3rd International Conference on Tomography of Materials and Structures
Lund, Sweden, 26-30 June 2017, ICTMS2017-87

FUNDAMENTAL STUDY ON ERROR OF MOVING DISPLACEMENT MEASURED USING THE NEW X-RAY CT APPARATUS

Taiju Ura[*1], Takayuki Fumoto[†2] and Kousei Takehara[‡2]

[1] Graduate school of Science and Engineering, Kindai University, JAPAN
[2] Department of Civil and Environmental Engineering, Faculty of Science and Engineering, Kindai University, JAPAN

Keywords: X-ray CT, Image measurement, Error, Mean value, Standard deviation

Summary: we developed a new X ray computed tomography apparatus hanged up inside a compression machine. The purpose of this study is to make clear a measurement accuracy of the moving vectors using the new X-ray CT apparatus and Super-Resolution KC method. When 40 ceramic balls were moved with the extra-precision movable carriage device, errors of moving displacement were calculated.

1. INTRODUCTION

It is important to understand an internal displacement of a composite material under some stress because of selecting an appropriate material. However there are little machine for visualizing an inside of a construction material under a high load. Therefore, we developed a new X ray computed tomography apparatus hanged up inside a compression machine [1]. The X ray CT apparatus can scan a part of the specimen under loading till 300kN.

In order to measure the internal displacement inside construction material, it is necessary to analyze some three dimension images with an image analysis method. We considered using Super-Resolution KC method which was developed as a Patricle Tracking Velocimetry (PTV) for fluid flows.

The purpose of this study is to make clear a measurement accuracy of the moving vectors using the new X-ray CT apparatus and Super-Resolution KC method.

2. EXPERIMENTAL METHOD

40 ceramic balls with a diameter of 14.288 mm were randomly packed in a polystyrene container with an inner diameter of 60 mm.

At first, the container in static situation was scanned with the new X-ray CT apparatus 12 times. Centers of gravity of the ceramic balls in scanned images at each times were measured by commercial 3 dimensional image analysis software. And the moving vector of the center of gravity from the first time image to other time image were calculated by Super-Resolution KC method.

Next, the container was moved each 0.01 mm at 12 times in the X axis direction with the extra-precision movable carriage device. The moving vectors of the center of gravity of the ceramic balls were measured by the same methods in static situation. Here, a voxel size of the scanned image was one side of 0.123mm.

In this study, all ceramic balls should move at same length and in same direction. However, it is considered that the moving vectors of the ceramic balls is uneven in accordance with a standard normal distribution. Therefore, based on this supposition, a mean value and a standard deviation were calculated at each cases. Here, difference between the calculated mean value and true moving displacement was calculated as a systematic error. And the calculated standard deviation was shown as a measurement error. It is considered that an actual error is shown as a total of the systematic error and the measurement error.

We consider that the total error should be littler than 0.01mm in order to measure the moving vectors inside the concrete. If the total error was larger than 0.01mm, an affine transformation was used for decreasing the total error. Because the total error might be increased by scanning mechanism of the new X ray CT apparatus.

* e-mail: ura249@yahoo.co.jp
† e-mail: fumoto@civileng.kindai.ac.jp
‡ e-mail: takehara@civileng.kindai.ac.jp

3. RESULTS

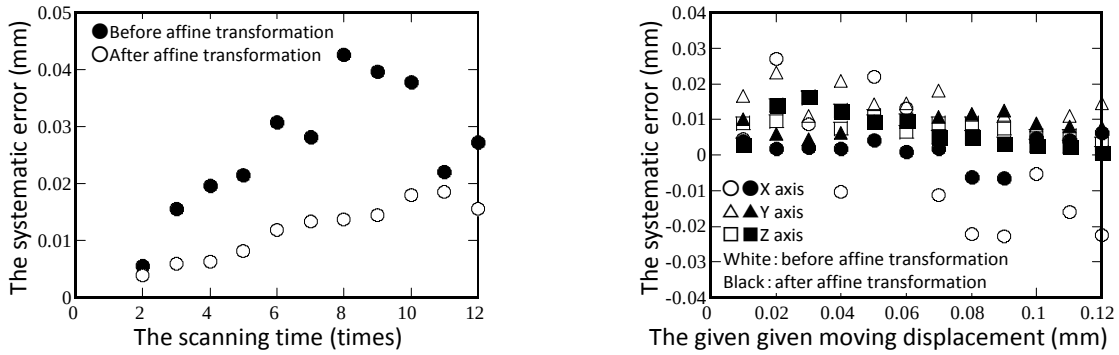
Figure 1(a) shows the relationships between the systematic error and scanning time. The systematic errors of 40 ceramic balls before the affine transformation were in range from 0.005mm to 0.043mm in the static situation. After the affine transformation, those systematic errors were decreased to 0.02mm or less. Those measurement errors were 0.016mm or less at the same time.

Figure 1(b) shows the relationships between the given moving displacement and the systematic error. Before the affine transformation, the systematic errors were in range from -0.022mm to 0.027mm in spite of the directions. After the affine transformation, the systematic errors were decreased to a range from -0.006mm to 0.013mm in X and Y axis directions. However, the systematic errors in Z axis directions were hardly any difference before and after the affine transformation. After the affine transformation, the measurement errors were decreased 0.011mm or less in spite of the directions.

As the results, the total error of the moving displacement were 0.02mm or less in case of using the new X ray CT apparatus and the Super-Resolution KC method.

References

[1] Takayuki Fumoto. Development of X-ray CT of new mechanism and application to compression test of polymer concrete. JSCE E2, Vol. 69, No. 2, pp. 182-191, 2013.



(a) (b)

Figure 1: (a) the relationships between the systematic error and scanning time, (b) the relationships between the given moving displacement and the systematic error