Effect of Water Quality on the Strength and Durability Characteristics of Concrete

Ajinkya B. Rajput[1], M. M. Joshi[2]
[1]*Student M.E Structure, Dept. of Civil Engineering, PLITMS Buldana*
[2]*Professor, Dept. of Civil Engineering, PLITMS Buldana*

***Abstract* - Water used for mixing concrete, exceeding the tolerable limits of impurities, may affect not only the concrete strength and durability but also setting time, soundness, efflorescence. Experimental studies were carried out in the present investigation to assess and analyse the influence of various individual substances such as sodium chloride, sodium sulphate, potassium chloride, calcium chloride, magnesium chloride, magnesium sulphate, calcium carbonate, magnesium bi-carbonate, hydrochloric acid, sulphuric acid, sodium carbonate and sodium bicarbonate on setting times, compressive strength development of Concrete.**

***Index Terms* - Setting time, Compressive Strength, Concrete, durability.**

I.INTRODUCTION

Conventional concrete is a mixture of cement, water, and coarse and fine aggregates. A more rational approach had to be thought of, since the standards of drinking water can differ from one locality to another. [2]. Strength, in almost all cases, is considered as the most important property of concrete, as it usually indicates the overall quality of concrete [7]. In case of water shortage at project site, it is usual to keep constraints on the use of potable water for purposes other than human consumption and hence recourse has often to be made to get whatever water available from natural sources without bothering much about the quality of water for mixing concrete. Under these circumstances, only a more precise specification could sift water, which then is suitable for mixing from those, which are not. [4].

IS 456-2000 also specifies the minimum pH-values as 6.0 and also permissible limits for solids of the water to be fit for construction purposes. The code did not specify the limits to the individual component substances like neutral, acidic and alkaline limits. Experimental studies were carried out in the present investigation to assess and analyse the influence of various individual substances such as sodium chloride, sodium sulphate, potassium chloride, calcium chloride, magnesium chloride, magnesium sulphate, calcium carbonate, magnesium bi-carbonate, hydrochloric acid, sulphuric acid, sodium carbonate and sodium bicarbonate on setting times, compressive strength development and chloride ion permeability of Concrete.

[7].

II. LITERATURE REVIEW

A brief review of the past literature carried by different researchers in effect of water Quality on strength and durabilityof concrete is discussed below:

"Water containing large quantities of chlorides (eg., sea water) tends to cause persistent dampness and surface efflorescence. Such water should, therefore, not be used where appearance of the concrete is important, or where a plaster-finish is to be applied (Lea, 1956 & Anderson, et al., 1985).[1]

When reinforced concrete is permanently under water, either sea or fresh, the use of sea water in mixing seems to have no defects (Shalon and Raphael, 1959). However, in practice it is generally considered inadvisable to use sea water for mixing unless this is unavoidable (Lea, 1956).

Natural waters that are slightly acidic are harmless, but water containing humic or other organic acids may adversely affect the hardening of concrete; such water, as well as highly alkaline water, should be tested. The effects of different ions vary, as shown by Steinour (1960). [6]

All cements containing lime are susceptible by acids. In acidic solutions, where the pH is less than 3.5, erosion of the cement matrix will occur. Moorland waters with low hardness, containing dissolved carbon dioxide and with pH values in the range of 4-7 may be aggressive to concrete. The pure water of melting ice and condensation contain carbon dioxide and will dissolve calcium hydroxide in cement causing erosion. In these situations the quality of concrete assumes a greater importance. (John Newman and Ban sang Choo, 2003) [7].

III. MATERIALS & METHODOLOGY

The materials used in the experimental investigation include.

1. Cement
2. Coarse aggregate
3. Fine aggregate
4. Water
5. NaCl, KCl, Na2SO4, CaCO3, CaCl2, MgCl2, MgSO4, Mg (HCO3)2, HCl, H2SO4, Na2CO3 and NaHCO3 with different concentrations found in Purna River Basin water.

The methodology used in the experimental investigation as below:

A total of 444 samples of standard moulds used in Vicat's apparatus were cast and tested for initial and final setting time experiments. A total of 1332 concrete cubes of (15x15 cm) 225 cm2 cross-sectional area were tested at 28 days and 90 days for compressive strength. A total of 666 samples were prepared and tested for chloride ion permeability.

Normal consistency, initial and final setting times of Cement are determined by the Vicat's apparatus, which measures the resistance of cement paste of standard consistency to the penetration of a needle under a total load of 300 gm. The initial set is an arbitrary time in the setting process, which is reached when the needle is no longer able to pierce the 40 mm deep pat of the cement paste to within about 5 to 7 mm from the bottom. The final set is reached, when the needle makes an impression on the surface of the paste but does not penetrate.

IV. RESULTS & DISCUSSION

The effects of individual chemical substances with different concentrations in mixing water on initial and final setting times of cement, short term and long term compressive strength development of Concrete were analysed. Powdered X-ray diffraction studies were carried out on twenty four selected representative samples and the patterns were obtained. By using these powdered X-ray diffraction patterns the probable chemical reactions that take place in hydration of cement with chemical substances in mixing water were formulated. The results are discussed as below:

[1] Presence of NaCl in water accelerates the initial and final setting times, of cement, significantly when the concentration is equal to 12.4 g/l. Further, concentration of 12.4 g/l results in a significant increase in compressive strength of concrete. Chloride permeability decreases with increase in NaCl concentration.

[2] Presence of KCl in water retards both the initial setting and final setting time, of cement, significantly at a concentration of 10.2 g/l. Further, a concentration of 10.2 g/l results in a significant increase in compressive strength of all the concretes studied in the present investigation. Chloride permeability decreases with increase in KCl concentration.

[3] Presence of Na2SO4 in concentrations equal to 15.4 g/l retards significantly the initial and final setting times of cement. Further, at the same concentration a significant decrease in compressive strength was observed. Chloride permeability increases with increase in Na2SO4 concentration in mixing water.

[4] Presence of CaCO3 in water retards the initial setting time but not significantly, however, it retards final setting time significantly at a concentration of 0.2 g/l in case of cement. Further, there is no significant effect on strength development even at a maximum concentration of 0.3 g/l, though said chemical is increasing the compressive strength of concrete. Chloride permeability decreases with increase in CaCO3 concentration.

[5] Presence of CaCl2 in concentrations equal to 1.0 g/l in water accelerates both initial and final setting time of both cements significantly. Its presence in water does not significantly increase the strength with an increase in concentration, the maximum tested concentration being2.0 g/l. Chloride permeability decreases with increase in CaCl2 concentration.

[6] Presence of MgCl2 in water retards significantly both initial and final setting times, of cement, at a concentration of 1.5 g/l and. Further a concentration equal to 1.5 g/l results in a significant decrease of compressive strength of

concrete. But in case of BCC, concentration of $MgCl_2$ is 2.0 g/l which is significant with respect to compressive strength. Chloride permeability increases with increase in $MgCl_2$ concentration.

[7] Presence of $MgSO_4$ in water accelerates significantly the initial and final setting times at concentration of 1.0 g/l. Its presence in water decreases the compressive strength slightly, but below significant level. Chloride permeability increases with increase in $MgSO_4$ concentration.

[8] Presence of $Mg(HCO_3)$ in water retards both initial and final setting times, of cement, significantly at a concentration of 0.3 g/l. There is no significant change in compressive strength development. Chloride permeability decreases with increase in $Mg(HCO_3)$ concentration.

[9] Presence of HCl in water retards significantly the initial and final setting times of cement when the concentration reaches 500 mg/l. Even in case of compressive strength, concentration of 500 mg/l of HCl results in significant decrease. Chloride permeability increases with increase in HCl concentration.

[10] Presence of H_2SO_4 in water retards significantly the initial and final setting times of cement in concentrations equal to 300 mg/l. The same concentration results in significant decrease in compressive strength. Chloride permeability increases with increase in H_2SO_4 concentration in the mixing water for all the concretes studied.

[11] Presence of Na_2CO_3 in water at concentrations of 6 g/l and 4 g/l retards significantly, the initial and final setting times of cemnt respectively. However, a concentration of 6 g/l of Na_2CO_3 results in significant increase in compressive strength of concretes experimented with. Chloride permeability decreases with an increase in Na_2CO_3 concentration in the mixing water.

[12] Presence of $NaHCO_3$ in concentrations equal to 10 g/l retards significantly the initial and final setting times of cement. In case of compressive strength, a concentration equal to 10 g/l results in a significant increase. Chloride permeability decreases with an increase in $NaHCO_3$ concentration in the mixing water.

V. CONCLUSION

The conclusion drawn from present investigation are as below:

1. Among, the neutral salts under consideration (NaCl, KCl, Na_2SO_4 and $CaCO_3$), only $CaCO_3$ in water does not affect the compressive strength of concretes significantly.
2. Slightly acidic compounds [$CaCl_2$, $MgCl_2$, $MgSO_4$ and Mg $(HCO_3)_2$] under consideration, only $MgCl_2$ affects the compressive strength significantly.
3. Strong acidic substances (HCl and H_2SO_4) in water reduce the compressive strength significantly with increase in the acids' concentration. Thus, great caution is to be exercised while using such water containing strong acids while preparing concrete.
4. Strong alkaline substances under consideration (Na_2CO_3 and $NaHCO_3$) in water increase the compressive strength significantly.
5. Mixing water containing Na_2SO_4 in concentration of 15 g/l and above is not suitable for concreting works as the compressive strength decreases significantly at this level and above.
6. Mixing water consisting of $MgCl_2$ in concentration of 1.5 g/l and above is not suitable for concreting works as the compressive strength comes down significantly at this level and above.
7. Mixing water consisting of $MgSO_4$ in concentration of 1.0 g/l and above is not suitable for concreting works as the compressive strength drops down significantly at this level and above.
8. Mixing water consisting of HCl in concentration of 500 mg/l and above is not suitable for concreting works as the compressive strength decreases significantly beyond this concentration.
9. Mixing water consisting of H_2SO_4 in concentration of 300 mg/l and above is not suitable for concreting works as the compressive strength decreases significantly beyond this concentration.

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