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Effect of Zinc Ion in Water on Properties of Ordinary Portland cement Concrete

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Abstract
The study is aimed at investigating the effect of presence of Zinc in water on setting times and compressive strength of cement concrete. In the present study, the effect of Zinc (Zn) on setting time and compressive strength of cement is assessed under laboratory conditions. The research program included tests of setting times and Mechanical strengths up to 28 days. In this research, the cement concrete cubes were cast with deionized water and deionized water containing the Zinc ions at various concentrations. The concentrations of Zinc (Zn) tested for different samples are 10, 50, 100, 500, 1000, 2000, 3000, 4000 and 5000 mg/L. The experimental results show that the presence of Zinc in deionized water accelerates both initial and final setting times up to 2000 mg/L. Zinc in deionized water up to 2000 mg/L there is a nominal change in compressive strength at early age (3-day). Beyond 2000 mg/L there is a significant change in the compressive strength at early ages as well as 28-day. Comparisons of the Zinc with those of control mix levels reveal that the presence of Zinc increases the compressive strength. The rate of increase in compressive strength is with increase in concentration of Zinc.

Keywords: *OPC, Initial setting time, Final setting time, Strength development, Mechanical Properties*

1. Introduction
Population growth and industrialization are continuously producing large amounts of liquid and solid waste, which is causing several environmental issues throughout the world. Most of the time, industrial wastewater is simply diverted into rivers and streams without being properly treated. One of the biggest users of water is the construction sector. In general, potable water is acceptable for use in cement concrete mixing. The supply of drinkable water is decreasing for the construction sector as a result of water body contamination, pushing it to utilize alternative sources of water. Industrial wastewater is significant in this aspect. The building sector may practice the reuse and recycling of industrial wastewater to achieve sustainable development. Concrete behaved without being Negatively impacted by the use of industrial effluent during casting. Reclaimed wastewater utilized in part or entirely as the mixing water might provide concrete with increased initial compressive strength. The qualities of cement concrete and mortar are significantly influenced by the quantity and quality of water used in the mixing process. As a result, an attempt was made to calculate the impact of Zinc (Zn) present in mix water on cement concrete setting times, mechanical strength. [2]

2. Materials and Methods
The following are the materials utilized in this experimental work:

- Ordinary Portland Cement (53 Grade)
- Fine aggregate (Ennore sand)
- Water (De-ionized)

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- Super plasticizer
- Heavy Metal (Zn)
- Chemicals

Ordinary Portland cement: Regular Portland Cement (53 grade) was utilized for this experimental investigation. Initial studies were performed on the product's fineness, specific gravity, setting times, soundness, and compressive strength. [3] All of the cement's tested qualities fall within the parameters of IS 12269:1987 and are listed in Tables 1 and 2.

Table 1 Physical Properties of Portland Pozzolanic Cement (OPC)

S. No.	Property	Result	IS 1489(part-1)-1991
1	Specific Surface(m^2/kg)	370	Not less than 300
2	Normal consistency	35%	Not specified
3	Setting times (minutes) a) Initial b) Final	95 165	Not less than 30 & Not more than 600
4	Compressive strength (MPa) a) At 72 ± 1 h b) At 168 ± 2 h c) At 672 ± 4 h	49 63 68	Not less than 33 Not less than 43 Not less than 53

Table 2 Chemical Properties of Portland Pozzolanic Cement (OPC)

Oxide	Proportion
Calcium Oxide	65.19
Silicon Oxide	21.53
Alumina Oxide	5.27
Iron Oxide	4.36
Magnesium Oxide	1.10
Alkalies	0.002
Silicate	1.5

Fine Aggregate: The fine aggregate used throughout this investigation was obtained from Ennore, Tamil Nadu minerals limited, Chennai. It is approved by Bureau of Indian Standards (BIS) to manufacture and supply of Indian Standard sand conforming to IS 650:1991 [1]. The physical and chemical properties of the sand are presented in Table 3 & 4.

Table 3 Properties of Fine Aggregate

Parameter	Result
Specific Gravity	2.65
Bulk Density	15.54
Fineness Modulus	2.74
Color	Greyish White
Water Absorption	0.94 %
Shape	Sub Angular

Water: De-ionized water was utilized in reference test samples and the same with Zinc spiked in various concentrations was utilized in the experimental test samples. [4]

Superplasticizer: Commercially available 'conplast SP-430' water reducing agent was used. The properties are given in the Table 5.

Table 4 Physical Properties of Super Plasticizer

Property	Value
Specific Gravity	1.20 – 1.22 at 30 °C
Chloride Content	Nil
Color	Brown
Air Entrainment	Less than 2%

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Heavy Metal: Zinc (Zn) is a heavy metal with atomic number 28. It is readily soluble in water. Zinc heavy metal spiked into de-ionized water in fixed proportions of 10 to 5000mg/L. [5]

Table 5 Physical Properties of Zinc (Zn)

Property	Value
Specific Density	8.5 gm/cc
Melting point	1455 °C
Boiling point	2730

2.1 Experimental System

The different concentrations of Zinc 10, 50, 100, 500, 1000, 2000, 3000, 4000 and 5000 mg/L has been utilized and the following equipment is used for casting and testing of specimens: (i) Cube moulds, (ii) 200T U.T.M (Universal Testing Machine) for cube compressive strength determination, (iii) Vicat's apparatus including moulds conforming to IS4031(part-5)-1988 for setting times, (iv)Le-Chatelier's equipment to determine the soundness of cement and (v) cement concrete cubes prepared with water containing Zinc. [6]

Setting time: Vicat's apparatus confirming IS4031 (part-5) 1988 consist of a frame to which a movable rod having an indicator is attached which gives the penetration, weighing 100g and having diameter and length of 10mm and 50mm respectively. Vicat's apparatus included three attachments-square needles for initial setting time, plunger for determining normal consistency and needle with annular collar for final setting time. [7]

Compressive Strength: The test specimens for determination of compressive strength of admixture cement prepared using standard cube moulds of size 150mm x 150mm x 150mm adopting IS procedure for the compactions. The cubes were demoulded after 24 hours of casting and cured in water having similar quality as used in preparation of mix. The cubes are tested for compressive strength for short term and long term. The compressive strength is computed as the average value of the three samples.

3. Results and Discussion

The results of the present investigation are presented both in tabular and graphical forms. In order to facilitate the analysis, interpretation of the results is carried out at each phase of the experimental work. This interpretation of the results obtained is based on the current knowledge available in the literature as well as on the nature of result obtained. The significance of the result is assessed with reference to the standards specified by the relevant I S codes;

3.1 Initial and Final Setting Times

The effect of Presence of Zinc on initial and final setting times is presented in Figure 1. Initial and final setting of cement got accelerated with increased presence of Zinc concentration in the deionized water. The acceleration in the initial and final setting is significant when the Zinc concentration exceeds 2000 mg/L. The decrease in the initial setting time is 35 minutes and that in the final setting time is 104 minutes at the maximum concentration of Zinc 2000 mg/L. [8]

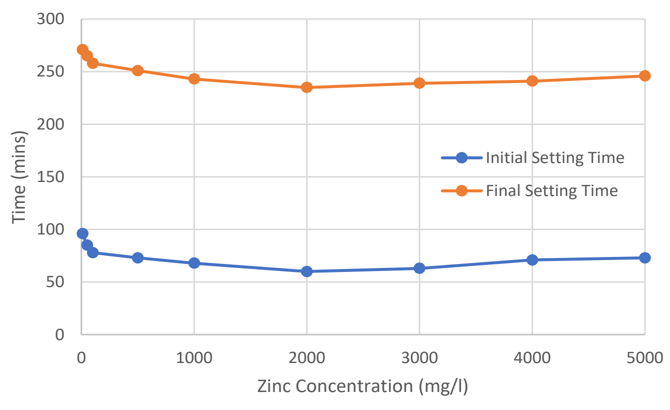

Figure 1 Setting Times of Ordinary Portland cement (OPC) Corresponding to Different Concentrations of Zinc in Deionized Water

3.2 Compressive Strength

The effect of presence of Zinc on compressive strength of cement concrete cubes is presented in Figure 2. There is nominal change in the compressive strength of concrete cubes for the early day samples like 3-day. As time proceeds, there is same trend for all concentrations of Zinc until the maximum concentration of 2000 mg/L.

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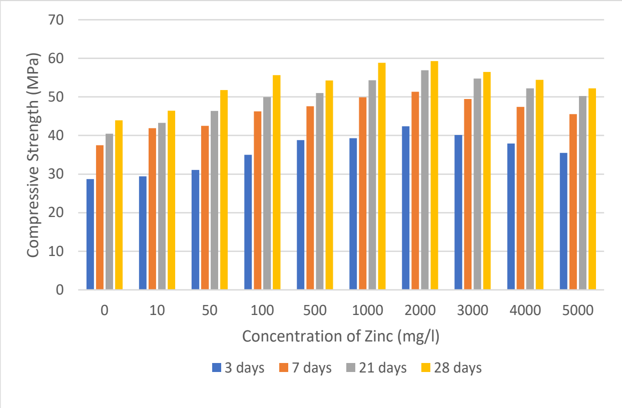

Figure 2 Compressive Strength of Ordinary Portland cement (OPC) Cubes at Different Periods Corresponding to Different Concentrations of Zinc in Deionized Water

There is a nominal change in the compressive strength of cement concrete cubes of 3-day age samples. As time elapses there is [12] continuous increase in compressive strength of all other age samples ranging from 7-day to 28 days. The compressive strength gradually increases with the increase in the concentration of the Zinc ions as well as duration. For 3-day, significant decrease in strength occurs beyond 2000 mg/L. Similarly, for 7-day, 14-day, 21-day and 28 days samples, significant decrease in strength occurs at 2000 mg/L concentration respectively and the trend continues up to the maximum concentration. The 28 days sample shows the maximum increase in compressive strength with increase in concentration of Zinc. [9]

3.3 Split Tensile Strength

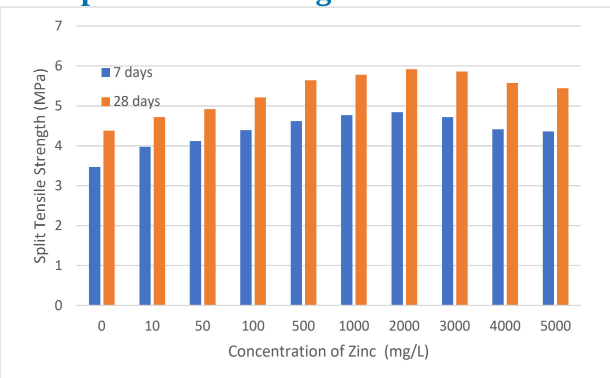

Figure 3 Split Tensile Strength of Ordinary Portland cement (OPC) Cubes at Different Periods Corresponding to Different Concentrations of Zinc in Deionized Water

The effect of presence of Zinc on Split Tensile strength of cement concrete cylinders is presented in Figure 3. There is nominal change in the Split Tensile strength of concrete cubes for the early day samples like 3-day. As time proceeds, there is same trend for all concentrations of Zinc until the maximum concentration of 2000 mg/L. There is a nominal change in the Split Tensile strength of cement concrete cylinder of 3-day age samples. As time elapses there is continuous increase in compressive strength of all other age samples ranging from 7-day to 28 days. All the outcomes of Split Tensile strength are in line with the Compressive Strength outcomes. [10]

3.4 Flexural Strength

The effect of presence of Zinc on Flexural Strength of cement concrete beams is presented in Figure 4. There is nominal change in the Flexural Strength of concrete beams for the early day samples like 3-day. As time proceeds, there is same trend for all concentrations of [13] Zinc until the maximum concentration of 2000 mg/L. There is a nominal change in the Flexural Strength strength of cement concrete beams of 3-day age samples. As time elapses there is continuous increase in Flexural strength of all other age samples ranging from 7-day to 28 days. All the outcomes of Flexural Strength are in line with the Compressive Strength outcomes. [11]

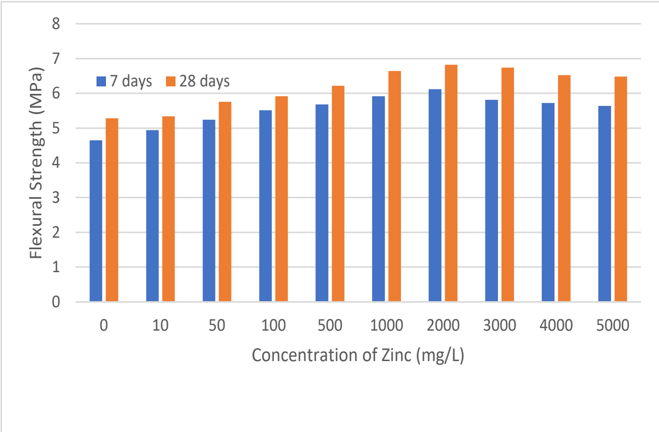

Figure 4 Flexural Strength of Ordinary Portland cement (OPC) Cubes at Different Periods Corresponding to Different Concentrations of Zinc in Deionized Water

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Conclusions

1. Presence of Zinc in water accelerates significantly the intial and final setting times, when the Zinc content exceeds 2000 mg/L.
2. Further, its concentration is higher than beyond 2000 mg/L, there is a significant increase in compressive strength.
3. Further, its concentration is higher than beyond 2000 mg/L, there is a significant increase in Split Tensile strength.
4. Further, its concentration is higher than beyond 2000 mg/L, there is a significant increase in Flexural strength.

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