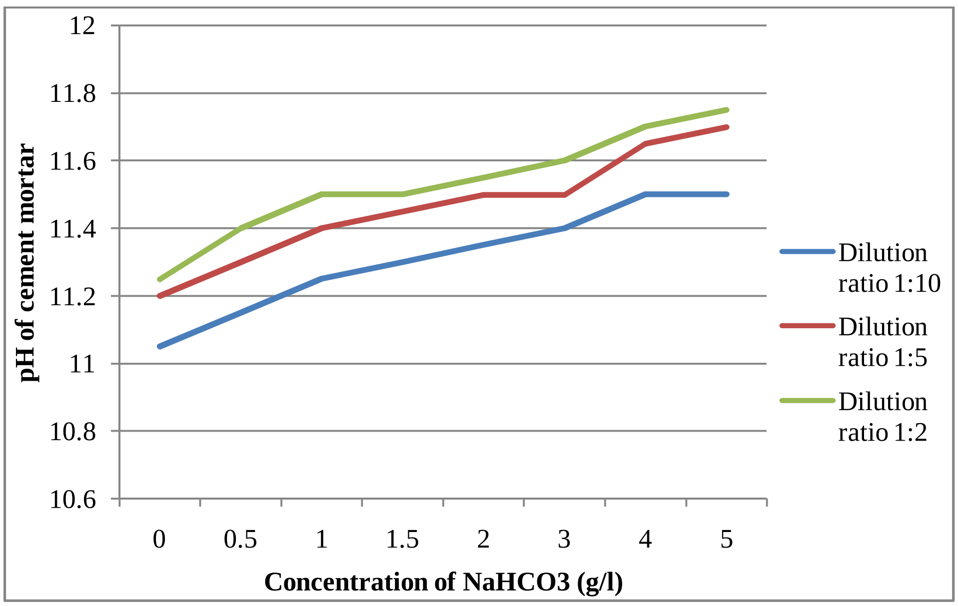

Fig.8 Variation of pH of cement mortar with varying concentrations of $NaHCO_3$

The Fig.8 shows that pH of cement mortar increases with the concentration of $NaHCO_3$. The pH of cement mortar is more at the concentration of 5 g/l. The pH of cement mortar increases with the dilution ratio but the rate of increase is retarded gradually.

E. Durability

To assess the durability of cement mortar with various concentrations of Na_2CO_3 & $NaHCO_3$, the cement mortar cubes were exposed to Acidic and Alkaline solutions prepared by mixing 2.5% by weight of H_2SO_4, HCL and NaOH in deionised water. Graphical representations of the same are presented below.

1) Resistance of Cement Mortar to H_2SO_4 Acid:

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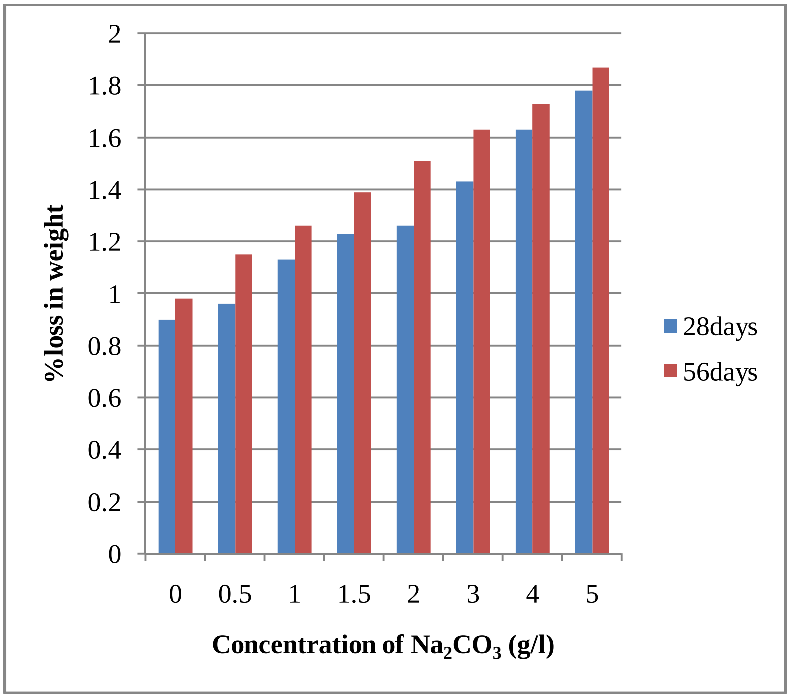

Fig.9 Percentage loss in weight of mortar cubes of various concentrations of Na_2CO_3immersed in 2.5% H_2SO_4 acid

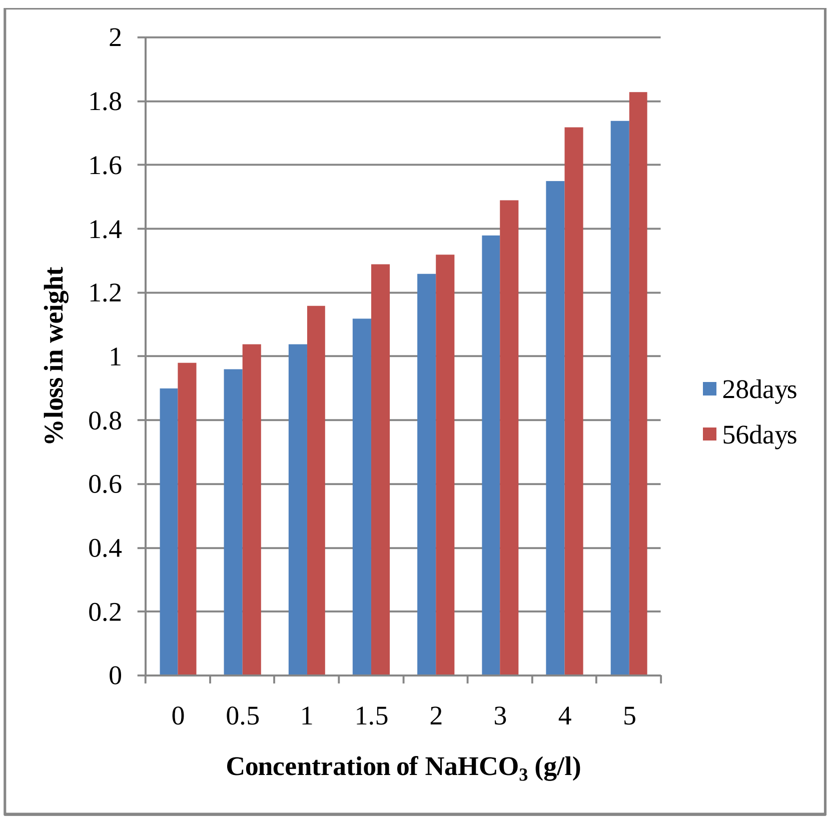

Fig.10 Percentage loss in weight of mortar cubes of various concentrations of $NaHCO_3$immersed in 2.5% H_2SO_4 acid

Fig.9 shows that loss of weight of mortar cubes increases with the concentration of Na_2CO_3. Loss in weight of mortar cubes is more at the concentration of 5g/l. Fig.10 shows that loss of weight of mortar cubes increases with the concentration of $NaHCO_3$. Loss in weight of mortar cubes is more at the concentration of 5g/l.

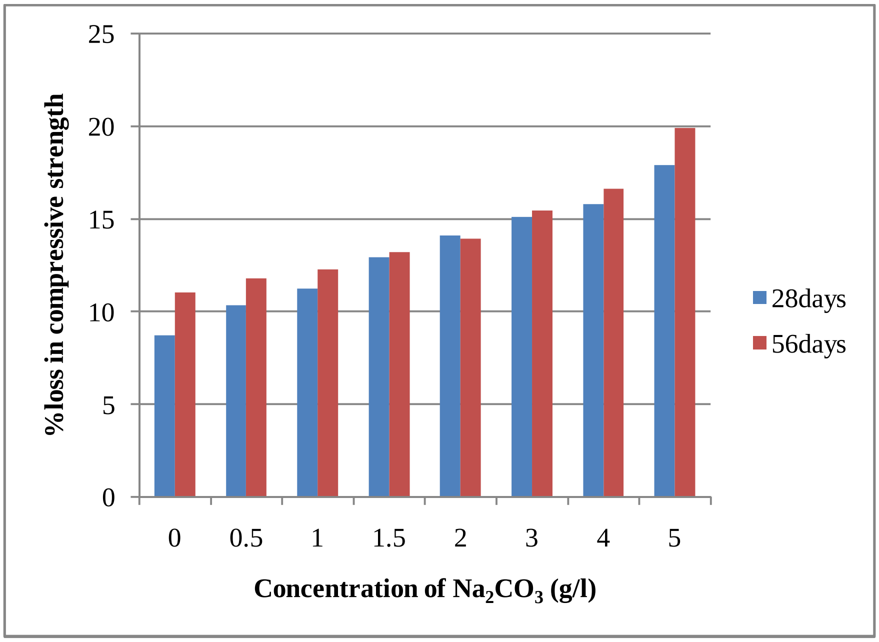

Fig.11 Percentage loss in compressive strength of mortar cubes of various concentrations of Na_2CO_3immersed in 2.5% H_2SO_4 acid

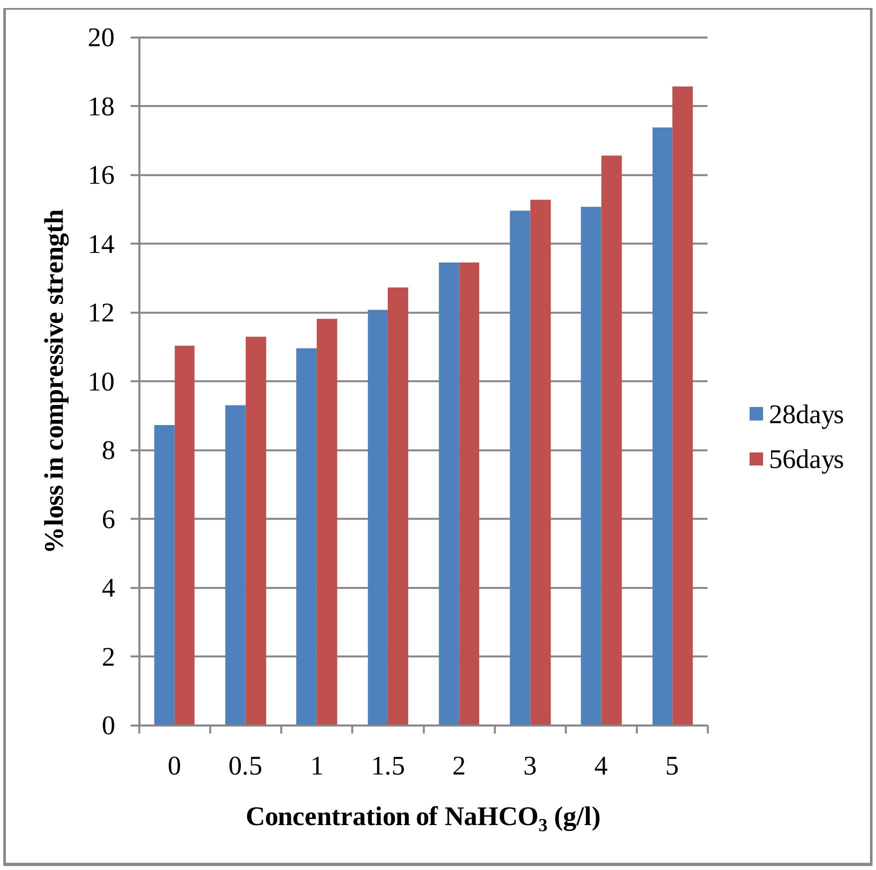

Fig.12 Percentage loss in compressive strength of mortar cubes of various concentrations of $NaHCO_3$immersed in 2.5% H_2SO_4 acid

Fig.11 shows that loss of compressive strength of mortar cubes increases with the concentration of Na_2CO_3. Loss of compressive strength of mortar cubes is more at the concentration of 5g/l.Fig.12 shows that loss of compressive strength of mortar cubes increases with the concentration of $NaHCO_3$. Loss of compressive strength of mortar cubes is more at the concentration of 5g/l.

2) Resistance of Cement Mortarto HCl Acid: Percentage loss in weight of mortar cubes on immersion of cubes in HCl acid is also increased with the concentration of sodium carbonate and sodium bicarbonate present in mixing water. Percentage loss in weight is 1.62% at 28days and 1.75% at 56days for 5g/l concentration of Na_2CO_3. Percentage loss in weight is 1.53% at 28days and 1.61% at 56 days for 5g/l concentration of $NaHCO_3$.

Percentage loss in compressive strength of mortar on immersion of cubes in HCl acid is also increased with the concentration of sodium carbonate and sodium bicarbonate present in mixing water. Percentage loss in compressive strength is 15.61% at 28days and 17.88% at 56days for 5g/l concentration of Na_2CO_3. Percentage loss in compressive strength is 15.31% at 28days and 17.18% at 56 days for 5g/l concentration of $NaHCO_3$.

3) Resistance of Cement Mortar to NaOH Alkaline: Percentage loss in weight of mortar cubes on immersion of cubes in NaOH base is also increased with the concentration of sodium carbonate and sodium bicarbonate present in mixing water. Percentage loss in weight is 1.75% at 28days for 5g/l concentration of $Na_2CO_3$and 1.75% at 28days for 5g/l concentration of $NaHCO_3$.

Percentage loss in compressive strength of mortar on immersion of cubes in NaOH is also increased with the concentration of sodium carbonate and sodium bicarbonate present in mixing water. Percentage loss in compressive strength is 17.37% at 28days for 5g/l concentration of $Na_2CO_3$and 17.23% at 28days for 5g/l concentration of $NaHCO_3$.

F. Scanning Electron Microscope (SEM) Analysis for Cement Mortar

To understand the mechanism of variation of properties of cement mortars made with different concentrations of alkaline substances in mixing de-ionized water, SEM images were obtained for the selected samples. The images of the same are presented below. The resolution adopted in the images is 10 µm.

Fig.13 depicts the scanning image of powdered cement mortar sample prepared with deionized water and that of the same for cement mortar sample prepared with Na_2CO_3 in deionized water is presented in Fig.14. The comparison of this present pattern with that of the deionised water indicates the formation of $Ca_4Si_6O_{15}(OH)_23H_2O$ (Gyrolite) compound.

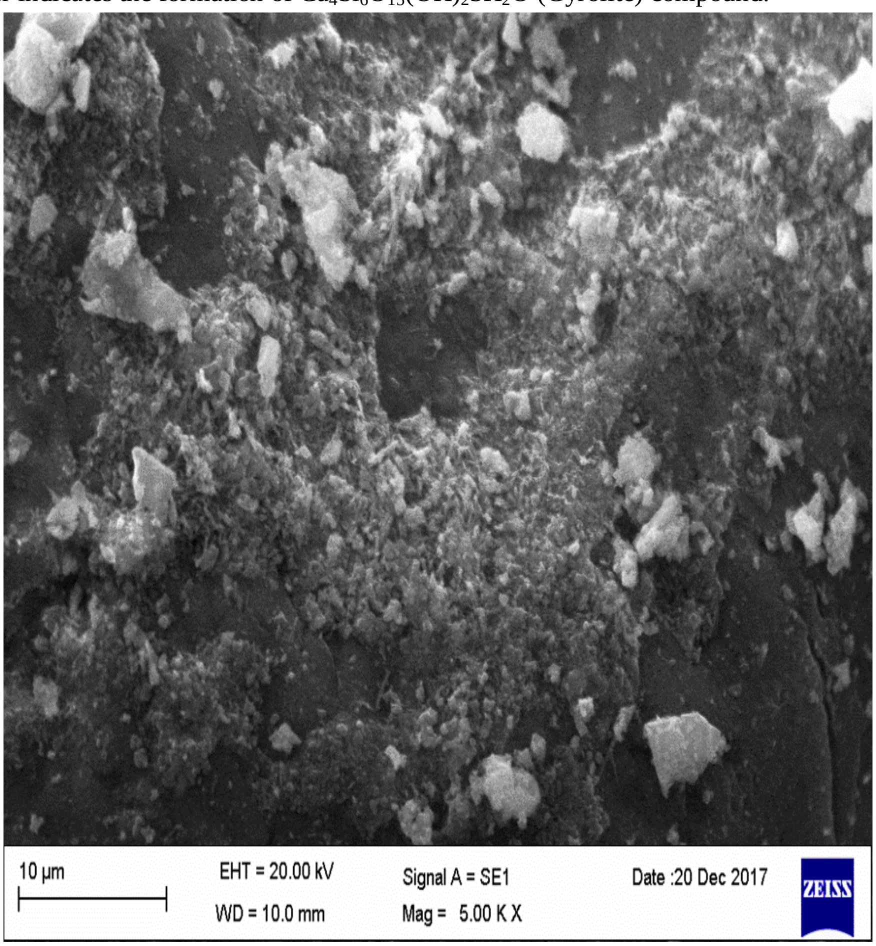

Fig.13 SEM image of powdered cement mortar sample prepared with deionized water

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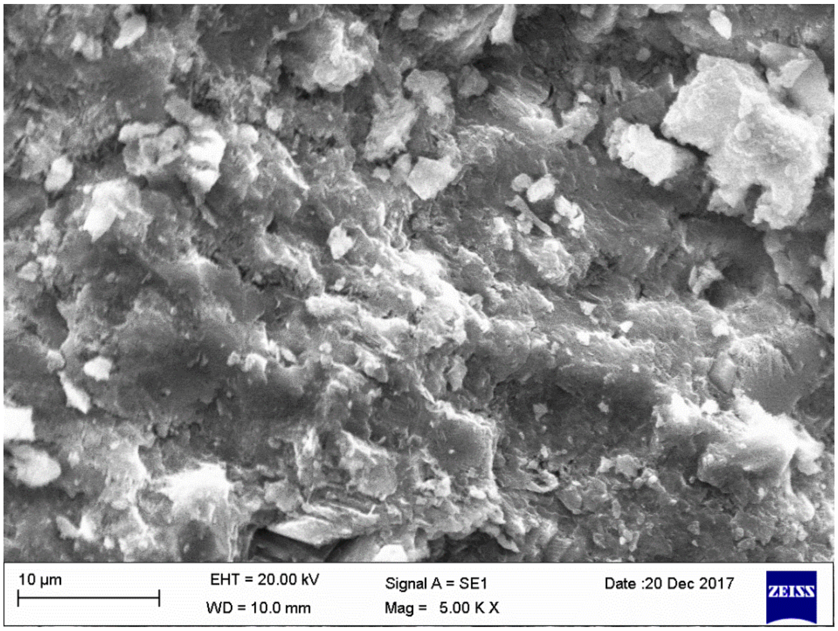

Fig.14 SEM image of powdered cement mortar sample prepared with Na_2CO_3 (5 g/l) in deionized water

The acceleration of setting of cement could be possibly attributed to the formation of Gyrolite. Continuous decrease in the compressive strength for all samples could be due to the formation of Gyrolite and Sodium Silicate. Gyrolite gel when comes in contact with water; it swells by imbibing a large amount of water through osmotic process. The hydraulic pressure so developed leads to expansion and cracking of the cement paste matrix surrounding the aggregate, thus leading to decrease in the compressive strength.

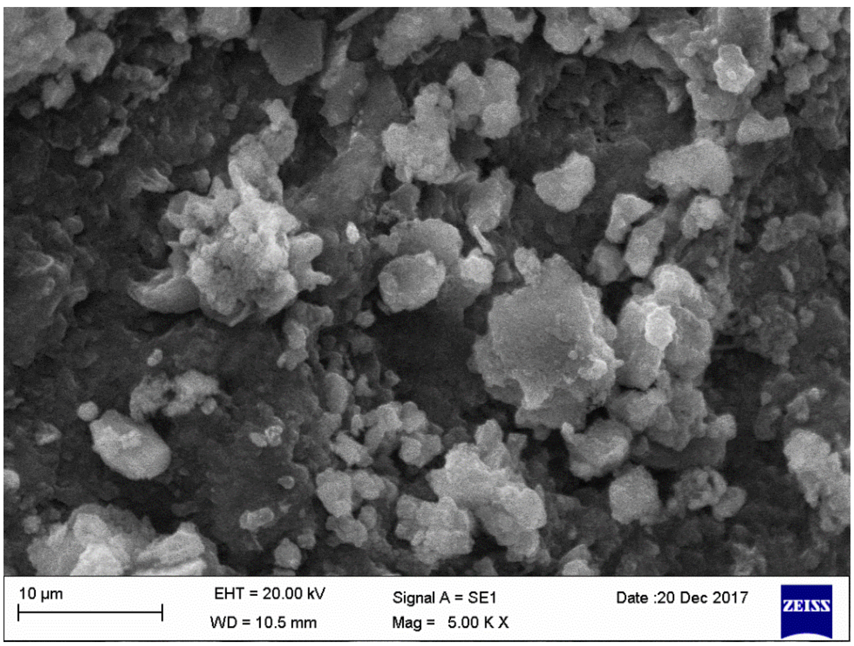

Fig.15 SEM image of powdered cement mortar sample prepared with $NaHCO_3$ (5 g/l) in deionized water

Scanning image in Fig.15 depicts the cement mortar prepared with $NaHCO_3$ (5g/l) in deionized water. The comparison of this pattern with that of deionised water indicates the formation of $Ca_4Al_2(OH)_{12}CO_36H_2O$ (Tetra calcium aluminate carbonate 12-hydrate) compound.

One of the possible reasons for the retardation of setting times of cement could be the formation of tetracalcium aluminate carbonate 12-hydrate. Continuous decrease in the compressive strength could be due to the formation of same tetracalcium aluminate carbonate 12- hydrate and sodium silicate. Alkali-silicate gel (tetracalcium aluminate carbonate 12-hydrate) of variable chemical composition is formed in the presence of hydroxyl and alkali-metal ions. Tetracalcium aluminate carbonate 12-hydrate gel comes in contact with water and swells by imbibing a large amount of water through osmotic process. The hydraulic pressure so developed may lead to expansion and cracking of the cement paste matrix surrounding the aggregate and thus leading to decrease in the strength.

V. CONCLUSIONS

A. From the test results, it is observed that both the initial and final setting times of cement got accelerated with the increase of Na_2CO_3 concentration in mixing water.

B. Initial and Final setting times got retarded with an increase in $NaHCO_3$ concentration in mixing water.

C. Compressive strength of cement mortar decreased with the increase of Na_2CO_3 concentration in mixing water. The rate of decrease in compressive strength gradually increases with the increase of Na_2CO_3 concentration in De Ionized water. The maximum decrease is 10.53% at the concentration of 5g/l at the age of 90days.

D. Compressive strength of mortar decreased with the increase of $NaHCO_3$ concentration in mixing water. The maximum decrease is at 5g/l concentration at the age of 90days.

E. pH of cement mortar is increased with the concentrations of Na_2CO_3 and $NaHCO_3$ in mixing water at the dilution ratios of 1:10, 1:5 and 1:2.

F. Loss of weight and loss of strength in 2.5% H_2SO_4 acid is increased with the increase in concentration of Na_2CO_3 and $NaHCO_3$ at 28days and 56days.

G. Loss of weight and loss of strength in 2.5% HCl acid is also increased with the increase in concentration of Na_2CO_3 and $NaHCO_3$ at 28days and 56days.

H. Loss of weight and loss of strength in 2.5% NaOH is increased with the increase in concentration of Na_2CO_3 and $NaHCO_3$ at 28days.

REFERENCES

[1] Venkateswara Reddy, H.SudarsanaRao K.N. Jayaveera, "Effects of Alkalinity Present In Water on Strength and Setting Properties of Fly Ash Concrete" CI-Premier PTE Ltd Singapore 2004.
[2] N. Smaoui, M.A.Berube, B.Fournier,B. Bissonnette, B. Durand,"Effect of alkali addition on the mechanical properties and durability of concrete" Science direct, cement and concrete research 35 pp203-212 year 2005.
[3] H.Y.Ghorab, M.S. Hilal and A. Anter, "Effect of mixing and curing water on the behaviour of cement pastes and concrete" part:2. Cement and concrete research. Vol. 20 pp 69-72 1990 pregamon press plc.
[4] IS 456-2000: Code of Practice for Plain and Reinforced Concrete.
[5] IS 383-1991: Specification of Coarse and Fine Aggregates from Natural Sources for Concrete
[6] IS 4031-968: Methods of Physical Tests for Hydraulic Cemen
[7] Concrete Technology by Shetty M.S, 1st edition, S. Chand IS 383-1970. Specification for coarse and fine aggregate from naturasources for concrete. Bureau of Indian Standards, New Delhi (India
[8] IS: 12269-1987. "53 Grade Ordinary Portland Cement Specifications". Bureau of Indian Standards, New Delhi.