Effect of Chemical Admixtures on the Performance of Strength of Cement Mortar Cubes

Harish V.

Assistant Professor,
Civil Engineering Department,
R. R. Institute of Technology, Chikkabanavara, Bengaluru, India

Kanakabandi Shalini

Assistant Professor,
Civil Engineering Department,
R. R. Institute of Technology,
Chikkabanavara, Bengaluru, India

Gurubasavaraja S. G.

Assistant Professor,
Civil Engineering Department,
R. R. Institute of Technology,
Chikkabanavara, Bengaluru, India

ABSTRACT

To increase the strength and stability of concrete, chemicals and admixtures play a important role in modifying the desired properties in any design mix. The development of these admixtures in their performance contributed a lot to the modern concrete over the conventional concrete. In the present study, effect of admixtures is considered to evaluate their performance on strength with their respective optimum dosages. Cement mortar cubes tested for 3 days, 7 days and28 days with standard water–cement ratio determined from the standard consistency test of cement paste following IS procedures reveal notable improvements in the strength. This study highlights the minimum water–cement ratio required in each category of the admixture, and its effect on strength is discussed.

Keywords: Admixture, Strength, Performance

INTRODUCTION:

Admixtures are the widely used additives in modern concrete to produce high performance concrete. The addition of these admixtures in the conventional concrete modifies the desired properties in fresh or green stage of concrete. The availability of admixtures can be categorized into many types; however, water reducers, accelerators and retarders have a wide range of applications in the construction field. The combination of more than one admixture in required dosages shall yield a high-performance concrete. Hence, laboratory experiments are carried out before the application of these admixtures in the field to determine the behaviour on properties of concrete in green state. The present study includes experimental tests to observe the behaviour of performance of low, medium and high end admixtures on the strength, Auramix 201, Auramix 300 plus, Auramix 402 and Auramix450 are six different admixtures having different chemical compositions used in this study. The Auramix series chemical admixtures are second-generation admixtures based on polycarboxylic ethers. Compressive strength being the most important property of concrete makes it necessary to determine the effect of modern admixtures on strength. Studies have shown that factors affecting strength include quality of materials and the water–cement ratio. Hence, admixtures are added to produce workable mix keeping water–cement ratio as low as possible in order to achieve high-performance concrete. Generally, test cubes of standard sizes are tested to determine the compressive strength. The present study aims at determining the strength of cement mortar cubes with the addition of optimum dosage of admixtures. The study reveals clear differentiation of strength for 3 days, 7 days and 28 days of cement mortar with the use of different admixtures enlisted above. Studies were carried out under controlled environment as per relevant IS codes.

MATERIALS AND METHODOLOGY:

Materials:

Laboratory experiments were carried out to determine the strength of cement mortar cubes having 70.6 mm size using admixtures. The materials included are cement, standard sand, water and admixture. The detailed description of these materials and the apparatus used are listed below:

Cement: Cement is manufactured from calcareous materials and is found to be the most reactive material when it is in contact with water. All the tests were carried out using OPC 43 grade cement conforming to IS 8112: 2013 (43 grade) of 38th week. The cement was sieved through 90 µm standard sieve to have a uniform sample.

Standard Sand: Standard manufactured sand corresponding to IS 650: 1991(reaffirmed 2008) was used in all the experiments. The standard manufactured sand consists of three different grades. Equal proportions of these grades, i.e., particles smaller than 2 mm and greater than 1 mm, particles having size smaller than 1 mm and greater than 500 µm and particles having size below 500 µm and greater than 90 µm, were used.

Water: Fresh and clean water corresponding to IS 456: 2000 was used in all the experimental tests. Standard water–cement ratio was found to be 0.4 for OPC 43 grade UltraTech cement as determined from.

Table 1: Parameters analyzed

S. No	Admixture	Minimum w/c ratio	Optimum flow achieved (s)	Admixture dosage (%)			
				0.5	0.6	0.7	0.8
1	Auramix 450	0.4	18.54	19.74	19.44	19.02	18.54
2	Auramix 402	0.4	19.32	20.62	20.43	19.32	20.1
3	Auramix 300 plus	0.4	22.51	22.51	23.27	23.34	23.89
4	Auramix 201	0.4	17.35	18.75	17.72	17.35	17.98

Table 2: Parameters Finalised

S. No	Admixture	Minimum w/c ratio	Optimum w/c ratio	Optimum admixture dosage (in %)	Optimum flow achieved (s)
1	Auramix 450	0.4	0.41	0.8	18.54
2	Auramix 402	0.4	0.51	0.7	19.32
3	Auramix 300 plus	0.4	0.43	0.5	22.51
4	Auramix 201	0.4	0.42	0.7	17.35

Chemical admixtures: The chemical admixtures used in the study were Auramix 201 and Auramix 300 Plus identified as medium end admixtures and Auramix 402 and Auramix 450 identified as high end admixtures as per the data provided by Fosroc Constructive Solutions

Admixtures applicable to IS 9103 were used for the analysis of all the test cubes. The optimum dosage of all the four different chemical admixtures is given in Table. The chemical admixtures used in the study were Auramix 201 and Auramix 300 Plus identified as medium end admixtures and Auramix 402 and Auramix 450 identified as high end admixtures as per the data provided by Fosroc Constructive Solutions

Apparatus:

The strength test of all the analysis was carried out using different apparatus. The detailed description of the main apparatus used in the present study is discussed as follows:

Cube molds:

Cube molds of size 70.6 mm × 70.6 mm × 70.6 mm of high-level accuracy with ISI certification mark along with a base plate was used for all the experiments. All the molds were applied with mold releasing oil to avoid rusting and to give a smooth and easy removal of the cubes.

Tamping rod and vibration machine:
The molds were filled in three different layers. The mix was compacted by temping with a rod for 25 times per layer. The mix was vibrated on a vibration table as per procedure laid down to achieve full compaction.

METHODOLOGY:

The methodology adopted for the present study was divided into two parts. In the first part or preliminary test, Marsh cone test was performed for water–cement ratios varying from 0.2 to 0.6 and admixture dosage varying from 0.3 to 1.5% by weight of cement at an interval of 0.3 to determine the minimum water–cement ratio required for the respective admixture to perform. Optimum water–cement ratio and optimum admixture dosage for corresponding flow value were also determined from this test. In the second part, the strength of cement water cubes was tested with the optimum admixture dosage values determined from the Marsh cone test. This test included a mixture of cement and standard sand with standard water–cement ratio of 0.4 of the cement used corresponding to IS 4031 (Part 6): 1988 and optimum dosage of admixture.
Typical test procedure to determine the performance of admixture on strength had the following steps;

(a) Dry mix of cement and standard sand in the proportion of 1:3 was prepared.
(b) Taking water–cement ratio as 0.4 admixture was added to water.
(c) Care was taken to see that the mortar prepared was homogeneous through the process of mechanical mixing.
(d) Prepared mortar was filled in the molds in three layers, each layer being tampered 20–25 times with the tamping rod.
(e) Prepared samples of molds were vibrated as per code to achieve full compaction.
(f) Cubes were cured in freshwater curing tank.
(g) Strength of 3 days, 7 days and 28 days was recorded.
(h) Tests were also conducted for mid and high end admixtures.
(i) All readings were recorded for reference.

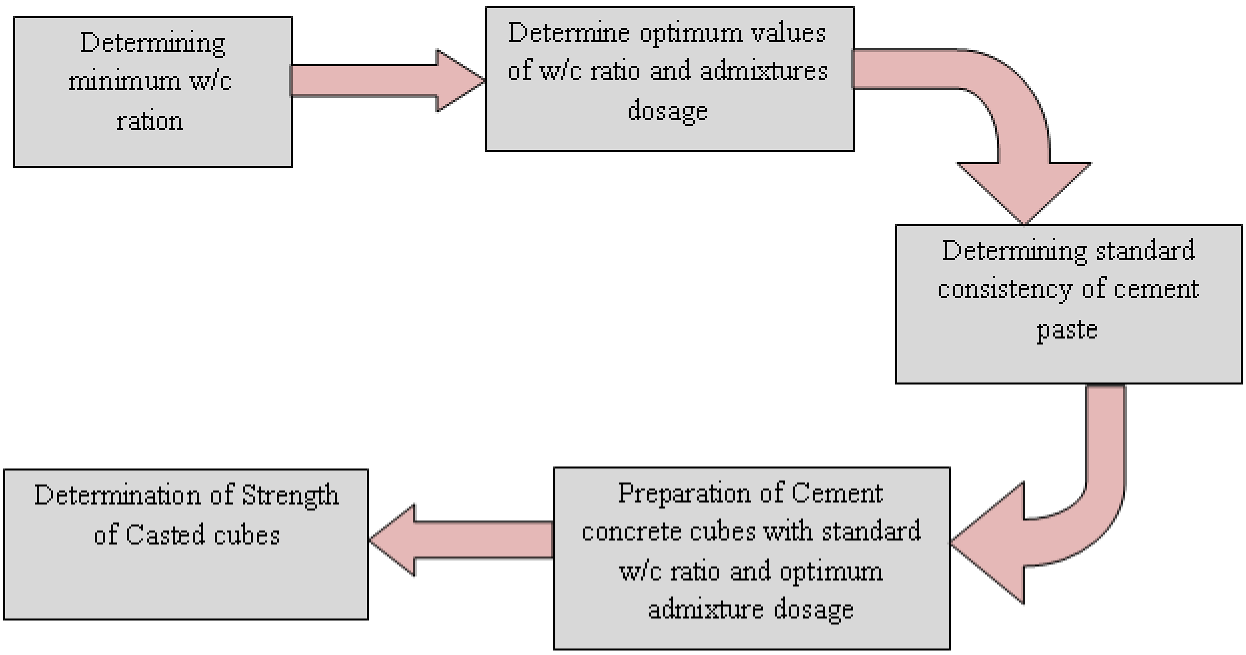

Figure 1: Methodology

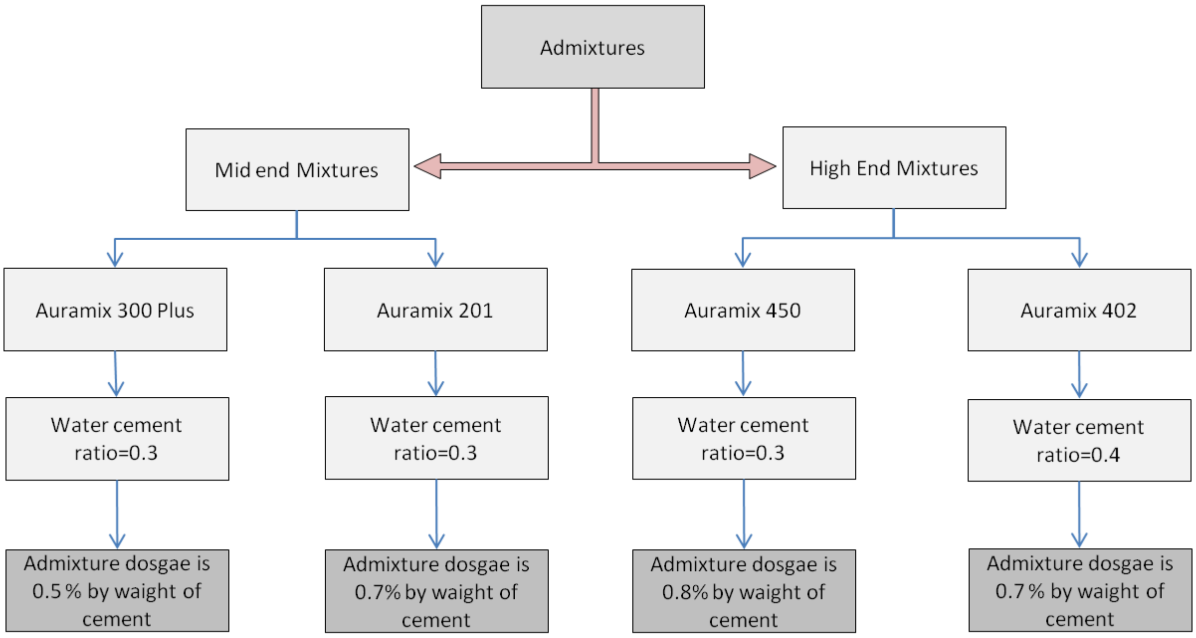

Figure 2 : Flowchart of the methodology proposed of strength test

RESULT INTERPRETATION:

Based on the analysis performed on all the admixtures under controlled environmental conditions following IS procedures, the results are summarized and discussed in the subsequent chapter. The minimum water–cement ratio required for the performance of admixture determined from the Marsh cone test is tabulated in Table. From the experiments conducted, it was observed that the optimum dosage of the admixtures used ranged from 0.8 to 0.5% by weight of cement. Hence, this study highlights the behaviour of flow values corresponding to 0.8% and 0.5% of admixture dosage. Saturation point on the flow curve is the optimum admixture dosage corresponding to the admixture used. Up to the saturation point, the flow value reduces at a high rate, but beyond this point there is a nominal reduction in the flow value.
Referring to Table1 and 2, it can be seen that the optimum dosage value of Auramix 201 and Auramix 450 is 0.8% by weight of cement used, whereas

Table 3: Average cube strength of cement concrete

Description	Strength in N/mm^2		
	3 days	7 days	28 days
Without admixture	27.65	35.87	54.45
Auramix 201	25.51	34.80	53.90
Auramix 300 plus	24.22	36.65	55.67
Auramix 402	26.50	34.58	56.76
Auramix 450	28.05	37.43	56.15

Plus and Auramix 402 is 0.6% by weight of cement used. Referring to Table 3, the behaviour of strength curve observed was similar for all the mortar mix prepared. Marginal improvement in the strength of cement mortar cube in comparison medium and high end admixtures for 3 days, 7 days and 28 days is observed. From results it is observed that Auramix 450 has the highest strength compared to the strength of cubes containing other admixtures. It is also observed that the high end admixtures show higher strength in comparison with medium end admixtures.
The performance of cube strength inclusive of medium end admixtures was found to be similar to the performance of cube strength without the addition of any admixtures. However, in this case, it is observed that the performance of cubes containing low end admixtures has underperformed.

CONCLUSIONS:

From the above experimental study, the following conclusions are drawn:

1. The required standard water–cement ratio for OPC 43 grade is 0.4.
2. From the above study, it can be concluded that the addition of admixtures does not yield high performance on the strength of mortars in comparison with the cubes tested without any addition of admixtures. However, high end admixtures show exhibited improvement as compared to medium and low end admixtures.
3. The low end admixtures have underperformed in comparison with the performance without the use of admixtures.
4. The performance of medium end admixtures is similar to that without the use of admixtures.

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