Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 52(1) (2020) 59-62
DOI: 10.22060/ceej.2018.14591.5691

Evaluation of mixing time and mixing speed on the Rheological Properties of Self-Consolidating Concrete

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ABSTRACT: Due to the composition, the production of self-consolidating concrete (SCC) requires more mixing energy to uniform and homogenize the concrete components. This limits the rate of concrete production in comparison with the conventional concrete and therefore it is an important financial factor. So, mixing energy (mixing time and power) is one of the main factors in concrete production and before large production, the appropriate mixing time and speed should be determined for each mixture. In this study, according to objectives and considering that mixing time and mixing speed are two main factors in content of mixing energy and according to guidelines and regulations, two SCC mix designs (powder type and VMA type) were mixed in three mixing times (3, 8 and 11 minutes) and each of them in two mixing speeds (20 and 40 rpm) and their effect on rheological properties was evaluated. The results showed that in each series of mixtures by increasing the mixing time up to a certain level that is called stabilization time (the shortest mixing time) and in this study is 8 minutes, the workability of concrete increased and after that, by mixing up to 11 minutes it decreased by 6 percent. Static yield stress in the 8 minutes mixing also had a minimum amount and by mixing up to 11 minutes it increased by 42 percent. This increment reached 62 percent for dynamic yield stress, so the rheology tests also confirmed these results.

Review History:
Received: 6/11/2018
Revised: 7/17/2018
Accepted: 8/5/2018
Available Online: 8/15/2018

Keywords:
Mixing time
Mixing speed
Mixing energy
Self-consolidating concrete
Stabilization time

1. INTRODUCTION

The performance of concrete depends on its microstructure, like all materials. Its microstructure is determined by some parameters like the mixing method and mixer conditions used for concrete production. A sufficient degree of mixing and a required mixing time are important technical and economical aspects in the production of SCC [1-3].

To determine the best-suited mixing method for a special application process, the main considered factor is the quality of the produced concrete. This quality is provided by the performance of the concrete and by the homogeneity of the mixture after mixing. The efficiency parameters of a mixer are affected by the order in which the various constituents of the concrete are introduced into the mixer, the type of mixer, and the mixing energy (power and duration) used [4-9].

2. METHODOLOGY

In this study, according to the fact that mixing time and mixing speed are two main factors in content of mixing energy and according to guidelines and regulations, two SCC mixture types (powder type and VMA type) were designed and mixed in three mixing times (3, 8 and 11 minutes) and each of them in two mixing speeds (20 and 40 rpm) and their effects on rheological properties were evaluated.

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3. RESULTS AND DISCUSSION

The results of workability tests are presented in Table 1. According to the results, the best-suited mixing situation happened when the mixing time was 8 minutes and the mixing speed was 40 rpm.

Rheological properties were separately studied by rheology tests. These results also followed the workability tests results.

The effects of the mixing time on the plastic viscosity are shown in Figure 1. According to Figure 1, it was found that in a set of mixtures with three mixing times, the maximum viscosity was related to the mixing time of 8 minutes. In this chart, taking into account the mixing time of 8 minutes, reducing the mixing time to 3 minutes, the plastic viscosity was decreased by 16% and with increasing the time of mixing up to 11 minutes, decreases by 10%. The results are in accord with the previous findings [10-13].

4. CONCLUSIONS

In this study, the effects of mixing time and mixing speed on workability and rheological properties were evaluated. And the results are as followed:

– In each type of mixtures, by increasing the mixing time over to a certain level which is called stabilization time (the shortest needed mixing time and in this study is 8 minutes), the workability of concrete mixtures increased and after that by mixing time of 11 minutes it decreased by 6 percent.

Table 1. Workability tests results

Mixing speed (rpm)	Mixing time (min)	T_{50} (s)		J ring (mm)		J ring diameter		V funnel (s)		VSI	
		Powder type mix	VMA type mix	Powder type mix	VMA type mix	Powder type mix	VMA type mix	Powder type mix	VMA type mix	Powder type mix	VMA type mix
	3	3.47	5.00	8.75	10.00	610	625	11.49	12.10	1	0
20	8	3.00	3.03	7.50	6.25	660	660	11.05	11.37	0	1
	11	3.57	2.31	8.75	12.50	650	660	11.76	10.33	1	1
	3	2.00	2.35	5.00	7.50	670	670	9.53	10.77	0	0
40	8	2.00	2.00	3.00	5.00	710	700	9.10	10.14	0	0
	11	2.00	3.57	17.50	11.25	590	640	9.93	11.61	1	2

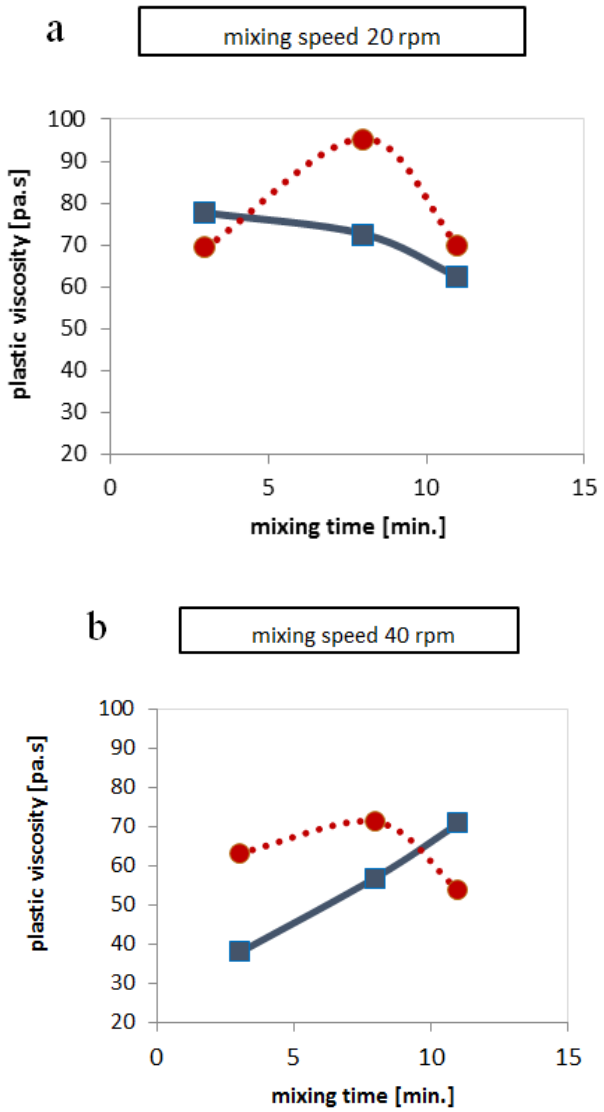

Fig. 1. The effect of mixing time on plastic viscosity (a): mixing speed is 20 rpm, (b): mixing speed is 40 rpm

- Static yield stress in the 8 minutes of mixing had the minimum amount and by mixing time of 11 minutes, it increased by 42 percent.

- This increment touched 62 percent for Dynamic yield stress, so the rheology tests also confirm workability test results.

- By increasing mixing speed from 20 rpm to 40 rpm, an average increase of 5% happened for slump flow and 8% for static yield stress.

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HOW TO CITE THIS ARTICLE

P. Ghoddousi , A.A. Shirzadi Javid, S. Aghajani, Evaluation of Mixing Time and Speed on the Rheological Properties of Self-Consolidating Concrete, Amirkabir J. Civil Eng., 52(1) (2020) 59-62.

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