



## SETTING TIME AND COMPRESSIVE STRENGTH STUDIES ON ALUMINOSILICATE WASTEGLASS ADMIXTURED CEMENT TREATED WITH DIFFERENT WATER

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### ABSTRACT

The concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. The environmental and economics concern is the biggest challenge the concrete industry is facing. The global cement industry contributes about 7% of greenhouse gases emission in to the earth's atmosphere. Today many researchers are ongoing in the use of supplementary cementitious materials using many waste materials like Pulverized Fly Ash (PFA) and Ground Granulated Blast Furnace Slag (GGBS). Like PFA & GGBS a waste glass powder also act as a filler material in partial replacement of cement which takes some part of reaction at the time of hydration. The utilization of waste glass in construction has attracted a lot of interest worldwide due to the large quantity consumptions and widespread construction sites. The objective of this study indicates the hydration of ordinary Portland cement in the presence of 0%, 10%, 20% and 30 wt% waste glass was studied at distilled water, seawater and groundwater by determining the setting time, and compressive strength measurements. The cubes were tested at the age of 3 days, 2 weeks, 4 weeks to study the development of compressive strength. Results indicated that compressive strength increases with increasing replacement percentages (0%, 10%, 20% and 30 wt%) of waste glass. All the experimental results indicate that seawater accelerates the cement hydration at early stage, but retarded the later stage of hydration.

**KEY WORDS:** waste glass, setting time, compressive strength, different hydration time, different water



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## INTRODUCTION

Cement and glass industries are facing a lot of challenges due to the high greenhouse gases emissions, the intensive use of energy and the intensive use of the earth's natural resources. The current situation of discarding waste glass to landfills is also not offering an environmental friendly management for the waste glass, due to the non biodegradable form of the waste glass. However, the chemical composition and the pozzolanic properties of waste glass are encouraging for the use of this waste in the cement and concrete industries and to provide an environmental friendly solution for the glass and cement industries.<sup>1</sup> Waste glass is a supplementary cementing material for using high performance concrete and mortars. They offer reduced cost, CO<sub>2</sub> emissions and global warming and also improve the cementitious properties like strength, durability, workability. The use of waste glass works to the root of efflorescence problem by eliminating the calcium hydroxide from the system. Understanding of setting behaviour is enormously significant in the field of cement chemistry. This information is helpful in scheduling the various stages of construction process, such as transporting, placing, compacting and finishing and is an obligation when deciding whether set-accelerating or set-retarding admixtures will be indispensable. The mechanism of cement hydration and the pozzolanic reactivity of waste glass were explained by a number of authors' by using Differential Thermal Analysis, Xray diffraction pattern, Scanning Electron Microscopy, Fourier Transform Infrared Spectroscopy and Electrical Conductivity Measurements<sup>2-6</sup>. These different techniques have shown that, in the case of admixed cement, paste has a greater influence on the hydration properties and improve the cementitious properties. Hence the present communication explains the setting time and compressive strength of waste glass admixed cement when mixed with distilled water (DW), ground water (GW) and sea water (SW).

## MATERIALS AND METHODS

Initial setting time and final setting time, Compressive strength has been measured on waste glass admixed cement (0, 10, 20, 30 wt %) in a water to cement ratio of 0.4 treated with Distilled Water (DW), Ground Water (GW) and Sea Water (SW). Setting time of admixed cement paste was measured using a Vicat needle apparatus and the compressive strength of waste glass admixed mortar cubes, at different hydration periods were determined using Compression Testing Machine (Techno-Science Trading Corporation, New Delhi, India) set up available in Department of Structural

Engineering, SRM University, India and using standard procedure<sup>7</sup>. A commercial Portland cement (PC) was used and subjected to chemical analysis using standard procedure suggested by ASTM and found the ingredients in percent as follows: CaO 63.32; SiO<sub>2</sub> 21.70; Al<sub>2</sub>O<sub>3</sub> 5.40; Fe<sub>2</sub>O<sub>3</sub> 3.40; MgO 2.09; MnO 0.12; SO<sub>3</sub> 2.10; Loss on ignition 0.79 and Insoluble residue 1.08.

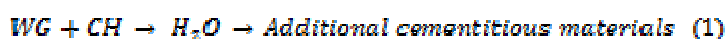
## RESULTS AND DISCUSSION

### Setting time measurements

The initial and final setting times of the Waste glass (WG) cement paste are shown in Table 1. The initial and final setting times of the 10% WG are shorter than those of Portland cement, because WG contains active silicon dioxide and aluminium oxide, they can react with hydrates of cement to form high amount of calcium sulphoaluminate then form the frame-work of cement paste in the early hydration period. Hence this process shortens the setting time<sup>8</sup>. When the replacement level is further increased to 20% and 30%, there is a marginal reduction in setting times when compared with those of the WG 10% admixed cement paste. This is due to the greater water demand at the higher WG content which could have produced a binder phase that is denser and could speed up setting. This seems to confirm that WG acts as an accelerating admixture when OPC is replaced by up to 30%. This is due to the fact that seawater contains more amounts of chloride and sulphate ions. For seawater treated samples, the setting times are shortened when compared to DW treated samples. These ions accelerate the cement hydration and the amount of formation of hydration products (Ettringite and C-S-H) are formed quickly and higher amounts. These processes shorten the setting time at all percentages. Groundwater contains fewer amounts of ions when compared to seawater, but higher than distilled water. Hence reaction rate are intermediate between the distilled water and sea water mixing admixed cement paste.

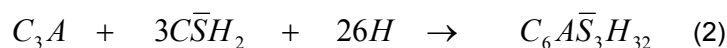
### Compressive strength measurements

The compressive strengths obtained for the different replacement percentages of WG and three hydration times (3 days, 2 weeks, 4 weeks) are given in Table. 1. Distilled water treated samples at all ages and all replacement percentages, showed higher compressive strength than that of the control (OPC). The reason for the high compressive strength of WG cement is due to small particle size, wide range of particle size distribution, higher amount of Al<sub>2</sub>O<sub>3</sub>, filler effect where WG particle fill the space between cement particles, acceleration of cement hydration and pozzolanic reaction of WG with CH to the following equation:



Wild and Khatib<sup>9</sup> found that the filler effect is immediate, the acceleration of OPC hydration has its major impact within the first 24 hours and the major impact within the first 24 hours and the maximum effect

of pozzolanic reaction occurs between 7 and 14 days. The percentages of replacement of WG increases with the increase of the hydration products according to the following equations<sup>10</sup>:



hydroxide



These hydration products are increasing the compressive strength than that of control cement. It was concluded that the replacement of recycling <sup>11</sup> WG percent increases the compressive strength and increases at all hydrated time. Seawater mixing WG admixed cement compressive strength was increased at an early stage when compared to treated with distilled water and groundwater in all replacement percentages of WG. The early acceleration of strength was due to the chloride and sulphate ions of the seawater. These ions are filling up the pores by reaction product and crystallization salt. It reduces the thickening time,

enhances the hydration process and the consecutive strength development. At 4 weeks hydration time compressive strength was decreased when compared to distilled water and groundwater. This may be attributed to reduction of chloride; sulphate ions and the reaction of C<sub>2</sub>S with seawater occur earlier and hence in the later stage strength decreases. The same trend was followed by all replacement percentages. The compressive strength of groundwater samples are higher in distilled water treated samples for all replacement percentages of WG.

**Table 1**  
**Setting time and Compressive strength of WG admixed cement treated with different water.**

Water	WG%	Setting time (h.min)		Compressive strength (MPa)		
		Initial	Final	3 days	2 weeks	4 weeks
DW	0	5.05	6.50	11.7	40.4	47.7
	10	4.45	6.25	20.3	47.2	55.3
	20	3.25	5.40	27.2	61.5	69.3
	30	2.30	4.40	32.5	69.2	74.2
SW	0	4.10	6.20	14.1	43.0	33.1
	10	3.55	6.00	24.3	50.7	41.7
	20	2.40	5.05	32.5	64.1	52.2
	30	1.55	4.15	37.5	72.6	57.5
GW	0	4.45	6.35	12.9	42.4	48.5
	10	4.15	6.15	22.5	49.1	58.2
	20	3.15	5.30	29.4	62.3	71.5
	30	2.10	4.30	34.2	71.2	78.5

## CONCLUSIONS

The following conclusions can be drawn based on the experimental study: The influence of increasing the percentages of WG to provide faster setting times. WG enhances the early strength when compared to OPC cement pastes. A relationship between strength and setting time has been established from these systems governing all hydration times are investigated. All the experimental investigations reveal that the hydration is faster in the initial stage, but slow in the final stage, for all samples, when mixed with sea water. The sample hydrated with ground water is found to have an intermediate chemical reaction to the distilled water and seawater treated mix. Compressive strength, setting

time studies are confirmation of the well known accelerating effect of WG and sea water in the hydration of the Portland cement. The influence of increasing the percentages of WG to provide faster setting times. Compressive strength, setting time studies are confirmation of the well known accelerating effect of WG and sea water in the hydration of the Portland cement. The utility of sea water for preparing paste may be considered after studying about its long term reaction. Shrinkage properties, corrosion resistance and adhesion capacity are needed to be studied in the future.

## CONFLICT OF INTEREST

Conflict of interest declared none.

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