International Journal of Advanced Science and Research
ISSN: 2455-4227
Impact Factor: RJIF 5.12
www.allsciencejournal.com
Volume 3; Issue 6; November 2018; Page No. 18-20

Effect of chemical compounds in water on strength of high-performance-concrete

Shivanand Saket[1], Dr. Sanjay Kumar Singh[2]
[1] M.Phil. Student, Department of Chemical Sciences, Govt. T.R.S. College, Rewa, Madhya Pradesh, India
[2] Professor, Department of Chemistry, Govt. T.R.S. College, Rewa, Madhya Pradesh, India

Abstract
The chemical constituents present in water may actively participate in the chemical reactions and thus affect the setting, hardening and strength development of concrete. This paper presents the results of an experimental investigation carried out to study the effect of chemical compounds in water on strength of high-performance-concrete with metakaolin in which Ordinary Portland cement is partially replaced by 20% of metakaolin by weight and aggressive chemical environment is simulated by subjecting the concrete to different concentrations of Hydrochloric acid (HCl) in deionised water during mixing and curing. In addition to that, health issues related to the safe handling of such water must be considered. The results indicate that the compressive strength and split tensile strength decrease with the increase in concentration of HCl when compared with concrete without HCl in mixing and curing water.

Keywords: chemical compounds, water, ordinary Portland cement, metakaolin, hydrochloric acid

1. Introduction

Concrete is one of the most durable construction material and Cement is one of the most energy intensive structural materials in concrete. The principal considerations on the quality of mixing water are related to performance in fresh as well as harden state. The quality of the water plays an important role in the preparation of concrete. Impurities in water may interfere with the setting of the cement and may adversely affect the strength and durability of the concrete also. The suitability of water can be identified from past service records or tested to performance limits such as setting times and compressive strength and durability test. Limits are specified for mixing water with their constituents such as total alkalis, chloride sulfate etc. Biological treatment and pathogen reductions are also ensure safety in handling of reclaimed water and saline water.

IS 3025 [1] recommended that, testing of water play an important role in controlling the quality of cement concrete work. Systematic testing of the water helps to achieve higher efficiency of cement concrete and greater assurance of the performance in regard to both strength and durability. Wateris susceptible to being changed due to physical, chemical or biological reactions which may take place between at the time of sampling and analyzing. Hence it is necessary to test water before used for cement concrete production. Samples should be collected, as far as possible, from midstream at mid depth, Sites should be selected such that marginal changes in water observed with naked eyes, where there are major river discharges or obstructions occurred, sample from 100maway of the discharge point in downstream side is taken for small streams. In case of long length river there should be at least three fixed sampling locations along the cross-section. Sampling locations can be fixed with reference to significant features In case of waste water form sewers and narrow effluent channels, samples should be drawn from one third water depths from the top without skimming the top or scrapping the bottom. Velocity of flow at the sampling point should be sufficient to prevent the deposition of solids. Sample should be drawn gently without causing aeration or liberation of dissolved gases. In most cases, sewage flows are intermittent and hence collection of sample at every hour is necessary. Waste waters usually decompose rapidly at room temperature, therefore, certain test setups, such as dissolved oxygen, sulfides, residual chlorine, nitrite and pH should be fixed at site. For certain other tests, preservatives should be added immediately to individual sample.

Arunakanthi *et al.* (2012) [2] carried out an experimental investigation to study, the effect of aggressive chemical environment on high performance concrete with metakaolin. Ordinary portland cement is replaced 20% by weight with metakaolin and aggressive chemical environment is simulated by subjecting the concrete to different concentrations of Hydrochloric acid 50mg/L, 100mg/L, 400mg/L and 800mg/Lin deionised water. Compressive strengths and split tensile strengths were determined at 7, 28 and 90 days. The results indicate that the compressive strength and split tensile strength decrease with the increase in concentration of HCl when compared with concrete without HCl in mixing and curing water.

Currently, high-performance concrete is used in massive volumes due to its technical and economic advantages. Such materials are characterized by improved mechanical and durability properties resulting from the use of chemical and mineral admixtures as well as specialized production processes. Mehta and Aitcin (1990) [3] suggested the term high performance concrete (HPC) for concrete mixtures that possess the following three properties: high-workability, high-strength, and high durability. Water is an important ingredient of concrete, which not only actively participates in the hydration of cement but also contributes to the workability of fresh concrete. Naturally available water contains many numbers of chemical impurities like chlorides, sulphates, various salts and acids in different concentrations. Generally the standard of water that is used for making concrete should be potable. I.S. 516-1959 [5], specifies the minimum pH values as 6.0 and also permissible limits for solids in water to be fit for construction purpose. But the drinking water may not be always available abundantly for mixing and curing. The impurities in water affect the strength and durability of hardened concrete. HCl is not a common natural chemical compound, but it can cause damage to concrete in industrial environments. L.De Ceukelaire (1992) [4] reported that the effects of hydrochloric acid on concrete are multiple. The changing mineralogy due to the leaching processes causes a loss of strength. Haung *et al.*, (2005) [6] reported that the damage resulted from HCl corrosion is dangerous for safe application of concrete structure, especially when the structure is subjected to tensile or bending load. After HCl corrosion, the flexural strength loss of the high strength concrete is larger than that of the normal strength concrete, which indicates that the sensitivity to HCl corrosion increases with increasing concentration.

2. Material and methods

2.1 Cement

Ordinary Portland (53 grade) cement of Ultratech brand was used. It was tested as per Indian Standards Specifications IS: 8112-1989. Its properties are specific gravity 3.1, normal consistency of 33%, fineness of 5%, initial setting time is 105 minutes and final setting time is 350 minutes.

2.2 Fine aggregate

The locally available natural river and was used as fine aggregate. It was tested as per Indian Standard Specification IS: 383-1970. Its fineness modulous is 2.69 and specific gravity is 2.7.

2.3 Metakaolin

Metakaolin obtained from KOAT manufacturing company, Vadodara, Gujarat, India is used in this investigation. The properties are Bulk Density (Gms / Ltr) 300 to 340, Average Particle Size 1.5 – 2.5 micron, Residue (> 45 micron) (max. %) 0.5 – 2%, Moisture content ≤ 1%, Specific Surface Area BET (m^2/gm) 12 – 18. GLENIUM B233 is the super-plasticizer of BASF Company. The properties are Aspect: Light brown liquid, Relative Density: 1.08 ± 0.01 at 25°C, PH: >6, Chloride ion content: < 0.2%

3. Results and Discussion

The effect of HCl concentration on the compressive strength and split tensile strength of HPC with and without metakaolin. Continuous decrease in compressive strength and split tensile strength is observed with the increase in concentration of HCl for both HPCs. If the difference is less than 10% the change is considered to be negligible and if the difference is more than 10% the change is considered to be significant. It is observed that there is significant decrease in both compressive strength and split tensile strength of both HPC's from 100 mg/L concentration of HCl. The percentage change in compressive strength and split tensile strength of HPC with and without metakaolin decreased with the increase in concentration of HCl. But the percentage change in compressive and split tensile strengths of HPC with metakaolin is less when compared with HPC without metakaolin. The XRD and SEM results show the formation of Calcium silicate hydrate (C-SH gel) and Portlandite (Ca $(OH)_2$) in both samples with out HCl. But the intensities of C-S-H gel and Portlandite differ in two samples. The XRD patterns corresponding to HPC without metakaolin and HPC with metakaolin. By analyzing the XRD patterns of samples of two HPC's, the formation of C-S-H gel and Portlandite are formed at angles as shown in table 1 and 2.

Table 1: Compounds and their intensities for samples of HPC's with out HCl

S. No.	Angle in degrees	Compound	Intensity	
			HPC without metakaolin	HPC with metakaolin
1.	12.56	C-S-H Gel	77	133
2.	17.93	Ca $(OH)_2$	265	65
3.	21.17	C-S-H Gel	33	86
4.	24.1	Ca $(OH)_2$	112	74
5.	34.32	C-S-H Gel	124	154
6.	37.4	C-S-H Gel	34	72
7.	42.23	$Ca(OH)_2$	63	37
8.	50.77	C-S-H Gel	91	121

Table 2: Compounds and their intensities for samples of HPC's with HCl

S. No.	Angle in degrees	Compound	Intensity	
			HPC without metakaolin	HPC with metakaolin
1.	10.91	Jennite	79	63
2.	12.31	C-S-H gel	57	69
3.	15.8	C-S-H gel	36	54
4.	18.23	Portlandite	268	63
5.	20.37	Jennite	43	37
6.	22.6	C-S-H gel	44	59
7.	28.72	Jennite	101	73
8.	28.81	Portlandite	103	51
9.	31.33	C-S-H gel	65	78
10.	36.31	C-S-H gel	43	72
11.	44.17	C-S-H gel	56	77
12.	46.61	Jennite	57	44

4. Conclusions

Compressive strength and split tensile strength of HPC increased with the replacement of cement by 20% metakaolin. But the strengths decreased with the increase in concentration of HCl in mixing and curing water. XRD studies it is concluded that the formation of C-S-H gel with more intensity and Portlandite with less intensity may be responsible for more strengths of HPC with metakaolin. XRD studies it is concluded that the formation of compound Jennite may be responsible for decrease in strengths with the increase in concentration of HCl. Deterioration of concrete due to HCl is more for higher concentration of HCl.

5. Acknowledgements
The authors are very much grateful to the authorities of Govt. T.R.S. College, Rewa for providing the facilities.

6. References
1. IS 3025(1-56 parts) Methods of sampling and test (physical and chemical) for water and wastewater.
2. Arunakanthi E, Sudarsana Rao H, Ramana Reddy IV. effects of hydrochloric acid in mixing and curing water on strength of high-performance metakaolin concrete‖, International Journal of Applied Engineering and Technology. 2012; 2(2):68-76.
3. Mehta PK, Aitcin PC. Principles underlying production of high-performance concrete.Cement, Concrete and Aggregates. 1990; 12(2):70-78.
4. De Ceukelaire L. State University of Ghent, Belgium, the effects of Hydrochloric acid on mortar. Cement and Concrete Research. 1992; 22(5):903-914.
5. IS 516: 1959, Standard Method of test for strength of Concrete.
6. Penfei Haung, Yiwang Bao, Yan Yao. Influence of HCl corrosion on the mechanical properties of concrete. Cement and Concrete Research. 2005; 35:584-589.