



HAL
open science

X-ray CT and digital volume correlation of Tuff stone under uniaxial compression

Masaru Abuku, Takayuki Fumoto, Shuya Hiranuma, Eikou Kim, Soichiro Wakiya, Hannelore Derluyn

► **To cite this version:**

Masaru Abuku, Takayuki Fumoto, Shuya Hiranuma, Eikou Kim, Soichiro Wakiya, et al.. X-ray CT and digital volume correlation of Tuff stone under uniaxial compression. 4th International Conference on Tomography of Materials & Structures ICTMS, Jul 2019, Cairns, Australia. hal-02392145

HAL Id: hal-02392145

<https://hal.science/hal-02392145>

Submitted on 3 Dec 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

X-RAY CT AND DIGITAL VOLUME CORRELATION OF TUFF STONE UNDER UNIAXIAL COMPRESSION

Masaru Abuku^{*1}, Takayuki Fumoto^{†1}, Shuya Hiranuma¹, Eikou Kim¹, Soichiro Wakiya²,
and Hannelore Derluyn^{‡3}

¹Kindai University, Japan

²Nara National Research Institutes for Cultural Properties, National Institutes for
Cultural Heritage, Japan

³CNRS/TOTAL/Univ Pau & Pays Adour/E2S UPPA, Laboratoire des Fluides
Complexes et Leurs Réservoirs-IPRA, France

Keywords: X-ray tomography, digital volume. correlation, displacement field, crack

Summary: We present X-ray CT of a dry or wet tuff stone specimen under uniaxial compression. The obtained CT data were analyzed using a digital volume correlation software to determine the displacement and strain fields.

1. INTRODUCTION

Weathering of cultural heritages made of stones are often caused by ingress of water into a porous material. To quantitatively understand such physical phenomena and then propose a proper countermeasure, the knowledge of transport phenomena and mechanics for porous media is essential.

In this study, we measured the strain of a dry or wet tuff stone specimen under uniaxial compression test as well as continually but simultaneously obtaining X-ray CT data of the specimen. Measurements we present here are intended to provide some useful quantitative data for precisely understanding the mechanical behavior of a stone under different weathering conditions and validating the calculation model. Tuff stone was selected as a type of stone of this study because it has been often used for curving scriptures in Kyushu, Japan and is suitable to be applied by a digital volume correlation.

2. METHODOLOGY

The experiments were performed at the department of Social and Civil Engineering, Kindai University, using a set-up (see Fig. 1(a)) [1] which enables to conduct X-ray imaging and uniaxial compression test simultaneously. Specimens of tuff stone from drill cores were prepared to be a diameter of 5 cm and a height of 10 cm and then grinded manually using a sandpaper. The specimens were dried in a room. One specimen was dried, while the other specimen was saturated with pure water using a vacuum pump. Each X-ray image was obtained with a resolution of 0.0615 mm and 2000 images were reconstructed to obtain the tomography. During X-ray projection, the mechanical load was not increased. Each of the axial and radial strain was measured by the two strain gauges at the middle height of the specimen and the average of the two was calculated.

The obtained CT data were analyzed using a digital volume correlation (DVC) software (TomoWarp2) [2] to determine the displacement and strain fields. The axial and radial strain of the specimens were then determined. The size of correlation window is 16 (x) x 16 (y) x 16 (z) voxels and the node spacing is also 16 voxels for each direction.

*e-mail: abuku@arch.kindai.ac.jp

†e-mail: fumoto@civileng.kindai.ac.jp

‡e-mail: hannelore.derluyn@univ-pau.fr

3. RESULTS

Fig. 1(b) compares the axial and radial strain measured by the gauges with those calculated based on the displacement field that was obtained by DVC of the X-ray CT data. The axial strain was calculated by dividing the difference in the displacement in the axial direction between two heights (1.5 cm and 8.5 cm) by the difference in height (7 cm). The radial strain was calculated for the circumference of the horizontal section of the specimen and the average between 4 cm and 6 cm where the gauges were glued to the surface of the specimens was taken.

Also, as an example, the displacement field of the wet specimen under a uniaxial mechanical load of 8.5 kN is also compared to the X-ray CT image at 4.1 cm height in Fig. 1(c) and (d).

References

- [1] T. Fumoto. Development of X-ray CT of new mechanism and application to compression test of polymer concrete, *JSCE E2*, 69, 2, 182-191, 2013.
- [2] E. Tudisco, E. Andò, R. Cailletaud & S.A. Hall. TomoWarp2: A local digital volume correlation code, *Software X*, 6, 267-270, 2017.

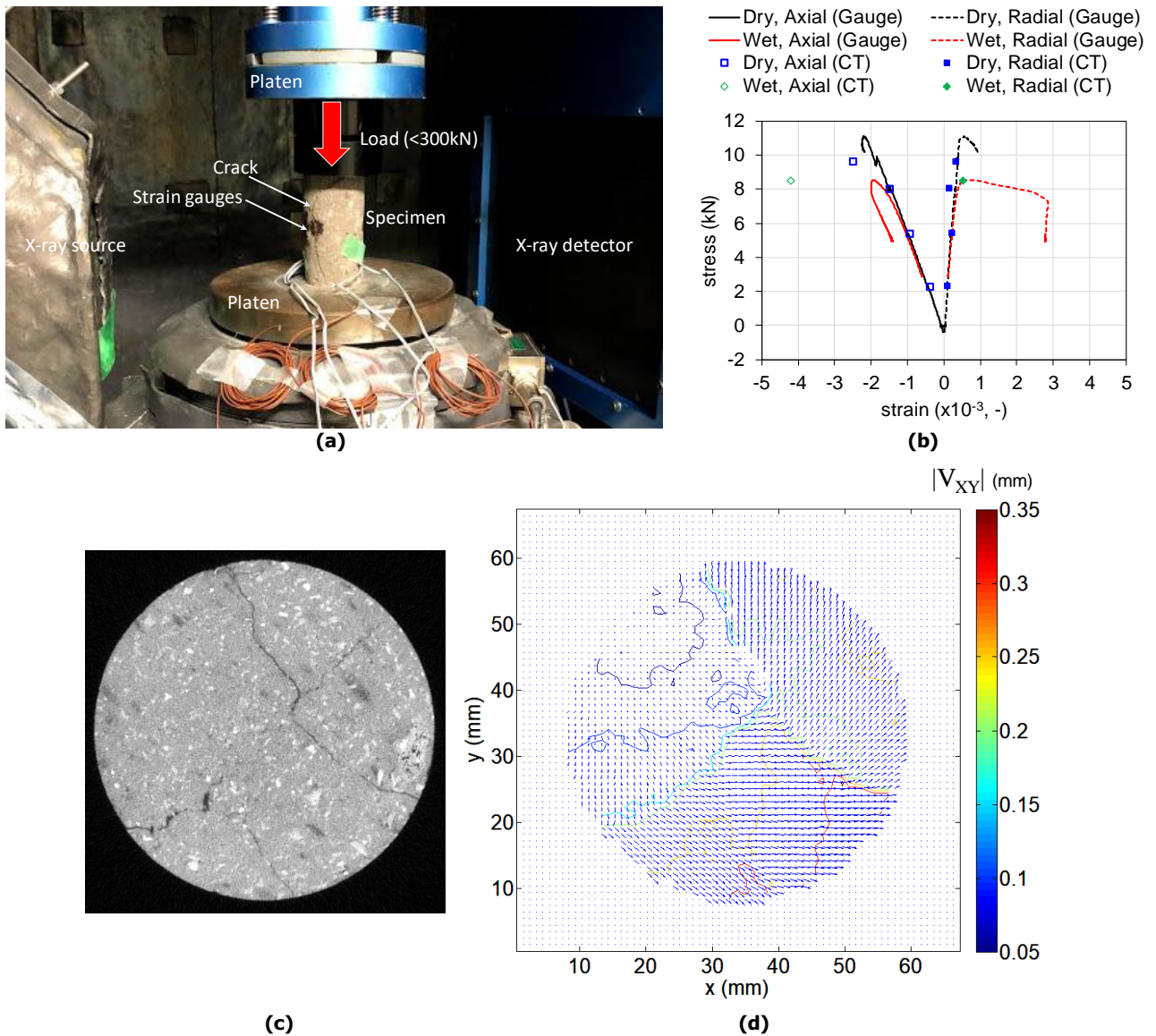


Figure 1: (a) Photograph of a setup with a specimen inserted between the loading platens. (b) Stress – strain relations of dry and wet tuff stone under uniaxial compression test, either measured by strain gauges or determined based on X-ray CT and digital volume correlation. (b) CT image and (c) the corresponding displacement field ($|V_{XY}|$ is the horizontal component of the displacement vector), at 4.1 cm height, of a wet specimen with some cracks under a uniaxial mechanical load of 8.5 kN. The displacement field was obtained by digital volume correlation.