MECHANICAL PROPERTIES OF CEMENT CONCRETE CASTED UNDER WATER

J.S.PACKIA SANTHINI[a]*, D.DEVA RAJA SUBHA [a], N.SUBASH[b], P.RAJA LEKSHMI[c]

[a] *Assistant Professor, Ponjesly College of Engineering, Tamil Nadu, India*

[b] *Assistant Professor, University College of Engineering, Tamil Nadu, India*

[c] *Assistant Professor, Gopalan College of Engineering and Management, Karnataka*

ABSTRACT

Mechanical properties and setting behaviour of concrete under water was investigated in this project. Internal curing (IC), self compacting and quick setting are the three most important parameters required for under water concrete. The internal curing & the quick setting properties are achieved by adding sodium silicate to the cement concrete. Self compacting property was achieved by using superplasticizer and to make the concrete not to dissolve in water, sunflower oil was used. Initially to find the optimum usage and the effect of sodium silicate in concrete strength and setting property, the water is replaced by sodium silicate by 0%, 25%, 50%, 75%, and 100%. The compression and split tensile strength was found on the hardened concrete. As a result, the design strength was achieved at 50% replacement of water by sodium silicate. If the sodium silicate was replaced above 50% the strength was decreased. The setting time also decreased with the increase in percentage of sodium silicate. Based on the sodium silicate content, the setting and strength varied. To have under water concrete, the concrete with 75% of sodium silicate by weight of water and 2.5% of superplasticizer by weight of cement along with 2% of sunflower oil by weight of cement was considered. For the control mix, the concrete with no admixtures and additives was taken. The concreting was done under water and the strength properties are investigated for both the control mix and altered concrete. The results obtained are compared and discussed.

Keywords : *under water concrete, sodium silicate, self compacting, quick setting concrete.*

1 INTRODUCTION

Under water concrete may achieved by different type of casting methods. Concrete used in under water construction should not dissolve in water; this may make the concrete to segregate[1]. This segregation may affect the strength of concrete[2]. Methods of concreting under water mainly

* For Correspondence *jssanthini9@gmail.com*

delivers the concrete at the placing point without any shake. If the concrete itself is so good and not wash out in water, it will be more strength and durable[3]. The strength of concrete as designed cannot achieve if casted under water, this is mainly due to segregation and wash out[4]. This can be prevent by using admixtures in concrete[5]. Here in this research, sodium silicate is used for quick setting the cement concrete, superplasticizer to improve the workability of concrete and sunflower oil to alter the viscosity of concrete[6]. This materials are mixed with conventional ways undergoing some alterations and the mechanical properties of the altered mixes are tested and discussed.

2 MATERIALS AND PROPORTION

OPC cement of 43 grade confirming to IS 546 is used. Fine and coarse aggregate of specific gravity 2.3 and 2.75 respectively are used. Sodium silicate in liquid form with 55% of water is used. Superplasticizer named conplast SP430 is used. The mix proportion for concrete is arrived using IS 10262:2009. Materials required per cubic meter of concrete as per standard is about 383 kg of cement, 640 kg of fine aggregate, 1190 kg of coarse aggregate and 191 kg of water. Water cement ratio of the mix is 0.5. The sodium silicate is replaced for water to alter the setting time. The replacement level of sodium silicate is 0%, 25%, 50%, 75%, and 100%. The details of mix is shown in table 1.

Table 1 Materials required per cubic meter.

Sl No	Cement (kg/m^3)	Fine Aggregate (kg/m^3)	% of sodium silicate added	Sodium silicate (kg/m^3)	Water (kg/m^3)	Coarse Aggregate (kg/m^3)
M1	383.18	641.8	0	0	191.6	1192.30
M2	383.18	641.8	25	47.9	143.7	1192.30
M3	383.18	641.8	50	95.8	95.8	1192.30
M4	383.18	641.8	75	143.7	47.9	1192.30
M5	383.18	641.8	100	191.6	0	1192.30

3 EXPERIMENTAL PROGRAM AND RESULTS

Compression, split tensile test and setting time are carried out for the mix proportions given in table 1. To know the effectiveness of curing, M1 is kept in both open air and within water. M2, M3, M4 and M5 are kept in open air. The results are shown in table 2 and 3.

Table 2 Compression Test results for specimens with different % of sodium silicate

Mix	% of sodium silicate	7 Days (N/mm^2)	28 Days (N/mm^2)
M1	0% with curing	10.56	27.89
M1	0% without curing	11.56	22.89
M2	25%	11.41	25.82
M3	50%	18.18	28.30
M4	75%	18.21	25.00
M5	100%	10.39	14.43

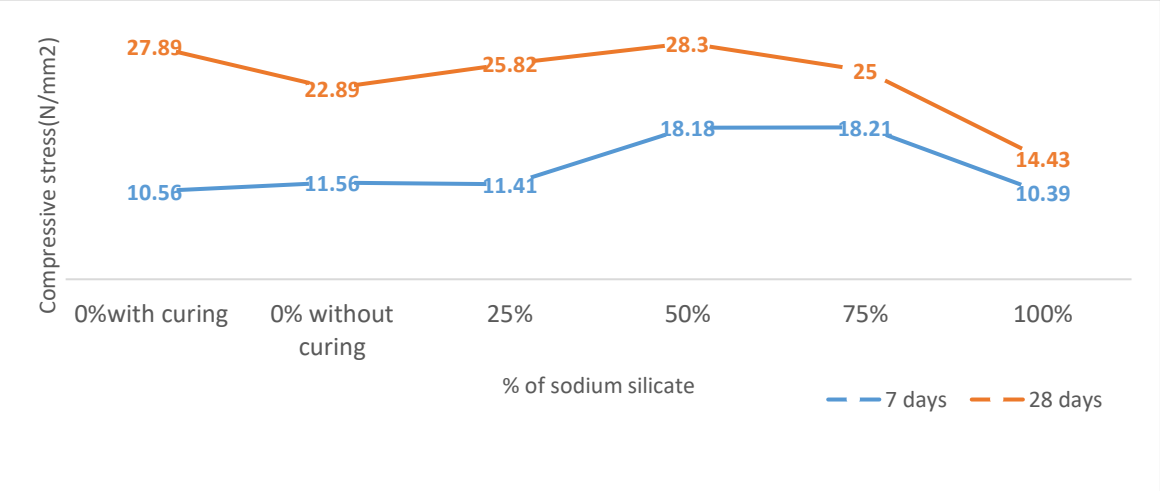

Fig 1 Compression Test results for specimens with different % of sodium silicate

Table 3 Split tensile test results for specimens with different % of sodium silicate

Mix	% of sodium silicate	7 Days (N/mm^2)	28 Days (N/mm^2)
M1	0% with curing	2.8	3.81
M1	0% without curing	1.8	2.81
M2	25%	2.58	3.19
M3	50%	2.35	3.81
M4	75%	1.79	2.88
M5	100%	1.03	2.22

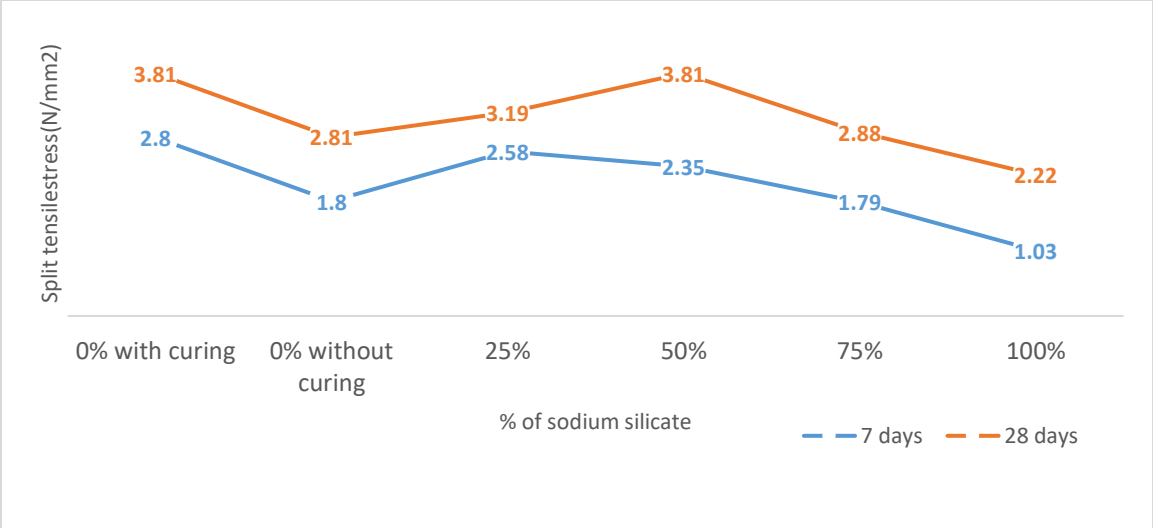

Fig 2 Spilt Tensile Test results for specimens with different % of sodium silicate

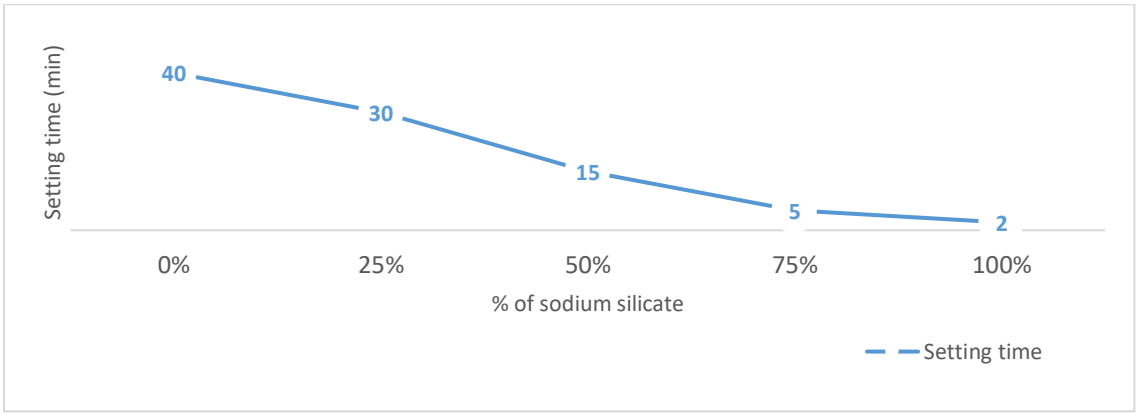

Fig 3 Percentage of sodium silicate vs setting time

The compression results of M1 at water curing equalized only with the strength of mix M3. The curing can be achieved also by adding sodium silicate as internal curing agent, this is proved by comparing M1 and M3. Also the mix M3 is suitable for under water concrete in the setting time property. The setting time of the mix M3 is quite reasonable to be used as the concrete that can be laid under water. Thus by observing the results, M3 is selected to the next step.

Optimizing Mix for Underwater Concrete

To modify the viscosity of concrete altered by adding sodium silicate, sunflower oil and superplasticizer are added to get a non-wash out and non-segregate concrete. By conducting the compressive strength test, the performance under water for the mixes in table 4 can be observed.

Table 4 Materials required per cubic meter. (W/C = 0.5)

Sl No	Cement kg/m^3	Fine Aggregate kg/m^3	% of sodium silicate added	Sodium silicate	Water (L)	Coarse Aggregate kg/m^3	Super Plast %	Sun Flower Oil
1	383.18	641.8	0	0	191.6	1192.30	0	0
2	383.18	641.8	75	143.7	47.9	1192.30	2.5	2

Table 5 Compression Test results for specimens cast in open air

Specimen no	Control Mix (M3)		Altered Mix	
	7 Days (N/mm^2)	**28 Days (N/mm^2)**	**7 Days (N/mm^2)**	**28 Days (N/mm^2)**
1	10.26	28.26	18.37	25.67
2	11.39	28.39	17.88	24.33
3	10.03	27.03	18.39	25.01
Average	10.56	27.89	18.21	25.00

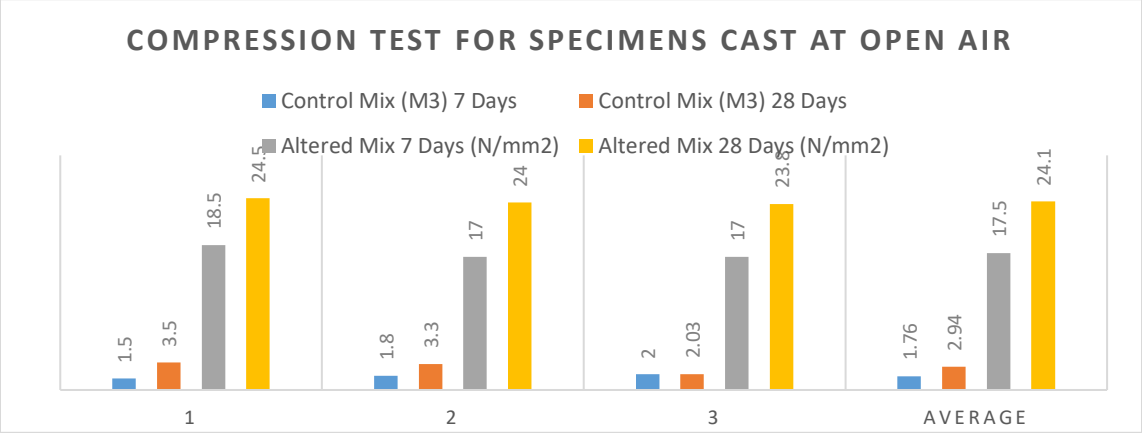

Fig 4 Compression Test results for specimens at open air

Table 6 Compression Test results for specimens cast in under water

Specimen no	Control Mix (M3)		Altered Mix	
	7 Days (N/mm^2)	**28 Days (N/mm^2)**	**7 Days (N/mm^2)**	**28 Days (N/mm^2)**
1	1.5	3.5	18.5	24.5
2	1.8	3.3	17	24.00
3	2.0	2.03	17	23.80
Average	1.76	2.94	17.5	24.10

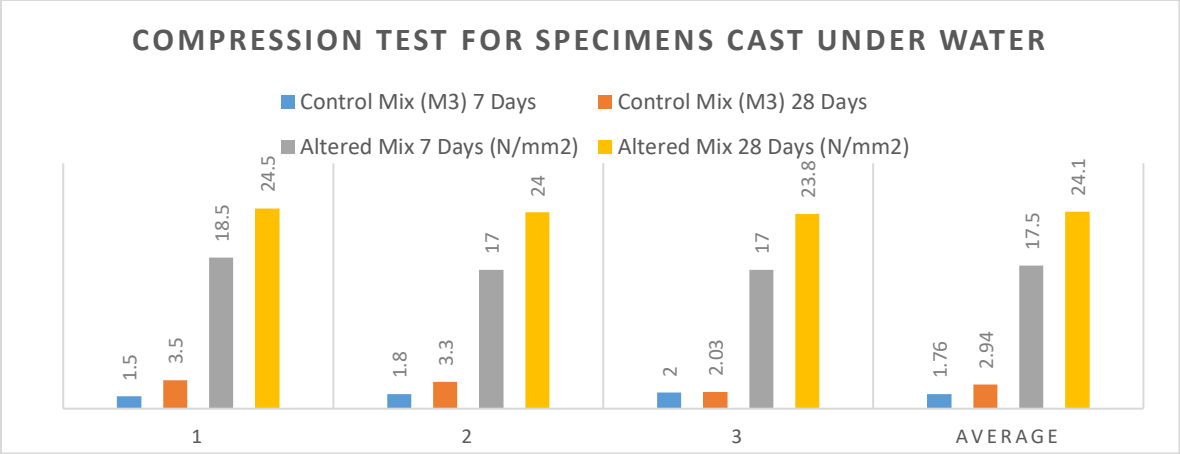

Fig 5 Compression Test results for specimens under water

From the table 5, 6 and fig 4,5, it is observed that, the concrete specialy designed by mixing the sunflower oil and superplasticizer is best suitable to cast under water.

4 CONCLUSION

The comparison was done between concrete with and without sodium silicate. The specimens with 50% of sodium silicate achieved the design strength even it was not subject to water curing. Also the setting time was reduced with the addition of sodium silicate in cement concrete. If the replacement of water by sodium silicate was above 50%, the strength was found to get decreased. The Altered mix with sunflower oil and superplasticizer got good strength under water as indicated in result, thus it can be used under water for construction.

REFERENCE

(1) Dabral, K.; Selvaraj, R.; J, S. Principles and Experimental Methods for Underwater Concrete Formulations. *IOSR J. Mech. Civ. Eng.* **2016**, *13* (05), 31–34. https://doi.org/10.9790/1684-1305043134.

(2) Al-Tamimi, A. K. *Design and Evaluation of Underwater Concrete*; Elsevier LTD, 2019. https://doi.org/10.1016/B978-0-08-102616-8.00014-9.

(3) Heniegal, A. M. Developing Underwater Concrete Properties with and without Anti-Washout Admixtures. *Int. J. Sci. Eng. Res.* **2016**, No. May.

(4) Nakhla, D. A.; Abou-Zeid, M. N. Performance of Low-Slump Underwater Concrete

Incorporating Antiwashout Admixtures. *Transp. Res. Rec.* **2005**, No. 1914, 61–70. https://doi.org/10.3141/1914-08.

(5) Wu, S.; Jiang, S. F.; Shen, S.; Wu, Z. The Mix Ratio Study of Self-Stressed Anti-Washout Underwater Concrete Used in Nondrainage Strengthening. *Materials (Basel).* **2019**, *12* (2). https://doi.org/10.3390/ma12020324.

(6) Jasim, A. T.; Murad, M. J. Performance Of Self Compacting Concrete Placed Underwater. **2015**, *5* (September), 158–166.

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