Effect and Impact on Performance of Concrete of Migration Type Rust Inhibitor

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Abstract. The purpose of this paper was to obtain a more in-depth understanding of the influence of migration type rust inhibitor on rust-inhibiting and the performance of concrete.Ten concents of migration type rust inhibitor BE were choosen, the relationship between content of BE with electrochemical impedance was investigated,and the influence of migration type rust inhibitor on rust-inhibiting was analyzed. When the content of rust inhibitor is 2%, the effects of BE on setting time of cement , strength of concrete,and durability of concrete were discussed,The results shows that BE has a great effect on rust-inhibiting;BE has a minor effect on setting time of cement;BE reduces the early strength of concrete,but has no influences on the late strength of concrete;BE can improve the durability of concrete.

Introduction

The durability of concrete directly affect the safety and using performance of buildings. Lacking of durability of concrete will short the life of the building and take maintenance costs increased greatly, which causing huge waste of social resources and even larger safety accidents.In general, factors which affect the durability of reinforced concrete structures are reinforcement corrosion, carbonization, freeze-thaw, erosion environment,etc. In many factors which affecting the durability of reinforced concrete, steel bar corrosion in concrete is the primary factor [1,2]. A lot of methods are used to prevent reinforcement corrosion, such as concrete surface protection treatment, electrochemical desalination and the use of rust inhibitor,etc.Among the rust inhibitor, the migration type rust inhibitor is a relatively economic and effective method [3,4]. Duing to the special composition, the migration type rust inhibitor can quickly enter inside the concrete by in gas phase and liquid phase to the concrete within the pore diffusion, each around the steel in the steel surface to form molecular layer, so as to protect the steel in anode and cathode area.BE is a good product of the migration type rust inhibitor, many units have research it and take a series of achievements [5,6].

The existing research is limited to coat BE on the surface of concrete or use electrochemical method to make it migrate to the surface of steel so as to achieve the resistance. But the simplest way to enter inside the concrete is mixed.In this paper,we will research the influence of migration type rust inhibitor on rust-inhibiting and the properties of concrete,which will provide technical support for the popularization and application of BE.

Experimental

Raw Materials. Ordinary portland cement(42.5) used in this study was supplied by nanjing coach cement.BE used in this study was supplied by high-tech institute of jiangsu province,whose mass fraction is 30%, the main corrosion inhibition of ingredients for alcohol amine organic compounds with benzene, the molecular formula is R-C6H4-C3H7NO.Water used in this study was tap wate. Sand used in this study was medium sand which fineness modulus is 2.5. Coarse aggregate used in this study was gravel which particle size is 5mm-31.5mm.

Process. (1) Test of rust resistance performance: Electrochemical impedance test technology was used to characterize the inhibitor rust of reinforced performance, measured by three electrode system,

A3 steel was used as the working electrode, a saturated calomel electrode (SCE) was used as the reference electrode, a platinum electrode was used as auxiliary electrode, the electrolytic tank capacity was 500 mL. The sample size of the working electrode was1.0cm×1.0cm×0.3cm, the effective working area was 1.0cm2, non-face inserts were sealed with epoxy resin.Before the experiment, working electrodes were polished followed progressively by 360,600,1000 grit sand paper to expose the bright uniform metal surfaces , then rinsed with distilled water and ethanol, and dried for reserver.Working electrodes were immersed in a constant temperature of the test solution for 30min, the potential corrosion of the working electrode in the test solution was measured for studying the effects of rust inhibitor on steel electrode potential of A3. Since the corrosion potential to be a stable then took electrochemical impedance measurements. The experimental temperature is (20 ± 1) ℃. Electrochemical workstation Princeton 2273 was used to measure electrochemical impedance spectroscopy (EIS). Electrochemical impedance test (EIS) used sinusoidal excitation signal, amplitude was 10 mV, scanning frequency range was 10^5Hz ~ 10^{-2}Hz.

(2) Concrete performance test: Setting time test accorded to standard GB/T1346-201, BE aqueous solution was mixed with cement which content was 2%(mass ratio of BE solution quality with the quality of cement is 2%,the same as below); Shrinkage test accorded to SL352-2006, water to cement was 0.5,sand to cement ratio was 2.5, the block size is 40mm×40mm×160mm; Strength test accorded to SL352-2006, mix proportion of concrete was referenced to table 1, the block size is150mm×150mm× 150mm; Carbonation test accorded to SL352-2006, mix proportion of concrete was referenced to table 1,the block size is 400mm×400m ×400mm; Chloride ion diffusion coefficient test accorded to RCM,mix proportion of concrete was referenced to table 1,the block size isΦ100±1mm,h=50±2mm.

Table 1 Mix proportion of concrete

Mix proportion/(kg.m^{-3})			
cement	sand	coarse aggregate	water
450	770	1143	1143

Results and Discussion

Effects of BE on the performance of resistance to rust. Figure 1 shows the concentration of rust inhibitor BE - electrochemical impedance relationship. the concentration of BE was the ratio of BE net amount with the water volume, the experimental medium for saturated was calcium hydroxide solution (pH = 12.5), the solution was simulated concrete pore solution. As you can see from Figure 1, reinforced impedance spectra is composed of a capacitive arc, we can not conclude that BE chang the reaction mechanism of the steel surface, just in the steel surface to adsorption form a layer of adsorption film to inhibit the corrosion of reinforcement.When the concentration of BE in the 0-100mg/L, with concentration increasing, corrosion reaction resistance is increasing, the effect of rusting is enhanced.This is because the rebar surface adsorption space is enough when the BE concentration is low, with the increasing of BE concentration, BE molecules are constantly adding adsorption film, so that the rust effect enhanced. When the concentration of BE in the 100-1000mg/L, impedance does not monotonously increases with the inhibitor concentration increases, but floating in a certain range, which may be due to the adsorption of BE reinforcement has a saturation value in certain concentration of BE,the concentration value is between 100mg/L-1000mg/L, and the adsorption of BE molecules reinforcement is a dynamic process, the molecules of BE in the outer layer can replace the molecules of BE adsorbed in the film, the replacing process leads to the fluctuation of the numerical electrochemical impedance. When the concentration of BE is higher than 1000mg/L, with the BE concentration increasing, the reaction impedance increaseing gradually, enhancing the anti-corrosion effect.The reason may be BE molecules are orderly arranged in the steel surface adsorption in a certain range of concentration,and when the concentration reaches a certain value, the BE molecules are reordered, more compact in the adsorbed film of the surface of the steel bar, So that

the rust resistance effect is stronger. To make a long story short, electrochemical tests show that BE has a good effect of rusting.

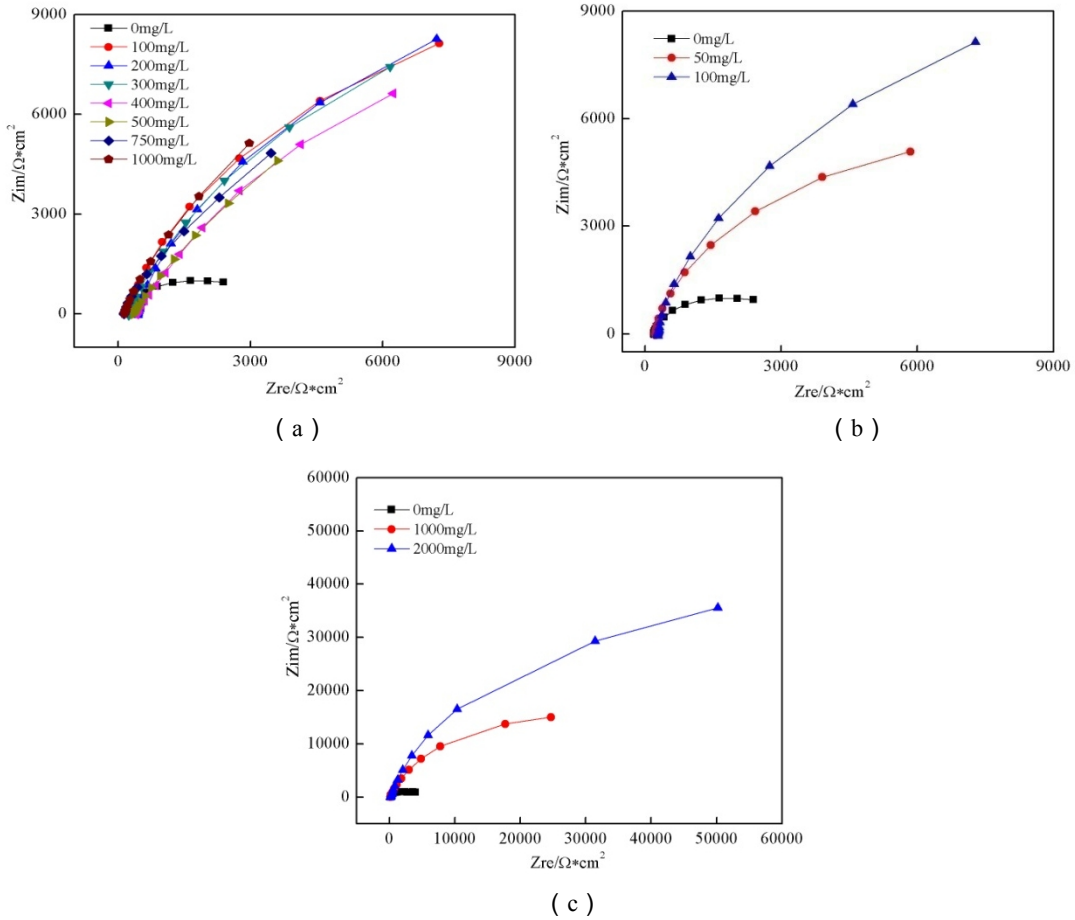

Fig. 1 Concentration of rust inhibitor BE - electrochemical impedance relationship

Effects of BE on Setting Time of Cement. Figure 2 shows the effects of BE on setting time of cement. After adding BE in ordinary Portland cement, concrete initial setting is accelerating, initial setting time is only 61.4% about the cement without BE; Final setting time is slightly extended, the process of cement hydration from the initial setting to the final setting is slowly.Overall, BE has little effect on the cement setting time in this content, in line with state regulations, fast-setting and retarding serious situation does not occur.

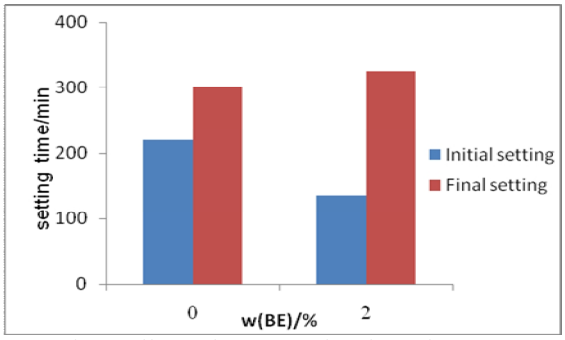

Fig. 2 Effects of BE on setting time of cement

Effects of BE on Strength of Concrete. Figure 3 shows the effects of BE on strength of concrete.After adding BE, compared with the concrete without BE, early strength decreases seriously which decreases 41.8%,but there is no difference in late strength.

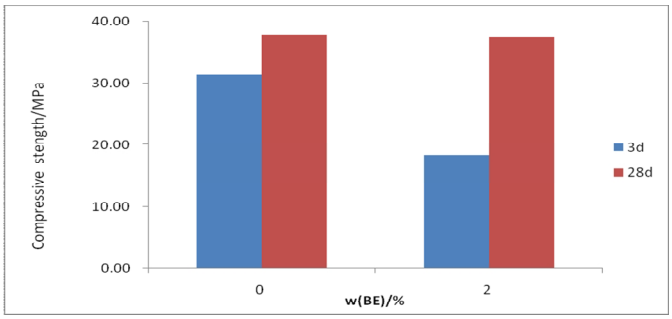

Fig. 3 Effects of BE on strength of concrete

Effects of BE on Shrinkage of Concrete. Figure 4 shows the effects of BE on shrinkage of concrete. After adding BE, from the early age of 3d, to the late age of 90d, mortar shrinkage values are low, especially less shrinkage increases after the age of 30d , the curve performances more gently. Less shrinkage helps to reduce the appearance of early shrinkage cracks, and enhance the durability of concrete, from this point,BE has a good effect on the durability of concrete.

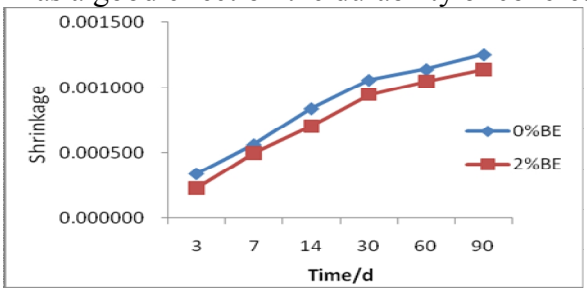

Fig. 4 Effects of BE on shrinkage of concrete

Effects of BE on Carbonation of Concrete. Figure 5 shows the effects of BE on carbonation of concrete. After adding BE, carbonation resistance of concrete has been raised, the density of concrete reinforced, the value of carbonation is relatively low, the value of the 28d carbonation is only 80% of the concrete without BE.

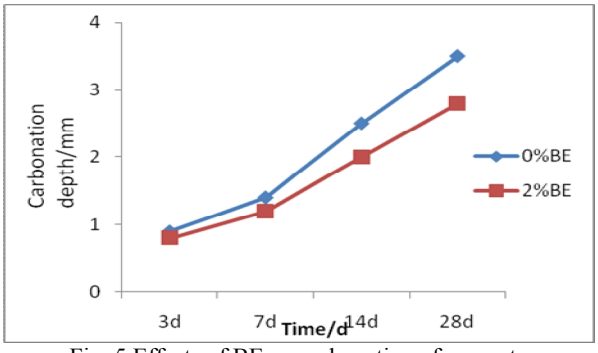

Fig. 5 Effects of BE on carbonation of concrete

Effects of BE on Chloride Ion Diffusion coefficient of concrete. The test of chloride ion diffusion coefficient shows that BE can significantly improve the resistance of concrete to chloride ion erosion, after adding BE, a substantial decline in the chloride diffusivity of concrete, its value is reduced from 5.27E-10 to 3.22E-10m2/s, only 61.1% of the original value, the resistance of concrete to chloride ion erosion ability is greatly enhanced.

In brief, by shrinkage test, carbonation test and chloride ion diffusion coefficient test,we can see concrete shrinkage,carbonation depth and chloride ion diffusion coefficient is reduced after adding BE, BE can fill the internal voids of concrete effectively, so that the compactness of concrete is improved and the durability is enhanced.

Conclusions

The test method was investiaged to evaluate the influence of migration type rust inhibitor on rust-inhibiting and the performance of concrete ,and yielded the following findings.

(1) BE can significantly improve the steel impedance, has strong ability of rust resistance.

(2) BE accelerates cement initial setting, but has not much impact on the final setting;BE reduces the early strength of concrete, but has not much influences on the later strength of concrete; BE can inhibit contraction, reduce carbonization depth,reduce the chloride ion diffusion coefficient, improve the durability of the concrete.

Acknowledgements

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References

[1] Mehta P K.Concrete-fifty year's progress,Proc.of 2nd Inter.Conf. on Concrete Durability,ACI SP126-A,1991,pp1-31.

[2] Broomfieid J P. Corrosion of Steel in Concrete:Understanding,Investigating and Repair,FN SPON,1997.

[3] Bjegovic D,Sipos L,Ukrainczyk V,et,al. Diffusion of the MCI 2020 and 2000 corrosion inhibitors into concrete.In:Swamy R N,ed.Proceedings of Steei in Concrete. Sheffield:Sheffield Academic Press,1994.865-877.

[4] Miksic B,Felner L,Bjegovic D,et al.Migrating corrosion inhibitors for reinforced concrete. In:Proceedings of the 8th European Symposium on corrosion Inhibitors. Ferrara:[s. n.],1995.569—588.

[5] Dinghai Hong, Dingxuan Wang, Junyou Huang. Journal of Southeast University,36 (S2): 154-159. (2006) (in Chinese)

[6] Junyou Huang, Xiaodong Hu, Dinghai Hong, et al.Journal of building materials,14 (4) :546-549. (2011) (in Chinese)