EFFECT OF SUGAR ON SETTING TIME OF PORTLAND CEMENT

A. F. Mazumder*

Department of Civil Engineering, Presidency University, Dhaka, Bangladesh
**Corresponding Author: mazumder_buet@yahoo.com*

ABSTRACT
Setting time is affected while concreting in hot weather condition. To prevent concrete to set early due to adverse effects of hot weather, admixtures are usually incorporated in it. On the other hand emergencies may arise, due to traffic congestion and for massive concreting, to increase the setting time. The objective of this paper is to investigate the effect of sugar as a retarding/accelerating admixture on Type - I and Type - V Portland Cement paste. The setting time tests were performed for different concentration (0 to 0.25%) of sugar. Sugar was added with water, and then mixed with cement. The test result revealed that for lower concentration (0.01~0.08%), sugar acts as retarding agent and for higher concentration (over 0.17~0.19%), sugar acts as accelerating agent. Optimum concentration was found to be 0.073% and 0.05% for Type - I and Type - V cement respectively.

Keywords: Initial Setting Time; final setting time; cement; sugar; admixture

INTRODUCTION
Traffic congestion has triggered on time arrival of concrete truck on construction site. In addition, high temperature also lowers the setting time of concrete. When water is added to cement, paste is formed which gradually stiffens and then hardens. The stiffening of cement paste is called setting. Normal setting of cement is associated with the hydration of Tri-calcium silicate (C_3S) and formation of the calcium silicate hydrate (C-S-H gel). Due to the conditions of hot weather, there is rapid evaporation of water from the surface of the fresh cement paste/concrete. As a result, the cement paste or concrete sets rapidly than its normal setting and reduces the length of time for concreting operations. So, less time is available for placing, compaction and finishing. That would lead to porous concrete and loss of strength. So, there is rise of demand of efficient retarder for cement paste/ concrete.
Retarding admixtures are mainly based on materials having lignosulfonic acids and their salts, hydroxy-carboxylic acids and their salts, sugar and their derivatives and inorganic salts such as borates, phosphates, zinc and lead salts. Retarding effects of a retarder depends upon a number of factors including dosage of the admixture, time of addition to the mix and curing conditions. Some admixtures act as retarders when used in small amounts but behave as accelerators when used in large amounts. For example, sugar behaves as a set retarder but the small amount of sugar will virtually prevent the setting of cement (Ashworth, 1963; Jumadurdiyev et al., 2005; Abalaka, 2011; Abalaka, 2011).
Owing to the retardation of ordinary Portland cement, sugar falls into three categories: non-retarding, good retarders and most effective retarders. The non-retarding sugars, α-methyl glucoside and α, α-trehalose are effectively non-retarding; the retarding sugars glucose, maltose, lactose and celloboise, are grouped together as good retarders; and sucrose and raffinose are the most effective retarders (Thomas and Birchall, 1983). Because of retarding action of retarder, the one day strength of concrete is reduced. However, ultimate strength is reported to be improved by using set controlling admixtures. Rate of drying shrinkage and creep would increased by using retarders, but the ultimate values cannot increase.
The main objective of this study is to investigate the possibilities of using sugar as retarding agent for Type I and Type V cement. The specific objective of this study is to determine the optimum dosages of sugar for both types of cement and its effect on setting time.

METHODOLOGY
The length of time for a mixed preparation of materials to reach a state of hardness, measured from the start of the mixing. The end point for dental materials is usually determined by a penetration test. The

setting and hardening of cement is a continuous process, but two points are distinguished for test purposes. The initial setting time is the interval between the mixing of the cement with water and the time when the mix has lost plasticity, stiffening to a certain degree. It marks roughly the end of the period when the wet mix can be molded into shape. The final setting time is the point at which the set cement has acquired a sufficient firmness to resist a certain defined pressure. It is different for different types of cement, depends upon the type of project in which it is being used. Initial setting time of ordinary Portland cement should be maximum 45 minutes according to the British Standard. Final setting time of cement should not be more than 10 hours.

To investigate the effect of sugar as a retarding agent, normal consistency test was undertaken according to ASTM C187. After completing normal consistency test, with the known consistency (water/cement ratio) six samples were tested to measure initial and final setting time according to ASTM C191. At first, one sample was tested without adding sugar to the mixture (control specimen). Then initial and final setting time was recorded, to know the actual situation of the cement. Then rest 5 samples were tested with different concentration of sugar, added to the mixture by mixing with water as a percentage of cement. The concentrations of sugar were taken as 0.05%, 0.10%, 0.15%, 0.20% and 0.25%. Then for all the samples initial and final setting time were recorded and compared with the control specimen. To find out optimum dosage of sugar Newton's Forward Interpolation method was adopted.

RESULTS AND DISCUSSIONS

Six specimens were tested to find out initial and final setting time. Among the specimens, one was control specimen without sugar content and other five specimens were having increasing amount of sugar. The amount of sugar was added as the percentage of cement content in the mixture. The concentration was 0.05%, 0.10%, 0.15%, 0.20% and 0.25%. Then following the same procedure initial and final setting were recorded for different concentration of sugar. Table 1 shows the experimental results.

Table 1: Sugar Concentration, Initial and Final Setting Time

Sugar added as the percentage of cement	Weight of sugar added (gm)	Setting Time			
		Type I Cement		Type V Cement	
		Initial (minutes)	Final (minutes)	Initial (minutes)	Final (minutes)
0	0	135	215	187.8	600
0.05	0.325	378	780	690.8	900
0.1	0.65	373	675	313.4	720
0.15	0.975	219	510	190	510
0.2	1.3	50	420	111.9	356
0.25	1.625	23	360	35.7	240

The outcome of this research is discussed below:

- The normal consistency was found to be 0.26 and 0.28 for Type I and Type V cement respectively.
- For lower concentration (up to 0.08%), sugar acts as retarder and for higher concentration (more that 0.17~0.19% approximately), sugar acts as accelerator comparing with the control specimen (without sugar).

The optimum sugar content for which highest amount of retardation was 0.073% (using Newton's Forward Interpolation Method) and 0.05% approximately for Type I and Type V cement respectively.

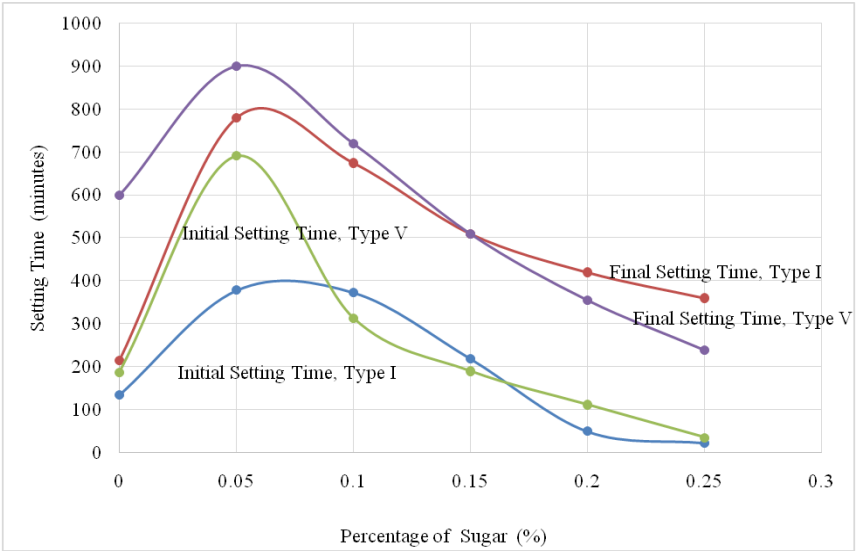

Fig. 1: Setting Time Vs Concentration of Sugar Diagram

Discussion can be made about result:

- The setting time of cement is highly affected by sugar and amount of sugar to be added to get additional time (in case of retardation) or reduce the time (in case of acceleration) before set, can be found out from Fig. 1.
- The retarding effects of sugar, when added to a mix, continue until it is removed from the solution by reaction with C_3A from the cement or by some other way, it is removed and incorporated into the hydrated material (Khan and Ullah, 2004).
- For higher concentration of sugar, setting time had decreased. The exact cause of this abnormal behavior of the retarding admixture to accelerate the initial set is not known. However, it was reported by some researchers that in addition to the reaction between lime and pozzolana, some other reaction between C_3A or its hydration products and pozzolana can occur (Plowan and Cabera, 1984). There may be some reaction between the pozzolana and the admixture to form some compounds giving rigidity to the paste earlier than that obtained by the hydration products of the cement. According to the opinion of the Author of this paper, higher concentration of sugar increases the reactivity of C_3A.

CONCLUSIONS

This research was undertaken to investigate the retarding action of sugar on setting time of cement paste. All other variable was kept constant, except the concentration of sugar. From the result of initial and final setting time it can be reported that

- Up to optimum sugar content (0.06-0.08%), sugar can be used as a retarding admixture for hot weather countries.
- Above 0.20% sugar content can be used as a accelerator for cold weather countries.
- Optimum concentration can be chosen for highest amount of setting time.
- From the graph below, extra time required for transporting, placing, compacting and finishing can be calculated and for that corresponding sugar concentration should be added to have desired initial setting time. This curve was drawn for 0 to 0.08% of sugar content by interpolating the data from 0 to 0.05% concentration. Otherwise, for required additional initial setting time, sugar concentration can be calculated from the equations and added to actual initial setting time.

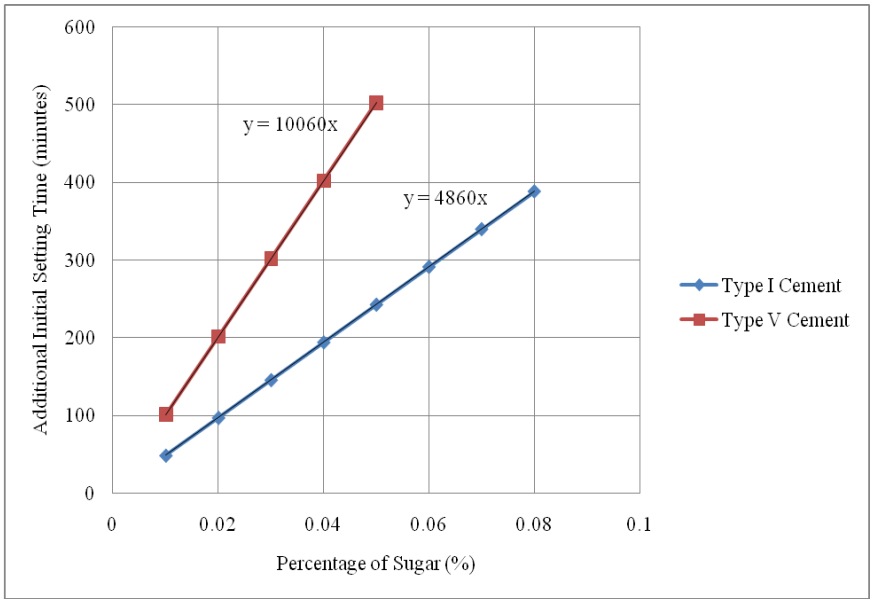

Fig. 2: Initial Setting Time Vs Sugar Concentration

ACKNOWLEDGMENTS

Tests of this study were undertaken in concrete laboratory of King Fahd University of Petroleum and Minerals (KFUPM).

REFERENCES

Abalaka, AE. 2001. Effects of Sugar on Physical Properties of Ordinary Portland Cement Paste and Concrete. *AU J.T.*, 14(3): 225-228.

Abalaka, AE. 2011. Comparative Effects of Cassava Starch and Simple Sugar in Cement Mortar and Concrete. ATBU Journal of Environmental Technology, 4(1).

Ashworth, R. 1963. Some Investigation into the use of sugar as an admixture to concrete. *Proc. Inst. Civ. Eng.*, 31: 129-145.

Jumadurdiyev, A; Ozkul, MH.; Saglam, AR. and Parlak, N. 2005. The Utilization of Beet Molasses as a Retarding and Water-reducing Admixture for Concrete. *Cement and Concrete Research*, 35: 874-882.

Khan, B. and Ullah, M. 2004. Effect of a Retarding Admixture on the Setting Time of Cement Pastes in Hot Weather. *Eng. Sci. Vol*. 15(1): 63-79.

Plowan, C and Cabera, JG. 1984. Mechanism and Kinetics of Hydration of C3A and C4AF. Cement and Concrete Research. 14(2): 238-248.

Thomas, NL and Birchall, JD. 1983. The Retarding Action of Sugar on Cement Hydration. *Cement and Concrete Research*. 13: 830-842.