AN EXPERIMENT OF SIMULATING THE STIRRUP FRACTURE DUE TO ASR

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1. INTRODUCTION

The deterioration of concrete structures by alkali silica reaction has been become a problem in 20years. Due to lack of research, the mechanism of damage on structures by ASR has not been clarified enough. In order to discuss actual structures features when stirrups fracture due to ASR, an experiment to simulate stirrups fracture had been conducted. The fracture time point could be figured out and the different phenomena could be compared on concrete surface before the stirrup fracture and after the stirrup fracture. So based on the phenomena, we can judge if the stirrup has been fracture on actual structures.

2. EXPERIMENTAL CONDITIONS AND DETERMINATION OF FRACTURE TIME

The simulating experiment and correlated parameters are show on Fig.1. Specimen is with dimension as 916mm×916mm×1600mm and inner with 456mm×456mm expansive mortar. The ratio of stirrups is 0.22%. The fracture stirrup location is on the third stirrup on total of 8 stirrups from upside to downside. In this experiment, the fracture time point could be found out by using the magnetic flux density, which is shown on Fig.2. Stirrups are tinged with magnetic. When magnet is closed, magnetic flux is generated. The magnetic flux is performed by magnetic flux density. If the stirrup is complete, the magnetic flux density is not scrambled and vice versa. So before and after 0.1m in the bending part(as 0.0m), if the difference value between the maximum and the minimum is turning to great, it may illustrates the moment is time point of the stirrups fracture. According to this method, it is determined that the different value is rising at the time point of 2.8 hours, which illustrates the stirrup is broken at this moment in this simulating experiment. It is very early time of 2.8 hours among this whole experiment.

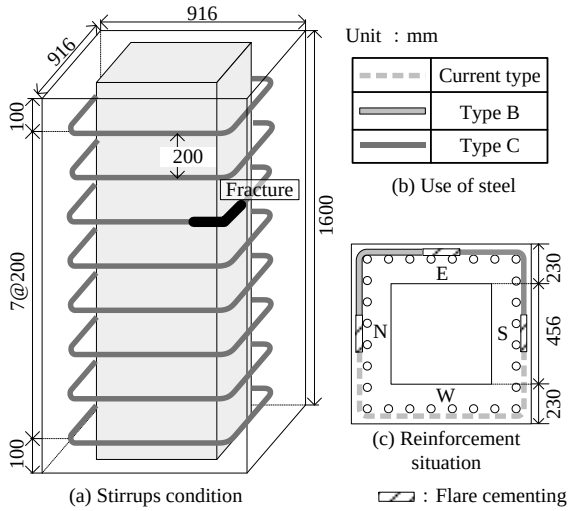

Fig. 1 Shape of Specimen

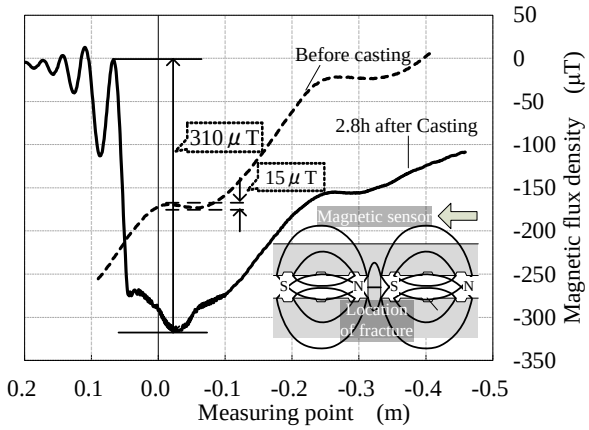

Fig.2 Magnetic Flux Density

3. EVOLUTION OF THE EXTERIOR DAMAGE

Fig.3 shows the ultimate fracture condition and the cross section of the fracture stirrup. The long cracks were spreading over concrete surface. The wide and long cracks were gone through the corner on the fracture area (Fig.3 (1)). The cross section deformation occurred. The increasing area on fracture section is larger than that on non-fracture section (Fig.3 (2)).

Fig. 4 reveals the evolution of the strain on measuring line. The definition of strain is shown on Fig.3. The method to figure is shown in Eq. (1)

$$\text{Strain on measuring line} = \frac{\text{The total cracks width on one measuring line}}{\text{The length of measuring line (916mm)}} \quad (1)$$

The strain could reflect the expansive energy. It is noticed that

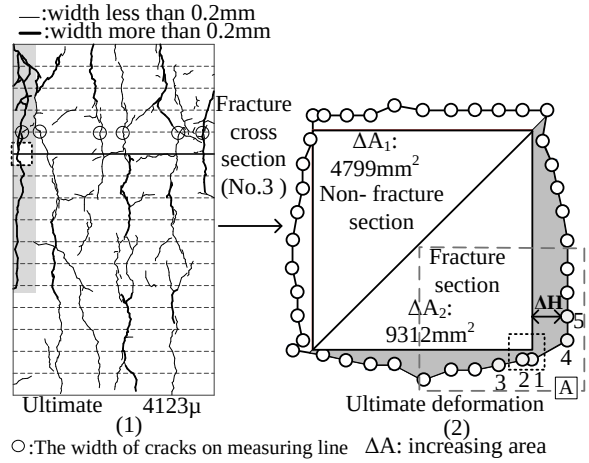

Fig.3 Ultimate Statues

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strain is as small as 54μ (A) of Fig.4, which reflects the slender cracks came out both on fracture section and non-fracture section before fracture time. Then as soon as fracture of stirrups, the width of cracks was rising sharply on the fracture section. The strain was increased by 1678μ. The ultimate strain was 4123μ. While the strain on non-fracture section as small as 1455μ. The reason is that expansive energy had been released on the fracture section after the stirrup fracture. As a conclusion, before the stirrup was fracture, cracks on each section were slender, which is similar. But after stirrup was fracture, the cracks on fracture section were turning to wide. Since the fracture of the stirrup happened at early time, the widths of cracks continue to become wider.

Fig.5 shows the evolution of damage at corners. There seemed to be no great difference occurred especially in fracture areas shown on Fig. 5(a) (b) before fracture. Cracks at corner were slender and long. However, along with the fracture, it would be notice that the wide cracks were concentrated at the corner which was the location within the fracture stirrup. Meanwhile, along with the concrete expanded outward, the concrete dislocation had taken place, which leaded to deformation of cross section, especially at corners. Before the stirrup fracture(Fig.5(a)), the dislocation was relatively small as about 2mm, while on the ultimate statue(Fig.5(b)) the dislocation was as large as 7mm on the fracture section. But the on non-fracture section, the dislocation was small. Compared with the status before fracture of the stirrup, the dislocation on non-fracture section changed not so large (2mm to 4mm).

It is demonstrated that as the stirrup was fracture at early time(2.8h), it is easy to continue producing stress concentration at the corner within fracture stirrup, which could make the ultimate cracks wide and with large dislocation.

Fig. 6 reveals the evolution of the dislocation on each measuring point. Angle is used to measuring the dislocation, which is initial value minus the value at last. As the stirrup fracture location could be determined, the distance of concrete expanded outward ΔH(dislocation of on concrete surface) could be measured. The measuring points are shown on Fig. 3A. The feature could be confirmed that before stirrup fracture, there was no obvious increase in ΔH, while as soon as the stirrup was fracture, ΔH was rising sharply and it was increasing by 57% of total. Then ΔH increased slowly and was turning stably. This phenomenon illustrates that distance of concrete expanded outward occurred suddenly when the stirrup was fracture with enormous energy.

As a conclusion, as soon as the fracture, the strain increased rapidly, which gained 41% of total strain on the fracture section. While the dislocation gained 57% of total dislocation on the fracture section. It illustrates that the dislocation influences more.

4. CONCLUSIONS

(1) Compared with the fracture before, the cracks on concrete surface would generate more and wider and gone through the corner after stirrup fracture. At same time, dislocation has been generated greatly.

(2) It could be confirmed that after the stirrup fracture, the increasing rate of the dislocation was larger than that of strain on the measuring line. It could be speculated that the characteristics after fracture is dislocation.

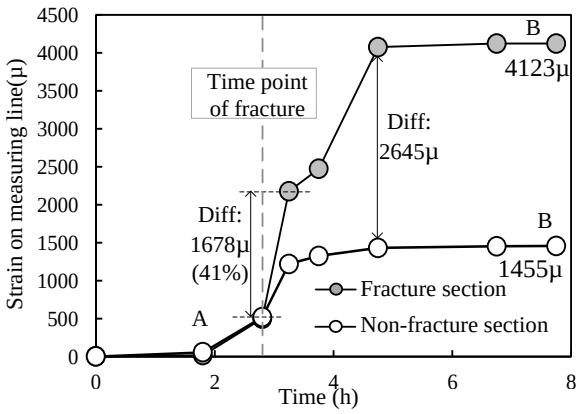
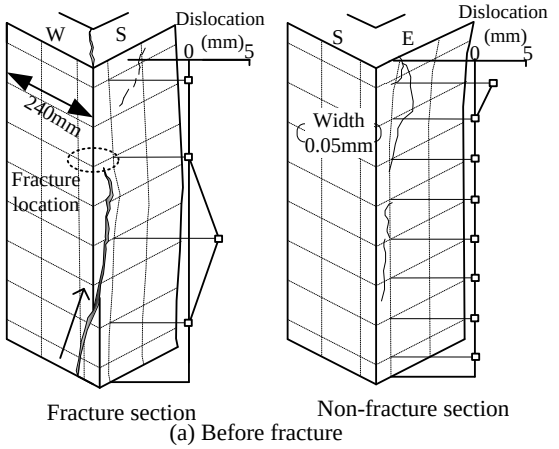


Fig. 4 Evolution of Strain on Measuring Line



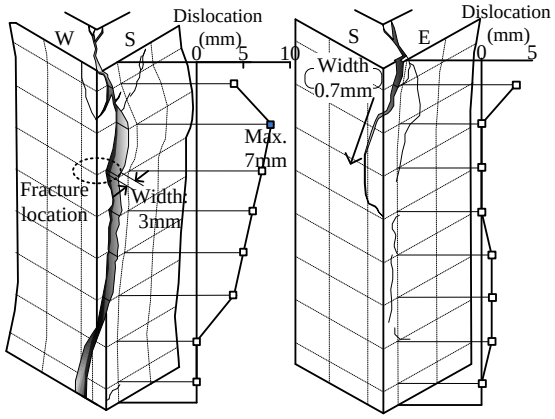


Fig.5 Evolution of Damage at Corners

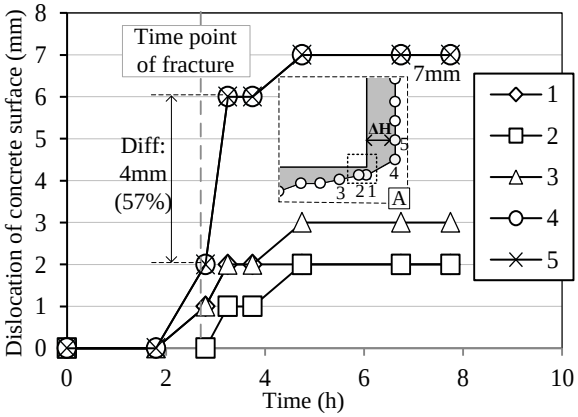


Fig.6 Evolution of Dislocation on Concrete Surface