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Review study on the use of Boric Acid in concrete

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ÖZET

Bu araştırma borik asit uygulamalarını kapsamaktadır(H_3BO_3). Borik asitin kimyasal yapısı, H_3BO_3: Borogypsum atığını içeren harçlar, borogypsum içermeyen referans numuneye göre daha yüksek sıkıştırma ve ayrılma gerilimi mukavemetleri ve daha yüksek ayar süresine sahiptir. % 1 atık içeren numunenin en iyi ayrılma gerilme mukavemetine sahip olduğu görülmüştür. (7.40 MPa) ve% 3 oranında atığı içeren numune en iyi basınç dayanımına (48.00MPa) sahipti. Kalsine olmamış borojips deneylerinin sonuçlarına göre,% 5 oranında atığı içeren numunenin en iyi yarılma mukavemetine (7.63 MPa) ve% 3 atığın da dahil olduğu numunenin en iyi basınç dayanımına (45.70 MPa) sahip olduğunu göstermiştir. Borik asit atağının beton yapıyı önemli ölçüde etkilemediği sonucuna varmışlardır. Borik asit de beton mukavemeti gelişimi üzerinde olumsuz bir etkiye sahipti. Ayrıca, diğer beton bozunma mekanizmalarında olduğu gibi borik asit liç oranı, kısmen difüzyonlu taşıma oranına ve sıkıştırma dayanımına bağlı olup, çimentoda B_2O_3 içeriğindeki artışla birlikte genleşme ve kuruma süresi özellikleri azalmıştır. Borogypsum, borik asit üretimi sırasında kolemanit cevheri ve sülfürik asit arasındaki reaksiyondan oluşan atıktır. Borogypsum, B_2O_3 içeriğinden dolayı birçok işlemde kullanılsa da, toprağı ve suyu kirletir. Damıtılmış su ve borik asit çözeltilerinin pH 5.2 ve 6.1 ile nüfuz ettiği betonarme çatlaklarda uzun süreli (2 yıl) bir inşaat demiri korozyonunun araştırılması, daha geniş açıklıklara sahip çatlaklarda daha yüksek bir korozyon ve / veya daha düşük pH ile suya nüfuz ettiğini göstermiştir. .

Anahtar Kelimeler: Borik asit, Borogypsum atık, Beton yapı, Beton.

ABSTRACT

This survey covers boric acid (H_3BO_3). Chemical structure of boric acid, H3BO3: The mortars including borogypsum waste had higher compressive and splitting tensile strengths and higher setting time with respect to reference sample which was borogypsum-free.it was seen that sample including 1% waste had the best splitting tensile strength (7.40 MPa) and sample including 3% waste had the best compressive strength (48.00MPa). According to results of non-calcined borogypsum experiments showed that sample including 5% waste had the best splitting tensile strength (7.63 MPa) and sample including 3% waste had the best compressive strength (45.70 MPa). they concluded that boric acid attack does not significantly affect the concrete structure. And boric acid had a negative effect on concrete strength development. Also,the rate of boric acid leaching, as with other concrete degradation mechanisms, depends in part on the rate of diffusive transport and compressive strength, expansion and setting time properties of cement decreased with the increase in B2O3 content of waste. Borogypsum is the waste that forms during boric acid production from the reaction between colemanite ore and sulphuric acid. Although borogypsum is used in many processes because of its B2O3 content it pollutes the soil and water. A long-term (2-year) investigation of rebar corrosion in reinforced concrete cracks penetrated by distilled water and boric acid solutions with pH 5.2 and 6.1 indicated a higher degree of corrosion in cracks with wider apertures and/or penetrated by water with lower pH.

Keywords: Boric acid, Borogypsum waste, Concrete structure, Concrete .

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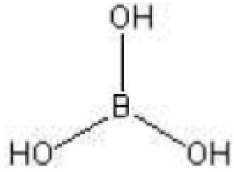
1.BACKGROUND

This survey covers boric acid (H3BO3). Chemical structure of boric acid, H_3BO_3:



Colemanite (Ca2B6O11•5H2O), ulexite (NaCaB5O9•8H2O) and borax (tincal) (Na2B4O7•10H2O) are the most important boron minerals that are used in production of boric acid and different kinds of borates. [1] .Boric acid is manufactured by reacting inorganic borate minerals with sulphuric acid in an aqueous solution. However, Waste containing more than 1% of boron in the form of boric acid/borates should be treated as hazardous waste. [2]

There are lots of studies to investigate and improve the addition of the boron wastes to cement and concrete production. In the study of [3], they used different ratios of borogypsum as concrete additive and they concluded that borogypsum retarded the initial and final setting times of concrete mixtures. Moreover, they reported that 3% and 5% borogypsum containing mixtures had higher compressive strength.

2. LİTERATURE INFORMATİON ON BORİC ACİD

Kunt and another concluded that mortars including borogypsum waste had higher compressive and splitting tensile strengths and higher setting time with respect to reference sample which was borogypsum-free.it was seen that sample including 1% waste had the best splitting tensile strength (7.40 MPa) and sample including 3% waste had the best compressive strength (48.00MPa). According to results of non-calcined borogypsum experiments showed that sample including 5% waste had the best splitting tensile strength (7.63 MPa) and sample including 3% waste had the best compressive strength (45.70 MPa). [1]

Bajza and another studied the effect of boric acid solutions on the physical properties and phase composition of concrete and hardened Portland cement paste (HPCP). the study, samples were taken from the walls of a damaged reinforced concrete tank used for boric acid storage. The Schmidt hammer compressive strength of samples unaffected by boric acid ranged from 29 to 45 MPa (n = 16; mean = 36.7 MPa; standard deviation = 4.7 MPa), whereas the values for two samples that exhibited boric acid attack were 40 and 41 MPa. The compressive strength determined from the core cylinders with no evident boric acid attack ranged from 26 to 45 MPa (n = 8; mean = 37.9 MPa; standard deviation = 6.9 MPa), whereas the values for the two samples with evident boric acid reaction were 44 and 48 MPa. From these results, they concluded that boric acid attack does not significantly affect the concrete structure. [4]

Jin and another investigated the effect of boric acid on the physical properties and performance of reinforced concrete. The basic mechanical properties (compressive strength, splitting tensile strength, and elastic modulus) of concrete reacted with boric acid solutions were compared with those exposed to an outdoor natural environment.Compared to specimens that were exposed to a natural environment, those reacted with boric acid had lower compressive strength, splitting tensile strength, and elastic modulus, indicating that boric acid had a negative effect on concrete strength development. [5]

Bothe and Brown (1999) conducted experiments to understand the mechanism by which soluble borates, such as boric acid, retard the hardening of cement. Boric acid solutions for 180, 240, and 300 days was conducted by Concrete Research & Testing, LLC (CRT). The depth affected by boric acid leaching for each cylinder specimen is measuredThe rate of boric acid leaching, as with other concrete degradation mechanisms, depends in part on the rate of diffusive transport. [6]
A previous EPRI study (Simons, et al., 2009) measu
red the degradation depth of concrete specimens that were immersed in 2,400 ppm B solutions. The data show that for concrete cylinders that were immersed at room temperature, the compressive strength of cylinders that were reacted with 2,400 ppm B solution is higher than for those that were reacted with 1,200 ppm B solution. [7] Kavas, Olgun and Erdoğan , studied effects of borogypsum on the setting time of cement and strength of the mortar. [8], Elbeyli ,

Kavas, Olgun and Erdoğan , studied effects of borogypsum on the setting time of cement and strength of the mortar. [8], Elbeyli , studied effects of the borax wastes addition on the mechanical and physical properties of cement and it was concluded that compressive strength, expansion and setting time properties of cement decreased with the increase in B2O3 content of waste. [9]

Borogypsum is the waste that forms during boric acid production from the reaction between colemanite ore and sulphuric acid. Although borogypsum is used in many processes because of its B2O3 content it pollutes the soil and water. One of the processes in which the borogypsum can be used is cement production (11).

A long-term (2-year) investigation of rebar corrosion in reinforced concrete cracks penetrated by distilled water and boric acid solutions with pH 5.2 and 6.1 indicated a higher degree of corrosion in cracks with wider apertures and/or penetrated by water with lower pH. [10] [12] On the other hand , and rebar exposed to the natural environment indicated that there is no clear relationship between boric acid concentration and weight loss and that boric acid has no significant effect on rebar corrosion. [13]

In addition, a study to support a U.S. patent indicated that boron containing compounds, including boric acid, are effective inhibitors of chloride-induced corrosion of steel in reinforced concrete structures [14].

3. THE USİNG OF BORİC ACİD

AIR DETRAINERS : Air-detraining admixtures reduce the air content inconcrete. They are used when the air content cannot bereduced by adjusting the mix proportions or by changingthe dosage of the air-entraining agent and other admixtures.However, air-detainers are rarely used and their effectiveness and dosage rate should be established ontrial mixes prior to use on actual job mixes. Decrease air content water-insoluble esters of carbonic and boric acid. [15]

In this study, there was investigated the effect of anhydrous boric acid as additive material on the compressive and flexure strengths of mortar samples which are produced with different cements. In addition, we tried to suppress the effect of the boron compound on the especially early strength of some mortar samples by using accelerator additives.

The negative effect of boron compounds on the early strength of cemented composites is well known. In this study, there was investigated the effect of boric acid compound to the compressive and flexural strengths. [16]

The boron compounds (boric acid and glass powder) in the reactions are believed to cause a delay in the hardening or even prevent the occurrence of hardening of the concrete It is not appropriate to add boric acid and glass powder to improve the shielding properties of concrete, due to adverse effects in cement hardening process.

The borax has a significant effect on the efficiency of shielding in thick concrete shields (10 cm), because it reduces gamma rays caused by families up to 80% [17] Boron compounds such as boric acid extend the period of cement hydration. Therefore, Boron compounds are used in concrete as an efficient set retarding admixture. [18]

4. CONCLUSİON

Concrete immersed in boric acid solutions exhibited an increase in compressive strength, tensile strength, and elastic modulus. Hydrated cement pastes immersed in boric acid solutions showed an increase in weight, bulk density, and compressive strength, but the porosity decreased due to the formation of poorly soluble calcium borate hydrates in the pore system of the hardened cement paste.

The corrosion rate of steel in intact concrete is usually low because of a protective passiveoxide film on the steel surface that is stable under the alkaline pH of the cement pore solution.However, corrosion may occur at an accelerated rate when the passive film breaks down, whichcan be caused by a reduction in the pH of the cement pore solution (e.g., by reaction with boricacid solution) or an ingress of chloride ions. Calculations using a commercial code indicated carbon steel corrosion rates increased with increasing boric acid concentration.

The published literature reviewed for this report appears to suggest that boric acid does notsignificantly degrade concrete properties. However, the published data are mostly based onimmersion tests and are applicable to systems involving no flow of the boric acid solution The results indicate that rebar corrosion rates generally increase with temperature and boricacid concentration. The experimental data indicate that pH is a critical parameter that determines the corrosionsusceptibility of rebar in borated water and the degree of concrete degradation by boric acidleaching. Corrosion rates estimated from published weight loss data on rebars immersed inboric acid solutions for 180 days range between 0.032 and 0.039 mm/yr [0.0013 and0.0015 in/yr], The average depth affected byboric acid leaching increased with time, solution concentration, and temperature. [19]

This report presents the results of the literature review, experiments, and modeling that were. conducted on boric acid degradation of cement, reinforced concrete, and reinforcement steel. Admixtures are those ingredients in concrete other than portland cement, water, and aggregates that are added to the mixture immediately before or during mixing . To achieve certain properties in concrete more effectively than by other means. May be used to produce concrete for radiation shielding. 1% acid weight of boric acid for concrete is considered enough for shielding purposes . [20]

It was found that as the percent of the sludges increase in the cement mixture the compressive strength decreased. Sludge recovered from a boric acid factory includes mainly borogypsum (BG).BG consists of approximately 75 % CaS04.2H20 and 11% B2O3 and it can used as aadmixture in Portland cement concrete. From the results in Table 3, compressive strength values generally decrease with increasing ratio of reactor waste in the cement mixes , BG improves the compressive strength of concrete by 12 % and then the strength decreases with the increasing percent of BG in the mixtures. In the earlier work, refined BG, containing 6-8 % B2O3 was US&~). B2O3 content of the BG used in this work was 1.6 %. [21]

Worldwide mining of boron mineral ores were 5,410,000 tons in 2006. Turkey accounts for half of the mined tonnage. Second most is mined USA (approx. 1/5 of worldwide tonnage). It is expected that the EU-27 consumes around 20% of this production. In cellulose insulation, for cellulose fiber fire resistance, 12% boric acid is added. [22]

5. REFERENCES

1- Kunt, K., Dur, F., Ertınmaz, B., Yıldırım, M., Derun, E. M., & Pişkin, S. (No Date). Utilization of Boron Waste as an Additive for Cement Production.

2- Larsen, P. B., Nielsen, B. S., Fotel, F. L., Kortegaard, P., Slothuus, T., & Hjelmar, O. (2015). Survey of Boric acid and sodium borates (borax).

3- Sevim, U.K.; Tümen, Y. Strength and fresh properties of borogypsum concrete. Construction and Building Materials. 2013; 48, 342-347.

4- Bajza, A., I. Rouseková, and M. Dubík. "Can Boric Acid Corrode Concrete?" V. Bilek and Z. Kersner, eds. International Symposium on Non-Traditional Cement and Concrete, Brno University of Technology, Brno, Czech Republic. pp. 447–456. 2002.

5- Jin, X., N. Jin, and Y. Tian. "Study on the Behavior and Durability of Reinforced Concrete in Boric Acid Environment." Key Engineering Materials. Vols. 400–402. pp. 441–446. 2009.

6- Bothe, J.V. and P.W. Brown. “Kinetics of Tricalcium Aluminate Hydration in the Presence of Boric Acid and Calcium Hydroxide.” Journal of the American Ceramic Society. Vol. 82. pp. 1,882–1,888. 1999.

7- Simons, J., R. Keating, J. Nestell, and M. Frey. “Repair and Replacement Applications Center: Boric Acid Attack of Concrete and Reinforcing Steel in PWR Fuel Handling .

8- Kavas, T.; Olgun, A.; Erdoğan, Y. Setting and hardening of borogypsum- Portland cement .

9- Elbeyli, İ.Y. Utilization of industrial borax wastes (BW) for portland cement production. Turkish J. Eng. Env. Sci. 2004; 28, 281-287.

10- Pabalan, R., Yang, L., & Chiang, K. T. (2013). Boric acid corrosion of concrete rebar. Paper presented at the EPJ Web of Conferences.

11- Mutuk, T.; Mesci, B. Analysis of mechanical properties of cement containing boron waste and rice husk ash using full factorial design. Journal of Cleaner Production. 2014; 69, 128-132.

12- W. Ramm and M. Biscoping, Nuclear Engineering and Design 179, 191 (1998)

13- Buildings.” Report 1019168. Palo Alto, California: Electric Power Research Institute. 2009.

14- J.D. Dillard and J.O. Glanville, Composition and Method for Combatting Chloride-Induced Corrosion in Steel in Reinforced Concrete. U.S. Patent Number 5,092,923. Issued March 3, 1992.

15- Kosmatka, Steven & Kerkhoff, Beatrix & C. Panarese, William. (2002). Design and Control of Concrete Mixtures.

16- Davraz, M., KİLİNÇARSLAN, Ş., & Pehlivanoğlu, E. (2014). The Effects of Accelerating Admixture on the Mechanical Properties of Boric Acid Added Mortars. Acta Physica Polonica, A., 125 .

17- Mohamed Hasan, Seraj Yousef & Mazin Nassar ,2011.Studying the effect of organic and non - organic additives in the radiation and mechanical properties of radiation shielding. Syrian Atomic Energy Commission

18- Davraz, M. (2015). The Effect of Boron Compound to Cement Hydration and Controllability of this Effect. Acta Physica Polonica, A., 128.

19- CNWRA.(2011).Final Report on Boric Acid Degradation of Reinforced Concrete.Geosciences and Engineering Division .

20- M. F. Kaplan., Concrete Radiation shielding, Longman Scientific & Technical, England. 1989.

21- Demirbaş, A., & Karslioğlu, S. (1995). The effect of boric acid sludges containing borogypsum on properties of cement. Cement and Concrete Research, 25(7), 1381-1384.

22- RPA (2008). Assessment of the Risk to Consumers from Borates and the Impact of Potential Restrictions on their Marketing and Use. Final Report prepared for European Commission. DG Enterprise and Industry.