Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 13; July-September, 2015 pp. 58-61

http://www.krishisanskriti.org/jceet.html

Study of Cement Mortar and its Reaction to King of Acids "Sulphuric Acid"

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Abstract—*Cement mortar is a workable paste which is used to execute the purpose of binding building blocks such as stones, bricks and concrete masonry units together and also to fill in and seal the irregular gap which may be in the form of trigonal and polygonal shapes. Cement mortar is also used miscellaneously for adding decorative colours and patterns to masonry walls. In a broader sense, mortar includes pitch, asphalt and soft mud, popularly known as 'clay'; which are vital adhesive elements used between mud bricks. Mortar comes from the Latin word "MORTARIUM" meaning crushed. Cement mortar is very sensitive to attack by sulphuric acid produced either from sewage or sulphur dioxide present in the atmosphere of industrial cities. The attack of the sulphuric acid is due to high alkanity of Portland cement mortar, which is also susceptible to some other acids as well. Sulphuric acid is particularly corrosive due to sulphate ion participation in sulphate attack, in addition to dissolution caused by the hydrogen ion. The response of cement mortar mixes to sulphuric acid attack was evaluated in a laboratory test program. The study suggests that there is an increase in thickness (expansion), loss in weight and reduction in compressive strength of specimens when acid is added to the cement mortar mixes. This research sheds a new light on the mechanism of sulphuric acid attack on cement mortar. The experimental techniques used in the study provide information on the extent of damage that take place on cement mortar as a result of acid attack.*

1. INTRODUCTION

Cement mortar is a workable paste which is used to execute the purpose of binding building blocks such as stones, bricks and concrete masonry units together and also to fill in and seal the irregular gap which may be in the form of trigonal and polygonal shapes. Cement mortar is also used miscellaneously for adding decorative colours and patterns to masonry walls. In a broader sense, mortar includes pitch, asphalt and soft mud, popularly known as 'clay'; which are vital adhesive elements used between mud bricks. Mortar comes from the Latin word "MORTARIUM" meaning crushed. Cement mortar is very sensitive to attack by sulphuric acid produced either from sewage or sulphur dioxide present in the atmosphere of industrial cities. The attack of the sulphuric acid is due to high alkanity of Portland cement mortar, which is also susceptible to some other acids as well. Sulphuric acid is particularly corrosive due to sulphate ion participation in sulphate attack, in addition to dissolution caused by the hydrogen ion. The response of cement mortar mixes to sulphuric acid attack was evaluated in a laboratory test program. Cement is a binder which sets and hardens independently, and can bind other materials together. Cement is a fine mineral powder manufactured with very precise processes. It is the main component of concrete.

There are some properties of cement. They are such as follows

- Cement imparts strength to the masonry.
- It is best binding materials in all the constructions.
- It has good resistance to moisture, temperature, and weather.

Acid is a molecule or other species which can donate a proton or accept an electron pair in a reaction. Some of the acids are listed below:

- Sulphuric acid(H_2SO_4)
- Bromous acid($hbro_2$)
- Nitric acid (HNO_3)
- Sulphurous acid(H_2SO_3)

Sulphuric acid is a highly corrosive strong mineral acid with the molecular formula H_2SO_4. It has a pungent smell, colourless to slightly yellow viscous fluid which is soluble in water at all concentrations. Sulphuric acid is a diprotic acid and shows different properties depending upon its concentrations.

1.1. Effect of sulphuric acid on cement mortar

Concrete is susceptible to attack by sulphuric acid produced from either sewage or oxide present in the atmosphere of industrial cities. This attack is due to high alkanity of Portland cement concrete, which can be attacked by other acids as well. Acidic attack represents a topic of increasing significance, owing to the spread of damages of concrete structures in both

urban and industrial areas. Cement type is an important factor affecting performance of cement based materials in an aggressive environment.

2. MATERIAL INVESTIGATION

2.1. Cement mortar

Cement mortar is a building compound created by mixing sand and a selection of aggregates with a specified amount of water. The mortar can be used for a number of applications, such as plastering over bricks or other forms of masonry. Mortar has been used for centuries as a means of adhering bricks or concrete blocks to one another. Cement mortar continues to be used in many different types of construction work.

2.2. Sulphate attack in cement mortar

There are two types of sulphate attack. They are

1. External attack.
2. Internal attack.

- External attack: this is more common and typically occurs where water containing dissolve sulphate penetrates the concrete. a fairly well defined reaction front can often be seen in polished section; ahead of the concrete is normal, or near normal. behind the reaction front, the composition and microstructure of the concrete will have changed. these changes may vary in type but commonly includes:
  - Extensive cracking
  - Expansion
  - Loss of bond between the paste and aggregate
- Internal: it occurs when a source of sulphate is incorporated into the concrete when mixed. examples include the use of sulphate-rich aggregate, excess of added gypsum in the cement or contamination. proper screening and testing procedure should generally internal sulphate attack.

Sulphate attack processes decrease the durability of concrete by changing the chemical nature of the cement paste, and of the mechanical properties of the concrete.

Fig. 1: Microscopical examination of an acid attack cement mortor cube

Fig. 2: cement mortar cube attacked by acid.

3. PREPARATION OF CEMENT MORTAR CUBES

3.1. Mixing procedure

Cement mortar (1:2, 1:3) mix is designed as per the guidelines IS:2250-1981

Based on the preliminary studies conducted in the constituent elements. In the due course of our work we prepared a total no of 6cement mortar cubes of dimension of 7cmx7cmx7cm. the mix was made to prepare cement mortar moulds for the compressive strength test of normal cement mortar.

Table 3.1: Mix proportions values for normal cement mortar mixes

Cement mortar mixes	Cement	Sand	Water
1:2	247g	493g	85.1ml
1:3	185g	555g	85.1ml

3.1.1. Procedure

- Sand sample was poured into the top sieve which has the screen opening of 1mm. after the shaking was complete the materials passing through the sieve was weighed.
- The correct amount of cement and sand was taken for the cement mortar mixes as given in the mixed proportion table (table 3.1).
- A constant amount of water was used for all the mix.

3.2. Compressive strength test

Cement mortar cubes are cast. During casting the cubes is manually compacted. After 254 hours the specimens is removed from the mould and subjected to water curing for 28 days. after curing, the specimen are tested for compressive strength using a calibrated compaction testing machine of 2000KN capacity.

3.3. Immersions of cement mortar cubes in sulphuric acid solution

The test specimens were immersed in the bucket filled with equal quantities of 1% sulphuric acid solution (pH=1). The

test program was conducted in 5 weeks when some of the test specimen disintegrated in the acid solution. The measurements of the test specimens were performed after selected periods of immersion in the acid. the increase in the thickness indicate that these specimen undergoes volume expansion or swelling as a consequence of sulphuric acid attack.

Fig. 3: Cement mortar cubes kept in a bucket containing sulphuric acid solution

4. EXPERIMENTATION

4.1. Initial weight of normal cement mortar cubes

Table 4.1: Initial weight results of normal cement mortar cubes

Weights of cubes	Ratio of cubes
700g	1:2
678g	1:3

4.2. weight of normal cements mortar cubes after curing for 28 days

Table 4.2: Weight results of normal cement mortar cubes after curing for 28 days

Weight of cubes	Ratio of cubes
744g	1:2
724g	1:3

4.3. Weight of acid attacked cement mortar cubes

Table 4.3: Weight resulopts of acid attacked cement mortar cubes

Ratio of cubes	Weight of cubes
1:2	727.5g
1:3	730.75g

4.4. Compressive strength of normal cement mortar cubes after 28 days of curing.

Table 4.4: compressive strengths results of normal cement mortar cubes

Cement mortar mixes	Compressive strength
1:2	16.2N/mm2
1:3	16N/mm2

4.5 Compressive strength of cement mortar cubes due to effect of sulphuric acid

Table 4.5: Compressive strength results of cement mortar cubes due to effect of sulphuric acid

Cement mortar mixes	Period	Reduction in compressive strength
1:2	5 weeks	4.6%
1:3	5weeks	5%

4.6. Thickness of acid attacked cement mortar cubes

The length (L), breadth (B), and depth (D) of the cement mortar cubes (7cmx7cmx7cm) with proportions such as 1:2, 1:3 with water content 85.1ml were observed at the end of 0, 8, 34 days after the test specimen were immersed in a bucket filled with equal quantities of 1 percent sulphuric acid solution.

4.6.1. Length, Breadth and Depth of acid attacked cement mortar cubes on 0 day of observation

4.6.1.1. Length, Breadth and Depth of acid attack 1:2 cement mortar cubes

Table 4.6.1.1: Results of length, breadth, and depth of 1:2 cement mortar cubes

Cubes	Length (cm)	Breadth(cm)	Depth(cm)
1	7.1	7	7
2	7.2	7	7
3	7.2	7.1	7.1
Average	7.16	7.03	7.03

4.6.1.2. Length, Breadth and depth of acid attack 1:3 cement mortar cubes

Table 4.6.1.2: Results of length breadth and depth of 1:3 cement mortar cubes

Cubes	Length (cm)	Breadth (cm)	Depth(cm)
1	7	7	7
2	7.1	7	7
3	7.1	7	7
Average	7.06	7	7

4.6.2. Length, Breadth and Depth of acid attacked cement mortar cubes on 8 day of observation

4.6.2.1. Length, Breadth and Depth of acid attack 1:2 cement mortar cubes

Table 4.6.2.1: Rresults of length, breadth, and depth of 1:2 cement mortar cubes

Cubes	Length (cm)	Breadth(cm)	Depth(cm)
1	7.2	7.1	7.2
2	7.2	7.2	7.1
3	7.2	7.2	7.1
Average	7.2	7.16	7.13

4.6.2.2. Length, Breadth and depth of acid attack 1:3 cement mortar cubes

Table 4.6.2.2: Results of length breadth and depth of 1:3 cement mortar cubes

Cubes	Length (cm)	Breadth (cm)	Depth(cm)
1	7.2	7.2	7.2
2	7.2	7.2	7.1
3	7.2	7.2	7.1
Average	7.2	7.2	7.13

4.6.3. Length, Breadth and Depth of acid attacked cement mortar cubes on 34 day of observation

4.6.3.1. Length, Breadth and Depth of acid attack 1:2 cement mortar cubes

Table 4.6.3.1: Results of length, breadth, and depth of 1:2 cement mortar cubes

Cubes	Length (cm)	Breadth(cm)	Depth(cm)
1	7.4	7.4	7.4
2	7.4	7.4	7.4
3	7.3	7.3	7.3
Average	7.36	7.36	7.36

4.6.3.2. Length, Breadth and depth of acid attack 1:3 cement mortar cubes

Table 4.6.3.2: Results of length breadth and depth of 1 :3 cement mortar cubes

Cubes	Length (cm)	Breadth (cm)	Depth(cm)
1	7.3	7.4	7.4
2	7.3	7.4	7.3
3	7.4	7.4	7.3
Average	7.33	7.4	7.33

Fig. 4: Acid attacked on 1:2 cement mortar cube observed on 0 day of observation.

Fig. 5: Acid attacked on 1:3 cement mortar cubes observed on 0 day of observation.

5. CONCLUSION

- There is an increase in thickness of the specimens when acid is attacked added to the cement mortar mixes.
- there is a reduction in compressive strength of cement mortar cubes attacked Acid.
- Loss in weight of cement mortar cubes takes place when it is immersed in a solution of sulphuric acid.

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