

THE EARLY AGE PERFORMANCE OF CONCRETE WITH NATURAL RETARDER

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ABSTRACT

An effort have been done to achieve 'green' concrete, it is using natural retarder. It is believed that sugar based admixture can also improve concrete performance. Sugar based retarder is important admixture to reduce time setting and also to retard concrete hardening. This research wants to investigate the performance of early concrete which is using natural retarder, that are sugar and sugar cane liquid with dosage of 0.03% of cement weight. This research conducts experimental method. The experiment uses cylinder and mortar cubes specimens. Those specimens are tested after 7 and 14 days curing. The variant of specimens is divided into plain, added by sugar 0.03% of cement weight, and added by sugar cane liquid 0.03% of cement weight. The compressive strength design is $f'_c = 30$ MPa. The experiment also conducts an observation of mortar surface hardening by trinocular electronic microscope. This research meets conclusions: (1) Cement with sugar 0.03% of cement weight has the highest value of penetration at final set and has proven more effective in prohibiting the hardening of cement paste; (2) The experimental results describe that sugar 0.03% of cement weight is giving sharp increase (87.27%) and also the highest value of mortar compressive strength at days-14. The hydration calcium silicates in mortar have been retarded by the presence of both sugar and also sugar cane liquid at early stages; (3) Retarding effect of concrete specimen's with sugar 0.03% of cement weight and sugar cane liquid 0.03% of cement weight works at days-7 and days-14 that they have lower compressive strength compared to plain concrete specimen; (4) The mortar hardening is affected seriously by the presence of sugar 0.03% of cement weight and sugar cane liquid 0.03% of cement weight; and (5) The natural retarders of sugar and sugar cane liquid can significantly promotes good performance of early age concrete.

Keywords: early age, natural, retarder, concrete

1. INTRODUCTION

An effort have been done to achieve 'green' concrete, it is using natural retarder. It is believed that sugar based admixture can also improve concrete performance. Sugar based retarder is important admixture to reduce time setting and also to retard concrete hardening.

In producing concrete, there is a significant contribution provided by admixture. Obviously, admixture affects the flow of cement paste without altering the composition or behaviour of aggregates (Ferraris, 2001). Retarder admixture preferably used to offset the effects of high temperature which decrease setting time and also to avoid complications when unavoidable delays may occur between mixing and placing (Mindess and Young, 1981). Retarder prolongs the time during the concrete being transported, placed, and compacted (Neville, 1999). The role of retarder in early age of concrete is significant. According to Viviani, et. al. (2005), mechanical properties of cement-based material, included mortar and concrete, in early ages is time-dependent and it involves hydration process. Hence, the admixture presence in concrete mix should be taken carefully.

Broadly speaking, sugar is widely applied as retarder in concrete mix. The dosage of sugar based retarder is ranged between 0.03%-0.15% by weight of cement (Jayakumaran, 2005). Several researches of sugar based admixture using in concrete have been reported (Jayakumaran, 2005; Etmawati and Yuwono, 2008; Nikodemus and Setiawan, B., 2008; Ganis and Nugroho, A., 2008; Susilorini, Retno, et. al, 2008a,b; Deutschen Bauchemie, 2006; Frias, et.al., 2006; Jayakumaran, 2005; Collepardi, 2005; Chandler, Cristophe, et.al., 2002; Medjo Eko, dan Riowski, 2001). In

this research, refined sugar or commonly named as sugar, is used for concrete retarder (Nikodemus and Setiawan, B., 2008; Susilorini, Retno, et. al, 2008a) as well as sugar cane liquid which is applied into concrete mix (Ganis and Nugroho, A., 2008; Susilorini, Retno, et. al, 2008b).

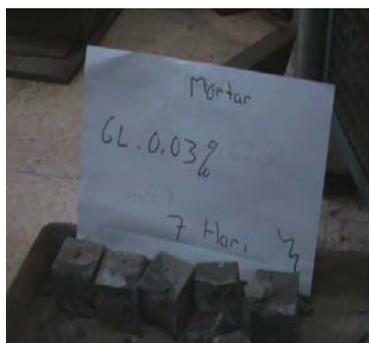
While sugar is used as admixture in this research, sugar cane liquid also applied into the concrete mix. sugar cane contains 20% sucrose of its weight (Harrison, 2009). Sugar cane (Figure 1) contains 30-50% cellulose and 20-24% lignin (Viera, et. al, 2007). It also contains by product such as lignocellulose (Ferraris, et. al., 2001), so they are used as pozzolanic materials for concrete production. Sugar is categorized as disaccharides and some carbohydrates are disaccharides (Ophardt, 2003). According to Peschard, et. al (2004), a dosage of 0.5% polysaccharides of cement weight will induce a strong modification of cement hydration that finally gives retarding effect of cement setting.



Figure 1. Sugar cane plantation
(Photograph by Syaefudin and Ardi, 2008)

The early age performance of concrete is significant factor in determining its future performance. Therefore, this research wants to investigate the performance of early concrete which is using natural retarder, that are sugar and sugar cane liquid with dosage of 0.03% of cement weight.

2. METHOD OF RESEARCH



(a)



(b)



(c)

Figure 2. Specimens and equipment
(a) Mortar cubes specimen age 7-days after tested
(b) Concrete cylinders are ready for compressive test
(c) Trinocular electronic microscope
(Nikodemus and Setiawan, 2008; Ganis and Nugraha, 2008)

This research conducts experimental method. The experiment uses cylinder and mortar cubes specimens. Those specimens are tested after 7 and 14 days curing. The variant of specimens is divided into plain, added by sugar 0.03% of cement weight, and added by sugar cane liquid 0.03% of cement weight. The compressive strength design is $f'_c = 30$ MPa. The experiment also conducts an observation of mortar surface hardening by trinocular electronic microscope.

3. RESULTS AND DISCUSSION

Result

It is shown by Figure 3 that final set time of cement with sugar 0.03% of cement weight is the longest (135 minutes), followed by plain cement together with cement with sugar cane liquid 0.03% of cement weight (60 minutes). The higher penetration (24 mm) is also achieved by cement with sugar 0.03% of cement weight and also cement with sugar cane liquid 0.03% of cement weight at final set compared to the plain one (19 mm).

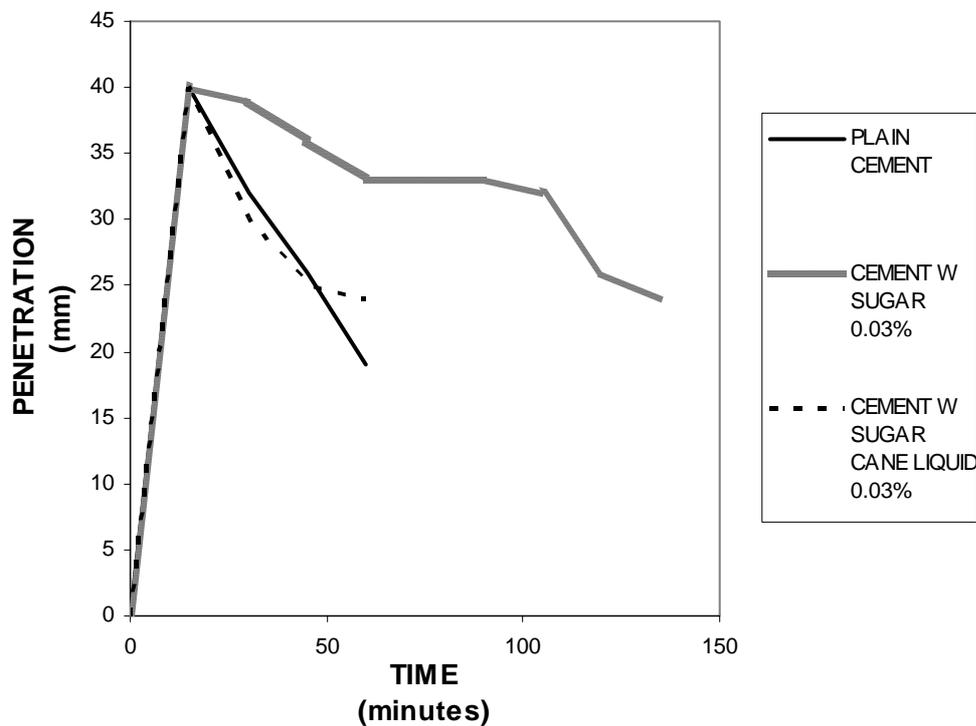


Figure 3. Vicat test of plain cement, cement with sugar 0.03% of cement weight, and cement with sugar cane liquid 0.03% of cement weight
(Modified from Nikodemus and Setiawan, 2008; Ganis and Nugraha, 2008)

It is shown by Figure 4 that mortar with sugar 0.03% of cement weight have very linear sharp compressive strength increase (87.27%) until days-14 (36.2 MPa). A soft increasing (25.020%) is also described by mortar with sugar cane liquid 0.03% of cement weight until days-14 (28.13 MPa). Steady state increase of compressive strength (0.52%) is shown by plain mortar that achieves 32.53 MPa at days-7 and 32.70 MPa at days-14.

A sharp compressive strength increase (16.50%) is also shown by concrete with sugar 0.03% of cement weight, that achieves 22.636 MPa at days-7 and grows to 26.37 MPa at days-14. The compressive strength of concrete with sugar cane liquid 0.03% of cement weight is also softly increases (10.25%) from 25.27 MPa at days-7 and grows to 27.86 MPa. A softer compressive strength growth (3.44%) is shown by plain concrete that moves from 27.35 MPa at days-7 to 28.29 MPa.

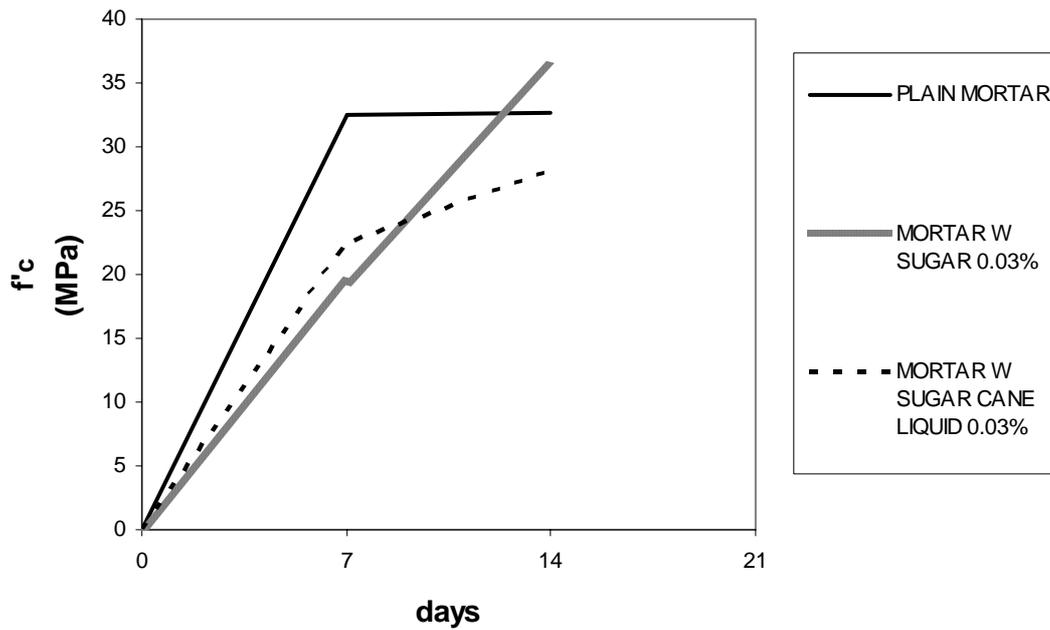


Figure 4. Compressive strength of plain mortar, mortar with sugar 0.03% of cement weight, and mortar with sugar cane liquid 0.03% of cement weight (Modified from Nikodemus and Setiawan, B., 2008; Ganis and Nugraha, 2008)

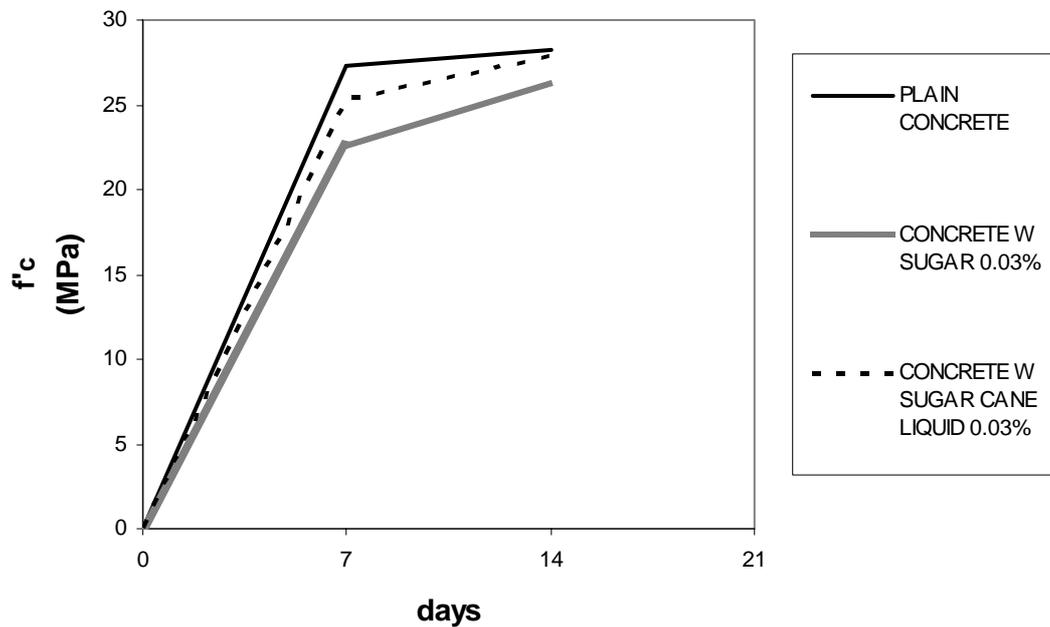


Figure 5. Compressive strength of plain concrete, concrete with sugar 0.03% of cement weight, and concrete with sugar cane liquid 0.03% of cement weight (Modified from Nikodemus and Setiawan, B., 2008; Ganis and Nugraha, 2008)

The observation of trinocular electronic microscope is conducted by trinocular lens with 10x magnification in first 6 hours setting (Nikodemus and Setiawan, 2008; Ganis and Nugraha, 2008) on Figure 6, 7, and 8. In the hours-1 of observation, it is found that the surface of plain mortar is found rough and porous compared to surface of mortar with sucrose 0.03% of cement weight. The surface of mortar with sugar 0.03% of cement weight seems softer and smooth, while the surface of mortar with sugar cane liquid 0.03% of cement weight is soft but little bit more

consistent. By hours-3, the surface of plain mortar is getting drier and harder compared to the surface of mortar with sugar 0.03% of cement weight and also sugar cane liquid 0.03% of cement weight. At hours-6, the surface of plain mortar is getting harder than the surface of sugar cane liquid 0.03% of cement weight, but the surface of mortar with sugar 0.03% of cement weight seems wetter compared to the others.

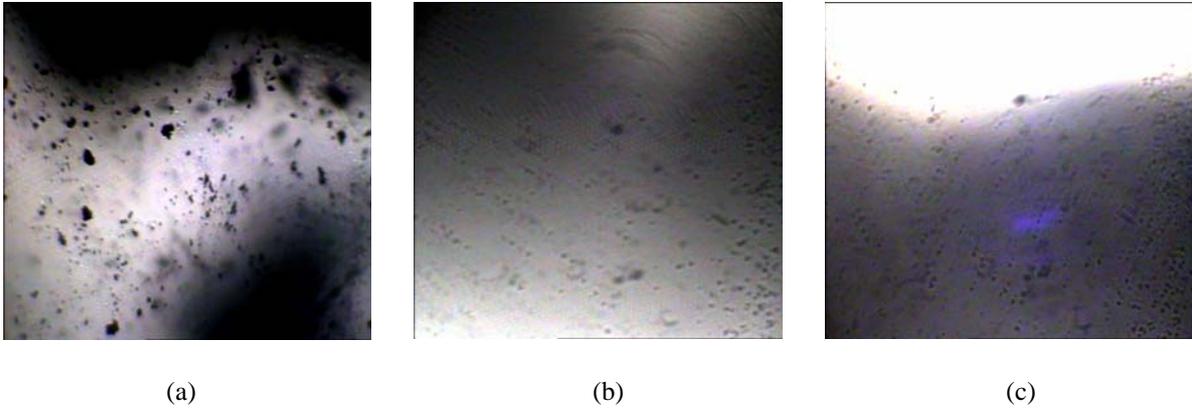


Figure 6. Plain mortar surface under trinocular microscope electronic (10x magnification)

- (a) Surface at day-1 hour-1
 - (b) Surface at day-1 hour-3
 - (c) Surface at day-1 hour-6
- (Nikodemus and Setiawan, 2008)

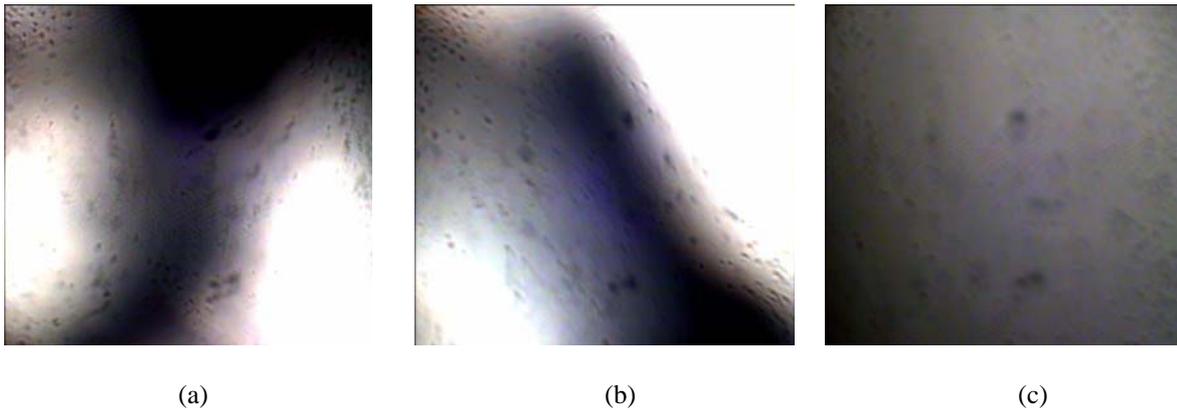


Figure 7. The surface of mortar with sugar 0.03% of cement weight under trinocular microscope electronic (10x magnification)

- (a) Surface at day-1 hour-1
 - (b) Surface at day-1 hour-3
 - (c) Surface at day-1 hour-6
- (Nikodemus and Setiawan, 2008)

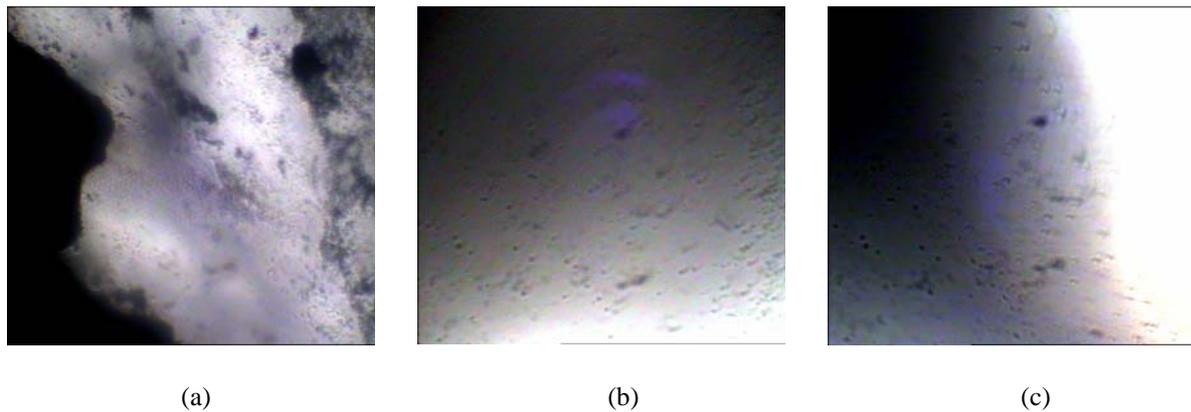


Figure 8. The surface of mortar with sugar cane liquid 0.03% of cement weight under trinocular microscope electronic (10x magnification)
(a) Surface at day-1 hour-1
(b) Surface at day-1 hour-3
(c) Surface at day-1 hour-6
(Ganis and Nugraha, 2008)

Discussion

It is studied classically by Young (1968) that addition of sugar into concrete mix will make interaction between sugar and C_3A which prevents rapid formation of cubic phase C_3AH_6 and generates the formation of hexagonal phase C_4AH_13 . It is also stated by Collepari, et. al. (1984, 1985) that glucose, gluconate, and lignosulfonate will stabilize ettringite in C_3A -gypsum system. Hence, glucose retards the consumption of gypsum and also formation of ettringite. Peschard, et. al (2004) emphasizes that the retarding effects depends on the chemical structure of admixture. Thus, both sugar and sugar cane liquid with dosage 0.03% of cement weight give retarding effect on compressive strength at days-7, but it doesn't take same effect at days-14. At days-14, the compressive strength of mortar with sugar cane liquid 0.03% of cement weight exceed the plain mortar and mortar with sugar 0.03% of cement weight. It can be said that sugar contains larger portion of sucrose compared to sugar cane liquid (which contains also cellulose and lignin). Mortar and concrete specimens which contain sugar cane liquid may be suffered by formation of C-S-H prevention because of the presence of cellulose and lignin.

The highest value of penetration (Figure 3) at final set (29 mm) described by cement with sugar 0.03% of cement weight (135 minutes) is showing strong action of retardation of cement setting compared to plain cement and also cement with sugar cane liquid 0.03% of cement weight. The sugar has proven more effective in prohibiting the hardening of cement paste.

The experimental results (Figure 4) describe that sugar 0.03% of cement weight is giving sharp increase (87.27%) of mortar compressive strength and the highest value of mortar compressive strength at days-14. But it doesn't clear here whether in older days the value is still higher than others. Nevertheless, the hydration calcium silicates in mortar have been retarded (Neville, 1999) by the presence of both sugar and also sugar cane liquid at early stages.

For concrete specimens, the retarding effect works on both concrete with sugar 0.03% of cement weight and concrete with sugar cane liquid 0.03% of cement weight. However, the highest value of compressive strength is taken by concrete with sugar 0.03% of cement weight (27.86 MPa) compared to plain concrete (28.29 MPa) and concrete with sugar cane liquid 0.03% of cement weight (26.376 MPa). According to Neville (1999), sugar admixture makes compressive strength of concrete will be slightly reduced about 7 days, but it will be increase in older ages. It is proved that at days-7 and days-14 the concrete specimen's with sugar 0.03% of cement weight and sugar cane liquid 0.03% of cement weight have lower compressive strength compared to plain concrete specimen.

The observation of trinocular electronic microscope (Figure 6, 7, and 8) of mortar specimens surface show that mortar with sugar 0.03% of cement weight has longer retarding effect in first 6-hours. It is wetter compared to the others. However, the addition of sugar and sugar cane liquid make the surface of mortar becoming softer than the plain one. Thus, the mortar hardening is affected seriously by the presence of sugar 0.03% of cement weight and sugar cane liquid 0.03% of cement weight.

Both sugar and sugar cane liquid with dosage 0.03% of cement weight perform retarding action by delaying the bond formation of hydration products C-S-H and prevent the early strength of mortar and concrete. Obviously, these natural retarders, sugar and sugar cane liquid, can significantly promotes good performance of early age concrete

4. CONCLUSIONS

This research meets conclusions as follow:

- (1) Cement with sugar 0.03% of cement weight has the highest value of penetration at final set. The sugar has proven more effective in prohibiting the hardening of cement paste
- (2) The experimental results describe that sugar 0.03% of cement weight is giving sharp increase (87.27%) of mortar compressive strength and the highest value of mortar compressive strength at days-14. However, the hydration calcium silicates in mortar have been retarded by the presence of both sugar and also sugar cane liquid at early stages
- (3) Retarding effect of concrete specimen's with sugar 0.03% of cement weight and sugar cane liquid 0.03% of cement weight works at days-7 and days-14 that they have lower compressive strength compared to plain concrete specimen
- (4) The mortar hardening is affected seriously by the presence of sugar 0.03% of cement weight and sugar cane liquid 0.03% of cement weight
- (5) The natural retarders of sugar and sugar cane liquid can significantly promotes good performance of early age concrete

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