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SELECTION OF TEST METHOD TO QUANTIFY WORKABILITY OF CEMENT PASTE AND MORTAR FOR VERY LOW WORKABLE TO HIGH WORKABLE MIX

Parth Thaker*, N K Arora
*Assistant Professor, Faculty of Technology, CEPT University, Ahmedabad, Gujarat, India
**Professor and Principal, L.E.College of Engineering, Morbi, India.

ABSTRACT

Cement paste and mortar fresh properties governs concrete characteristics.Selection of test method to measure workability is based on mix characteristic. Very low workability mix test method differs from the high workable mix.First attempt was made by authors to develop correlation between two tests and cover entire range of workability i.e. from very low to high workable mix. Mini flow table testand marsh cone test were selected for cement pasteand mortar.Marsh cone test is applicable beyond W/C ratio 0.50 for cement paste. Mini flow table test shows same flow diameter above W/C ratio 0.50 for cement paste. It is possible to evaluate flow behaviour of cement paste up toW/C ratio 0.62 by modifying cement paste cone volume.Marsh cone test was applicable beyondW/C ratio 0.72 for cement mortar having cement to fine aggregate proportion 1:1. Mini flow table test has diameter 250mm which is useful to measure low to medium workable mix of mortar. High workable cement mortar mixture spread is more than 250mm therefore it is necessary to do dimension change in mini flow table test. Modified mini flow table test having diameter of 450mm was applicable for entire range i.e. very low to high workable mix.

KEYWORDS: Workability tests, Cement paste and mortar, Mini flow table test, Marsh cone test

INTRODUCTION

Fresh properties of cement paste and mortar such as workability, flowability and cohesiveness governs the concrete characteristics. Therefore, measurement of fresh properties of cement paste and mortar is the area of the interest for many researchers. Various test methods has been developed to measure workability of cement paste, mortar and concrete. Many researchers have given classification of workability tests based on principle of measurement. Tattersall (1991) has divided workability measurement tests in three classes as shown in Figure 1. According to tattersall classification majority workability measurement tests has been covered in class –II and III.

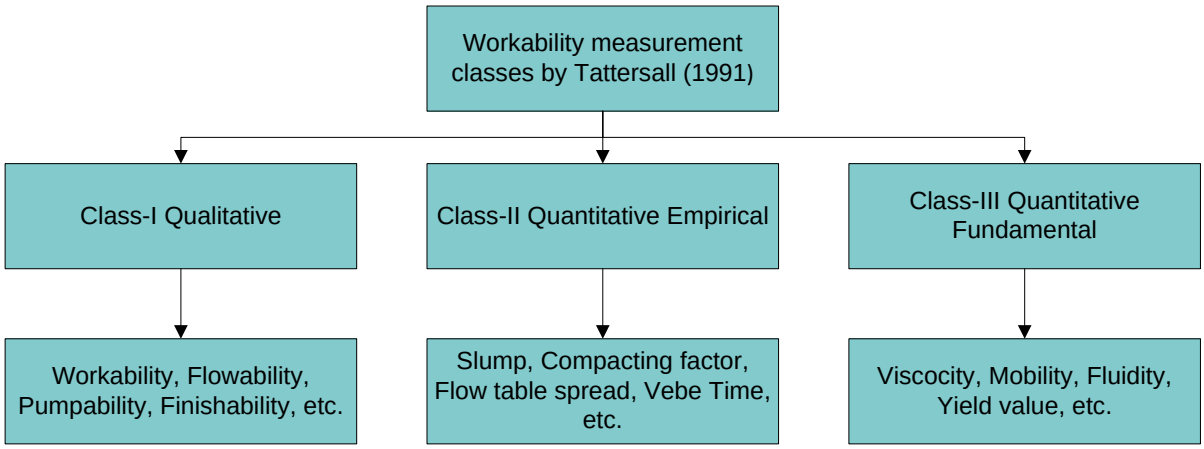

Figure 1 Classification of workability test by Tattersall

Hackley and Ferraris (2001) have classified workability tests in four categories as per flow behaviour such as confined flow test, free flow test, vibrating flow tests and rotational rheometers. Measurement of workability test selection depends on type of mix. Agull et al. (1999) have studied the fluidity of cement paste based on marsh cone test. Marsh cone test, mini spread test and rheometer were used to understand flow behaviour of superplasticized cement paste by Jayashree and Gettu (2008). Mini conical slump flow test and marsh cone tests were performed to develop numerical approach by Bouvet et al (2010). Chandra and Björnström (2002) wereused mini flow table test to study theinfluence of cement and superplasticizers type and dosage on the fluidity of cement mortars. Harini et al. (2012) have investigated effect of size and type of fine aggregates on flowability of mortar with use of mini flow table test.

Marsh cone test and mini flow table test are commonly used tests to measure workability of cement paste and mortar. Marsh cone test is used for flowable mixes whereas mini flow table test is used for low to medium workability mixes. This study is focused to find a suitable workability test which can use for low to high workable mixes.

MATERIALS, MIXING AND TESTING DETAILS

The materials and testing procedure provided here are for the cement paste tests only. The details for the mortar test program are provided in cement mortar section.

Materials

Portland cement (conforming to OPC 53 grade of the Indian standard IS 12269–1987) was used for all tests of cement paste and mortar; its chemical and physical properties are given in Table 1 and 2 respectively. All tests, cement paste and mortar were performed using this cement.

Table 1 Chemical Properties of Cement

Sr. No.	Chemical testing of cement	Results obtained	According to IS 12269:1987
1	Lime Saturation Factor (LSF)	0.91	0.80 to 1.02
2	Alumina to iron Oxide Ratio % (A/F)	1.22	0.66 (min.)
3	Insoluble Residue (% by mass)	0.84	3.0 (max)
4	Magnesia - MgO (% by mass)	3.46	6.0 (max)
5	Sulfuric Anhydride - SO3 (% by mass)	2.38	3.0 (max)
6	Total loss on ignition (% by mass)	1.38	4.0 (max)
7	Maximum Chloride (% by mass)	0.04	0.10 for Normal Concrete

Table 2 Physical Properties of Cement

Sr. No.	Physical testing of cement	Resultsobtained	According to IS 12269:1987
1	Setting Time		
	Initial (Minutes)	100	30 min (Min)
	Final(Minutes)	200	600 min(Max)
2	Fineness (Blaine)		
	Specific Surface (m2/kg)	318	225 (min)
3	Soundness : Expansion by		
	Le-chatelier Method (mm)	1.6	20 (max)
	Auto clave (%)	0.13	0.8 (max)
4	Compressive strength (MPa)		
	3 days	38.0	27.0 (min)
	7 days	47.0	37.0 (min)

28 days	63.0	53.0 (min)

The fine aggregates were natural sand with a specific gravity of 2.41 and an absorption value of 0.40% by mass. Sieve analysis test was performed as per Indian standard specification IS: 383-1970. Table 3 shows test results of sieve analysis of fine aggregates and it does indicate fine aggregates of zone -III.

Table 3 Sieve Analysis of Fine Aggregates

Sieve no.	Percent passing	Specification of IS: 383-1970
10 mm	100	90-100
4.75mm	95.2	90-100
2.36mm	89.2	85-100
1.18mm	79.8	75-100
600 µm	69.8	60-79
300 µm	22.4	12-40
150 µm	2.4	0-10

Cement paste and mortar preparation

Hobart mixture as shown in Figure 2 was used to prepare cement paste and mortar.First of all, cement was taken in mixing bowl and water was poured as per mix requirements. The cement and water was mixed for2 minutes in Hobart mixture. Mixing was stopped and sides of the mixing bowl have been scrapped for 20 to 30 seconds. Again mixing was carried out for 3 minutes ± 15 seconds and it was ensured that mix prepared was homogeneous and lump free.

Cement mortar was prepared in the proportion of 1:1 of cement and fine aggregates. Cement, fine aggregates, and water as per mix requirementswere taken into mixing bowl. Mixing was stopped after 2 minutes and sides of the mixing bowl have been scrapped for 20 to 30 seconds. Again mixing was carried out for 3minutes ± 15 seconds to get homogeneous mix.

Figure 2 Hobart mixture

Marsh cone test for cement paste and mortar

The marsh cone test has been performed to know the relative fluidity of cement paste. A metal cone with 8mm nozzle diameter was used cement paste whereas 12.5mm nozzle diameter was used for cement mortar.Figure 3 shows the set up for marsh cone test. 1000ml cement paste or mortar volume was poured into the metal cone and time required to 500ml flow out was measured using stop watch. Test result was recorded in terms of flow time (seconds). Lower flow time indicates greater fluidity of cement paste or mortar compared to higher flow time.

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Figure 3 Marsh cone test set up

Mini flow test for cement paste and mortar

Zhor and Bremner (1998) have developed mini flow test to understand flow behaviour of cement paste by modification of mini slump test. A truncated cone, with height = 57 mm, bottom diameter = 38 mm and top diameter = 19 mmwas filled by cement paste. A truncated cone was lifted gently and15 jolts in 15 seconds were applied. The cement paste spread was measured in terms of average diameter of flow i.e. average of four symmetrically distributed measurements. Visual observations have been made to identify bleeding and segregation of cement paste.

In case of cement mortara truncated cone of height= 50mm, bottom diameter =100mm and top diameter =70mm was used. All other procedure remains same for mini flow table test of cement mortar.

TEST RESULTS AND DISCUSSION

Mini flow table test results for cement paste

The cement paste mixes were prepared taking the initial w/c ratio as 0.36 and varying it in incremental sequence. Figure 4 shows the test results of mini flow table test before modification.It has been observed that average flow diameter remains constant after water cement ratio 0.50.

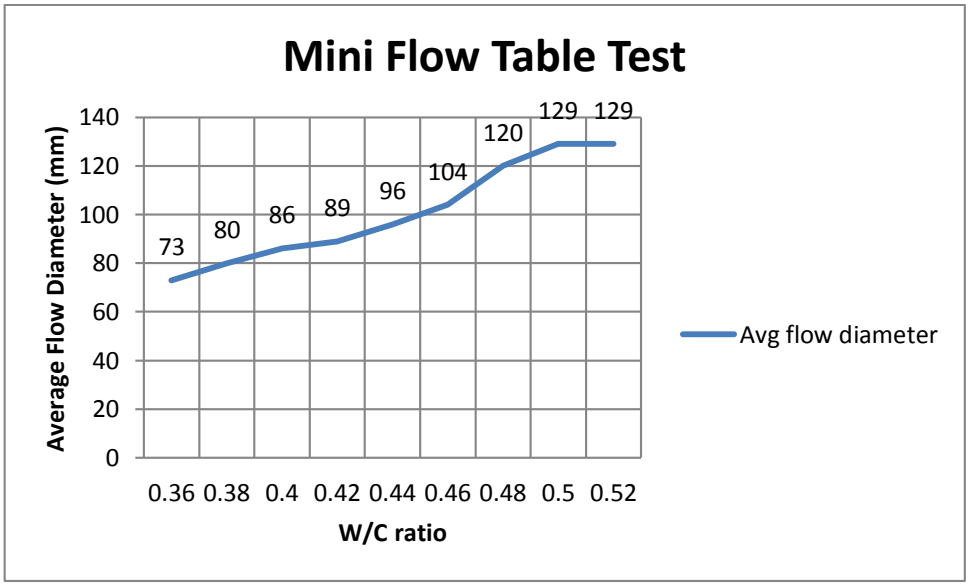

Figure 4 Mini flow table test results before modification

Flow behaviour of cement paste is same as fluid for high water cement ratio. Spread of cement paste depends upon volume of cone for high water cement ratio. Some modification has been done in cone size to overcome this limitation.

Height at the centre and ends were measured for maximum spread of cement paste as shown in Figure5. It has been observed that height at centre and ends were 5mm and 3mm respectively.

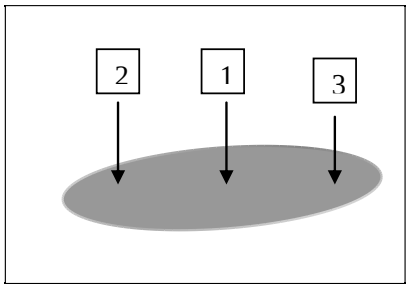

Figure 5 Schematic representation of height measurement for maximum spread

Modified cone dimensions have been found out considering the maximum spread height (5mm) and maximum possible diameter (250mm). Total volume requires to reach maximum possible spread was 245436.9mm^3. For the pilot study the volume has been taken in terms of cylinder instead of cone. PVC pipe of 60mm diameter having 87mm height (total volume = 245986.7mm^3) were used as a cone and mini flow table test were performed to know the maximum limit of water cement ratio.Modification of cone volume has increased the upper boundary of water cement ratio from 0.50 to 0.62. It is observed that the spread of the cement paste overflows out of mini flow table beyond water cement ratio 0.62.Therefore, it is difficult to measure flow behaviour of cement paste when water cement ratio exceeds 0.62.

Mini flow table test results for cement mortar

Mini flow table test were suitable for stiff workable to medium workable mortar mix. If diameter of cone and spread of the mix were same then it is defined as a stiff mix. High workable mix spread is more than the diameter of flow table i.e. 250mm. Therefore, modification in the diameter of mini flow table has been carried out by following Domone (2006) as shown in Figure 6 and7.An acrylic sheet of diameter 450 mm and weight 492 gm was attached on the base plate of the mini flow table.

Figure 6Mini flow table apparatus

Figure 7 Modified mini flow table apparatus

Modified mini flow table test is suitable to evaluate workability of high workable mortar mixes.

Marsh cone test results for cement paste and mortar

The cement paste mixes were prepared taking the initial w/c ratio as 0.40 and varying it in incremental sequence. In the procedure, 1000 ml sample of cement paste was poured and time of 500ml sample flow out was

measured. Clogging was observed up to water cement ratio 0.50 for cement paste. It was observed that the marsh cone test has been applicable after the w/c ratio of 0.50, as cement paste mix was relatively fluid after that w/c ratio.

The cement mortar mixes were prepared taking the initial w/c ratio as 0.45 and varying it in incremental sequence. Cement and fine aggregate proportion was taken as 1:1. It was observed that the marsh cone test has been applicable after the w/c ratio of 0.72, as cement mortar mix was relatively fluid after that w/c ratio.

CONCLUSION

A series of cement paste and mortar sample with varying water cement ratio were performed by marsh cone test and mini flow table test to understand the suitability of test for low to high workable mixes. Mini flow table test shows same flow diameter after W/C ratio 0.50 for cement paste. Marsh cone test were useful to measure flow behaviour of cement paste and mortar above water cement ratio 0.50 and 0.72 respectively. Therefore, it was not possible to find correlation between two tests and covers entire range of workability i.e. low to high workability. Marsh cone test was applicable to study flow characteristic of high workable mix only while standard mini flow table test is not suitable for high workable mix.Modified mini flow table test having diameter of 450mm was applicable for entire range i.e. very low to high workable mix.

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REFERENCES

[1] Agull L, G R, Aguado A. Fluidity of cement pastes with mineral admixtures and superplasticizer- A study based on the Marsh cone test. Mater Struct. 1999;32(September):479–485.

[2] Bouvet A, Ghorbel E, Bennacer R. Cement and Concrete Research The mini-conical slump flow test : Analysis and numerical study. CemConcr Res. 2010;40(10):1517–1523. doi:10.1016/j.cemconres.2010.06.005.

[3] Chandra S, Björnström J. Influence of cement and superplasticizers type and dosage on the fluidity of cement mortars - Part I. CemConcr Res. 2002;32(10):1605–1611. doi:10.1016/S0008-8846(02)00839-6.

[4] Domone, P. (2006). Mortar tests for self-consolidating concrete. Concrete international, 28(4), 39-45.

[5] Hackley, V., and Ferraris C.F. (2001). The Use of Nomenclature in Dispersion Science and Technology. (Special Report 960-3). Gaithersburg, MD: National Institute of Standards and Technology.

[6] Harini M, Shaalini G, Dhinakaran G. Effect of size and type of fine aggregates on flowability of mortar. KSCE J Civ Eng. 2012;16(1):163–168. doi:10.1007/s12205-012-1283-4.

[7] IS: 12269—1987, Specifications for 53 grade ordinary Portland cement, Bureau of Indian Standards, New Delhi, India

[8] IS: 383-1970, Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi, India.

[9] Jayashree C. GR. Experimental study of the flow behaviour of superplasticized cement paste. Mater Struct. 2008:1581–1593. doi:10.1617/s11527-008-9350-5.

[10] Tattersall, G.H. (1991). Workability and Quality Control of Concrete. London: E&FN Spon.

[11] Zhor, J., and Bremner, T.W. (1998). Advances in Evaluation of Lignosulphonates and Concrete Admixtures, Fourth CANMET/ACI/JCI Conference: Advances in Concrete Technology, SP 179-58, American Concrete Institute, 1011-1042.

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AUTHOR BIBLIOGRAPHY

	**ParthThaker** He is Assistant Professor at the Faculty of Technology since 2008. He received his B.E. in Civil Engineering from Gujarat University in 2005, and a Master's degree in Structural Design from CEPT University in 2009. He is currently pursuing his Doctoral Studies on rheological aspect of concrete. He teaches courses related to Structural Analysis and Design, Field Studies, Earthquake Resistant Construction, and Concrete Technology. He has been a contributor to various national and international journals, and magazines through his research papers and articles. He is actively associated with the Indian Association of StructuralEngineers, Gujarat Chapter.
	**Dr. N. K. Arora** He is Professor of Applied Mechanics and Principal of Lakhdhirji Engineering College, Morbi. He has about 21 years of teaching experience. His major areas of research interest are rheological aspect of concrete, use of waste material and recyclable aggregates in concrete, Geopolymer concrete etc. He has published about fifty papers in various national and international journals.