THE PERFORMANCE CONCRETE USING SUGAR AS 'GREEN' RETARDER AND ACCELERATOR

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Abstract

Concrete structure has become popular material in construction world. Its popularity comes from the strength, durability, and low environmental impact. The durability of concrete is positive contribution in environmental revitalization. The 'green' concrete merely uses 'green' materials. This paper purposes to use sugar as 'green' materials for concrete retarder admixture. The research tries to deliver two extreme dosages of sugar retarder admixture, it is 0.03% and 0.3% of cement weight that becomes ingredient of concrete mixture. Several mortar cubes and concrete cylinders specimens are used with compressive strength design f'_c = 30 MPa and divided into variant of plain, added by sugar 0.03% of cement weight, and added by sugar 0.3% of cement weight. All specimens are cured for 7, 14, and 28 days, and then tested for its compressive strength. There is also an observation of mortar surface hardening by trinoculer electronic microscope. This research meets conclusions as follow: (1) The use of sugar as concrete admixture will fulfill the need of safe and 'green' concrete admixture, (2) The dosage of sugar admixture of 0.03% by weight of cement can perform as retarder because its value of compressive strength at days 7 is lower than plain mortar; the surface of mortar seems wet and softer; and the Vicat test shows that the penetration time is longer compared to the plain mortar and the mortar with sugar admixture of 0.03% by weight of cement, and (3) The dosage of sugar admixture of 0.3% by weight of cement can perform as accelerator because its value of compressive strength at days 14 is higher than plain mortar; the surface of mortar seems harder and smoother; and the Vicat test shows that the penetration time is shorter compared to the mortar with sugar admixture of 0.03% by weight of cement.

Keywords: *accelerator; concrete; 'green' material; retarder; sugar*

Introduction

Concrete structure has become popular material in construction world. Its popularity comes from the strength, durability, and low environmental impact. It is strongly believed that the durability of concrete is positive contribution in environmental revitalization. While the environmental revitalization is necessary need, then the 'green concrete' (concrete environmentally friendly) is the answer of the need. The 'green' concrete merely uses 'green' materials. Some innovation has been invented due to improve the 'green' concrete quality, especially in admixture using in concrete mixture.

The concrete admixture is used in concrete or mortar to improve particular properties (Jayakumaran, 2005). Ones should be noted are retarder and accelerator admixture. Concrete retarder is used to delay cement setting while the concrete accelerator is the opposite. Sugar has been found to delay cement setting (Medjo Eko and Rikowski, 2001). The common dosage of sugar that is used for retarder are ranged 0.03%-0.15% by weight of cement, and the dosage above 0.25% will generate rapid setting of cement (Jayakumaran, 2005). However, some studies state that certain dossage of sugar can delay (Jayakumaran, 2005; Suranto, 2008) or even accelerate cement setting (Jayakumaran, 2005). Even though many research of sugar use in concrete are reported (Crosswell, Steve; 2007; Deutschen Bauchemie, 2006; Frias, et.al., 2006; Jayakumaran, 2005; Collepardi, 2005; Chandler, Cristophe, et.al., 2002; Medjo Eko, dan Riwoski, 2001), the optimum dosage of sugar for retarder and accelerator use has not been clearly defined by previous researches. This research is purposed to use sugar as 'green' materials for concrete retarder admixture. The research tries to deliver two extreme dosages of sugar retarder admixture, it is 0.03% and 0.3% of cement weight that becomes ingredient of concrete mixture.

Method of Research

Several mortar cubes and concrete cylinders specimens are used with compressive strength design f'_c = 30 MPa and divided into variant of plain, added by sugar admixture of 0.3% by cement weight, and added by sugar admixture of 0.3% by cement weight. The sugar which is used in this research is local sugar with brand "Gulaku". All specimens are cured for 7, 14, and 28 days, and then tested for its compressive strength. There is also an observation of mortar surface hardening by trinoculer electronic microscope.

Results and Discussion

It is important to understand the hydration process of cement in concrete hardening. Cement consists of C_3S (tricalcium silicate), C_2S (dicalcium silicate), C_3A (tricalcium aluminate), and C_4AF (tetracalcium aluminoferrite) and also gypsum as setting additive regulator (Neville, 1999; Morsy and Shebl, 2007). The hydration process begins when cement is mixed with water. The reaction of C_3A and C_4AF predominates at the initial stage of hydration which delivers ettringite as product. The reaction of C_3S and β- C_2S predominates at the time of initial set onwards forming calcium silicate hydrates and $Ca(OH)_2$. The use of retarder can retard the concrete hardening. It is not very clear to describe the retarding process, but the mechanism can be explained as follow. The retarder will modify the crystal growth and morphology and then being absorbed in the membrane of hydrated cement which is formed rapidly (Jayakumaran, 2005). It is also slowing the growth of calcium hydroxide nuclei. When there is need to accelerate the early strength development of concrete, then it may use accelerator. The accelerator purposes to accelerate the hydration of calcium silicates, mainly C_3S. A common accelerator used is calcium chloride, but it has serious defect, that is the presence of chloride ions in the vicinity of steel reinforcement or other embedded steel is highly conducive to corrosion (Neville, 1999). Hence, the use of sugar as accelerator will fulfill the need of safe and 'green' concrete admixture.

The initial setting time is tested by Vicat test (Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008). Figure 1 shows the penetration and resistance of plain mortar and mortar with sugar addition (0.03% and 0.3% by weight of cement). The result emphasizes that mortar with sugar admixture of 0.03% by cement weight takes longer time to penetrate compared to mortar with sugar admixture of 0.3% by cement weight.

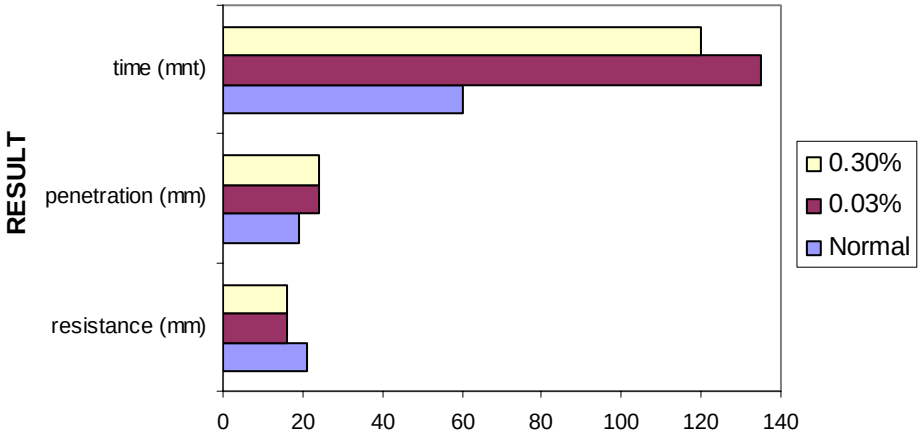

Figure 1. The Vicat test result of plain mortar and mortar with sugar admixture (0.03% and 0.3% by weight of cement) (Modified from Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008)

Figure 2 explains about the result test of mortar compressive strength (Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008). The experimental result shows that mortar specimens with sugar admixture of 0.03% by cement weight have lower compressive strength as 19.333 MPa compared to plain concrete specimens at 7 days age, but it becomes higher at 14 days age as 36.2 MPa and little bit higher at 28 days age as 37.8 MPa. The compressive strength of mortar specimens with sugar admixture of 0.3% by cement weight increases sharply. For 7 until 28 days age as, it is found as 41.3 at 7 days age, 42.93 MPa at 14 days age, and 42.53 MPa at 28 days age.

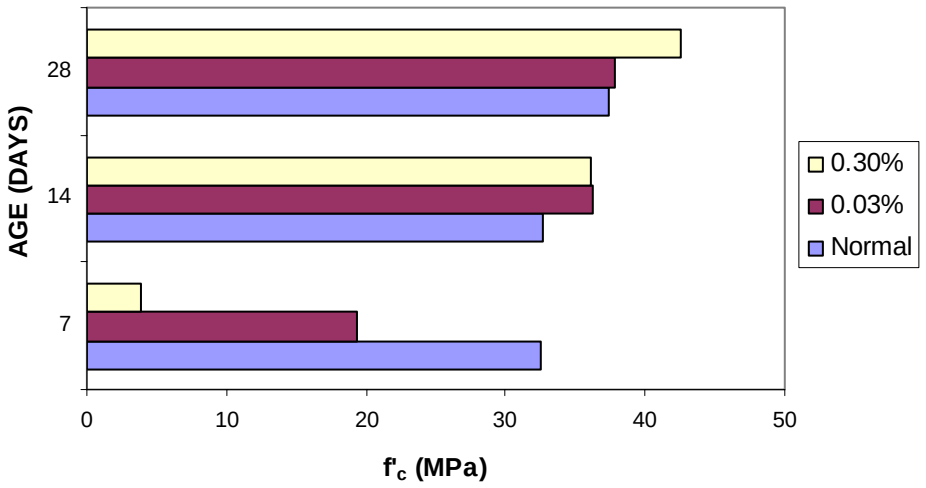

Figure 2. The mortar compressive strength of normal concrete and concrete with sugar admixture (0.03% and 0.3% by weight of cement) (Modified from Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008)

The result of the test of concrete cylinder compressive strength (Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008) is described by Figure 3. The experiment result shows that there is a delay of compressive strength at age of 7 days of concrete specimens with sugar admixture of 0.03% by cement weight, it is found 22.635 MPa while the plain concrete specimens found as 28.746 MPa. Their compressive strength significantly increases at age of 14 days as 27.539 MPa and becomes higher at 28 days as found as 37.122 MPa. The compressive strength of concrete specimens with sugar admixture of 0.3% by cement weight of cement weight increases at 7 days age as 33.57 MPa and it is getting sharply higher at 14 days age as 41.87 MPa. Surprisingly, the compressive strength of concrete with sugar admixture of 0.3% by cement weight at 28 days age decreases as 24.52 MPa.

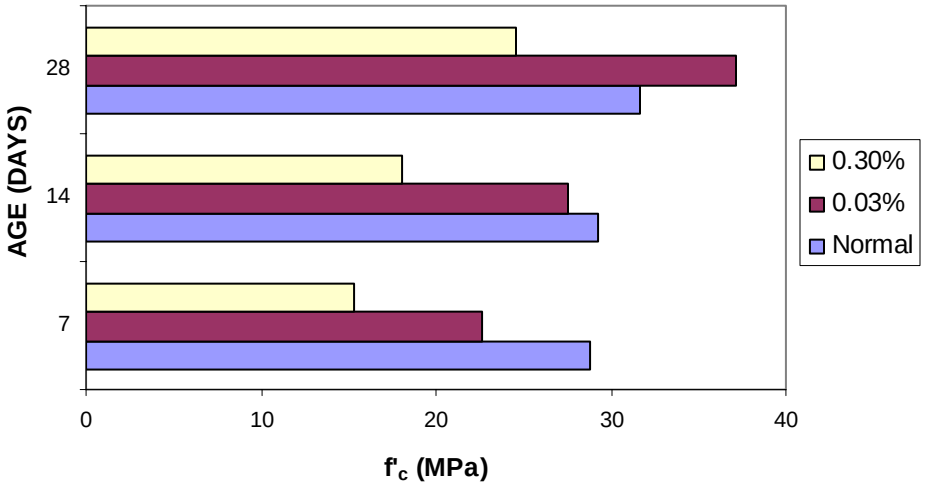

Figure 3. The concrete compressive strength of normal concrete and concrete with sugar admixture (0.03% and 0.3% by weight of cement) (Modified from Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008)

The observation of electronic microscope with trinoculer lens and 10x magnification (Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008) on Figure 4 finds that the surface of mortar on day 2 and 4 with sugar admixture 0.3% by weight of cement is harder and smoother compared to plain mortar and mortar with sugar admixture 0.03% by

weight of cement. The surface of mortar with sugar admixture 0.3% by weight of cement on day 2 and day 4 seems wet and softer compared to plain mortar and mortar with sugar admixture 0.03% by weight of cement.

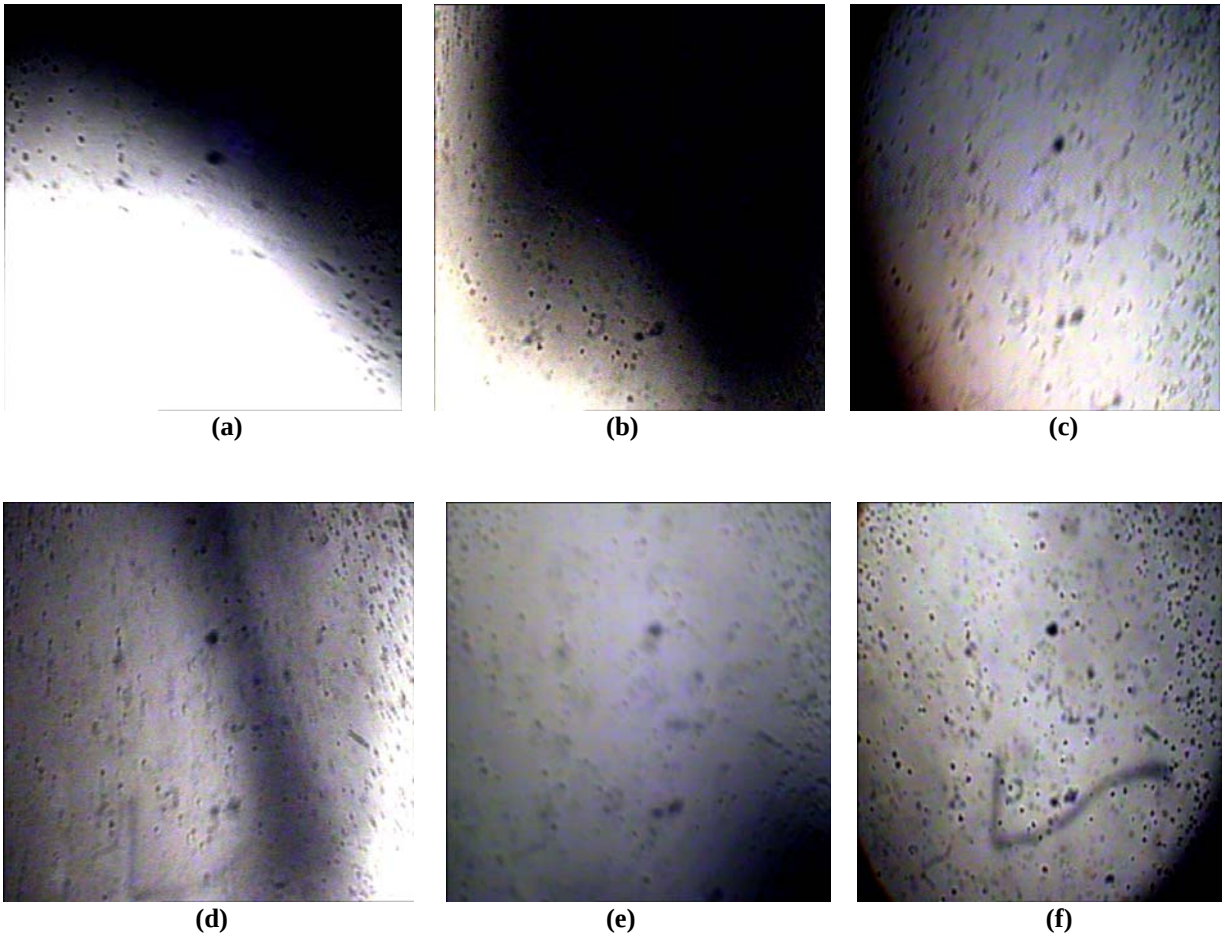

Figure 4. Trinoculer electronic microscope observation result
(a) plain mortar on day 2
(b) mortar with sugar admixture 0.03% by weight of cement on day 2
(c) mortar with sugar admixture 0.3% by weight of cement on day 2
(d) plain mortar on day 4
(e) mortar with sugar admixture 0.03% by weight of cement on day 4
(f) mortar with sugar admixture 0.3% by weight of cement on day 4
(Etmawati and Yuwono, 2008; Nikodemus and Setiawan, 2008)

The result of mortar compressive strength on days 7 proves that the sugar admixture of 0.03% by weight of cement is retarder because its value of compressive strength is lower (19.333MPa) than plain mortar even though it increases at days 14 compared to plain mortar. The observation of electronic microscope shows that the surface of mortar with of sugar admixture of 0.03% by weight of cement seems wet and softer. The accelerator performance is also supported by the Vicat test that the penetration of 24 mm can be reach after 135 minutes, that is longer that the time can be achieved by the plain mortar and the mortar with sugar admixture of 0.03% by weight of cement

It is found that mortar compressive strength with sugar admixture of 0.3% by weight of cement can perform as accelerator. The accelerating performance is shown by the increase of the value of compressive strength (to become 36.2 MPa) at days 14 (36.2 MPa) compared to plain mortar (32.7 MPa). The observation of electronic microscope also shows that the surface of mortar with of sugar admixture of 0.3% by weight of cement seems harder and smoother. The accelerator performance is also supported by the Vicat test that the penetration of 24 mm can be reach after 120 minutes, the time duration is shorter compared to the mortar with sugar admixture of 0.3% by weight of cement.

Conclusions

This research meets conclusions as follow:

(1) The use of sugar as concrete admixture will fulfill the need of safe and 'green' concrete admixture
(2) The dosage of sugar admixture of 0.03% by weight of cement can perform as retarder because its value of compressive strength at days 7 is lower than plain mortar; the surface of mortar seems wet and softer; and the Vicat test shows that the penetration time is longer compared to the plain mortar and the mortar with sugar admixture of 0.03% by weight of cement
(3) The dosage of sugar admixture of 0.3% by weight of cement can perform as accelerator because its value of compressive strength at days 14 is higher than plain mortar; the surface of mortar seems harder and smoother; and the Vicat test shows that the penetration time is shorter compared to the mortar with sugar admixture of 0.03% by weight of cement

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