Effect of Waste Water of Boron Industry on Mortar Properties

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Abstract During boron production, too much waste water (WW) and mud are composed. People build ponds for the storage of WW. There ponds damage environment and vegetation. Because of boron content, these stored WW cannot find recycling opportunities in industry. Concrete technology may be appropriate for the elimination of wastes in such large quantities. Efforts to utilize WW in concrete is still under discussion. The literature for the utilization of boron in concrete technology but there is no study for WW which is composed during boron production. This study was done to eliminate this deficit. For this purpose, the WW was supplied from Eti Maden Kırka Boron Management. WW was replaced in mortar production by mixing water in the ratio of 0, 10, 20, 40%. Half of the specimens placed in standard cure 28 days, other half placed in the WW 28 days at a constant temperature. Unit weight, ultrasonic pulse velocity, flexural strength and compressive strength experiments were done on the specimens in order to determine the impact of the WW on the mortar properties. As results of the experiments, WW increase the setting time and reduce the strength. Especially in the hot weather, problems arising from early stiffing can be eliminated by using WW. But in the cold weather using this WW is not recommended because of the fact that setting time delays and by using WW this setting time will increase a lot.

Keywords: waste water, boron, physical properties, mortar.

1. Introduction

With the development of the industry, harmful wastes are produced inevitably. Much studies have been conducted in order to eliminate negative effect of this wastes to environment, people and creatures (Chakraborty, Jo, Jo, & Baloch, 2017; Domingo & Luo, 2017; Koolivand, Mazandaranizadeh, Binavapoor, Mohammadtaheri, & Saeedi, 2017; Plazzotta, Manzocco, & Nicoli, 2017; Won & Cheng, 2017). Literature have various studies on whether some wastes could be used or not in construction sector. In a study, Sandrolini and Franzoni explored usability of waste wash water (coming from a concrete plant) in mixing water for concrete. Within this context the WW effects on mechanical-physical characteristics and microstructure of concrete were investigated. The results showed that concrete and mortar prepared with recycled water exhibit 28-day mechanical strength in no way lower than 96% of the reference specimens and, in some cases, even better (Sandrolini & Franzoni, 2001). A paper evaluated the use of dry sludge additive in concrete, for which it must be certified that the resulting concrete has the appropriate mechanical strength and durability. The addition of sludge decreases the mechanical strength of concrete, in this sense, sludge is an improper additive for short-term high-strength concrete and for reinforced and pre-stressed concrete (Yagüe, Valls, Vázquez, & Albareda, 2005).

Because boron reserves in Turkey have 67% of total reserves of whole world and being high quality boron that it have feature on demand in the world market, importance given to boron increasing in Turkey (Güyagüler, 2001; Kistler & Helvaci, 1994; Poslu & Arslan, 1995). This wastes must be eliminated within scope of sustainable environment and protection of natural resource. Within this context, studies about this scope must be increase. The studies about reusing or recycling of boron industry wastes in cement concrete or mortar and making it harmless to nature are primary studies which have been done (Bentli, Özdemir, Çelik, & Ediz, 2002). In the study conducted by Ozdemir and Ozturk, the utilization of clay wastes containing boron as cement additives was investigated. The effect of on chemical and mechanical characteristics of cement with clay waste addition to clinker and gypsum was determined. It was observed that cement could be replaced by the first and second type clay waste up to 5% and 10%, respectively (Özdemir & Öztürk, 2003). The objective of another study was to determine the effects of pectin on the setting time of the Portland cement and cement with boron. The result showed that the general effect of pectin was to speed the setting time of the cement up. Pectin behaved as a retarder up to a level of 0.1%, and then as an accelerator beyond 0.1% for the CW cement. The presence of pectin in cement with boron has a positive effect to the both late and early compressive strength of the mortar (Kavas, Olgun, Erdogan, & Once, 2007). A paper presents a study of the durability and mechanical features of Portland cement mortars mixed using municipal water and wastewater having various boron ratios. (Yılmaz, 2016)

Production of large amounts of waste wash water produced from Eti Maden Kırka Boron Management plants leads to environmental problems for this region and this spread over a large area day by day as shown in Figure 1. With this paper, boron waste water (BWW) usage in either mortar producing or cure water treatment for the specimens is aimed. Within this scope, standard mixing water is replaced by different BWW ratios in the specimens. Specimens produced with or without BWW are soaked in standard and also in BWW pool at constant temperature. All results of specimens obtained from experiments were evaluated.

2. Experimental study

2.1. Materials

Cement: The products of Eskisehir Cement Factory CEM I 32.5 R cement were used. Properties of cement are shown in Table 1.

Water: Eskişehir tap water was used as mixture water. The contents of water were 45 mg/lt sulfate, 57 mg/lt calcium, 83 mg/lt magnesium, 49 mg/lt chloride, 438 mg/lt evaporation balance and pH was 6.75.

Aggregate: The standard sand named RILEM Cembureau prepared by Trakya Cement Set Cement Industry and Trade Inc. suitable for TSE EN 196-1 was used.

Waste Water: It was supplied from Eti Maden Kırka Boron Management.

2.2. Method and tests

Mixing ratios of cement, water and aggregate were 1, 0.5, 3 respectively. In the production of mortar, standard mixed water has been replaced by wastewater (0, 10, 20, 40%). Half of the specimens placed in standard cure 28 days, other half placed in the WW 28 days at a constant temperature. Unit weight, ultrasonic pulse velocity, flexural strength and compressive strength experiments were done on the specimens in order to determine the impact of the WW on the mortar properties. Preparation and molding of mixtures shown in Figure 2.

Figure 1. Boron waste disposal area

Table 1. Properties of cement

SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	SO_3	LOI	Spec. Gravity	Blaine, cm^2/g
19.65	62.14	5.34	2.89	1.34	0.35	0.7	3.05	3.75	3.07	3258

Figure 2. Preparation and molding of mixtures

3. Discussion

Effect of waste water on setting time is shown in Figure 3. Even though the start-up time of the setting was increased with the addition of wastewater, this increase had not been occurred remarkably. However, the settling time increased at a rate of 23% as the amount of BWW in the mortar mixture increased. It is determined that boron delayed the setting time in previous studies which had been done with solid boron waste. In this study, it was observed that waste water produced by boron production delayed setting time by affecting reactions with cement.

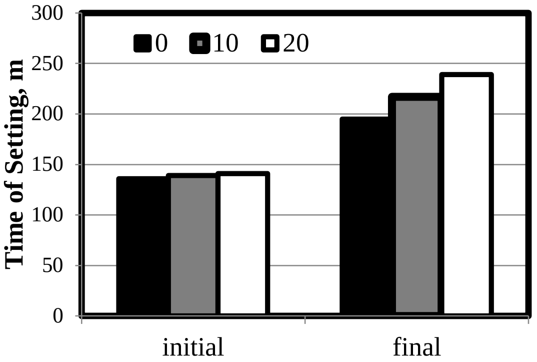

Figure 3. Setting time of mixtures

The effect of BWW on the unit weight of mortar is shown in Figure 4 when the BWW is used as mixing water and curing water. In normal curing environment, the addition of BWW to the mortar mixture reduced the unit weight of mortar by 17%. When 20% BWW was used in mixing water for samples which were cured by BWW, the tendency of decrease in unit weight showed similar results to samples in normal cured condition. As a result of using 40% BWW in mixing water and BWW as curing water, samples disintegrated and could not be measured. The use of too much BWW in mixing water, and the use of this BWW as curing water, had an effect on the durability after the mortar had hardened and this deteriorating effect led to the disintegration of the mortar.

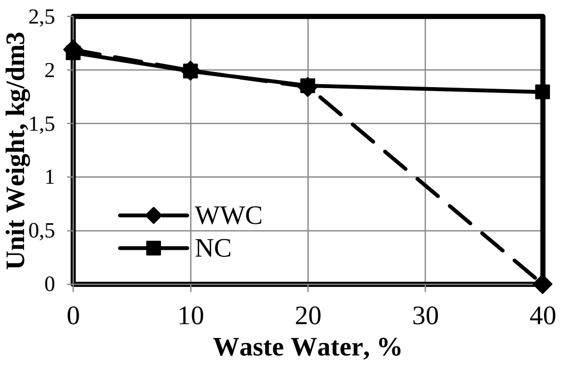

Figure 4. Unit weight of specimens

The effect of ultrasonic pulse velocity on the mortar samples of BWW is given in Figure 5. When Figure 5 is examined, the addition of BWW to the mortar mixing water at a rate of 40% increases the ultrasonic pulse velocity by 58%. Herein, with the increase in the workability of the BWW and the result of obtaining mortar with less voids ultrasonic pulse velocity has been increased.

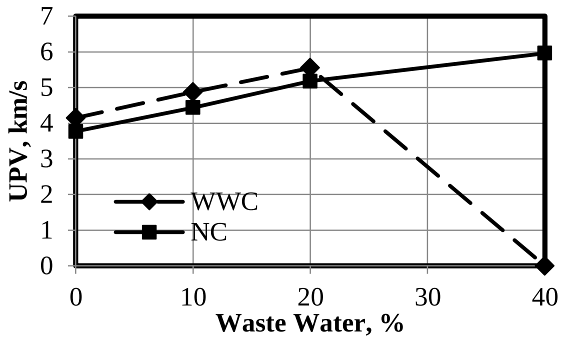

Figure 5. UPV variation of specimens

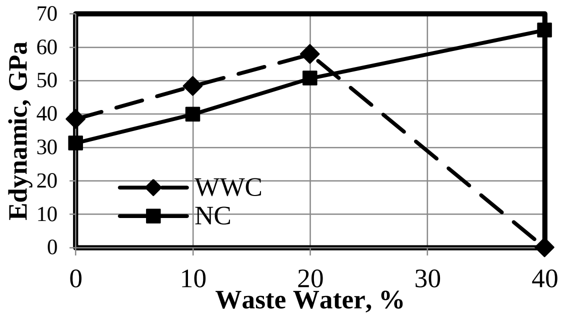

Figure 6. Variation of dynamic modulus of elasticity

The variation of the dynamic elasticity modulus with BWW which is calculated by depending on the ultrasonic pulse velocity and unit weights is given in Figure 6. Because the unit weight reduction was less than the increase in ultrasonic pulse velocity, the dynamic modulus of elasticity of the mortars had been increased by the addition of BWW.

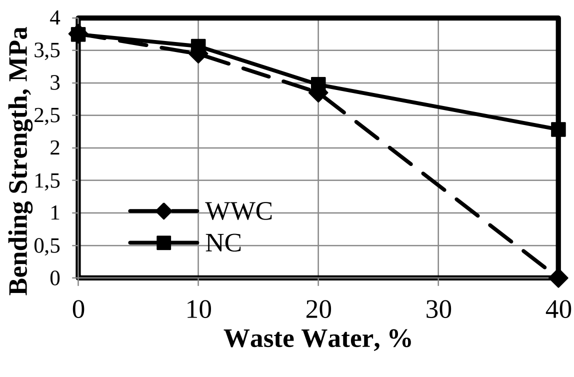

Figure 7. Bending strength of specimens

The changes in the bending strength of the mortars in which BWW was used as mixing and curing water are shown in Figure 7. It can be seen from Figure 7 that when the BWW is used as mixing water, the bending strength decreases at rates 40% as the amount of BWW increases. When a small amount of BWW is used in mortars and using BWW as curing water, there is no significant change in bending strength. But when a high rate of BWW used in mortars and also using BWW as curing water, the bending strength could not be obtained.

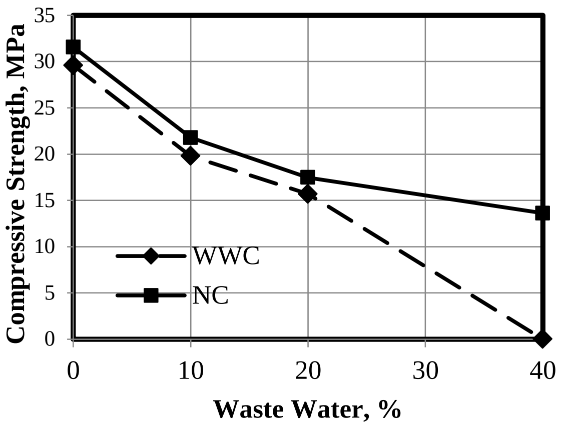

Figure 8. Bending strength of specimens

The effect of the BWW on the compressive strength of mortar is given in Figure 8. It can be understood from Figure 8 that when the ratio of BWW in mixing water increases, the strength of the mortar decreases by 57%. BWW affects the hydration reactions of the cement in the negative direction and slows down the formation of solid structures and leads to the loss of strength. When the effect of the curing water is examined, the resistance loss is about 5% when the BWW is used 20% or less in the control mixtures and mortar mixture and when the BWW is used as the curing water.

4. Conclusion

The conclusions of the study are summarized as follows:

• The BWW involved in the mixing did not have a significant effect on the initial setting, but delayed the setting time

• When high BWW concentration in mixtures and BWW is used as the cure water the mixture is disintegrated because the sample is not able to gain enough strength.

• The use of wastewater caused some decrease in unit weight of mortars.

• WW usage have a positive effect on ultrasound transit speed and dynamic elasticity modulus values of mortars.

• The use of wastewater as mixing water has significantly reduced bending and compressive strength of mortars. However, when used as curing water, decrease of strength because of this BWW is less than 5%.

As a result, it was seen that WW generated in the production of boron could not be excessively used in the mixtures which can be evaluated in concrete industry. However, in this case, it is recommended to use it in hot weather considering the effect of delaying setting time of BWW. It could be recommended to use BWW as cure water in concrete technology. It is recommended for new studies to investigate the availability of this BWW as cure water in concretes with high mineral or chemical additives.

References

Bentli, T., Özdemir, O., Çelik, M., & Ediz, N. (2002). Bor Atıkları ve Değerlendirilme Stratejileri. Paper presented at the The First International Boron Symposium.

Chakraborty, S., Jo, B. W., Jo, J. H., & Baloch, Z. (2017). Effectiveness of sewage sludge ash combined with waste pozzolanic minerals in developing sustainable construction material: An alternative approach for waste management. Journal of Cleaner Production, 153, 253-263.

Domingo, N., & Luo, H. (2017). Canterbury earthquake construction and demolition waste management: issues and improvement suggestions. International Journal of Disaster Risk Reduction, 22, 130-138.

Güyagüler, T. (2001). Türkiye bor potansiyeli, 4. 4. Endüstrıyel Hammaddeler Sempozyumu.

Kavas, T., Olgun, A., Erdogan, Y., & Once, G. (2007). The effect of pectin on the physicochemical and mechanical properties of cement containing boron. Building and Environment, 42(4), 1803-1809.

Kistler, R. B., & Helvaci, C. (1994). Boron and borates. Industrial minerals and rocks, 6, 171-186.

Koolivand, A., Mazandaranizadeh, H., Binavapoor, M., Mohammadtaheri, A., & Saeedi, R. (2017). Hazardous and industrial waste composition and associated management activities in Caspian industrial park, Iran. Environmental Nanotechnology, Monitoring & Management, 7, 9-14.

Özdemir, M., & Öztürk, N. U. (2003). Utilization of clay wastes containing boron as cement additives. Cement and Concrete Research, 33(10), 1659-1661.

Plazzotta, S., Manzocco, L., & Nicoli, M. C. (2017). Fruit and vegetable waste management and the challenge of fresh-cut salad. Trends in Food Science & Technology, 63, 51-59.

Poslu, K., & Arslan, İ. (1995). Dünya bor mineralleri ve bileşikleri üretiminde Türkiye'nin yeri. Endüstriyel Hammaddeler Sempozyumu, 33-34.

Sandrolini, F., & Franzoni, E. (2001). Waste wash water recycling in ready-mixed concrete plants. Cement and Concrete Research, 31(3), 485-489.

Won, J., & Cheng, J. C. P. (2017). Identifying potential opportunities of building information modeling for construction and demolition waste management and minimization. Automation in Construction, 79, 3-18.

Yagüe, A., Valls, S., Vázquez, E., & Albareda, F. (2005). Durability of concrete with addition of dry sludge from waste water treatment plants. Cement and Concrete Research, 35(6), 1064-1073.

Yılmaz, A. (2016). Bor İçeren Atık Suların Portland Çimentosu Harcı Üretiminde Kullanılması. Dokuz Eylül Üniversitesi Mühendislik Fakültesi Fen Ve Mühendislik Dergisi, 18(54), 481-490.