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Design and Analysis of Landing Gear Lug attachment in an Airframe

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ABSTRACT: The present paper presents the results of an experimental investigation carried out to study the effect of Hydrochloric acid on High performance concrete with phosphogypsum in which Ordinary Portland cement is partially replaced by 20% of phosphogypsum by weight and aggressive chemical environment is simulated by adding different concentrations of Hydrochloric acid (HCl) in deionised water during mixing and curing to the concrete. Compressive strengths and split tensile strengths were determined at 7, 28 and 90 days. With the increase in concentration of HCl the compressive strength and split tensile strength decrease when compared with concrete without HCl in mixing and curing water.

KEYWORDS: Phosphogypsum , Ordinary Portland cement, , Hydrochloric acid, Compressive strength, Split tensile strength.

I. INTRODUCTION

Concrete is a widely used construction material around the world and its properties have been undergoing changes through technological advancement. Nima Farzadni et al. [6] say that with a higher demand for housing and infrastructure and a fast population growth, accompanied by recent developments in civil engineering, such as high-rise buildings and long-span bridges, higher compressive strength concrete is needed. Due to its technical and economic advantages, currently, high-performance concrete is used in massive volumes. Mehta and Aitcin [4] suggested high performance concrete (HPC) mixtures that possess the following three properties: high-workability, high-strength, and high durability. One of the important ingredient of concrete is water, which not only actively participates in the hydration of cement but also contributes to the workability of fresh concrete. Naturally available water contains many number 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. 456-2000, 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 [2] reported that the effects of hydrochloric acid on concrete are multiple. The changing mineralogy due to the leaching processes causes a loss of strength. Pengfei Haung et al. [7] 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. The present paper, therefore attempts to provide essential information on the strength of high performance concrete with phosphogypsum with different concentrations of hydrochloric acid. Now a days the manufacture of cement involves the consumption of valuable natural materials like lime, gypsum etc., in huge quantities. Phosphogypsum is produced from the fabrication of phosphoric acid by reacting hosphate pore (apatite) with sulfuric acid. Adnan Cloak lan [1] studied the effect of phosphogypsum – Portland cement – natural pozzolan ratios on the physical mechanical and durability properties of gypsum. Mulla et al.[5], conducted has done typical analysis of phosphogypsum applications in cement concrete and proved that the major constituent of phosphogypsum is gypsum and the other constituents are in minor quantities. At 5 % replacement of cement (by weight) with phosphogypsum there is gain in strength as compared with percentile replacements.

II. EXPERIMENTAL PROGRAM

Materials

Cement: OPC (53 grade) of Ultratech brand was used. It was tested as per Indian Standards Specifications IS: 8112-1989. specificgravity of cement is 3.1, normalconsistency is 33%, fineness is 5%, initial setting time is 105 minutes and final setting time is 350 minutes.

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

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*Phosphogypsum:*The Phosphogypsum used in the investigation was obtained from Coromandel international Ltd, Ennore, Chennai. The Phosphogypsum passing through 90µ sieve was used throughout the experiment. The specific gravity of Phosphogypsum was found to be 2.34.
Super-plasticizer: 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%

Variables studied

(a) Concrete mix: The mix ratio of cement: sand: corse aggregate is 1:0.76:1.8 with water/ binder ratio as 0.3. The dosage of superplasticizer is 1% by weight of cement. 20 % of Cement was replaced with of Phosphogypsum.
(b) Mixing and curing environment: The four concentrations of HCl (50 mg/L, 100 mg/L, 400mg/L and 800 mg/L) were adopted during the mixing in the deionised water and cured in same condition.
(c) Exposure period: Specimens were tested periodically after the specified curing periods of 7, 28 and 90 days.
(d) Size of specimens: 150mm x150mm x150mm size of cubes for compressive strength test and 150mm dia-300mm height of cylinders for splittensile strength test.
(e) Samples for XRD testing: The cubes with maximum concentration of HCl after 90 days testing are collected and grinded and sieved under 40µ sieve. This powder sample is sent for XRD testing. A total of 135 cubes and 135 cylinders were cast in the laboratory. After 72 hours, all the specimens were demoulded and cured in water in a curing tank at room temperature. After specific exposure period, specimens were tested for compressive strength, split tensile strength in accordance with test procedure IS 516 : 1959 [3].

III. RESULTS AND DISCUSSION

Effect of HCl on compressive strength: The effect of HCl concentration on the compressive strength and splittensile strength of HPC with and without metakaolin is presented in table: 1, 2, 3 and 4 and figures 1,2,3 and 4. Continuous decrease in compressive strength and splittensile 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 splittensile strength of HPC with and without phosphogypsum decreased with the increase in concentration of HCl. But the percentage change in compressive and split tensile strengths of HPC with phosphogypsum is less when compared with HPC without phosphogypsum. The XRD and SEM results show the formation of Calcium silicate hydrate (C-S-H 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 phosphogypsum and HPC with phosphogypsum are shown in figures 3 and 5. 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 5 and 6. The intensity of C-S-H gel is more and the intensity of Portlandite is less for HPC with phosphogypsum when compared with HPC without phosphogypsum. This may be the cause for the strengths of HPC with metakaolin to be high under aggressive environment. The XRD tests are conducted for the two samples after 90 days with 800 mg/L concentration (maximum) of HCl. It is observed that inaddition to the compounds formed above, a compound named **Jennite** **($Ca_9H_2Si_6O_{18}(OH)_8.6H_2$)** is formed in both HPC's with HCl. So the decrease in strengths may be due to the formation of Jennite. The angles at which the compounds are formed is shown in the table 4. The XRD patterns are shown in figures 5 and 6 respectively. The compound Jennite has triclinic and pinacoidal structure. This is of massive form.
The probable chemical reaction upon the hydration of cement with mixing water containing H_2SO_4 concentration is
$2H_2SO_4 + SiO_2 + 3CaO + 10H_2O \longrightarrow Ca_3Si(SO_4)_2(OH)_6.9H_2O$
In tables and graphs CHPC is HPC without phosphogypsum and PHPC is HPC with phosphogypsum.

Table 1: Compressive strength in N/mm^2 for different concentrations of HCl

S No	Dosage of HCl mg/L	Compressive strength (N/mm^2)					
		7 days		28days		90 days	
		CHPC	**PHPC**	**CHPC**	**PHPC**	**CHPC**	**PHPC**
1	0	39.5	44.0	58.0	65.0	63. 5	68.0
2	50	36. 6	40.1	55.6	58.9	59.0	64.0
3	**100**	**28. 5**	**35.7**	**44. 8**	**45.9**	**45.0**	**46.0**
4	400	26.2	27.1	35.2	37.0	37.0	39.0
5	800	23.2	23.6	26.5	28.6	24. 7	28.0

Table 2:%age change in compressive strength for different concentrations of HCl

S No	Dosage of HCl mg/L	Percentage change in Compressive strength					
		7 days		28days		90 days	
		CHPC	**PHPC**	**CHPC**	**PHPC**	**CHPC**	**PHPC**
1	0	0.00	0.00	0.00	0.00	0.00	0.00
2	50	-7.44	-8.82	-4.14	-9.35	-7.01	-5.88
3	**100**	**-27.97**	**-18.93**	**-22.79**	**-29.40**	**-29.08**	**-32.35**
4	400	-33.68	-38.36	-39.40	-43.08	-41.69	-42.65
5	800	-41.37	-46.48	-54.24	-56.06	-61.12	-58.82

Table 3: Split tensile strength in N/mm^2 for different concentrations of HCl

S No	Dosage of HCl mg/L	Split tensile strength (N/mm^2)					
		7 days		28days		90 days	
		CHPC	**PHPC**	**CHPC**	**PHPC**	**CHPC**	**PHPC**
1	0	4.19	4.64	5.35	5.64	5.67	5.75
2	50	3.82	4.24	5.04	5.45	5.23	5.43
3	**100**	**3.14**	**3.55**	**3.8**	**4.05**	**4.25**	**4.4**
4	400	2.497	2.91	3.1	3.43	3.35	3.86
5	800	1.86	2.56	2.34	3.05	2.76	3.12

Table 4:%age change in split tensile strength for different concentrations of HCl

SNo	Dosage of HCl mg/L	Percentage change in Split tensile strength					
		7 days		28days		90 days	
		CHPC	**PHPC**	**CHPC**	**PHPC**	**CHPC**	**PHPC**
1	0	0.00	0.00	0.00	0.00	0.00	0.00
2	50	-8.83	-8.62	-5.79	-3.37	-7.76	-5.57
3	**100**	**-25.06**	**-23.49**	**-28.97**	**-28.19**	**-25.04**	**-23.48**
4	400	-40.41	-37.28	-42.06	-39.18	-40.92	-32.87
5	800	-55.61	-44.83	-56.26	-45.92	-51.32	-45.74

Table 5: Compounds and their intensities for samples of HPC's with out HCl

SNO	Angle in degrees	Compound	Intensity	
			CHPC	PHPC
1	12.58	C-S-H Gel	76	132
2	17.94	$Ca(OH)_2$	266	66
3	21.18	C-S-H Gel	32	86
4	24	$Ca(OH)_2$	110	72
5	34.34	C-S-H Gel	124	154
6	37.3	C-S-H Gel	34	72
7	42.24	$Ca(OH)_2$	64	38
8	50.76	C-S-H gel	90	120

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Table 6:Compounds and their intensities for samples of HPC's with HCl

SNO	Angle in degrees	Compound	Intensity	
			CHPC	PHPC
1	10.92	Jennite	78	64
2	12.32	C-S-H gel	56	68
3	15.7	C-S-H gel	38	52
4	18.22	Portlandite	268	64
5	20.38	Jennite	44	38
6	22.8	C-S-H gel	44	58
7	28.74	Jennite	100	72
8	28.8	Portlandite	102	52
9	31.32	C-S-H gel	64	78
10	36.3	C-S-H gel	44	72
11	44.16	C-S-H gel	58	78
12	46.6	Jennite	56	42

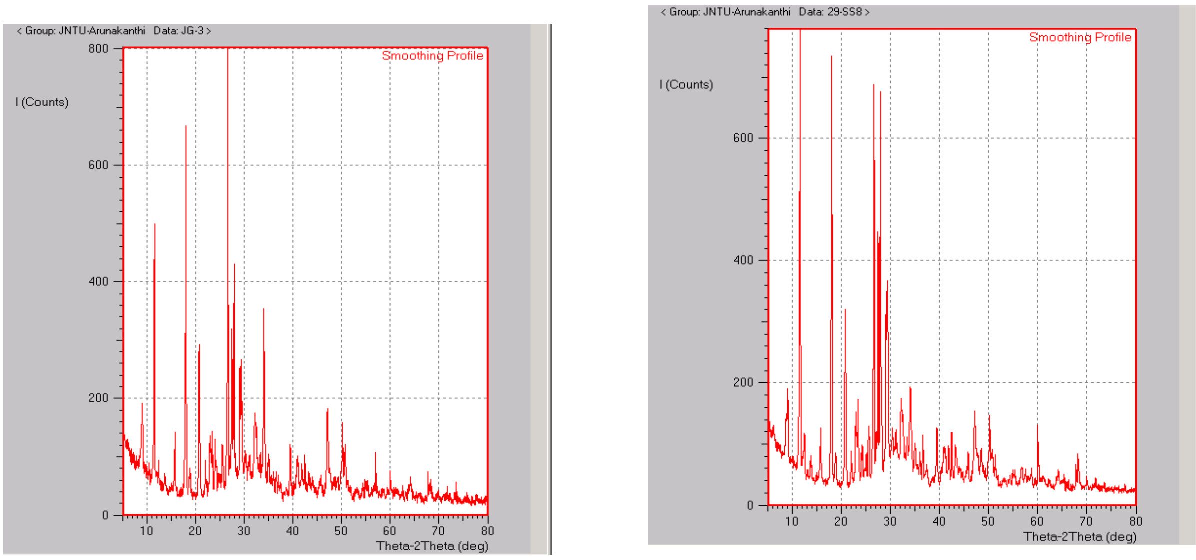

Figure 5: XRD pattern of HPC i) with out phosphogypsum ii) with phosphogypsum

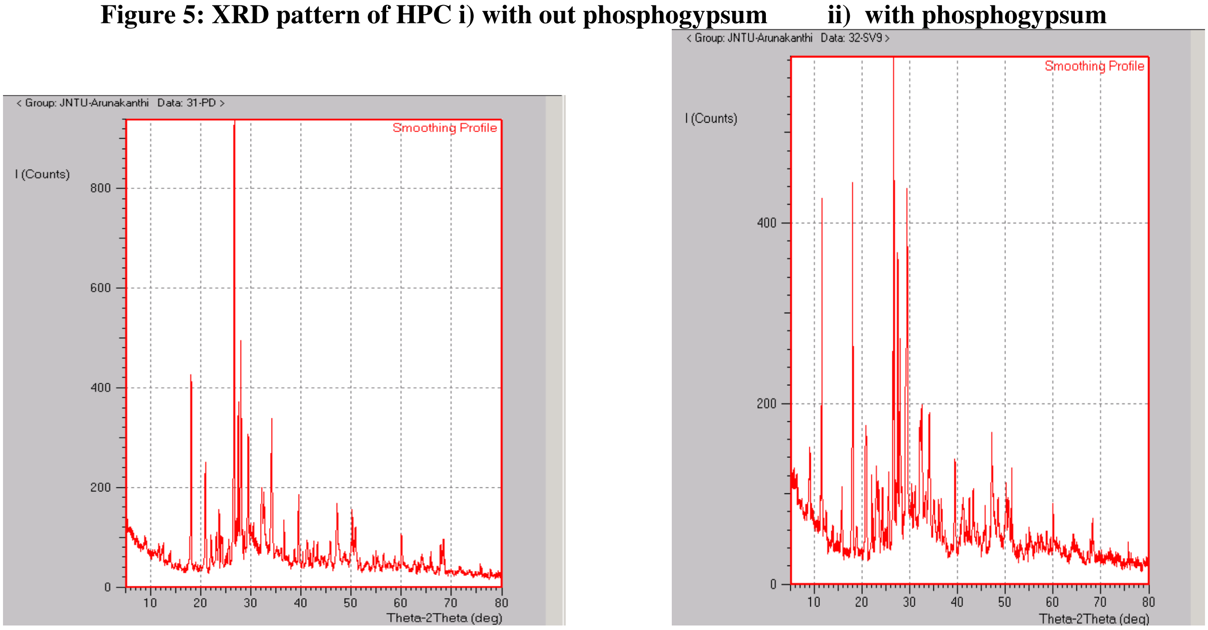

Figure 6: XRD pattern of HPC i) with out phosphogypsum + HCl ii) with phosphogypsum + HCl

IV. CONCLUSIONS

Based on the above results of the investigation conducted on high-performance concrete with partial replacement of cement by 20% phosphogypsum and subjected to various concentrations of HCl, the following conclusions can be drawn:

1. Compressive strength and split tensile strength of HPC increased with the replacement of cement by 20% phosphogypsum. But the stengths decreased with the increase in concentration of HCl in mixing and curing water.
2. Compressive strength and split tensile strength increase as the curing period increases for later ages of curing i.e., 7 days, 28 days and 90 days for 20% phosphogypsum and for 0 mg/L concentration.
3. From 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 phosphogypsum.
4. From 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.
5. Deterioration of concrete due to HCl is more for higher concentration of HCl.

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