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Fluidity of Cement Pastes with Admixtures and Super Plasticizer

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Abstract: *The Marsh cone is a simple device for measuring viscosity by observing the time it takes for a known volume of liquid to flow from a cone through a short tube. It is standardized for use by mud engineers to check the quality of drilling mud. Other cones with different geometries and orifice arrangements are called flow cones, but have the same operating principle. The Marsh Cone (SS with Stand) is a simple device used for routine quick measurements of fluid viscosity. It's a type of viscometer. It is an excellent indicator of changes in drilling fluid properties. The Marsh Funnel conical in shape - 152 mm in diameter at the top and 305 mm long with a capacity of 1,500 cm3. A 12- mesh screen covers half of the top and is designed to remove any foreign matter and drilled cuttings from the fluid. The fluid runs through a fixed orifice at the end of the funnel, which is 50mm long by 4.7 mm diameter in size..*

Keywords: Fluidity

I. INTRODUCTION

1.1 Review Stage Importance of Aggregate

The flow cone test (Scanlon 1994) is intended for use in measuring the flow properties of grout for preplaced-aggregate concrete, but can also be used for other highly flowable grouts. The test is standardized in ASTM C939 and is considered appropriate for use in both the field and the lab. To perform the test, grout is poured into the flow cone. The level indicator is used to ensure that a standard volume of grout is used for each test. The opening at the bottom of the cone is opened and the time for the grout to flow out of the cone is recorded. The test is not considered applicable to grouts that become clogged in the cone and do not continuously flow out the opening. Test results for such mixtures should be discarded.

The Marsh cone test (Zhor and Bremner 1998; Ferraris, Obla, and Hill 2001) is a non-standard test most typically used for oil well cements. The Marsh cone is a funnel with a long neck and an opening of 5 mm. A stand holds the Marsh cone in place above a glass graduated cylinder. After one liter of cement paste is placed in the cone, the orifice at the bottom of the neck is opened. The time for various volumes of paste to flow out of the orifice is measured. Since the weight of the cement paste in the funnel should be sufficient to overcome the yield stress, the time of flow should be related to viscosity.

1.2 Reason to use Marsh Cone

- Marsh cone test is reliable and simple method to study the rheological properties of cements and mortars.
- Flow time of cement/mortar through marsh cone is indicator of viscosity, which depends upon cement super plasticizer compatibility.
- It is widely used to study cement super plasticizer compatibility and to determine optimum super plasticizer dosage of a specific cement-super plasticizer combination
- The Marsh cone test is a workability test used for specification and quality control of cement pastes.
- Marsh cone test standard varies from one country to another, but its principle is usually the same
- The time needed for a certain amount of material to flow out of the cone is recorded. This measured flow time is linked with the fluidity of the tested material.
- The concept is simple The longer the flow time, the lower is the fluidity

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- The Marsh cone test is a simple approach to get some data about cement pastes behaviour. It is used in cement based materials mix design in order to define the saturation point, i.e. the dosage beyond which the flow time does not decrease appreciably.
- The cone is filled with the fluid material while the nozzle is kept closed. When the cone is filled with measured quantity of fluid, the nozzle is opened and the fluid is allowed to flow freely.
- The time needed for measured quantity of material to flow out is recorded as Marsh cone time.
- The saturation point is defined as the chemical admixture dosage beyond which the flow time dose not decrease appreciably.
- The dose at which the Marsh cone time is lowest is called the saturation point. The dose is the optimum dose for that brand of cement and admixture (plasticizer or super plasticizer) for that w/c ratio
- The addition of super plasticizers with mineral admixtures like fly ash, etc. to concrete imparts a high strength and workability to it, even at very small water cement ratios. But to get the maximum benefit from this amalgamation of concrete and admixtures, the incompatibility issues between these two need to be studied.
- In the present work, the aim is to find the optimum dosage for different super plasticizers, for a particular grade of cement, using Marsh Cone test. The results of these rheological tests conducted on the cement slurry are analyzed graphically to find the optimum dosage of a super plasticizer and its compatibility with the concrete.

1.3 Advantages of Marsh Cone Test

- Marsh cone test is reliable and simple method to study the rheological properties of cements and mortars. Flow time of cement/mortar through marsh cone is indicator of viscosity, which depends upon cement super plasticizer compatibility.
- Marsh cone test is used to formulate the optimum dose of particular admixture to the cement thereby avoiding cement-admixture incompatibility. For high Strength concrete and high performance concrete, depending on location i.e. distance of site from the plant, the retention time of the concrete plays important role.
- Marsh cone test is reliable and simple method to study the rheological properties of cements and mortars. Flow time of cement/mortar through marsh cone is indicator of viscosity, which depends upon cement super plasticizer compatibility. There are three tests to find the optimum amount of super plasticizer for concrete. They are
  - Marsh cone test
  - Mini-slump test
  - Flow table test
- Marsh cone test is a reliable and simple method to study the rheological Properties of mortar and cement.
- In marsh cone test, the cement slurry is prepared and its flow ability is measured. Out of the above three tests, marsh cone test gives the best value for flow ability. Flow time of cement slurry or mortar though marsh cone is an indicator of viscosity which depends upon cement super plasticizer compatibility.
- The flow ability is undoubtedly influenced by the mixing time of SP addition, and testing with other time intervals for the addition of SP and/or adding different percentage amounts could result in a more accurate saturation point value. In this case, the measurement results are influenced by the time of SP addition, but this way is not necessarily more accurate.
- However, in order to obtain a greater precision in the testing times, the tests were recorded on video and later, from these videos the different testing times were determined.
- A correlation was found between the results obtained using the Marsh cone test and the concrete mixer method.
- Through both methods, it is possible to determine the same saturation point in terms of the SPA/C value, from either the time, in the case of the Marsh cone test, or the minimum value of the mixer power consumption, in the case of the concrete mixer method. In addition, through both methods, a significantly greater eject can be seen when the SPA/C is less than 1%, from which point the eject decreases until approximately 2%, where the eject is almost zero.
- If concrete mixer method results are correlated with the slump flow test results, it can be seen that results proportional to those of t500 and inversely proportional to D were obtained. In this test, it is also possible to

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detect that the eject of the SPA/C is greater up to the value of 2%, a value defined as the saturation point both by the Marsh cone method and by the concrete mixer method.

- If the concrete mixer method results are correlated with the L-box test results, it is not possible to determine a proper correlation. This is because the L-box test evaluates the passing capacity of concrete while the concrete mixer method evaluates the flow ability of concrete.
- For this reason, the concrete mixer method is not a direct alternative for the L-box test, since the concrete mixer method does not enable the evaluation of whether there is segregation. Since segregation implies that either there is an excess amount of water or that the SPA no longer interacts with the concrete but remains on its surface, it is understood that segregation is only possible in the section where the maximum power consumption value is already stabilized. Therefore, if progressively greater quantities of SPA are added, the onset of segregation could be predicted.
- If the concrete mixer method results are correlated with the V-funnel tests results, as both methods evaluate the flow ability of concrete, it can be appreciated that there is a direct relationship between the two methods.

II. PICTORIAL REPRESENTATION

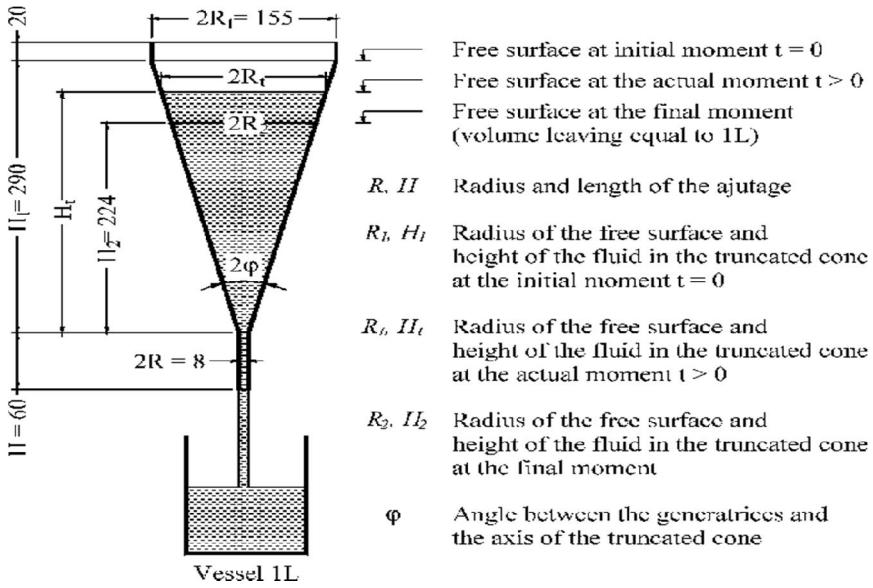

Figure 1: Basic Dimension of the Cone (Figure A)

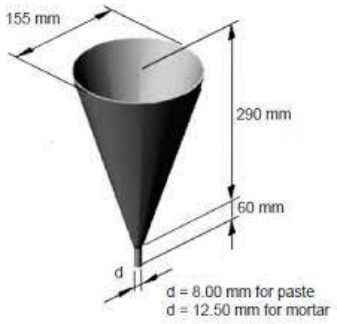

Figure 2: Basic Dimension of the Cone (Figure B)

Figure 3: Front View of the Cone

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2.1 Procedure

- Marsh cone test is a test for finding the optimum dosage of plasticizers and superplasticizers for different types of cement.
- The amount of plasticizers added to concrete ranges from 0.1 to 0.5 % of the total weight of cement.
- The Marsh cone test is a workability test used for specification and quality control of cement pastes. Marsh cone test standard varies from one country to another, but its principle is usually the same.
- The time needed for a certain amount of material to flow out of the cone is recorded. This measured flow time is linked with the fluidity of the tested material. The longer the flow time, the lower is the fluidity.
- The Marsh cone test is a simple approach to get some data about cement pastes behaviour. It is used in cement based materials mix design in order to define the saturation point, i.e. the dosage beyond which the flow time does not decrease appreciably.
- The cone is filled with the fluid material while the nozzle is kept closed. When the cone is filled with measured quantity of fluid, the nozzle is opened and the fluid is allowed to flow freely.
- The time needed for measured quantity of material to flow out is recorded as Marsh cone time.
- The saturation point is defined as the chemical admixture dosage beyond which the flow time dose not decrease appreciably. The dose at which the Marsh cone time is lowest is called the saturation point.
- The dose is the optimum dose for that brand of cement and admixture (plasticizer or superplasticizer) for that w/c ratio.
- Steps involving the Marsh cone test are as follows-
- First, you need to prepare a cement paste of 1L with a desired water-cement ratio by adding 2kg of cement to them.
- While preparing the cement paste, the mixing should take place in the mortar mixer. The mortar mixer is used to avoid the formation of lump at the bottom of the vessel.
- You can take water cement ration ranging from 0.3 to 0.5.
- 70 percent of water is added at the beginning of mixing in the first step and the remaining water is added in the second step with superplasticizers. The dosage of superplasticizer will be 0.1 percentage of the weight of cement.
- Take 1L slurry and pour into marsh cone by closing the aperture with a finger.
- Start the stop and remove the finger. Note the time taken in seconds for complete flow out of cement paste. This time in seconds is called marsh cone time.
- Repeat the above steps with different amount of plasticizer with the desired water-cement ratio. The Saturation point is the dose at which marsh cone time is lowest. This dose is the optimum dose of super plasticizer of plasticizer for that brand or type of cement.
- Observations for 0 minutes, 15 minutes and 60 minutes retention period are taken.
- You can do this experiment with different type of cement and find out the right amount of plasticizer for your brand of cement.
- Optimum dose of chemical admixture varies with the type of the chemical admixtures as well as type of cement and w/c ratio.
- As w/c ratio decreases, the optimum dose of admixture expressed as percentage of cement in concrete mix increases.
- Mostly optimum admixture dose expressed as percentage of cement in concrete.

2.2 How to Determine the Saturation Point of the Super Plasticizer

- Saturation point of superplasticizer (SPS): the SP dosages are calculated by the relationship between the amount of cement and the solid content of the superplasticizer, defined in percentage terms (% SP/c).
- The SPS is defined as the percentage of superplasticizer from which, even adding more SP, the improvement in paste flow characteristics is insignificant and may even be impaired .
- The graphs representing the flow test of the pastes and mortar using the Marsh cone generally have well-defined behavior and approximate to a decreasing exponential curve, where the x-axis is the percentage of SP and the y-

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axis is the flow time (Fig. 1). The SPS is located at the point near the horizontal asymptote of the flow curve. It is verified that the SPS is a reference point that can be found in the interval of the change of direction of the flow curve, and it can be considered as any point within this region.

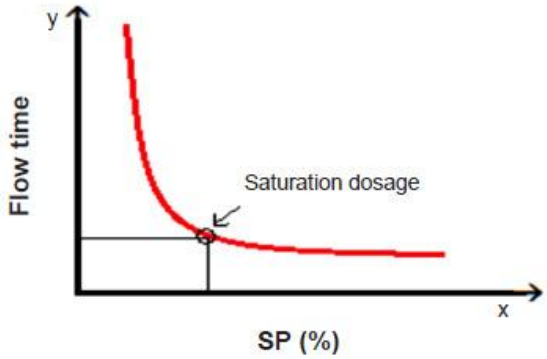

Figure 4: Location point of saturation of the super plasticizer (SPS).

- The concrete dosage is defined by fix amount of materials, and for this reason, the determination of a single reference point for the SPS is important.
- Therefore, to determine the SPS location in the curve, it is necessary an accurate methodology.
- For this reason, some methods were proposed and can be found in the literature: Aïtcin 6, AFREN De Larrard 7, Gomes 10, and that suggested by ASTM C939/2010 18 (Fig. 3).
- The method of Aïtcin 6 consists of the repetition of the Marsh cone test in times of 5 to 30 min.
- The intersection point of the lines that represent the tests in these times determines the SPS (Fig. 3a).
- This method is characterized for analyzing the paste fluidity loss, which is important when a longer time of applications is required, mainly, on the compatibility analyses among the paste's constituent materials. It was observed that this method does not consider any mathematical model that defines the SPS objective

III. Experimental Work

3.1 Material Used

A. Cement

Table 1: Physical Properties of Birla Shakti OPC 43 Grade Cement

Sr. No	Properties	Value	Requirements of IS:8112 1989
1	Specific Gravity	3.15	-
2	Standard Consistency	30%	-
3	Initial Setting Time	103 min	Min 30 min
4	Final Setting Time	231 min	Max 600 min
5	Soundness	2.5	Less than 10%
6	Fineness	8.5	Less than 10%
7	Compressive strength (N/mm^2)		
	3 Days	29.71	Not less than 22 N/mm^2
	7 Days	39.67	Not less than 33 N/mm^2
	28 Days	51.64	Not less than 43 N/mm^2

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B. Chemical Admixture

1. Algisuperplast N
2. Armix Plast 111
3. Masterrheobule 1126SM

C. Procedure

- First, you need to prepare a cement paste of 1L with a desired water-cement ratio by adding 3kg of cement to them.
- While preparing the cement paste, the mixing should take place in the mortar mixer. The mortar mixer is used to avoid the formation of lump at the bottom of the vessel.
- You can take water cement ration ranging from 0.3 to 0.5.
- 70 percent of water is added at the beginning of mixing in the first step and the remaining water is added in the second step with super plasticizers. The dosage of super plasticizer will be 0.1 percentage of the weight of cement.
- Take 1L slurry and pour into marsh cone by closing the aperture with a finger.
- Start the stop and remove the finger. Note the time taken in seconds for complete flow out of cement paste. This time in seconds is called marsh cone time.
- Repeat the above steps with different amount of plasticizer with the desired water-cement ratio. The Saturation point is the dose at which marsh cone time is lowest. This dose is the optimum dose of super plasticizer of plasticizer for that brand or type of cement.
- Observations for 0 minutes
- You can do this experiment with different type of cement and find out the right amount of plasticizer for your brand of cement.
- Optimum dose of chemical admixture varies with the type of the chemical admixtures as well as type of cement and w/c ratio.
- As w/c ratio decreases, the optimum dose of admixture expressed as percentage of cement in concrete mix increases.
- Mostly optimum admixture dose expressed as percentage of cement in concrete.

IV. Result Analysis

4.1 Results of Algisuperplast N

Table 2: Results of Algisperplast

Sr. No	Cement (Kg)	W/C Ratio	Admixture Dosage (%)	Marsh Cone Time	
				0 Min Retention (Sec)	60 Min Retention (Sec)
1	2.00	0.50	0.00	116.87	117.47
2	2.00	0.50	0.20	67.230	59.42
3	2.00	0.50	0.40	64.610	54.23
4	2.00	0.50	0.60	60.180	53.94
5	2.00	0.50	0.80	58.054	52.44
6	2.00	0.50	1.00	58.000	50.19
7	2.00	0.50	1.20	59.010	51.12
8	2.00	0.50	1.40	57.270	51.23
9	2.00	0.50	1.60	59.430	51.29
10	2.00	0.50	1.80	58.410	52.01
11	2.00	0.50	2.00	58.500	53.27

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4.2 Results of Armix Plast 111

Table 3: Results of Armix Plast 111

Sr. No	Cement (Kg)	W/C Ratio	Admixture Dosage (%)	Marsh Cone Time	
				0 Min Retention (Sec)	60 Min Retention (Sec)
1	2.00	0.50	0.00	128.35	123.15
2	2.00	0.50	0.20	94.28	93.22
3	2.00	0.50	0.40	86.21	85.47
4	2.00	0.50	0.60	84.95	83.65
5	2.00	0.50	0.80	80.64	79.24
6	2.00	0.50	1.00	73.18	76.54
7	2.00	0.50	1.20	72.24	73.47
8	2.00	0.50	1.40	74.11	78.24
9	2.00	0.50	1.60	76.24	81.94
10	2.00	0.50	1.80	76.18	81.24
11	2.00	0.50	2.00	78.94	81.64

4.3 Results of Masterrheobule 918

Table 4: Results of Masterrheobule 918

Sr. No	Cement (Kg)	W/C Ratio	Admixture Dosage (%)	Marsh Cone Time	
				0 Min Retention (Sec)	60 Min Retention (Sec)
1	2.00	0.50	0.00	122.61	120.31
2	2.00	0.50	0.20	80.755	76.32
3	2.00	0.50	0.40	75.41	69.85
4	2.00	0.50	0.60	72.565	68.795
5	2.00	0.50	0.80	69.347	65.84
6	2.00	0.50	1.00	65.125	62.295
7	2.00	0.50	1.20	63.27	60.15
8	2.00	0.50	1.40	66.19	64.735
9	2.00	0.50	1.60	67.835	66.615
10	2.00	0.50	1.80	67.295	66.625
11	2.00	0.50	2.00	68.72	67.455

4.4 Discussion on Result Analysis (Graphical Representation)

A. Algisuperplast N

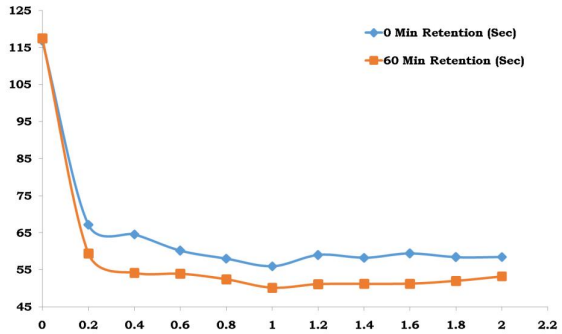

Figure 5: Graphical Representation of Algisuperplast N

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B. Results of Armix Plast 111

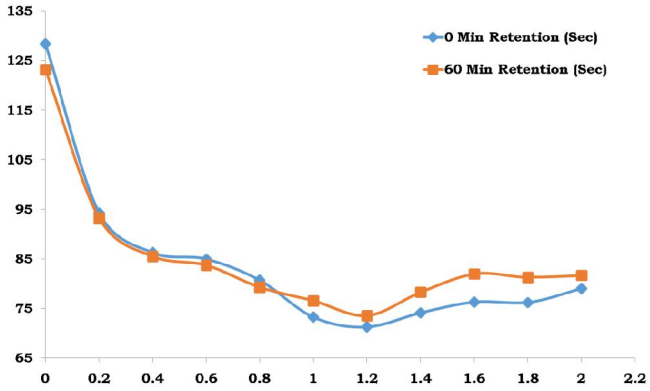

Figure 6: Graphical Representation of Armix Plast 111

C. Results of Masterrheobule 918

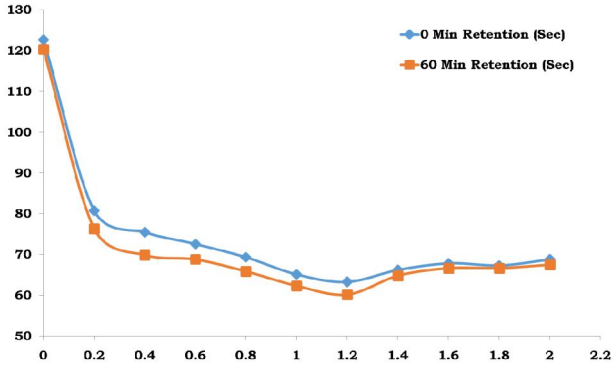

Figure 7: Graphical Representation of Masterrhe0bule 918

V. CONCLUSION

- Optimum dose of chemical admixture varies with the type of the chemical admixtures as well as type of cement and w/c ratio.
- As w/c ratio decreases, the optimum dose of admixture expressed as percentage of cement in concrete mix increases.
- Mostly optimum admixture dose expressed as percentage of cement in concrete mix decreases with increase in retention time.
- The reaction between Birla Shakti OPC 43 Grade with Conplast SP 440 is less time consuming as compared to the reaction between Birla Shakti OPC 43 Grade and Armix Plast 111 & Masterrheobule 918 admixtures, for 0 minutes retention.
- For Birla Shakti OPC 43 Grade, Algisuperplast N is more reactive than Armix Plast 111 & Masterrheobule 918.

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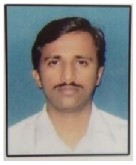
BIOGRAPHY

Ms. Mousami Shinde completed her Bachelor Degree in 2016 from KIT College of Engineering, Kolhapur. She is pursuing her M.Tech Civil and Structural Engineering from the same institute. Her area of interest is Concrete Technology and RCC Structural Design. She has an industrial experience of 4 years.



Mr. S. M. Kolekar is working as an Assistant Professor in KIT College of Engineering (Autonomous), Kolhapur. He is pursuing PhD from VTU, Belgaum. His areas of interests are Concrete Technology and Structural Analysis. He published 7 international journal papers. His total teaching experiences 20 year.

Mr. A. B. Sawant is working as an Assistant Professor in KIT College of Engineering (Autonomous), Kolhapur. Completed masters in Civil Construction and Management from Government College of Engineering, Karad. His areas of interests are Concrete Technology and Construction Management. Received grant for Research Project under Research Initiation Scheme by Shivaji University, Kolhapur. He published 32 international journal papers and attended 10 National and International Conferences. His total teaching experiences 20 year.