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NEW SYSTEM WITH X-RAY CT FOR STUDY OF BOND CRACK IN CONCRETE AROUND DEFORMED REBAR SUBJECTED TO TENSION

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Summary: New measurement system with x-ray CT was developed to observe the bond crack in concrete in the vicinity of deformed steel bar. A sleeve rebar has been designed for in-situ test so as to avoid the use of a loading apparatus to apply the tensile stress during CT measurement. This research shows that the mechanism of the initiation and propagation of the bond crack with increased tensile stress was clarified.

1. INTRODUCTION

A large number of reinforced concrete structures suffer from the development of cracks. They can reduce the durability and structural performance of the concrete structures. Concrete shows high resistance against increased compressive stress while cracks can be relatively easier to occur with tension. It has been said that the formation of crack is inherent for concrete structures. Despite the fact investigation of crack formation and propagation in concrete has been limited with the observation of their appearance. In this way quantitative information is the width and length of crack which appears on the surface of the concrete. Goto developed the observation of internally developed cracks in the vicinity of deformed rebar using a red ink method [1]. Picture showing the formation of the cracks successfully was taken although the reinforced concrete had been destroyed before taking it. X-ray radiography has been also used to detect cracks inside concrete specimen without destruction. However obtained results are in a two dimension with mixed information of the crack depth.

X-ray CT has been recently used to observe internal crack in structural materials such as concrete [2]. However dynamic behaviour of the formation and propagation of crack in reinforced concrete specimen accompanies with following problems.

- Closure of opening crack during CT measurement after unloaded.
- Unnecessary image of the support installed by a loading apparatus that sits in X-ray CT machine.
- Necessity of a sophisticated loading system without support for in-situ test.

Bond crack around the deformed rebar embedded in concrete is significant to predict the structural performance and the corrosion of the rebar. Little study has been conducted to observe precisely the mechanism of the formation of the bond crack and its propagation in concrete. This is partially because of the reasons mentioned above. Therefore to break through this circumstance and solve the problems simple and inexpensive system with sleeve rebar has been developed for in-situ test to study bond crack in concrete by X-ray CT.

2. EXPERIMENTAL METHOD

A sleeve rebar is designed for restrained tensile rebar as shown in Fig.1(a). The rebar consists of sleeve and bolt with nut. Upper nut is fixed while the bolt is tightened so as to induce the tensile force in the sleeve. The sleeve of a diameter of 13mm was processed using a regular deformed steel bar (D13) according to in JIS G3112.

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Concrete cylinder of a diameter of 55mm and a length of 200mm was tested. Maximum aggregate size was 15mm. After cured in water the tensile force was applied to the sleeve rebar and increased in a step wise manner. At each load level the concrete was tested by X-ray CT.

Micro focal X-ray CT was employed in this study. The voltage was 200kV and the detector of X-ray was a flat panel with 8.0 x 8.0 inches in the view size. Resolution was 57μm per pixel and the slice thickness was also 57μm.

3. RESULTS

Tensile stress was successfully induced into the sleeve rebar embedded in concrete. As the stress increased the crack formed at the tip of rib of the deformed rebar as shown in Fig.1(b). The formation of the secondary crack was also detected and at last principal bond crack was developed around the sleeve rebar. In this way unique system can be used to study precisely the internal crack formation and propagation by X-ray CT.

Development of in-situ test for X-ray CT is needed to study the dynamic behaviour of the bond crack formation and propagation with increased tensile force. It is expected that using present new system more characteristics of the bond crack are clarified.

References

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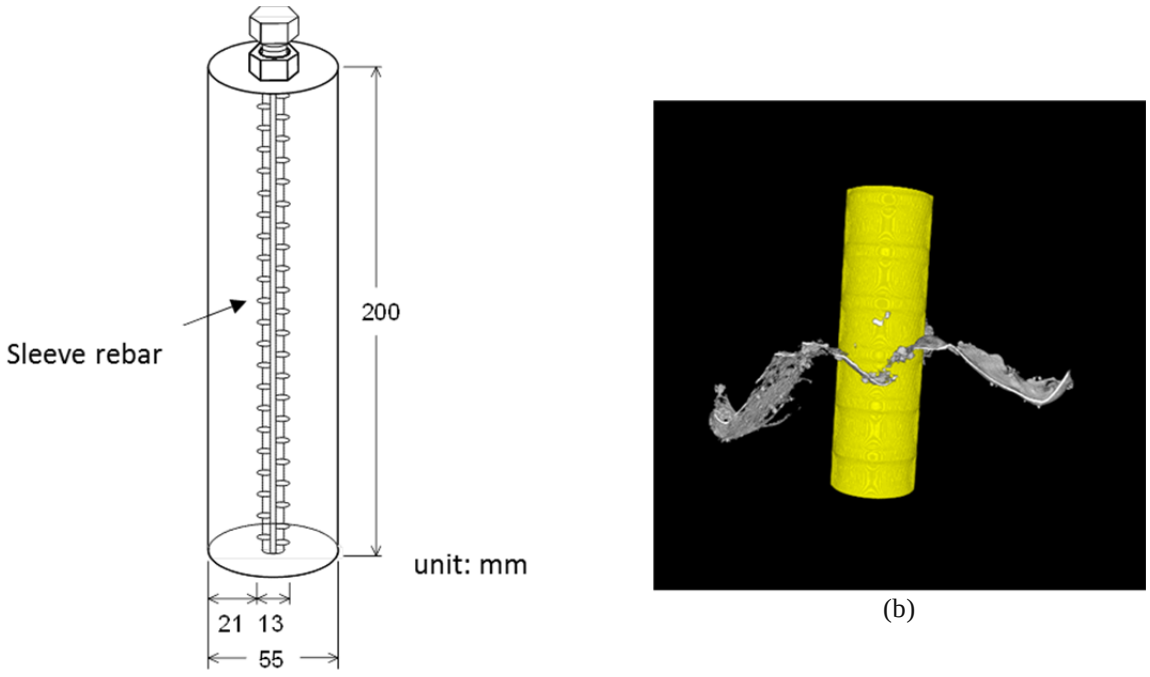

(a) (b)

Figure 1: (a) Newly designed sleeve rebar to induce tensile stress (b) 3D image of bond crack around sleeve rebar