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BOND STRENGTH OF STEEL BARS IN CONCRETE UNDER HIGH TEMPERATURES

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ABSTRACT

This work investigated the temperature effects on bond strength between steel reinforcement (rebar) and concrete. Two different steel bars with epoxy coating and without coating were experimentally studied under different high temperature conditions (heating rates and target temperatures). The results showed that at 200 ºC, epoxy coated rebars have higher bond strength than that of uncoated bars; however, with the temperature higher than 200 ºC, the reduction of bond strength of epoxy coated rebars is higher than that of uncoated rebars.

Keywords: high temperature, steel bar, concrete, bond strength.

INTRODUCTION

The bond behavior between concrete and steel reinforcement has been considered as an important characteristic in reinforcement concrete (RC) structures. The effect of high temperature on the bond is critical to evaluate the performance of RC structures under fire condition. Several studies have been conducted to investigate the high temperature effect on bond behaviors. Diederichs and Schneider (1981) performed a pull-out test to investigate the variation of the bond strength on the three different types of reinforcing steel (ribbed steel bars, plan round bars and deformed prestressing bars) under the heated and the cooled condition in the temperature range 20 to 800 °C. From the study, it was found that the bond strength is affected not only upon the temperature level, but also upon the test procedure and the shape of the bar.

In previous researches, the test configurations did not model accurately the heating effect under real condition. Also, the effect of elevated temperatures on epoxy coated rebar has not been studied. This is important because epoxy coated rebars behave much differently from uncoated rebar does in terms of bond (Elleithy, 1998). In this study, a new specimen configuration was developed and used; the bond behaviors between concrete and steel reinforcements were studied using two different bars: epoxy-coated and uncoated bars, and various experimental parameters such as different heating rates (2°C/min and 15°C/min) and target temperatures (200°C, 400°C, 600°C, and 800°C).

RESULTS AND CONCLUSIONS

Steel bars were embedded in concrete cylinders. A new specimen configuration was developed in which two concrete caps were used to cover the steel bars so the temperature can rise simultaneously and uniformly in steel and concrete (see Fig. 1). The steel-concrete

specimens were heated to target temperatures first and then cooled down to room temperature. Then, pull-out test was conducted to obtain the bond strength, which is the ultimate pulling force divided by the surface area of rebar embedded in concrete. The effect of the target temperatures are shown in Fig. 2. The results of both uncoated test series and coated test series show the ultimate bond strength decreases as the exposed temperature increases. However, the bond strengths of the specimens exposed to 200 ^{o}C are higher than the reference specimens. Particularly, the bond strengths of the coated specimens exposed to 200 ^{o}C are significantly increased. The increase is likely to be explained with improvement of the bond effect due to the melted epoxy between concrete and rebar at 200 ^{o}C. At higher temperatures than 200 ^{o}C, the bond strength is decreased with the burning of the epoxy and increasing of thermal mismatch between concrete and rebar.

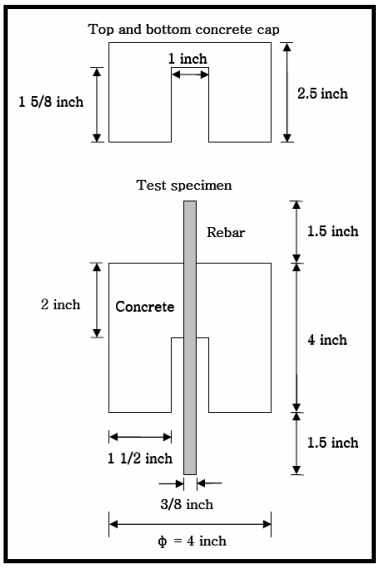

Fig. 1 - Specimen configuration

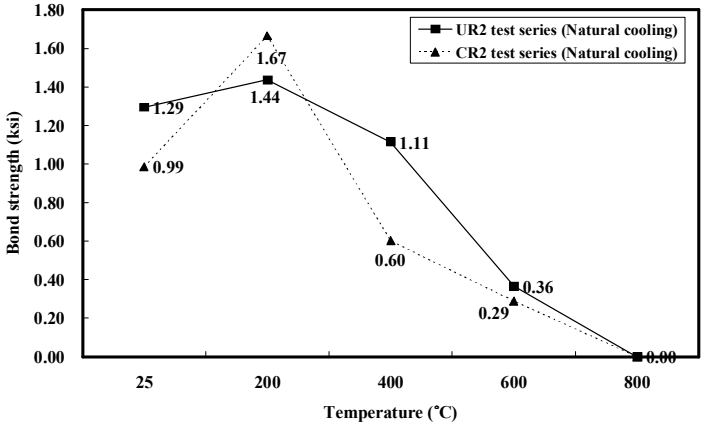

Fig. 2 - Effects of temperatures on bond strength

In Fig. 2, UR2 is for uncoated rebar under heating rate of 2°C/min; and CR2 is for coated rebar under heating rate of 2°C/min. Apparently, the coating resulted in a higher increase of the bond under the low temperature range and a higher reduction of bond under the higher temperature range. At 800°C, the bond strength reduces to zero. For the effect of heating rate, our test data showed that higher heating rate resulted in higher reduction of the bond.

ACKNOWLEDGMENTS

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