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Research Paper

Effects of Chemicals as Impurities in Mixing Water on Properties of Concrete

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Abstract - *The hardening of cement gives strength and durability to concrete. The impurities in mixing water may affect the setting, hardening and strength of the concrete. Great control on properties of cement and aggregates is exercised, but the control on the quality of water is neglected. The suitability of a particular source of water for making concrete can be checked by casting concrete cubes using water under question and potable water and comparing its 7 days and 28 days strength. If the compressive strength is up to 90 percent, the source of water may be accepted. The aim of the present study was to know the effect of chemical impurities in mixing water on different properties of concrete. This work was carried out for a mix of concrete with 0.473 w/c ratio using mixing water with various concentration of Calcium Sulphate ($CaSO_4$), Sodium Hydroxide (NaOH), Calcium Hydroxide ($Ca(OH))_2$, Ferrous Sulphate ($FeSO_4$), and Sodium Nitrate ($NaNO_3$) to study effect of chemical impurities on the strength development of concrete at 7, 14, 28 and 56 days. Decrease in strength of concrete was observed with age and concentration of chemical in mixing water.*

Key words: Water quality, initial and final setting time, soundness, compressive strength etc.

Introduction

Water is an important ingredient of concrete. Part of mixing water is utilized in the hydration of cement and the balanced water is required for imparting workability to concrete. Thus the quantity and quality of water is required to be looked into very carefully. The strength and durability of concrete is reduced due to the presence of chemical impurities in water.

Most of the specifications recommended the use of potable water for making concrete. A practical solution would be tests for time of set and strength of concrete between the water under consideration and the water of proven quality.

Literature Review

Abrams[1] cast concrete cylinders using a large number of waters, many of which were unpotable and tested them in compression at ages up to twenty eight months and found that inspite of the wide variation in the quality of water used, most of the samples gave good results. Abrams[1] quoted that seawater with a total salinity of about 3.5 percent produces a slightly higher early strength but a lower long-terms strength, the loss of strength is usually no more than 15% and can therefore often be tolerated. Thomas and Lisk[2] suggested that the sea water slightly accelerates the setting time of cement. Lea, [3] reported that water containing large quantities of chlorides e.g. sea water tends to cause persistent dampness and surface efflorescence. Mc Coy[4] reported that water with pH of 6.0 to 8.0, which does not taste saline or brackish is suitable for use. Steinour[5] described that impurities in water may interfere with the setting of the cement, adversely affect the strength of the concrete or cause staining of its surface, and also lead to corrosion of the reinforcement. Addition of 2 per cent Sodium Benzoate reduces the compressive strength of concrete. P. Ghosh et. al.[6] reported that presence of micro-organism in mixing water increases the compressive and tensile strength of concrete. G.Reddy Babu et. al[7]. Reported that samples prepared with treated wastewater of electroplating industry did not show loss of strength, though their setting time had increased. In high concentration of metal ions, the compressive and flexural strength marginally increased.

Objective of Investigation

The parameters considered for the hardening and strength development of cement include: initial and final setting times and compressive strength of cement mortar cubes at different periods (7, 14, 28 and 56 days). Water containing different concentrations of chemical substances is used in the experimental work as mixing water.

Following are the objectives of present study

- To asses the effect of individual substance like calcium sulphate, sodium hydroxide, calcium hydroxide, ferrous sulphate and sodium nitrate with different concentrations in mixing water on initial and final setting time of cement.
- To examine the effects of these chemicals with different concentrations on strength development of concrete.

Material and Methods

A total of 63 samples of standard mould used in Vicat's apparatus were cast and tested for initial and final setting time. A total of 315 concrete cubes of 100 cm^2 cross-sectional area were cast and tested at 7, 14, 28 and 56 day for compressive strength. The properties of materials are given in the following sub-section.

Cement: Portland Pozzolana Cement (PPC) obtained from the single source is used in this study. Physical properties of the cement used for the study are given in Table 1.

Fine & Coarse Aggregate: The properties of sand are determined in accordance with IS 2386 (Part I & part III) - 1963 and are presented in Table 2 and Table 3.

Water: The characteristics of tap water used in the study are presented in the Table 4. The tests are performed as per IS 3025: 1964.

Chemical substances: Table 5 gives the list of chemical substances along with the range of concentrations and pH values used in the study.

Design of Concrete Mix: The mix design is done according to method proposed by Department of Environment, U.K.

Testing of Concrete: The testing of concrete is carried out as per IS 516-1959.

Results

Influence of chemicals on Setting Time and Compressive Strength: The effect of calcium sulphate on initial and final setting time is shown in Fig. 1. It is observed that the initial and final setting of cement got accelerated but there is reduction in the rate of acceleration with increase in concentration of calcium sulphate. The initial setting time is 156 minutes at a concentration of 5 g/L which increases to 172 minutes at a concentration of 20 g/L The final setting time is 308 minutes at a concentration of 5 g/L which increases to 408 minutes at a concentration of 20 g/L. The percentage change in compressive strength with concentration of calcium Sulphate is presented in Fig. 2. 7 days compressive strength increases with increase in concentration of calcium Sulphate. There after there is decrease in strength of concrete with age and concentration of calcium Sulphate.

Increase in compressive strength of early day's samples may be due to the intrusion of calcium ions into silicates to generate the tricalcium silicates. Continuous decrease in compressive strength for samples of all other ages is attributed to the formation of ettringite. It is evident that sulphate related expansions in concrete are associated with ettringite. The deterioration in the cohesiveness of the cement hydration product is caused by the sulphate attack leading to a progressive loss of strength and loss of mass.

The effect of sodium hydroxide on initial and final setting times is shown in Fig. 3. It is observed that the initial and final setting of cement got accelerated with increase in concentration of sodium hydroxide. There is significant acceleration at higher concentration. The initial setting time is 153 minutes at a concentration of 1 g/L which further decreases to 135 minutes at a concentration of 4 g/L. The final setting time is 261 minutes at a concentration of 1 g/L which decreases to 251 minutes at a concentration of 4 g/L.

The percentage change in compressive strength of concrete cast with various concentrations of sodium hydroxide solution in water is shown in Fig. 4. Decrease in compressive strength is observed as concentration of sodium hydroxide increases in water, maximum concentration studied being 4 g/L.

The acceleration of setting time could be due to formation of gyrolite. Continuous and significant decrease in the compressive strength for all samples ranging from 7 days to 56 days could be due to the formation of gyrolite and sodium silicate.

The effect of calcium hydroxide on initial and final setting times is shown in Fig. 5. It is observed that the initial and final setting of cement got accelerated but there is reduction in the rate of acceleration with increase in concentration of calcium hydroxide. The initial setting time is 153 minutes at a concentration of 1 g/L which increases to 175 minutes at a concentration of 4 g/L The final setting time is 327 minutes at a concentration of 1 g/L which increases to 368 minutes at a concentration of 4 g/L.

The percentage change in compressive strength of concrete cast with various concentrations of calcium hydroxide solution in water is shown in Fig. 6. 7 days compressive strength increases with increase in concentration of calcium hydroxide. There after there is decrease in strength of concrete with age and concentration of calcium hydroxide, the maximum concentration studied being 4 g/L.

Increase in compressive strength of early day's samples may be due to the intrusion of calcium ions into silicates to generate the tricalcium silicates. Continuous decrease in compressive strength is due to formation of tobermorite.

The effect of ferrous sulphate on initial and final setting times is shown in Fig. 7. It is observed that the initial and final setting of cement got accelerated with increase in concentration of ferrous sulphate. There is significant acceleration at higher concentration. The initial setting time is 168 minutes at a concentration of 2 g/L which further decreases to 154 minutes at a concentration of 8 g/L. The final setting time is 315 minutes at a concentration of 2 g/L which decreases to 257 minutes at a concentration of 8 g/L.

The percentage change in compressive strength of concrete cast with various concentrations of ferrous sulphate solution in water is shown in Fig. 8. Compressive strength of concrete increases with increase in concentration of ferrous sulphate for all ages except 56 days where decrease in strength is observed, the maximum concentration studied being 8 g/L.

The effect of sodium nitrate on initial and final setting times is shown in Fig. 9. It is observed that the initial and final setting of cement got accelerated with increase in concentration of sodium nitrate. There is significant acceleration at higher concentration. The initial setting time is 175 minutes at a concentration of 2 g/L which further decreases to 139 minutes at a concentration of 8 g/L The final setting time is 449 minutes at a concentration of 2 g/L which decreases to 389 minutes at a concentration of 8 g/L.

The percentage change in compressive strength of concrete cast with various concentrations of sodium nitrate solution in water is shown in Fig. 10. 7 days compressive strength increases with increase in concentration of sodium nitrate. Significant increase in strength is observed at a concentration of 6 gm/lit and above. Decrease in strength of concrete with age is observed for greater than 6 g/L of sodium nitrate, the maximum concentration studied being 8 g/L.

Conclusion

i. The initial and final setting time of cement was found to be within the prescribed limits inspite of addition of chemicals in mixing water.

ii. Presence of $CaSO_4$ accelerated the setting of cement at lower concentrations in comparison with control mix. It also increased the 7 days strength. But it ultimately reduced the strength as concentration increases. There was no significant effect at concentration of 5 g/L. Significant decrease in strength was observed when concentration of Ca^{++} ions was more than 1000 mg/L and that of SO_4^{--} ions was more than 5000 mg/L.

iii. Presence of NaOH accelerated the setting of cement with increase in concentrations in comparison with control mix. The acceleration was significant even at a concentration of 1 gm/L. It reduced the compressive strength for all ages with increase in concentration. .

iv. Presence of $Ca(OH)_2$ accelerated the setting of cement in comparison with control mix. Significant increase in compressive strength of concrete at 7 days was there at higher concentration. For 14 days, 28 days and 56 days there was reduction in strength of concrete. The reduction was significant at higher concentration for 56 days. Significant decrease in strength was observed when concentration of OH^- ions was more than 850 mg/L.

v. Presence of $FeSO_4$ accelerated the setting of cement with increase in concentration in comparison with control mix. The acceleration was significant at higher concentration. It increased compressive strength of concrete except for 56 days. It increased the 7 days strength significantly at higher concentration.

vi. Presence of $NaNO_3$ accelerated the setting with increase in concentration in comparison to control mix. $NaNO_3$, increased the compressive strength at 7 days with increase in concentration, there after strength decreased with concentration at 14 days, 28 days and 56 days. Significant decrease in strength was observed when concentration of Na^+ ions was more than 1000 mg/L and that of NO_3^- ions was more than 2500 mg/L.

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Table 1: Physical Properties of Cement

Sr.No	Property	Value
1	Specific Gravity	3.09
2	Fineness	6%
3	Initial Setting Time	189 Mints.
4	Final Setting Time	479 Mints.
5	Water for Standard Consistency	38.75 %
6	Compressive Strength 7 days	33 Mpa
7	Compressive Strength 28 days	47 Mpa

Table 2: Properties of Sand

Sr.No	Property	Unit	Results
1	Specific Gravity	--	2.63
2	Bulk Density	kN/m^3	18.05
3	Fineness Modulus	-	3.26
4	Particle size variation	mm	0.15 to 4.75
5	Loss of weight with concentrated Hydrochloric acid	%	0.124
6	Water absorption	%	2.56

Table 3: Properties of Aggregate

Sr.No	Property	Unit	Results
1	Specific Gravity	--	2.85
2	Bulk Density	kN/m^3	15.99
3	Fineness Modulus	-	7.17
4	Particle size variation	mm	4.75 to 20
5	Water absorption	%	1.92

Table 4: Characteristics of Tap Water

Sr.No.	Parameter	Tap Water
1	PH	7.6
2	TDS (mg/L)	241.0
3	Alkalinity (mg/L)	96.0
5	Hardness (mg/L)	110.0
6	Sulphates(mg/L)	40.0
7	Chlorides (mg/L)	49.98

Table 5: Classification and Details of Chemical Substances

Sr. No	Name & Symbol	Range of Concentration	Range of pH
1	Calcium sulphate ($CaSO_4$)	5 to 20 g/L	7.8-8.0
2	Sodium hydroxide (NaOH)	1 to 4 g/L	12.0-12.3
3	Calcium hydroxide [$Ca(OH)_2$]	1 to 4 g/L	12.2-12.4
4	ferrous sulphate ($FeSO_4$)	2 to 8 g/L	5.4-6.5
5	Sodium nitrate ($NaNO_3$)	2 to 8 g/L	8.8-8.9

Table 6: Material Taken for M-25 Concrete Mix

Sr. No	Ingredients	Mix Designations
1	W/c ratio	0.473
2	Cement (kg/m^3)	380
3	Fine aggregates (Kg/m^3)	761.63
4	Coarse aggregates (Kg/m^3)	894.09
5	Water (Lit/m^3)	180

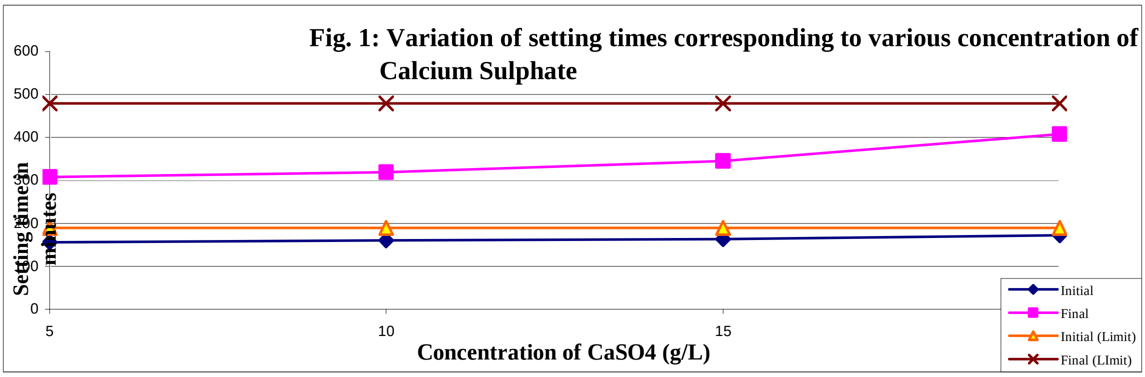

Fig. 1: Variation of setting times corresponding to various concentration of Calcium Sulphate

Fig. 2 : %ge change in compressive strength of concrete at different ages corresponding to various concentration of Calcium Sulphate

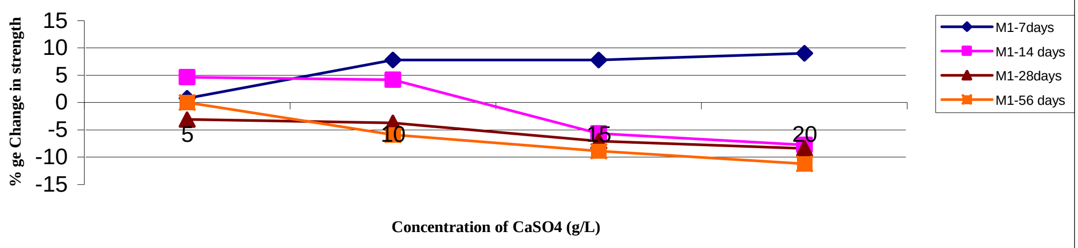

Fig. 3 : Variation of setting times corresponding to various concentration of Sodium Hydroxide

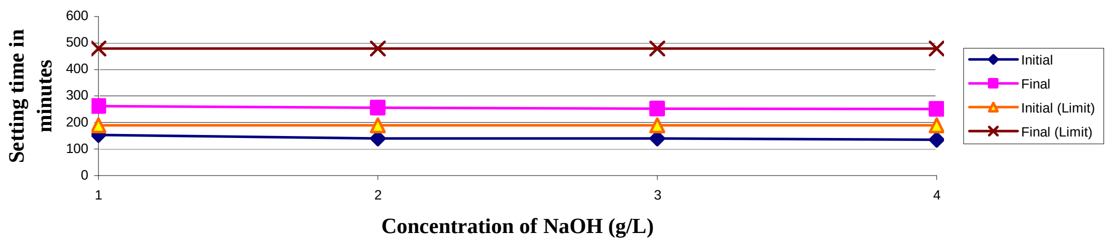

Fig. 4 : % ge change in compressive strength of concrete at different ages corresponding to various concentration of Sodium Hydroxide

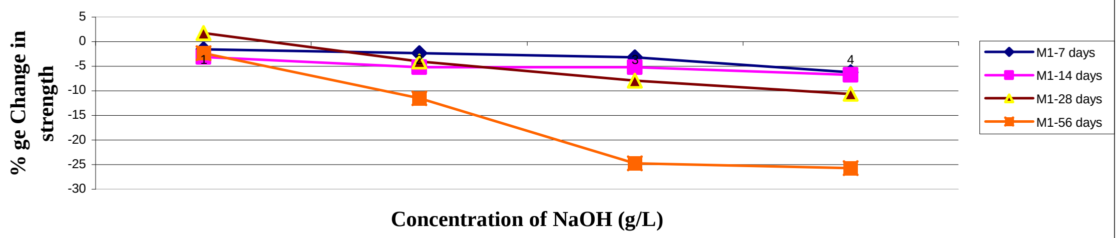

Fig. 5 : Variation of setting times corresponding to various concentration of Calcium Hydroxide

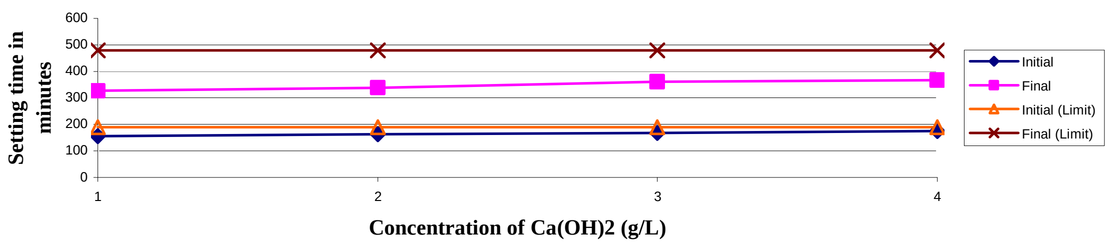

Fig. 6 : % ge change in compressive strength of concrete at different ages corresponding to various concentration of Calcium Hydroxide

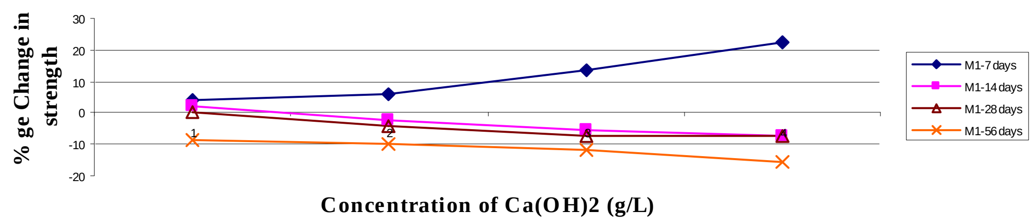

Fig. 7 : Variation of setting times corresponding to various concentration of Ferrous Sulphate

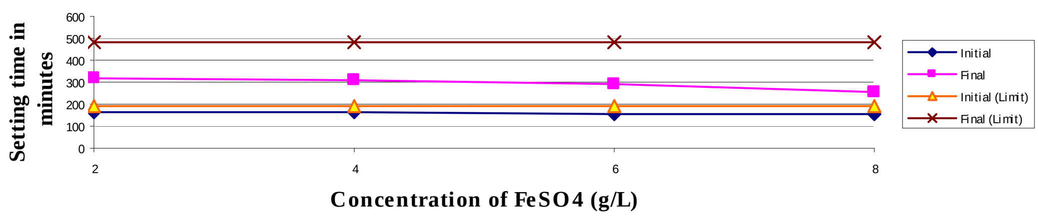

Fig. 8 : % ge change in compressive strength of concrete at different ages corresponding to various concentration of Ferrous Sulphate

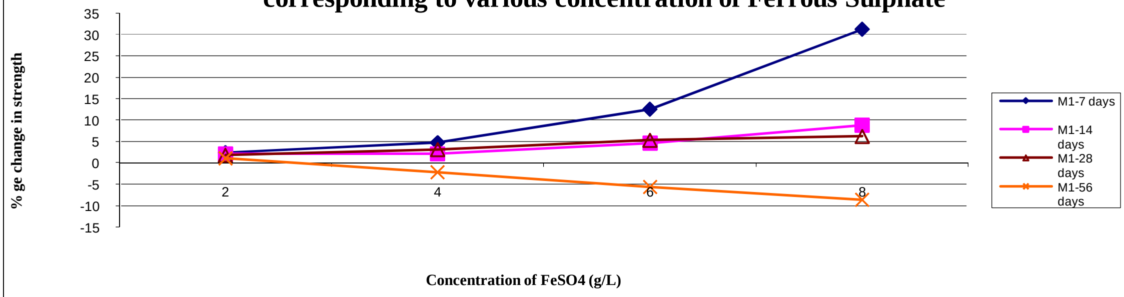

Fig. 9 : Variation of setting times corresponding to various concentration of Sodium Nitrate

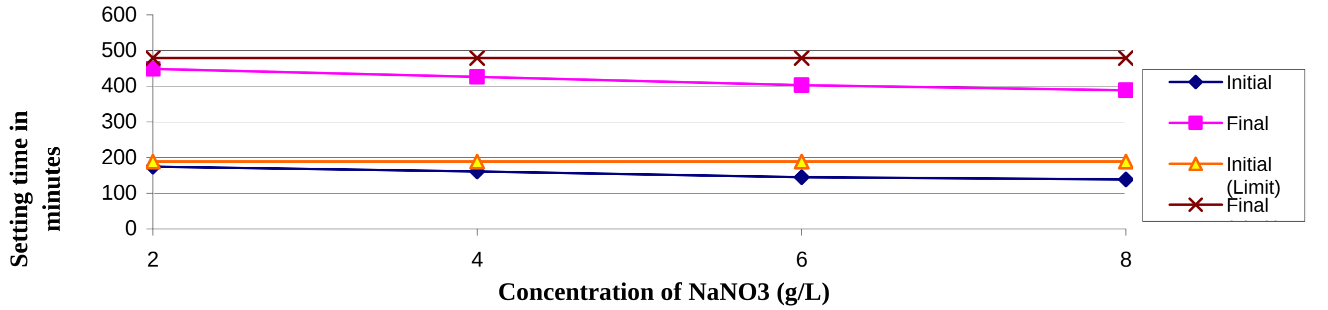

Fig. 10 : % ge change in compressive strength of concrete at different ages corresponding to various concentration of Sodium Nitrate