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BEHAVIOUR THE CONCRETE UNDER SEVERAL ENVIRONMENTAL CONDITION-SULPHUR ACID H_2SO_4

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Abstract: *Behaviour the concrete elements and in general the concrete, such building material, under the exposure under environmental conditions represents the basic requirements of design in long time period . Investigated behavior the concrete in this paper is focused under the Sulphur Acid H_2SO_4 effect in 5.5% percent of Sulphur Acid compared with usually non attacked concrete in different ages of concrete. Recently the deterioration of concrete, followed by loss of mass caused by Sulphur. In this study case the concrete used in columns of bridges in Highway was under different environmental conditions in the long trace and the presence of Sulphur Acid was present in some parts. The experimental results presented in this paper are in function of preliminary data of the presence the waste water in foundations.*

Key words: *Sulphur Acid; Compressive Strength; loss of mass; concrete*

1. Introduction

Concrete is susceptible to attack be sulphuric acid result from contact with sewage water or sulphur dioxide present in atmosphere. The sulphuric acid is particularly corrosive due to the sulphate ion participating in sulphate attack. The components of the cement paste break down during contact with acids. The attack is oriented in decomposition of the concrete, which is depend of the porosity of the cement paste, penetration of the acidic soluble and the concentration of the acids. The deterioration of concrete by sulfuric acid attacks can be characterized by loss of mass; erosion of concrete; and erosion caused by the expansion of products due to the reaction of the calcium compounds in concrete with sulfuric acid. Understanding of the performance of concrete in structures and evaluations under the sulphuric acid will lead us on the selections of the materials, protective chemical admixtures during the mix design, and the concentrations of the sulphuric acid in water to achieve the much higher-quality acid resistant cementations materials [1, 2].

Usually experimental studies on concrete deterioration due to sulfuric acid attack are performed using specimens statically immersed in acid solutions. In this case, concrete

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surfaces are under soluble attack and deterioration products will remain on the surfaces. It is concerned that the results obtained from these experiments could evaluate the deterioration of concrete under sewage and wastewater subjected to the loss of mass under acidic sulphate soluble [1, 4].

2.Experimental Procedures

2.1 Materials and specimens

The essential agents for sulphate attack are sulphate anions (SO_4^{2-}). These are transported to the concrete in various concentrations in water, together with cations, the more common of which are calcium, magnesium and sodium. Where porous concrete is in contact with saturated ground the water phase is continuous across the ground/concrete interface and sulphate ions will be readily carried into the body of the concrete. Well compacted, dense, low water/cement ratio concrete in such an environment will, however, initially restrict access of the ions to the surface layer. Migration of sulphate ions from unsaturated ground into the concrete can take place by diffusion provided there is sufficient water to coat the particles of soil, but the rate will be slow and dependent on the sulphate concentration [3, 5].

The experimental program utilized two different mix Designs, focused on the concentration of H_2SO_4, prepared according the EN 206-1 need to fulfil following parameters [6]:

- Class of Concrete: C30/37
- Class of Exposure: XC2;XA2
- Class of Consistency:S3
- Porosity: (1-3)%

The properties of materials used in this study and the mix proportions are shown in Table 1 and Table 2, respectively.

Physical properties of material Table 1

Cement	Ordinary Portland Cement ; CEM II ; 42.5 Density: 3.05 (gr/cm3); Blaine fineness 3050 (cm^2/g)
Coarse Aggregate	Crushed Stone / Query Gllama; Dmax= 22.4 mm; Density- 2.63 g/cm^3 FM= 4.85; Water absorption: 0.56
Fine Aggregate	Crushed Stone / Query Kastrioti; Density- 2.59 g/cm^3 FM= 3.25; Water absorption : 0.79
Chemical Admixture	SIKA –Viscocrete 1020

Mix Proportions and concentration of the H_2SO_4 Table 2

Cement	330kg/m3
Crush Aggregate	835kg/m3
Fine Aggregate	1015kg/m3
Chemical Admixture	1.1. Kg/m3
W/C -ratio	0.55
Porosity	1.3
Concentration the H2SO4	5.5 %

2.2. Preparation the Sulfate acid solutions

The sulfuric acid solution will be prepared with the requested concentration in water according the rules and adequate equipment for safety during the process. The structure of the molecules is presented in Fig.1.

When you mix acid with water, it's extremely important to add the acid to the water rather than the other way around [7, 8].

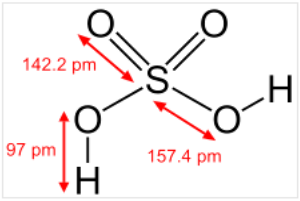

Fig. 1. *Molecular Structure –H_2SO_4*

Acid and water react in a vigorous exothermic reaction, releasing heat, sometimes boiling the liquid. Mixing sulfuric acid and water is particularly risky because the splashed acid is corrosive enough to immediately burn skin and clothing. The activities during the preparations are presented in fig. 2.

Fig. 2. *Process of preparing the Sulphur Acid*

When you mix together sulfuric acid and water, sulfuric acid donates a hydrogen ion, producing the hydronium ion. Sulfuric acid becomes its conjugate base, HSO_4-. The equation for the reaction is:

$$H_2SO_4 + H_2O \rightarrow H_3O^+ + HSO_4^- \quad (1)$$

Preparing the soluble on the beginning and final process is presented in fig.4.

a) *beginning process* b) *normalized process*

Fig. 4. *Preparing the soluble*

2.3. Behaviour the concrete sample in Acid Sulphuric soluble

Concrete is susceptible to acid attack because of its alkaline nature. The alkaline components of the cement paste (calcium hydroxide) break down with acid exposure.

$$H_2SO_4 + Ca(OH)_2 \Rightarrow CaSO_4 + 2H_2O \quad (2)$$

Sulphuric acid attack causes extensive formation of gypsum in the regions close to the surfaces, and tends to cause disintegration and mechanical stresses which ultimately lead to spalling and exposure of the fresh interior surface. Normally, the chemical changes of the cement matrix are restricted to the regions close to the surfaces because of less penetration of the Sulfuric acid in concrete. [1, 2].

However, in some cases it is observed that scaling and softening of the concrete occurs due to the early decomposition of calcium hydroxide and the subsequent formation of large amount of gypsum. The chemical reactions involved in sulphuric acid attack on cement based materials can be given as follows :

$$3CaO \cdot 2SiO_2 \cdot 3H_2O + H_2SO_4 ==\Rightarrow CaSO_4 \cdot 2H_2O + Si(OH)_4 \quad (3)$$

Sulphate attacks are categorized into two broad classes based on the origin of source of sulphate, as either external sulphate attack (ESA) or internal sulphate attack (ISA). In external sulphate attack, the source of sulphate is external to concrete and often originate from its surrounding like soil, sea water, sewerage water, groundwater and the like. Sulphate ions contained in the concrete ingredients like cement, water, aggregate and admixture are the reason for internal sulphate attack [6, 7].

2.3.1. Curing the concrete samples in Acid Sulphuric soluble

For comparison the effect of the Sulphuric Acid in concrete in this paper we prepared parallel two sets of concrete samples:

- Plain concrete set of samples
- Concrete set of sample under sulphate acid soluble

In procedure of curing after the 24 hours casting the test specimens, cubes, are de-moulded and immediately immersed in clean and fresh water tank and allow it for curing for 7days, 28 days and for 90 days in potable water. Specimens were also cured in 5.5% H_2SO_4 acid in same ages.

The curing is done according the EN 2016-1, and target is oriented in two parameters:

- Loss of mass
- Reduction of compressive strength

Effects of the Sulphuric Acid is presented in curing process is presented in Figure 5.

Fig. 5. *The concrete samples during the maintenance under Sulphuric Acid*

3. Test Results and Discussion

3.1. Weight loss of test specimens

As can be seen from the Table 3, the weight loss of concrete specimens exposed to sulphate solution will analyse in three different stages. In Stage I, the weight loss decreases until to 7 days. In Stage II, from 7 days to 28 days. In Stage III, the weight loss after 28 days. The weight loss is presented in Table 3.

Evaluations the loss of weight for samples under sulphuric acid Table 3

Sample no.	Age /days	Plain concrete /weight/gr	Samples under Sulphuric Acid weight/g	Loss in mass/gr	Loss in Percent (%)
"1"	7	8027	7805	222	2.77
"2"	7	8024	7804	220	2.74
"3"	7	8018	7802	216	2.69
"4"	28	8107	7425	682	8.41
"5"	28	8101	7423	687	8.37
"6"	28	8065	7402	663	8.22
"7"	90	8115	7195	920	11.34
"8"	90	8021	7155	866	10.80
"9"	90	8019	7095	924	11.52

The results of mass loss in surface is followed with the damages, focused in edges, of concrete samples. Some of visual changes are presented in Figure 6.

Fig. 6. *Sample of paste, washing and weighting after the ages-90 days*

3.2. Reduction of Compressive Strength under presence of Sulphuric Acid

The test results for compressive strength are presented in Table 4, for same conditions evaluated in loss of mass.

Examinations and inspections of the shape of the samples comparing the plain samples and samples under Sulphuric Acid are presented in Figure 7.

Reduction of Compressive Strength under Sulphuric Acid in different ages Table 4

Sample no.	Age /days	Plain concrete/Compressive Strength/N/mm^2	Samples under Sulphuric Acid/Compressive Strength/N/mm^2	Reduction of Compressive Strength (%)
"1"	28+7	39.90	37.67	5.59
"2"	28+7	36.70	36.45	0.68
"3"	28+7	38.10	35.12	7.82
"4"	28+28	43.28	38.9	10.12
"5"	28+28	40.8	37.45	8.21
"6"	28+28	39.9	36.85	7.64
"7"	28+90	45.10	37.55	16.74
"8"	28+90	43.44	36.30	16.43
"9"	28+90	43.61	35.50	18.60

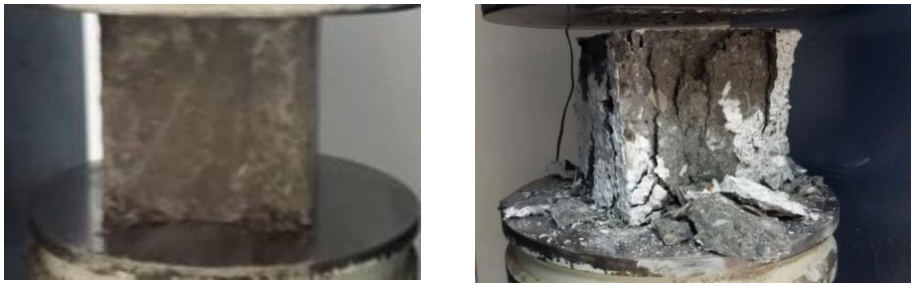

Fig. 7. *Effect of the Sulphuric Acid in failure mode of examined samples*

3.3. Discussion on the Results

3.3.1. Sulphuric acid attack on concrete

The loss of mass of concrete cubes in H_2SO_4 medium is due to ettrignite formation. The calcium silicate hydrate reacts with H_2SO_4 to fragile silica gel which is easily

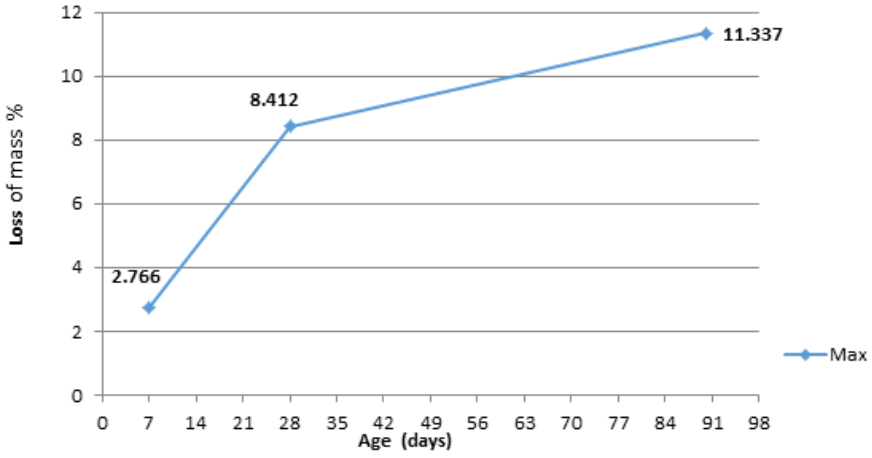

Fig. 8. *Loss of mass of concrete cube samples in different ages (7; 28. 90) days under 5.5% sulphuric acid*

destroyed external physical force. The calcium sulfate formed by initial reaction can proceed to react with calcium aluminate phase in cement to form ettrignite, which can

cause expansion, cracking, loss of weight and strength and disintegration of concrete [5].

The loss of mass in time process under sulfate acid attack is presented in Figure 8.

The disintegration process of concrete structure is followed in reduction of compressive strength, which will lead to the loss of bearing capacity in concrete elements and other effects in reinforcement steel bars. The concrete cubes are exposed for 7; 28 and 90 days when achieve the compressive strength in 28 days. In fact the concrete under this conditions was (28 +7=35) days; (28+28=56) days and (28+90=118) days. The reduction of compressive strength and results are presented in Figure 9.

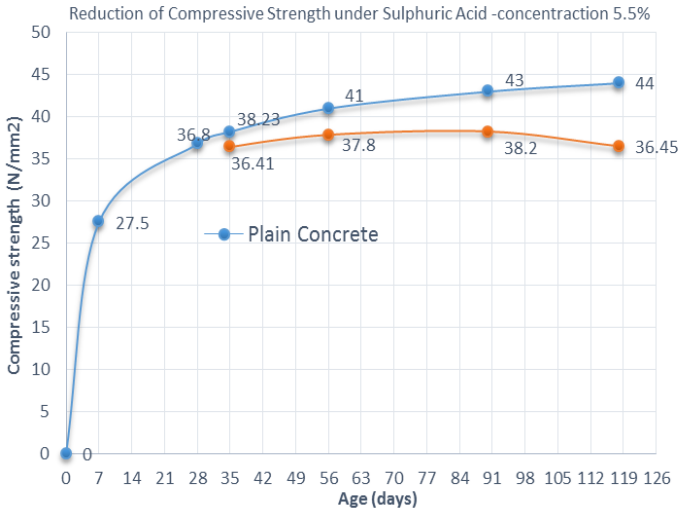

Fig. 9. *Effect of Sulphuric Acid with contraction 5.5% in compressive strength*

4. Conclusions

The research study was focused to understand the mechanism of concrete deterioration caused by sulphuric acidic on the flow process such fluid soluble. As a result of experiments the following conclusions are obtained:

- Regarding concrete deterioration caused by sulphuric acid, the flow through the concrete structures will increase the deterioration in function of concentrations and time of exposed the concrete.
- The compressive strength values of acid effected the decrease comparison of the plain common concrete in values about 17 %, depend of the time of exposed
- The loss of mass and changeable the concrete structures increase about the 11 %, and will lead toward the damages in concrete structures
- The relationship between the mass loss experienced by all concrete specimens subjected to sulphuric acid and the reduction in their compressive strength can be attributed to the fact that immersing concrete specimens in sulphuric acid results in loss of cement paste and structural integrity, weakening of the concrete matrix and a reduction in the specimen's diameter

- Improvement of the degradation mechanism of the concrete will be possible using the chemical admixtures especially in typical thin concrete elements.
- Effect of increasing the concentration $> 5.5\ \%$ of H_2SO_4,focused in 10 % concentration will be results with more damages in foundation in concrete column of bridges

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