MEASUREMENT OF DEFORMATION INSIDE CONCRETE UNDER LARGE COMPRESSION STRESS BY X-RAY CT AND PTV

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Summary: The movements of aggregates in the construction material under large compression stresse are important factor for strength and strain of the materials. Fumoto et.al. have developed a new X-ray CT for testing of specimens under relatively large compression stresses. In this paper, the movements inside a construction material are measured by a PTV, which has developed by Takehara et. al.

1. INTRODUCTION

The concrete includes about 60 % aggregates inside its volume. Usually, the crushed stones and the river stones are used as the aggregates. Commonly, the aggregates are harder than the other materials in concrete. For this reason, the hardness of the aggregates affect to elastic modulus of concrete and the volume change of concrete during the drying process. However, the behaviours of the aggregates in the concrete under compressive stress or during the drying process still are unclear.

The X-ray computed tomography (CT) scan can measure the interior structure of construction materials without any intrusion of sensors. In the common X-ray CT, however, a value of the load is small, because the loading machine has to be set on the rotating table. In the actual construction concrete, however, the value of load to the concrete specimen is much larger than that in the common X-ray CT.

Fumoto [1] have developed a new X-ray CT scan system which can measure the interior structure of a construction material under relatively large compression stresses. In this research, the movements of aggregates inside a construction material are measured by Super-Resolution KC method [2] which was developed as a Particle Tracking Velocimetry (PTV) for fluid flows.

In this study, we try to measure the behaviours of the light weight aggregate in concrete under the compressive stress. As the tracer particle for PTV, the zirconia balls, of which diameter is 0.65 mm, are mixed with the concrete. The gap between unloaded and loaded 3D CT images is revised by the affine transformation. The results show that the three dimensional movements inside the materials were measured with very high resolution by the PTV.

2. EXPERIMENTAL METHOD

Tap-water, high-early strength portland cement, mountain sand, light weight aggregate, the zirconia balls and polycarboxylic superplasticizer are mixed using a mixer. The mixed concrete is placed into six cylinder molds of 75 mm in diameter and 150 mm in height. After curing in the water at 293 K for 28 days, the six specimens are used for testing.

At first, the relationship between strain and stress of three specimens are measured with compressive machine. Another specimen is measured movement of the aggregates inside the specimen in order to investigate these relations by the new X ray CT system. The 3D CT images under each load conditions were reconstructed by the workstation.

The centre of gravity, peak brightness, size, long axis, short axis and aspect ratio of the zirconia balls were calculated for each 3D CT image by the commercial software. The movements of the zirconia balls under the specific load are measured using Super-Resolution KC method.

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3. RESULTS

Figure 1 shows an example of the sliced images of the 3D CT images and the movement of the tracer particles by the PTV. In Figure 1(a), the cement paste part and large aggregates are recognized the difference of the brightness of the image. The bright small spots show the zirconia balls and the spots are used as the tracer particles for the PTV. In this case, total 9489 particles are picked up from the 3D CT image by the software. As the preliminary experiments, both specimens with and without the zirconia balls are tested by the standard compressive machine. From the results of the experiments, no difference is recognized between the properties of specimens with and without the zirconia balls. It indicates that the zirconia balls can be used as the tracer particles for the movements inside the concrete.

The compression stress acts vertically and no stress acts on the side of the specimen. Figure 1(b) shows the movements of the tracer particles measured by the PTV. The vectors in figure 1(b) shows only in the sliced area of which thickness is 4 mm, 572 vectors are tracked in this area and 9488 vectors in total area.

From figure 1(b), the tracer particles in the upper left triangle area move in the left slant lower direction and those in the lower right triangle area move in the right slant upper direction. The measured movements correspond well to the shear deformation of the concrete under vertical compression stress.

It is very interesting result that the tracer particles move along the large aggregates in the shear layer. To understand this result, we need to measure the movement of the large aggregates and tracer particles simultaneously.

References

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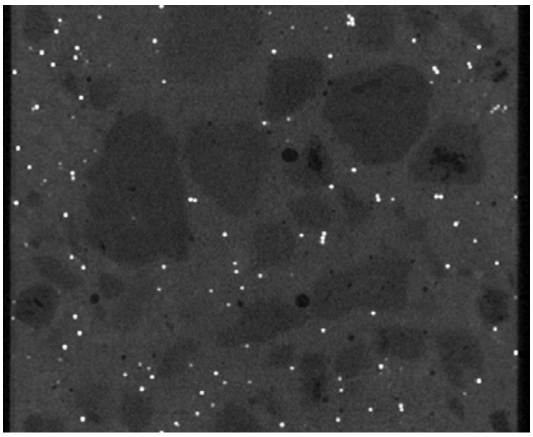
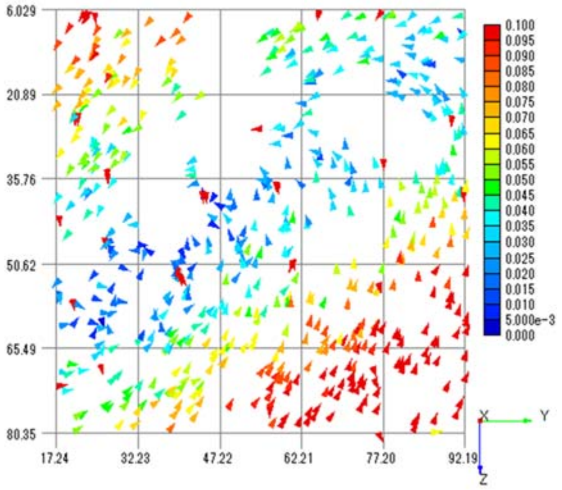


(a)



(b)

Figure 1: An example of the results (a) the sliced 2D image of the specimen, (b) movements of the tracer particles measured by the PTV