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Effect of Crack Repair by Bio-Based Materials Using Alginate and Bacillus Subtilis under Wet and Dry Environment Part-II

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1 Introduction

According to past research reported by Kawaai *et al.*, (2017), precipitation of calcium carbonate in alkaline environment has been confirmed by precipitation tests using aerobic Bacillus subtilis (natto) encapsulated in calcium alginate capsules. When sodium alginate dissolved in a liquid is used for repairing cracks in concrete, there is a strong possibility that the alginate reacts with calcium ions available on the cracked surface, thus forming a polymer comprising calcium alginate via ion-link on the cracked surface. This could result in in-situ encapsulation for the microorganism and nutrients in the cracks. Based on the above background, this study examines the durability of repaired mortar under seawater splayed environment.

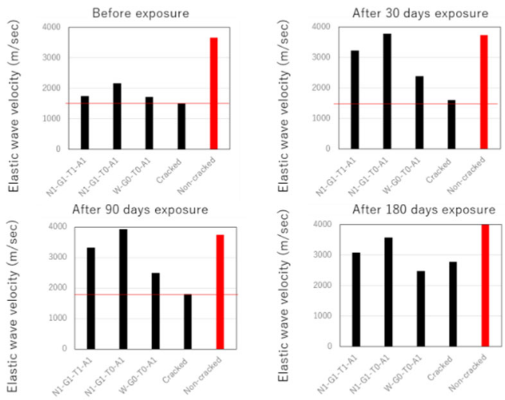
2 Experimental Programs

The experimental parameters include the presence (N1 mixtures) and absence (W mixture) of Bacillus subtilis (natto), the concentration of sodium alginate is specified as 1.5 wt.% for all the mixtures tested. The use of Tris buffer solution with concentrations of 0.1 mol/L is also considered as a testing parameter. In this study, three mixtures were totally prepared. Mortar specimen with a water cement ratio of 0.5 was prepared using a cylindrical mold of $\phi 50\times 100$ mm. And split crack was induced using the mortar specimens in which the crack width was targeted around 0.5 mm. And then, the repair mixtures were poured into the cracks. The specimen after repairing was exposed to seawater splayed condition. The seawater was pumped up from Kurihama bay and splayed to specimens. Seawater was splayed twice in a day and specimen was exposed for 6 months. The elastic wave velocity was measured every 1 month after exposure test. The sensors were set at the side surface of specimen and the elastic wave velocities against vertical direction along the crack were evaluated.

3 Experimental Results and Discussion

The elastic wave velocity of each specimen exposure to seawater splayed condition after 0, 30, 90, 180 days is shown in Figure 1. Before exposure to seawater splayed condition, the specimens were exposed to experimental room (20 degree centigrade and 60 % R.H.) and specimens were dried. Therefore the results of all of elastic wave velocity of specimens before exposure were equivalent to cracked mortar. After exposed to seawater splayed environment, the elastic wave velocities of mortar with crack were increased. Especially in the cases of specimen with Bacillus subtilis, the elastic wave velocities of specimen were clearly increased.

It was assumed that the repair substance inside of crack remained and the elastic wave penetrate that part. Figure 2 show the result of X ray CT in crack after 180 days exposure. From this figure, it can be said that the substance produced by Bacillus subtilis were remained inside of crack even after exposed to seawater splayed condition.



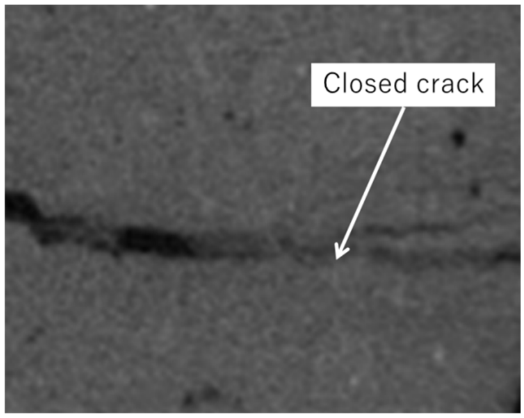


Figure 1. Elastic wave velocities before and after exposure. **Figure 2**. Crack closure situation by X ray CT.

4 Conclusions

- Based on the observations made on the sealing rate of crack repair, the presence of gel films remained intact on the cracked surface under exposure conditions could contribute to higher sealing effect in the cases of the N1 mixtures.
- The results suggest that the repair effect of crack produced by Bacillus subtilis would be kept even after exposed to seawater splayed condition.

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Reference

Kawaai, K., Nishida, T. and Saito, A. (2017). Calcite-alginate bio-composite formation in alginate gel films for self-healing concrete application, Proceedings of the 5th Seminar Workshop on the Utilization of Waste Materials in conjunction with the 2nd International Symposium on Concrete and Structure for the Next Generation, Manila Philippines, 5.