철근 콘크리트의 Zwitterion 및 인산염 기반 하이브리드 부식 억제제: 염화물 임계값 및 사용 수명 결정

Hybrid Corrosion Inhibitor-Based Zwitterions and Phosphate in Reinforced Concrete: Determining Chloride Threshold and Service Life

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Abstract : Corrosion of reinforcement steel is a major cause of deterioration in reinforced concrete (RC) structures. In order to protect these structures from corrosion, corrosion inhibitors are added to the concrete mix. In recent years, zwitterionic compounds have shown promising results as corrosion inhibitors in concrete due to their ability to form a protective layer on the surface of the reinforcement steel. The experimental study involves preparing concrete samples with different concentrations of adding the hybrid corrosion inhibitor at a high concentration of chloride ions. This study aims to determine the chloride threshold value and service life of hybrid corrosion inhibitors in reinforced concrete based on zwitterions. The samples are subjected to accelerated corrosion tests in a chloride environment to determine the threshold value and service life of the corrosion inhibitor. The effect of hybrid inhibitor on mechanical properties is guaranteed in allowable range. The chloride threshold concentration and service life of hybrid inhibitor containing samples perform greater than those of plain RC.

키워드 : 철근부식, 내식성, 콘크리트 , 친환경 억제제
Keywords : steel rebar corrosion, corrosion resistance, concrete, eco-friendly inhibitor

1. Introduction

The durability of these structures is compromised when steel reinforcement corrodes. Corrosion leads to cracking and spalling of concrete, which ultimately reduces the service life of the structure. The use of corrosion inhibitors in reinforced concrete has gained significant attention as a method to mitigate the effects of corrosion. Inhibitors work by forming a protective layer on the surface of the steel reinforcement, which prevents the corrosive agents from reaching the metal. While the use of corrosion inhibitors is beneficial in extending the service life of reinforced concrete, there is still a need for reliable methods to predict the service life of these structures. Service life prediction of reinforced concrete structures is a complex process that involves the interaction of several parameters such as material properties, environmental conditions, and exposure to corrosive agents. Probabilistic models are based on stochastic analysis, which takes into account the uncertainties associated with the prediction of service life. Probabilistic models are useful for evaluating the reliability of concrete structures and can be used to develop risk-based maintenance strategies. In short, the use of corrosion inhibitors in reinforced concrete is an effective method to mitigate the effects of corrosion and extend the service life of these structures. However, reliable methods for service life prediction are necessary to ensure the long-term performance of reinforced concrete structures.

2. Materials and methods

Table 1. The concrete mix containing hybrid inhibitor (kg/m^3)

Sample ID	W/C	Cement	Water	Sand	Coarse aggregate	LA : TSP	Inhibitor : Cement
HI-0	0.5	400	200	778	956	2 : 0.25	0
HI-1							0.125 wt.%
HI-2							0.25 wt.%
HI-3							0.5 wt.%
HI-4							1 wt.%

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A hybrid corrosion inhibitor consisting of L-Arginine (LA) and trisodium phosphate dodecahydrate (TSP) was used in this study. The concrete mix for all samples was listed in Table 2, and the total amount of inhibitor to cement ratio was varied between 0-1 weight percentage (wt.%) of cement. The ratio of LA to TSP was always kept constant at 2:0.25 as it was found to be the optimum dose for forming a high-performance passive film on the steel rebar surface[1]. The slump and air content test was investigated to evaluate the workability of concrete mixes. Besides, chloride diffusion coefficient is determined by non-steady state migration coefficient method according to NT Build 492 standard[2]. The wet-dry cycle (W-D) was used, with 3 days of wetting and 4 days of drying, equivalent to one cycle per week. A 10 wt.% NaCl solution was used for wetting cycle and measuring LPR. The service life of all RC samples wes predicted by Life 365 software based probabilistic approach.

3. Results and Discussion

3.1 Slump and air content

The slump test is used to assess the workability of concrete mixes, indicating their ability to deform under load during casting. The results of the test, as shown in Figure 1, indicate a range of slump values between 9.5 and 16 cm. This suggests that the hybrid inhibitor has the potential to improve the workability of concrete mixes, making it a promising eco-friendly admixture. Besides, the air content of concrete is a critical parameter that affects the likelihood of air bubbles forming in the concrete matrix. These air bubbles can connect pores and decrease the compressive strength of the concrete, which is a crucial property. The increase in air content can improve the workability of the concrete mix. The air content of the concrete mix remains relatively unchanged when the hybrid inhibitor concentration is below 0.25 wt.% cement. However, at higher concentrations of the hybrid inhibitor , the air content increases from 0.3 to 0.5%.

3.2 Chloride diffusion coefficient (Dnssm)

Figure 2 shows the non-steady-state chloride diffusion coefficient of concrete samples after 24 hours. The chloride diffusion coefficient for HI-0, which represents the absence of hybrid inhibitor, was approximately 14.34×10^{-12} m^2/s. When the concentration of hybrid corrosion inhibitor was increased to 1 wt.% cement, there was only a slight variation in the chloride diffusion coefficient. Therefore, the addition of hybrid inhibitor did not significantly affect the chloride diffusion coefficient.

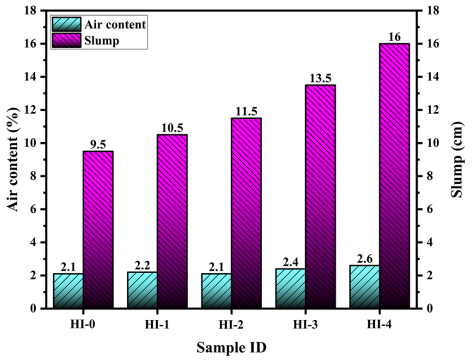

Figure 1. Slump and air content results of concrete mix

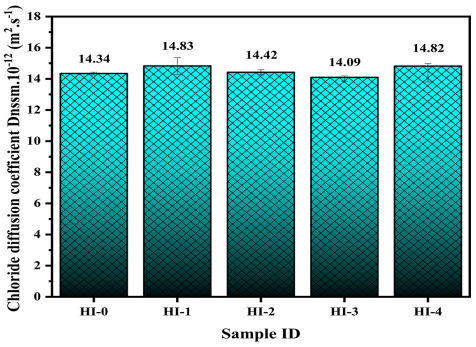

Figure 2. Chloride diffusion coefficient results of RC samples

4. Conclusion

The slump results of all samples increase with the increment of hybrid inhibitor, meaning that the workability of concrete mix is improve with the presence of hybrid inhibitor. Besides, the hybrid inhibitor does not affect the chloride diffusion coefficient of concrete samples. The combination of LA and TSP as eco friendly corrosion inhibitor is absolutely potential to apply in engineering industry.

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