Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 51(6) (2020)335-338
DOI: 10.22060/ceej.2018.14305.5619

Evaluating the Rheology Properties of Self-Consolidating Concrete Using the Plate Test Method

A. A. Shirzadi Javid*,P. Ghoddousi, M. Jaberizadeh, B. Bozorgmehr
School of Civil Engineering Iran University of Science & Technology, Tehran, Iran

ABSTRACT: Setting time and thixotropy of self-consolidating concrete (SCC) mixtures are two important parameters that affect the early age properties. In order to determine these parameters, there are traditional methods that have advantages and disadvantages such as low accuracy or high cost of testing. The aim of this study is introducing an acceptable method (called plate test) of determining setting time and thixotropy of SCC mixtures. The proposed method is including a rough plate immersed in fresh mixture from one side and attached to the accurate scale from another side. In this study the thixotropy of different self-consolidating concrete mixtures (SCC) containing silica fume and slag were tested. Results of the thixotropy obtained from the plate test were compared with the results obtained from penetration resistance and rheometer respectively. Results showed that the mixture containing slag produced the less temperature comparing with the mixture containing silica fume. It was also shown that the amount of thixotropy obtained from the plate test had a difference of 4% up to 10% in comparison with the rheometer and the results of the setting time had also shown a maximum difference of 9% compared with the results of penetration resistance test. The results proved that the plate test has an acceptable accuracy and can be recommended.

Review History:
Received: 4/9/2018
Revised: 6/10/2018
Accepted: 6/10/2018
Available Online: 6/23/2018

Keywords:
Self-compacting concrete
Rheology
Thixotropy
Plate test method
Resistance to penetration

1. INTRODUCTION

Nowadays, materials based on cement are highly practical in construction industry. An advance material which is commonly used in many projects is self-consolidating concrete (SCC) that its properties in fresh state is crucially important for construction procedure. Various methods are used to measure these properties. The plate test method has been recently introduced by researchers [1-6]. In this study, the plate test method is used as a new method for determining setting time and thixotropy of SCC mixtures as its properties in fresh states and the result of the plate method are compared with standard methods to evaluate its accuracy.

1.1. Thixotropy

The behavior of the constant flowing state of cement based materials can be easily defined by Bingham or H-B models [7]. However, there is a transitional state between stability and constant flow which cannot be described by common models [8] and thus, is defined as thixotropic behavior of the materials. The most common definition for thixotropy is presented as: the reversible changes in viscosity due to the increasing or decreasing changes in applied shear stress. Thixotropy is measured by various methods in which a rheometer device is almost required.

*Corresponding author's email: shirzad@iust.ac.ir

1.2. Setting Time

The setting time is considered as a transition between fresh and hardened states and is defined as the time in which the stiffness of the materials can resist against the penetration of the testing devices [9].

2. METHODOLOGY

In this study, the rheological properties of different mixtures containing various percentage of cementitious materials such as silica fume and slag were tested by a rheometer as a standard device. The setting time of mixtures were also measured by using the penetration resistance method according to the standard testing procedure ASTM-C403 [10]. The obtained results from standard methods were compared to the results of the plate test. The temperature of mixtures was under observation to provide another confirmation on the results accuracy. The schematic sketch of the plate test device is depicted in the Figure 1.

3. RESULTS AND DISCUSSION

3.1. Static Yield Stress

The most important parameter in rheology properties of self-consolidating concrete is static yield stress which is

defined as the minimum shear stress that is required for mixture to start flowing. According to the results, the static yield stress measured by plate method, had a meaningful

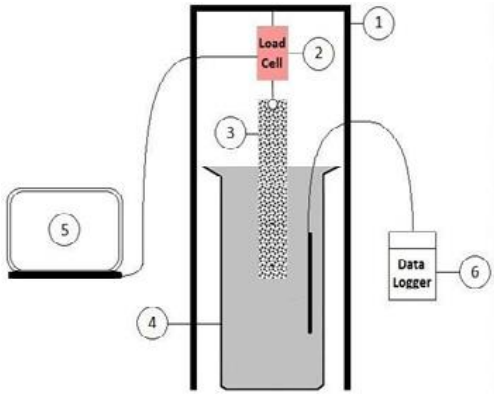

Fig. 1. The plate device – (1) Holder, (2) Load cell, (3) Rough plate, (4) Container, (5) Computer, (6) Temperature data logger

difference compared to the rheometer method. This is due to the fact that the amount of shear stress measured by rheometer, is equivalent to the amount needed to break the structure of the colloidal networks and internal three-dimensional structures of the sample so that the mixture flows. Also, different rheometers with different blade sizes, present different values that are due to their mechanism, geometry, etc. but in the plate device, shear stress is caused solely by movements of the aggregates downwards as a result of sedimentation. Thus, the shear stress measured by plate device is not sufficient to flow the mixture.

3.2. Thixotropy

Thixotropical behavior of the material is caused by physical structural build up. Therefore, the calculation should include the linear part of the shear stress variation of the plate method. Thus, the thixotropy of the mixtures calculated at the first 30 minutes after mixing by using the equation introduced in [8] for both methods of the plate test and rheometer. There was a difference between results of the two methods that are presented in Table 1. These minor differences confirm the capability of the plate method in determining thixotropy.

3.3. Setting Time

There is not a specified point to show the setting time based on previous studies and the setting procedure is defined in a period of time that materials harden. Additionally, at the setting time, the temperature of the mixture increases [11] due to the chemical reactions of the cementitious materials and the hydration products. In this regard, the simultaneous control of the plate test results and temperature variations proved that at a relatively close to the moment when the apparent mass of the plate starts to decrease, the temperature of the mixture increases. Thus, this moment is considered and introduced as the initial setting time of the plate. The negligible difference between the results of plate and standard methods are presented in Table 1 and shows the viability of the assumptions in determining setting time by plate method.

This minor differences that are presented in the Table 1, prove that the plate test can be considered as an applicable method in order to measure the properties of the self-consolidating concrete in the fresh states.

Table 1. Difference of the plate test results in comparison to the standard methods

Mixture Index	Thixotropy	Setting time
C-44-N-0	7.26%	6%
C-44-SF-10	4.67%	6%
C-44-GF-50	10.43%	9%
C-42-N-0	3.71%	6%
C-42-SF-10	10.74%	5%
C-42-GF-50	4.29%	9%

4. CONCLUSIONS

In this study, the rheological properties and setting time of self-consolidating concrete were tested by using both the plate test and standard testing methods. The ensuing lines were concluded by comparing the plate test results with standard methods:

- The static yield stress measured by rheometer had a substantial difference in comparison to the plate test values. This shows that the plate test is not an applicable method to evaluate static yield stress.
- The thixotropy determined by both methods of plate test and rheometer. The results were close to each other with a minor difference of minimum 3.71% up to maximum 10.74%. This is an indication of the plate test capability to measure thixotropy.
- The diagram slope of apparent mass of the plate had experienced a decrease at a time close to the setting time measured by penetration resistance device. This phenomenon occurred simultaneously with the increase in the temperature of the mixture. Therefore, the moment when the apparent mass of the plate decreases, is introduced as the initial setting time of mixture. The maximum difference between results of the plate method and penetration resistance test, was 9%.

REFERENCES

[1] H. Sleiman, A. Perrot, S. Amziane, A new look at the measurement of cementitious paste setting by Vicat test, Cement and Concrete Research, 40(5) (2010) 681-686.

[2] P.H. Billberg, N. Roussel, S. Amziane, M. Beitzel, G. Charitou, B. Freund, J.N. Gardner, G. Grampeix, C.-A. Graubner, L. Keller, Field validation of models for predicting lateral form pressure exerted by SCC, Cement and Concrete Composites, 54 (2014) 70-79.

[3] P.H. Billberg, N. Roussel, S. Amziane, M. Beitzel, G. Charitou, B. Freund, J.N. Gardner, G. Grampeix, C.-A. Graubner, L. Keller, Field validation of models for predicting lateral form pressure exerted by SCC, Cement and Concrete Composites, 54 (2014) 70-79.

[4] P. Ghoddousi, A.A.S. Javid, J. Sobhani, A.Z. Alamdari, A new method to determine initial setting time of cement and concrete using plate test, Materials and Structures, 49(8) (2016) 3135-3142.

[5] S. Amziane, A. Perrot, The plate test carried out on fresh cement-based materials: How and why?, Cement and Concrete Research, 93 (2017) 1-7.

[6] J. Tchamba, S. Amziane, G. Ovarlez, N. Roussel, Lateral stress exerted by fresh cement paste on formwork: laboratory experiments, Cement and Concrete Research, 38(4) (2008) 459-466.

[7] F. De Larrard, C. Ferraris, T. Sedran, Fresh concrete: a Herschel-Bulkley material, Materials and structures, 31(7) (1998) 494-498.

[8] N. Roussel, A thixotropy model for fresh fluid concretes: theory, validation and applications, Cement and Concrete Research, 36(10) (2006) 1797-1806.

[9] C. Astm, 125 Standard terminology relating to concrete and concrete aggregates, Annual Book of ASTM Standards, 4 (2003).

[10] C. ASTM, 403, Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance, ASTM International, (1999) 19428-12959.

[11] R. Madandoust, MM. Ranjbar, M. Pour Hosseini, Evaluating the setting time of Pazzolanic concrete mixtures using Ultrasonic method, National Congress on Civil Engineering, Semnan, (2011), (in Persian)

HOW TO CITE THIS ARTICLE

A.A. Shirzadi Javid, P. Ghoddousi, M. Jaberizadeh, B. Bozorgmehr, Evaluating the Rheology Properties of Self-Consolidating Concrete Using the Plate Test Method, Amirkabir J. Civil Eng., 51(6) (2020) 335-338.

DOI: 10.22060/ceej.2018.14305.5619