Using Moisture Sensor to Monitor Fresh Concrete Uniformity

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ABSTRACT

In this paper, moisture sensor was used to monitor moisture of concrete inside mixer at a relative high frequency for four different mixing procedures. Experiment were performance to study the moisture change inside the concrete throughout the mixing process, the mixing uniformity were estimate through moisture content reading. Results showed that moisture sensor is an effective tool to estimate the uniformity of concrete mixing, different mixing procedure will need different mixing time for concrete to reach a stabilize moisture reading.

INTRODUCTION

Uniformity is concerned for the efficiency of concrete mixing, which means if concrete has been adequately mixed; concrete from different portions of a batch will have essentially the same properties including moisture content. A lot of methods including flow measurement [1], water content measurement [2], water-to-cement ratio determination [3] and aggregate settlement [4] had been conducted to estimate the uniformity of concrete mixture, but no effective methods or equipments can accurate reflect the mixing efficiency. Moisture sensor is base on the microwave reflection of concrete at different moisture condition. Because of its sensitivity of moisture, moisture sensor is a promising tool for in situ estimate moisture content in different parts of concrete inside mixer, which can be further used to reflect the uniformity of concrete inside mixer.

In this paper, moisture sensor was used to monitor the moisture inside mixer at a relative high frequency of four times per second for four different mixing procedures. Experiment were performance to study the moisture change inside the concrete throughout the mixing process, the mixing uniformity were estimate through moisture content reading.

RESEARCH SIGNIFICANCE

Mixing time is one of the most important factors affecting the efficiency of mixing. The mixing time required should be based on the ability of the mixer to produce uniform concrete throughout the batch and from batch to batch. The time required to achieve this depends primarily on the design of the mixer, concrete material characteristics, including aggregate, cement content used and admixtures. Industry require mixing time as less as possible which can save cost and increase produce frequency, but inadequate mixing result in lower strengths and also in greater variations in batch to batch or within batch. This is why the ready mix concrete plant normally have a requirement of minimum mixing time, however, overly long times do not improve the quality of concrete and severely limit the output of the batching plant. Because long mixing times may cause some breakdown of the aggregate and may decrease the air content. By all these requirements, an effective way of estimate when concrete mixing can reach uniformity is necessary.

Among all the methods, moisture sensor is a promising tool for in situ estimate moisture content in different parts of concrete inside mixer, hence can be used to reflect the uniformity of concrete inside mixer. Moisture sensor can monitor the moisture inside mixer and aggregate bin at a relative high frequency in order to quality control[5]. Hydronix had successfully develop their moisture sensor for industry use in monitoring concrete mixing[67], but no systemic study had been performance in studying the mixing efficiency of different mixing procedures through moisture sensor. In this paper, experiment were performance to study the moisture change inside the concrete mixing throughout the mixing process, the mixing uniformity were estimate through moisture content reading when concrete mixing.

EXPERIMENTAL PROGRAM

Material and Mixing Procedure

In order to study the effectiveness of moisture sensor, four different mixing procedures including one step mixing, two-step mixing and two kinds of multi-step mixing were selected in mixing C3 concrete. Details of different mixing procedures in this research are tabulated in Table1:

Table 1--Description of different mixing methods

Mixing No.	Mixing description	Mixing procedure
1	One step mixing	Aggregate, sand, cement, water added together
2	Step by step mixing (multi-steps mixing procedure)	Add aggregate and half of the water first, mix for 30 seconds, add sand, cement and the left water step by step, allow enough time for mixing thoroughly in different steps
3	Slurry premixing(two steps mixing procedure)	Mix cement with water first into slurry, add aggregate after
4	Continuous mixing (multi-steps mixing procedure)	Add aggregate and half of the water first, mix for 30 seconds, add sand, cement and the left water continuously

Experiment

In order to study the mixing effect, four different kind of concrete mixing methods were used in this research, moisture sensor were used in tracing the moisture content of concrete inside the mixing. Moisture sensor can take the moisture reading four times per second, the degree of stabilize of the moisture content curve can be used to reflect the uniformity of concrete, i.e., when moisture content reading reach certain degree of stabilize, concrete reaches uniformity mixing.

Moisture Sensor

Moisture sensor has been used to control quality of concrete mixing. Moisture in concrete mixture can be monitored based on the principle of microwave energy. The microwave absorption technique provides an accurate method for measuring moisture in concrete because water absorbs approximately 100 to 500 times as much (dependent on frequency) microwave energy as the same quantity of dry materials.

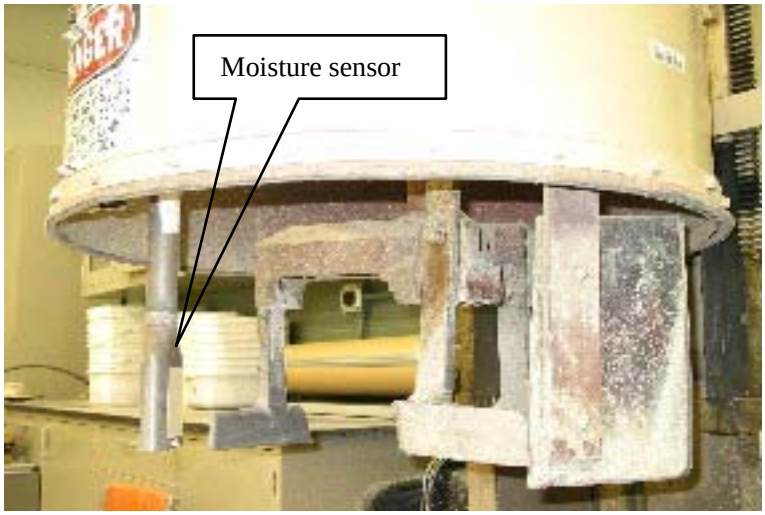

Fig. 1 Installation of moisture sensor

Hydronix, a sensor manufacture developed a single head sensing system based on electromagnetic theory. The method presumes a measurement of two different absorption parameters of material, which can overcome the problem form density dependence properties. The sensor radiates the low-powered field of microwave energy into concrete materials and detects the energy absorbed. The moisture sensor is used in concrete mixer and aggregate bin to monitor the moisture changing in concrete mixer through microwave reflection.

RESULTS AND CONCLUSIONS

As it is known, a period of time will be necessary for concrete to reach a stabilize moisture content in different parts, stabilized moisture content is the average moisture content read through moisture sensor when the reading stabilized, and the time for concrete to reach a stabilize moisture reading is the time for mixing to reach that. Results showed that different mixing procedure will need different time for concrete to reach a stabilize moisture reading, one step mixing will require a longer time (50 seconds) to reach stabilization. Certain time period will also needed for multi-steps mixing, but the time will vary according to different loading procedure.

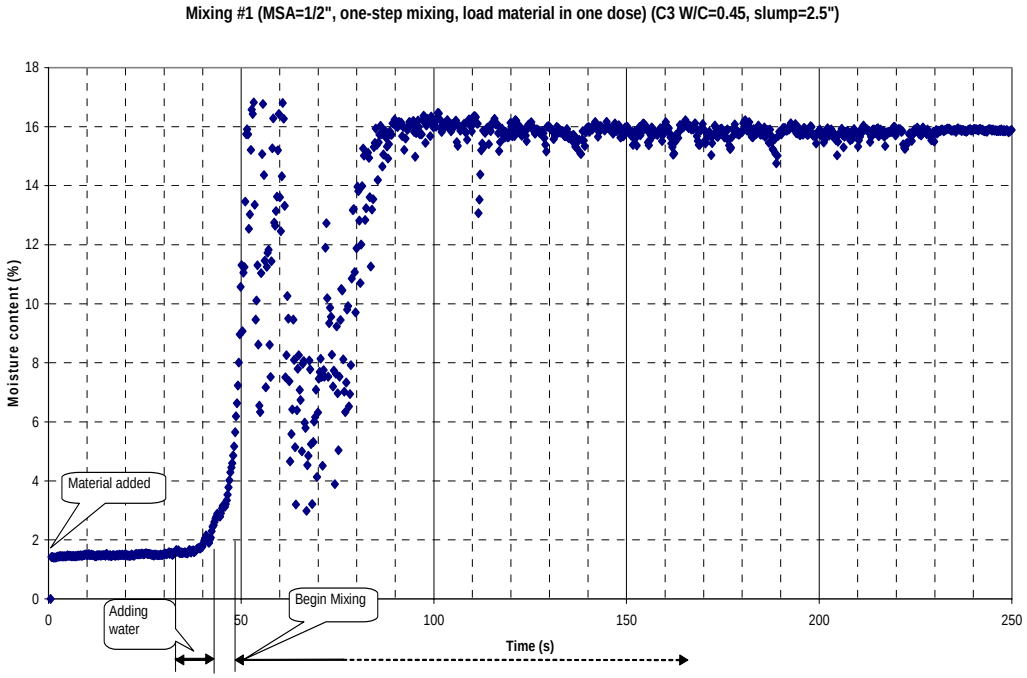

Fig. 2--Moisture content of concrete mixing by one step mixing procedure

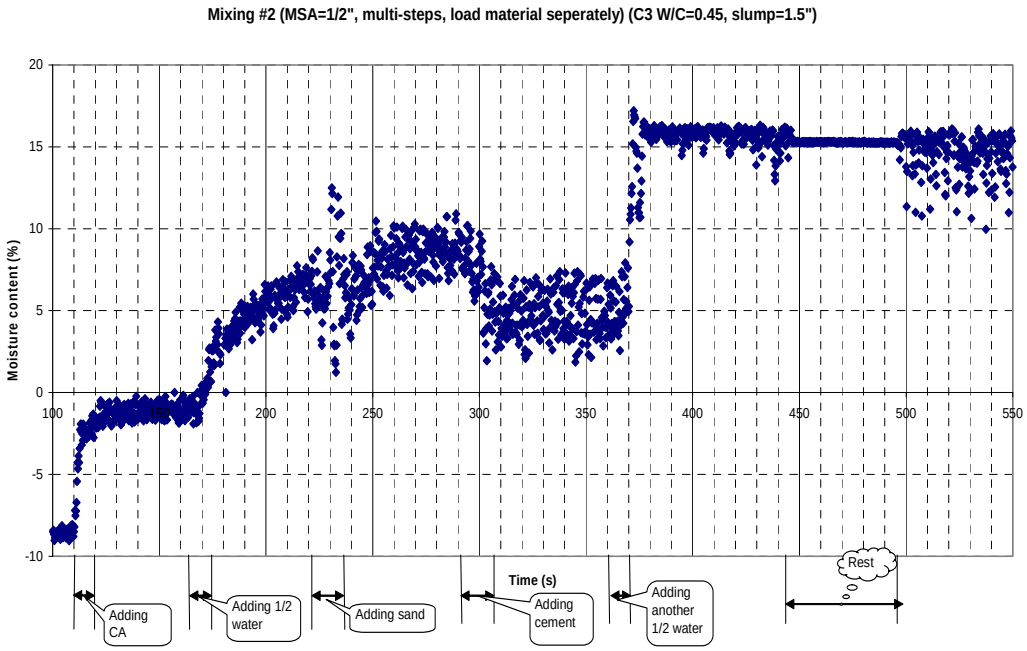

Fig. 3--Moisture content of concrete mixing by multi steps mixing procedure (allow enough time for mixing thoroughly in different steps)

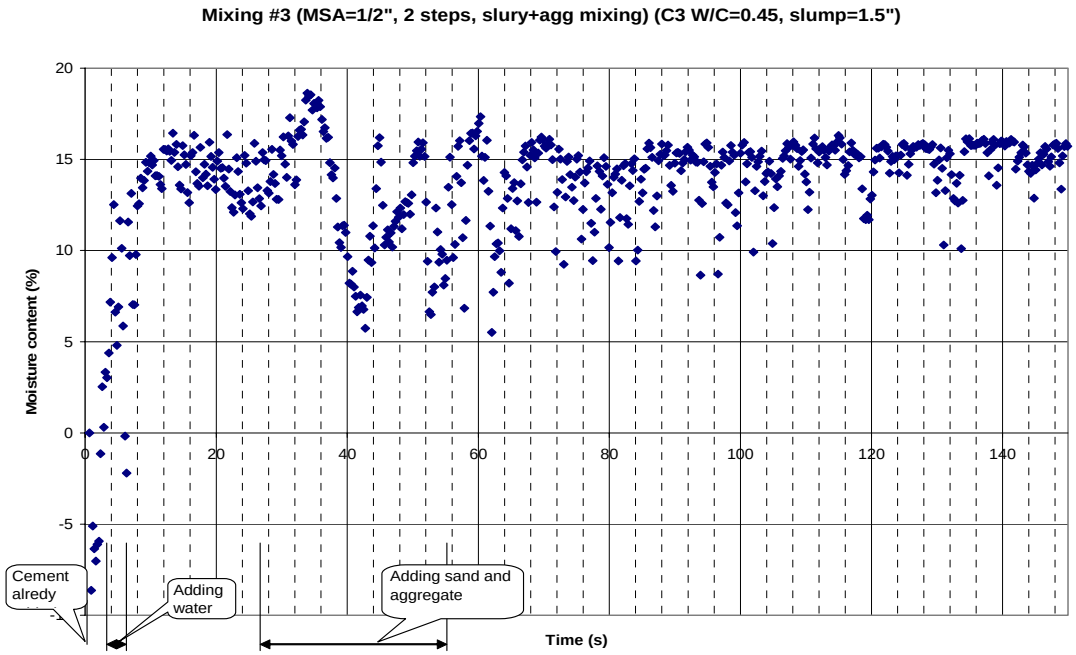

Fig. 4--Moisture content of concrete mixing by 2 steps mixing procedure (Slurry + aggregate mixing)

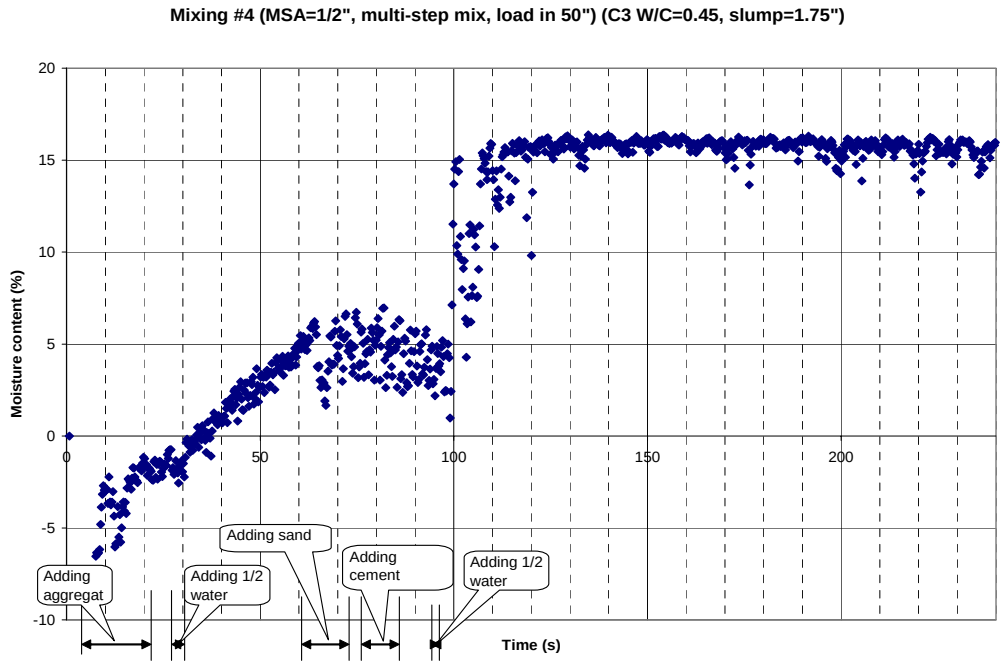

Fig. 5--Moisture content of concrete mixing by multi steps mixing procedure[1]

Total mixing time which is counting from loading to the moisture content reading stabilized. As it is shown, different mixing procedures will all reach similar moisture reading which is because they have the same mix design, but the mixing time for concrete to reach a stable reading is different, which mean different

[1] It should be noticed that in figure 3, 4, 5, the moisture reading begun form minus reading which is according to the calibration condition of moisture sensor, which normally set Saturated Surfaced Dried (SSD) sand as zero humility.

mixing procedure will take different for concrete to reach uniform. It is also noticed from Figure 4 showed that slurry plus aggregate can not reach very stable moisture reading which may caused by the property of concrete, which is sticky, hence cause an error of the moisture reading by the un-stable contact of concrete and sensor, this will be discussed later.

CONCLUSIONS

From the study of moisture content changing through the concrete mixing, it was found that different mixing procedure will need different time for concrete to reach a stabilize moisture reading, which means it will take different mixing time for concrete to be mixed uniform, that is, one step mixing will require a longer time to reach uniform, and multi-step mixing can significant decrease the required mixing time. Results showed moisture sensor is an effective tool to estimate the uniformity of concrete mixing,

FUTURE STUDY

Results showed that moisture sensor is a very promising tool for in-situ monitoring the moisture through concrete mixing, but it was also found that some aspects still be improved. Enough amount of concrete are needed to cover the surface of the sensor head; hence a larger amount of concrete will be necessary. The reading can only reflect the moisture content accurately when sensor face is fully covered by materials, hence the low reading of moisture content not always means lower moisture, but can also means insufficient material or poor cover by the materials. This is why the reading of slurry plus aggregate mixing procedure is strange which can not reach a stable moisture through further mixing of concrete, a sensor surface locate in the bottom of the mixer pan might solve this problem, but it is not suitable for rotating pan. With the increasing of mixing time, the concrete will become sticky, which will cause concrete not always fully cover the surface of the sensor, reflect by the higher un-stabilization in moisture reading.

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