Effect of Sulphuric Acid on High Performance Mortar

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Abstract

Mortar is a heterogeneous material obtained by mixing cement paste (binder) with fine aggregates (filler). The most two important properties of hardened mortar are its compressive strength and durability. The former can be quantitatively measured while the latter cannot. It can be said that generally, factors that favour concrete strength usually benefit its durability. Factors that affect the strength and durability of mortar includes quality and quantity of cement used in a mix, grading of aggregates. An experimental study was conducted to assess the acid resistance of mortar at different normality condition .The program consisted immersion of mortar cube specimens in solutions of Sulfuric acid with different normalities such as 0.3N,0.5N,1.0N for period of 7 ,14,21,28 days and evaluation of its resistance in terms of surface erosion, changes in weight and compressive strength at regular intervals. High strength mortar samples did not show any noticeable change in colour and remained structurally intact though the exposed surface turned slightly softer. Samples almost lost its surface smoothness after exposure in the acid solution within one month and showed very low weight loss in 7 days, it ranges from 0.9% to 2.6%, 1.8% to 5.3% in 14 days, 2.1% to 5.6% in 21 days and 5.8% to 13.2% in 28 days in 0.3N Sulfuric acid. Compressive strength loss at the end of test varied from 13% to 21.3% for 0.3N, 29% to 37.2% for 0.5N, 44% to 51.9% for1.0N in 14 days respectively.

Keywords:Mortar, Strength, Durability, Normalities, sulfuric acid, Compressive strength.

1. Introduction

1.1 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. Sometimes referred to as sand cement, mortar blends today often incorporate different grades of plastics to create various types of polymer cement mortars. Mortar has been used for centuries as a means of adhering bricks or mortar blocks to one another.

Cementmortar continues to be used in many different types of construction. Professional building projects often employ mortar as the binder between bricks in walls, fences, and walkways. Around the house, cementmortar is often employed to make quick repairs in patio slabs and reset loosened stones or bricks in a walkway or retaining wall. Cementmortar also makes an excellent medium for creating a smooth surface to walls made from bricks and other forms of masonry. The ingredients in cementmortar vary somewhat, depending on the manufacturer specifications. A typical mortar will include both sand and cement, with lime added to the mix. Other types of aggregates may be added, depending on the texture that is desired for the mortar. In recent years, the inclusion of synthetic materials such as polymers have helped to create cementmortar products that provide additional flexibility without negatively impacting the binding powers of the cementmortar.

1.2 Mortar Types

Mortar nomenclature has developed over many years to its current form. Designations for mortar are found in ASTM C 270, *Standard Specification for Mortar for Unit Masonry*. In the United States, the three common types of mortar specified for new construction today are N, S, and M. These arbitrary designations were assigned by taking every other letter from the term “mason work.” Astute observers will notice that an “O” and a “K” also appear in that term. While these are recognized mortar types, they are typically usedfor non-load bearing walls and for tuck pointing or other repair work.

Mortars are differentiated primarily by their strength: M is the highest strength, S is next, and N is a moderate strength mortar.(O and K are lower strengths yet, which is important in repair work so as not to create a mortar that is stronger than the wall/units where it is being placed). Various applications of mortar is shown in table 1.

Table 1: Application of Various Mortars

Location	Building Segment	Recommended Mortar	Alternative Mortar
Exterior, above grade	Load-bearing walls Non-load bearing walls Parapet walls	N O N	S or M N or S S
Exterior, at or below grade	Foundation walls, retaining walls, manholes, sewers, pavements, walks and partitions	S	M or N
Interior	Load-bearing walls Non-load bearing walls	N O	S or M N

1.3 High Performance Mortar

High performance mortar is a mortar mixture, which possess high durability and high strength when compared to conventional mortar. According to ASTM-C270, if the 28 days compressive strength of mortar is above 17.5 N/mm2 it is called as high performance mortar.

High performance mortar comprises of the same materials as that of the conventional cement mortar. The use of some mineral and chemical admixtures like Silica fume and Super plasticizer enhance the strength, durability and workability qualities to a very high extent.

High Performance mortar works out to be economical, even though its initial cost is higher than that of conventional mortar because the use of High Performance mortar in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs.

Hence it has been increasingly realized that besides strength, there are other equally important criteria such as durability, workability and toughness. And hence we talk about 'High performance mortar' where performance requirements can be different than high strength and can vary from application to application.

High Performance mortar can be designed to give optimized performance characteristics for a given set of load, usage and exposure conditions consistent with the requirements of cost, service life and durability. The high performance mortar does not require special ingredients or special equipments except careful design and production. High performance mortar has several advantages like improved durability characteristics and much lesser micro cracking than normal strength mortar. Various applications of mortar is shown in table 2.

Table 2: Benefits of High Performance Mortar

Performance Benefits	Cost & Other Benefits
• Ease of placement and consolidation without affecting strength • long-term mechanical properties • early high strength • toughness • volume stability • longer life in severe environments	• Less material • fewer beams • reduced maintenance • extended life cycle • aesthetics

1.4 Durability of Mortar

A long service life is considered synonymous with durability. Since durability is one set of conditions does not necessarily mean durability under another, it is customary to include a general reference to the environment when defining durability. According to ACI committee 201, durability of Portland cement mortar is defined as its ability to resist weathering action, chemical attack, abrasion, or any process of deterioration; that is durable mortar will retain its original form, quality, and serviceability when exposed to its environment.

1.5 Sulphate Attack

Sulphate attack is a chemical breakdown mechanism where sulphate ions attack components of the cement paste. The compounds responsible for sulphate attack are water-soluble sulphate-containing salts, such as alkali-earth (calcium, magnesium) and alkali (sodium, potassium) sulphates that are capable of chemically reacting with components of mortar.

2. Literature Review

The Salient characteristic of the high performance mortar were presented by the various authors form walks of life. In general it has been concluded that high performance possess relatively high strength and durability compared to ordinary mortar. The percentage reduction in compressive strength of high performance mortar after sulphate attack is reported to range between 25 to 40%.

Aitan Mohan Malhotra et al investigated the influence of mix proportions on the strength development and behavior of high strength mortars.

Chaid et al, had a study which aimed to test the properties of high performance mortars containing natural pozzolana. The durability of these materials was subjected to various conditions to which the samples were exposed was quantified by the change of strength, density, UPV and Vickers hardness. The environmental conditions were as follows: immersion in sea water, saturated sulphate solution (gypsum), running water and cyclical exposure to air/ water.

Dolui et al, done experimental study where the chloride ions are allowed to diffuse through mortar samples having three different water – cement ratios (0.4, 0.5, and 0.6) . The diffusion co efficient and permeability co efficient are determined from Fick's law of diffusion in steady state.

3. Experimental Programme

3.1 Materials used

*Cement:*Ordinary Portland cement of 53 grades was used conforming to IS 12269:1987. Various test result for cement is shown in table 3.

Table 3:Test results for cement

Test on cement	Result
Fineness	*1.2%*
Consistency	*28%*
Initial Setting Time	*29 minutes*
Final Setting Time	*609 minutes*
Specific Gravity	*3*

Fine aggregate: Locally available river sand of 2.36 mm size sieve passed of zone III, conforming to IS 383 – 1970. The specific gravity and fine modulus was found to be 2.69 and 2.75 respectively.
Water: Potable water was used for this investigation.

Mortar mix proportions: The mortar having constant mix proportion of 1:2 with three different W/C ratio of 0.2, 0.3 & 0.4 is used.

*Test specimen:*The steel cement mortar mould of size 70.6 mm X 70.6mm x 70.6mm is used to examine the compressive strength of mortar. The test procedures are conducted as per IS: 516-1979. 28day cement mortar specimen was tested. In each mix, three specimens were tested up to failure and the average load value is noted.

3.2 Test Methods

*Titration process:*The amount of sulphuric acid to be added in the immersed mortar cubes to maintain the initial normality of the solution is found by titration. The sample is taken in burette and it is titrated against sodium hydroxide solution of known normality. Phenolphthalein is added as an indicator and the end point is the disappearance of pink colour. Using this procedure amount of sulphuric acid is added for 0.3N, 0.5N& 1N normality are calculated.

*Percentage Loss in load carrying capacity :*The average loss in load carrying capacity for 28 days are calculated for mortar cube immersed in sulphuric acid of different normalities 0.3N, 0.5N & 1N with W/C ratio of 0.2, 0.3 & 0.4.

*Percentage Loss in Weight:*Difference in weight loss for 7, 14, 21 & 28 days are calculated for mortar cube immersed in sulphuric acid of different normalities 0.3N, 0.5N & 1N with W/C ratio of 0.2, 0.3 & 0.4.

SL. NO	SAMPLE	AVERAGE % LOSS IN LOAD CARRYING CAPACITY		
		0.3N	0.5N	1N
1	0.2	21.3	37.2	51.9
2	0.3	17.3	32.3	50.9
3	0.4	13.0	29.0	44.0

4. Test Results

4.1 Titration process

Amount of sulphuric acid for different normalities is shown in table 4.

Table 4: Amount of sulpuric acid for 0.3, 0.5 & 1 Normality

NORMALITY	AMOUNT OF SULPHURIC ACID ADDED (ML)
0.3N	8.5
0.5N	13.8
1N	28

4.2 Percentage in load carrying capacity

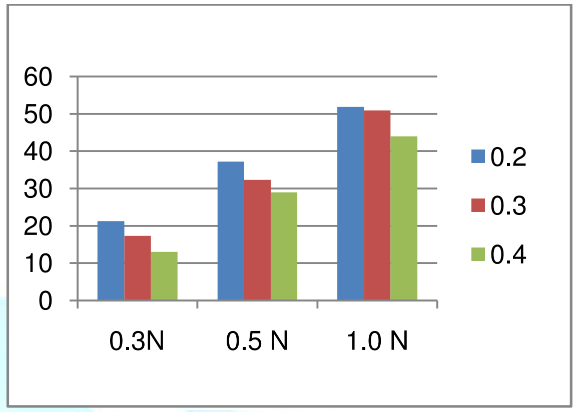
SL. NO	SAMPLE	AVERAGE LOAD CARRYING CAPACITY (N/ mm^2)		
		0.3N	0.5N	1N
1	0.2	10.86	8.83	6.63
2	0.3	9.70	8.33	5.93
3	0.4	9.86	8.03	6.10

Average load carrying capacity and percentage loss in load carrying capacity for mortar cube of W/C ratio 0.2, 0.3 and 0.4 is shown in table 5 & table 6 respectively for various noramilities.

Percentage loss in load carrying capacity for mortar cube of W/C ratio 0.2, 0.3 and 0.4 is shown in graph 1 for various noramilities.

Table 5: Average Load Carry Capacity for 0.3N, 0.5N & 1NSulphuric Acid at 28 Days

Table 6: Average % loss in load carry capacity for 0.3N, 0.5N & 1N sulphuric acid at 28 days



Graph 1. Comparison of average % loss in load carrying capacity for various normalities

4.3 Percentage in Weight Loss

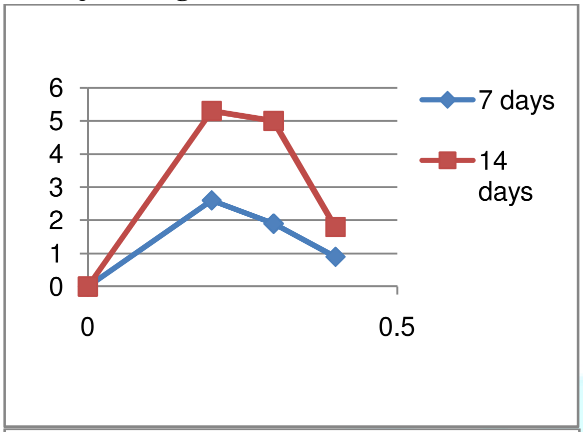
Percentage loss in weight for mortar cube of W/C ratio 0.2, 0.3 and 0.4 is shown in table 7, 8 & 9 for various noramilities at 7, 14, 21 & 28 days.

Percentage loss in weight for mortar cube of W/C ratio 0.2, 0.3 and 0.4 is shown in graph 2 (a) & (b), 3 (a) & (b) and 4 (a) & (b), various noramilities at 7, 14, 21 & 28 days.

Table 7: Average % weight loss for 0.3N in sulphuric acid at 7, 14, 21 & 28days

SL.NO	SAMPLE	AVERAGE % WEIGHT LOSS IN DAYS			
		7D	14D	21D	28D
1	0.2	2.6	5.3	5.6	13.2
2	0.3	1.9	5	4.3	10.4
3	0.4	0.9	1.8	2.1	5.8

Graph 2(a) & (b) Comparison of average % loss in weight for 0.3N at 7, 14, 21 & 28days



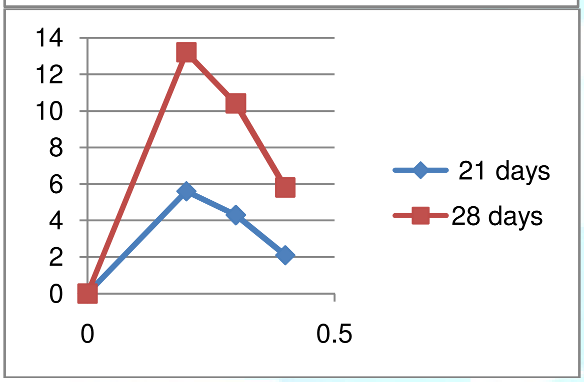
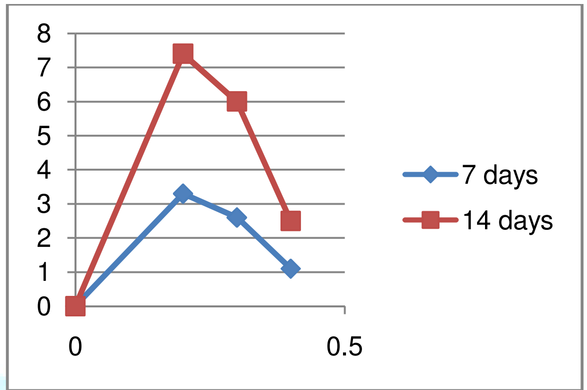


Table 8: Average % weight loss for 0.5N in sulphuric acid at 7, 14, 21 & 28days

SL.NO	SAMPLE	AVERAGE % WEIGHT LOSS IN DAYS			
		7D	14D	21D	28D
1	0.2	3.3	7.4	5.7	13.5
2	0.3	2.6	6.0	4.5	10.0
3	0.4	1.1	2.5	2.6	7.7

Graph 3(a) & (b) Comparison of average % loss in weight for 0.5N at 7, 14, 21 & 28days



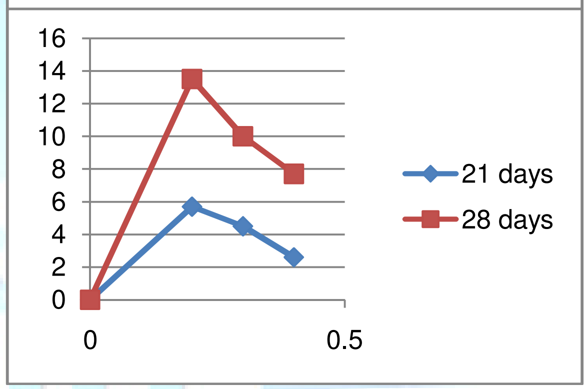
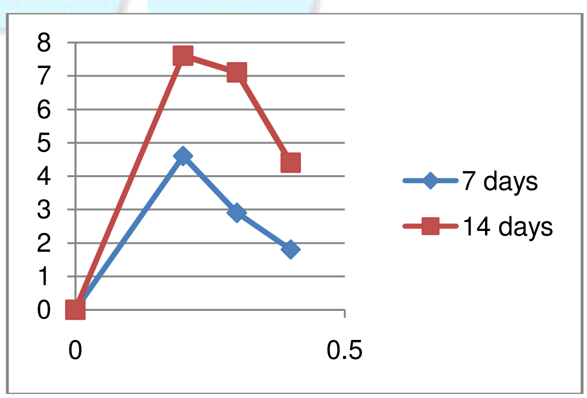
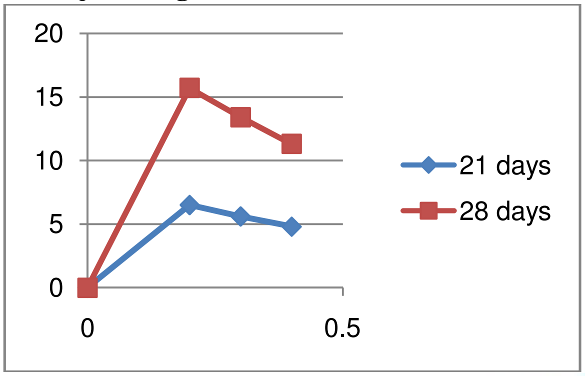


Table 9: Average % weight loss for 1N in sulphuric acid at 7, 14, 21 & 28days

SL.NO	SAMPLE	AVERAGE % WEIGHT LOSS IN DAYS			
		7D	14D	21D	28D
1	0.2	4.5	7.6	6.5	15.7
2	0.3	2.9	7.1	5.6	13.4
3	0.4	1.8	4.4	4.8	11.3

Graph 3(a) & (b) Comparison of average % loss in weight for 1N at 7, 14, 21 & 28days





5. Conclusion

• The mortar having constant mix proportion of 1:2 with three different W/C ratio of 0.2, 0.3 & 0.4 is used.
• The normalities in which the mortar cubes are immersed are 0.3, 0.5 and 1.0.
• It has been observed that sulphate present in sulphuric acid affects the weight and load carrying capacity of the normal mortar more than the high performance mortar.
• The affect of sulphuric acid for mortar is found to be less when the water cement ratio is higher. In 0.3N for 0.2W/C ratio it ranges from 2.6% to 13.2% for 0.3W/C it ranges from 1.9% to 10.4 % and for 0.4W/C it ranges from 0.9% to 5.8 %. In 0.5N for 0.2W/C ratio it ranges from 3.3% to 13.5% for 0.3W/C it ranges from 2.6% to 10 % and for 0.4W/C it ranges from 1.13% to 7.7 %. In 1.0N for 0.2W/C ratio it ranges from 4.53% to 15.7% for 0.3W/C it ranges from 2.9% to 13.4 % and for 0.4W/C it ranges from 1.8% to 11.3 %
• From the results it is understood that, the higher the W/C ratio leads to less % loss in load carrying capacity. For 0.2 W/ ratio it ranges from21.3% to 51.9% and for 0.3 W/C ratio 17.3% to 50.9% and for 0.4 W/C ratio 13% to 44% for different normalities.

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