

実験報告書様式(一般利用課題・成果公開利用)

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 <b>xperimental Report</b> 	承認日 Date of Approval 2017/9/12 承認者 Approver Takenao Shinohara 提出日 Date of Report 2017/9/12
課題番号 Project No. 2016B0155 実験課題名 Title of experiment Deformation analysis of reinforced concrete using imaging technique 実験責任者名 Name of principal investigator Hiroshi Suzuki 所属 Affiliation Japan Atomic Energy Agency	装置責任者 Name of Instrument scientist Takenao Shinohara, Tetsuya Kai 装置名 Name of Instrument/(BL No.) BL22 実施日 Date of Experiment 18-23/ March/ 2017

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)  
 Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

<p>1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.</p> <p>A ferritic steel deformed-bar with 12.7 mm in a nominal diameter was embedded in a rectangular concrete with the size of 50×50×130mm. In order to visualize the internal deformation of concrete around the embedded rebar, the cement paste markers involving 34 wt% Gd<sub>2</sub>O<sub>3</sub> powder (hereafter called “Gd marker”) with the size between 0.6 and 1.7 mm were two-dimensionally dispersed around rebar, to be covered with 15 % area of the concrete placing surface. The RC specimen was demolded 72 hours after placing, and then cured in water for 7 days. After that, it was placed in a constant temperature (20±1 °C) and humidity (60±5 RH%) room for 24 hours. In order to reduce water in concrete that causes neutron attenuation by hydrogen, the RC specimen after curing process described above was dried at 60 °C for 4 days before the neutron experiment.</p>
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<p>2. 実験方法及び結果 (実験がうまくいかなかった場合、その理由を記述してください。)</p> <p>Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.</p> <p>The RC specimen mounted on the loading device was set up on a sample stage of BL22, RADEN. The L/D ratio was set to be 1000. The incident neutrons scattered and absorbed by a sample are taken by a cooled CCD camera after converting to visible rays by a scintillator. Total four images were taken in 15 minute in an exposure time at the same measurement configuration. The distance between the scintillator and the sample edge was set to be 200 mm so as to reduce an influence of scattering from the sample. The resolution of the transmission image was 2048×2048 pixels (16bit), and a spatial resolution was approximately equivalent to 50 μm/pixel.</p> <p>Figure 1 shows a neutron transmission image of the RC specimen taken in 15 minutes by RADEN. The Gd markers dispersed in concrete can be observed in the image clearly. The rectangle dark area at the bottom of the center of the image represents the PVC pipe fitted in rebar to make an un-bonded region. In addition, the image contrast between concrete matrix and the embedded rebar can be observed as well.</p>
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## 2. 実験方法及び結果(つづき) Experimental method and results (continued)

The analytical condition was, at first, optimized by evaluating the displacement of the Gd marker image as a function of a travel distance of the sample stage, in order to determine the position of the Gd marker on the transmission image accurately. The position of the Gd marker image in the neutron transmission image of the RC specimen was evaluated at each position by the image analysis technique using an open source image processing program, ImageJ 1.51n. The transmission images were taken at 0.0 mm, 0.1 mm, 0.2 mm, 0.3 mm, 0.31 mm, 0.33 mm, 0.36 mm and 0.4 mm from the original position in the vertical.

Displacement of the Gd marker image was evaluated by a change in the position of the marker as a function of a travel distance of the vertical sample stage. As shown in Figure 1, the displacement of the marker from the initial position was successfully evaluated within approximately  $\pm 0.1$  mm accuracy by the image analysis for selected markers with higher contrast and circularity.

Furthermore, concrete deformation under pull-out loading to the embedded rebar was evaluated by the same way, and its reaction compressive deformation on the concrete part was successfully observed by analyzing the displacement of the markers. The results obtained in this study bring beneficial knowledge that the measurement accuracy of the marker displacement can be improved more by choosing a spherical shape of the marker and by increasing the contrast of the marker.

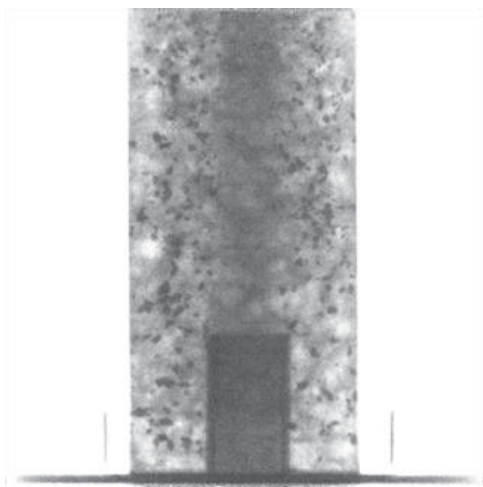


Figure 1. Transmission image of reinforced concrete with Gd markers.

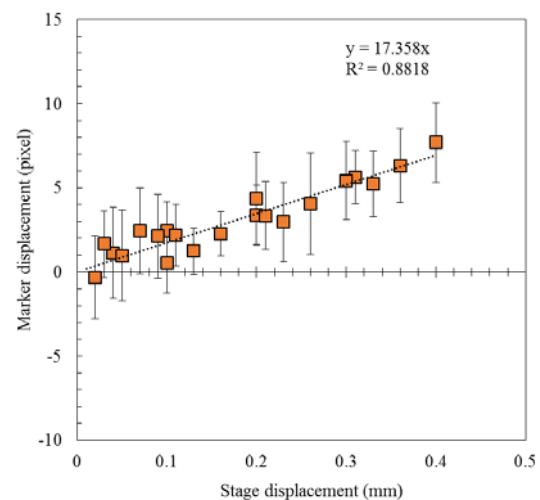


Figure 2. The relation between the marker displacement and the stage displacement.