Influence of cyclic loading on bond condition for post-installed adhesive anchor

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1. Introduction

A post-installed adhesive anchor is generally employed for seismic retrofitting and renewal construction work for reinforced concrete structures. Bond degradation of that may cause serious accidents involving human lives like "SASAGO tunnel ceiling collapse" occurred in 2012. Therefore, it is important to investigate the bond strength quantitatively, to establish more reliable construction quality control of the post-installed adhesive anchor. The bond strength between adhesive and rebar or between adhesive and concrete may be affected by their bond conditions. Accordingly, the measurement of the stress distribution along the embedded anchor bar must be helpful to understand its bond condition. In our previous experiment in 2015A0163, it was demonstrated that the neutron diffraction can be a useful technique to measure the stress distribution of the anchor bar embedded in concrete, and it was found that the stress distribution along the embedded anchor bar shows different trend depending on the type of adhesive. On the other hand, considering a seismic design using the post-installed adhesive anchor, it is necessary to investigate bond degradation due to cyclic loading. In recent the 2016 Kumamoto earthquake, very strong earthquakes measuring 7 on the intensity scale occurred twice within 2 days, and many buildings including RC structures damaged by first quake were collapsed at the second strong quake. Considering this case, therefore, the post-installed adhesive anchor must be designed to keep stable state against multiple huge earthquakes occurred within a short period. In this study, therefore, the stress distributions along the embedded anchor bar are measured under cyclic loading using neutron diffraction, and the deterioration mechanism of the bond condition will be discussed based on results change in the stress distribution.

2. Experiment

Specimen. The cylinder-shaped specimen with 67 mm in diameter and 150 mm in height, covering with a steel tube with 3 mm in thickness is prepared. The deformed rebars with a diameter of 10 mm was fixed in the anchor hole by injection of epoxy resin or cement adhesive. The specifications of the samples and the loading histories for each sample are listed in Table 1.

Optical layout. The experiment was conducted using BL19, TAKUMI, in J-PARC MLF. The 5 mm radial collimators are installed, and the incident beam size was set to be 10 mm in width and 10 mm in height. The pull-out loadings are applied to the anchor bar, and stress distribution along the embedded anchor bar was measured every loading conditions.

Table 1 The specifications of the samples and the loading histories

Sample	Length of Bonded region	Adhesive	Loading history No strain measurement at load in parentheses
No. 42	150 mm	Epoxy	1kN > 17kN > (34kN) > 17kN > (51kN) > 17kN
No. 18	50 mm	Epoxy	1kN > 5.6kN > 17kN > 5.6kN
No. 28	50 mm	Cement	1kN > 10.7kN
No. 22	50 mm	Epoxy acrylate	1kN > 2.6kN > 8.2kN

3. Results

The result of the No. 42 sample is only discussed in this experimental report. The stress distributions along the anchor bar from the loading edge of the sample are shown in Fig. 1. This is a relative change in the stress distribution from the initial variation measured under 1 kN of tensile loading. Under applying 17 kN as a long-period loading condition, the stresses gradually decease to zero toward the free edge of the sample at X=150 mm. The plateau region appeared from X= 35 mm to 55 mm in Fig. 1 might be caused by local bond degradation due to poor filling of the epoxy resin between rebar and concrete. After unloading to 17 kN from 34 kN as a short-period loading condition, the stress distribution cannot return to initial variation before applying a short-period loading. Instead, the stresses increase in the region from X=0 mm to 85 mm probably due to bond degradation in the corresponding region, and relatively larger bond degradation appears at X=55 mm and 85 mm locally. Especially, the local bond degradation at X=55 mm is the result further development of bond degradation appeared under initial loading of 17 kN. After unloading to 17 kN from 51 kN as an ultimate loading condition, the stresses increase more in the region from X=0 mm to 105 mm due to homogeneous degradation in the corresponding region.

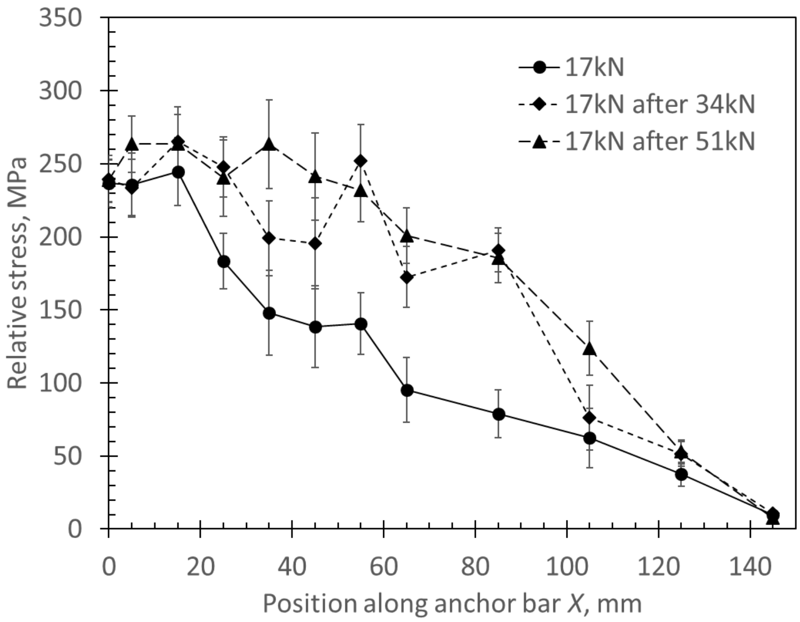

Fig. 1 Relative stress distribution measured by neutron diffraction.

4. Conclusion

In this experiment, a change in stress distribution of the post-installed adhesive anchor in response to the cyclic loading was investigated using neutron diffraction. As a result, it was found that bond degradation appears in the post-installed adhesive anchor subjected to overloading, and that the bond degradation develops more after second overloading if it is higher than first overloading. In our future work, a long-term durability of the post-installed adhesive anchor under creep will be investigated by measuring a change in the stress distribution using neutron diffraction.