EFFECT OF SPECIMEN HEIGHT ON DEFORMATION AND ELASTIC WAVE VELOCITY OF TAGE TUFF DURING DRYING

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1. INTRODUCTION

Deterioration effect due to physical weathering is common in clay bearing clastic sedimentary rocks such as Tuff. Tunneling through tuffaceous rocks suffer severe crown settlements making enormous financial problems. Monuments and structures made out of tuff rocks are subjected to wetting and drying process due to change in weather condition. In both cases, rapid evaporation of moisture from saturated rock mass deforms the rock depending on its inherent susceptibility. Therefore it is important to understand the behaviour of pore water evaporation followed by deformation and change in elastic properties through experimental measurements. However current literature has been paid a little attention to the study of inherent deformation induced by abrupt environmental changes in tuffaceous rocks.

In this paper we compare the drying induced deformation behavior of Tage Tuff having different heights and drying directions. It also includes the ultrasonic wave velocities during drying to clear the effect of shrinkage on mechanical properties of rock.

2. MATERIALS AND METHODS

Tage Tuff is a greenish grey colour pyroclastic sedimentary rock having 2.55 g/cm^3 grain density, 29.9 – 31.2% porosity and 5.17×10^{-8} m/s hydraulic conductivity (Adikaram et al., 2011; Osada et al., 2011). It compose of 27.4% quartz, 8.2% anorthite, 49.2% clinoptilolite, 6.3% cristoblite and 3.6% smectite, the last being a type of clay (Funatsu et al., 2004).

A set of cylindrical specimens having 5 cm diameter were cored across and along the bedding plane from a block of Tage Tuff obtained from Tochigi prefecture in Japan. Cored specimens were oven dried for 105ºC for 24 hours and later vacuum saturated for 72 hours to measure the weights and ultrasonic wave travel times in dry and saturated conditions. Saturated specimens were prepared in one-dimensional drying condition in a 50°C climatic chamber with 50% relative humidity. Two specimens were dried simultaneously to obtain strain and ultrasonic wave velocity separately (Fig. 1). The strain and weight of one specimen was automatically measured using four triaxial strain gauge rosettes glued at 90° to each other centrally on the periphery and electric balance respectively (Exp A). Transducers were used to measure the ultrasonic wave velocity of the second specimen and its weight was manually recorded (Exp B). When the strain occurrence and weight change were stabilized, the experiment was stopped.

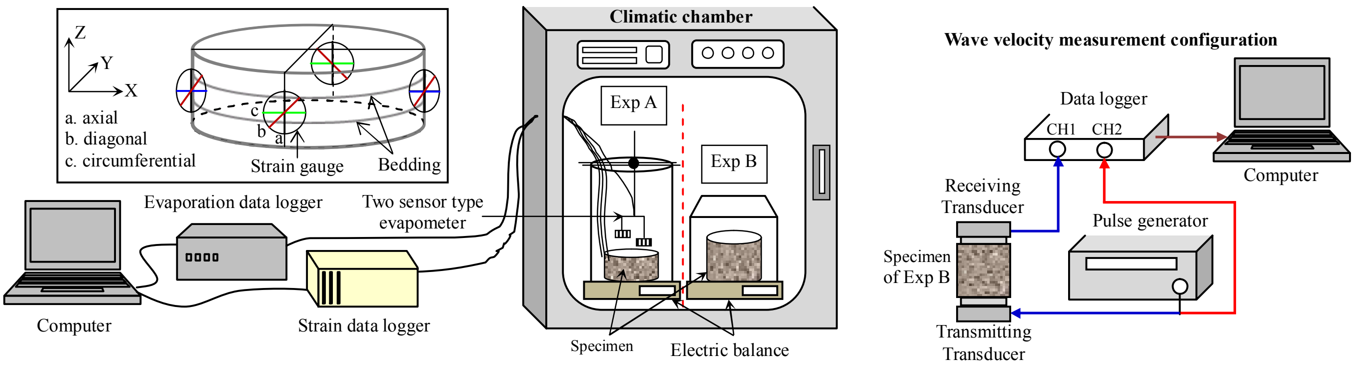

Fig.1 Experimental configuration

3. RESULTS AND DISCUSSION

Prior to analyse the measured strains, a convention was adopted that the shrinkage strain is negative and the expansion is positive. It was observed that the magnitudes of the strain occurred in three directions were different reflecting the presence of anisotropy of Tage Tuff (Fig. 2(a)). The largest strain magnitude was registered in the Z direction. All specimens showed expansion at the beginning of drying as they heated up to 50°C from natural environment temperature which is about 15-20°C (Fig.2(b)). Specimen thickness effect the strain equilibrium time and it is around 250h for 3cm

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thick specimens and 450 h for 5cm thick specimens. Regardless of specimen height, final shrinkage strains of same direction dried specimens were identical. Final shrinkage strain showed a value of -4000μ and -3200μ for specimens dried along Z and X directions respectively.

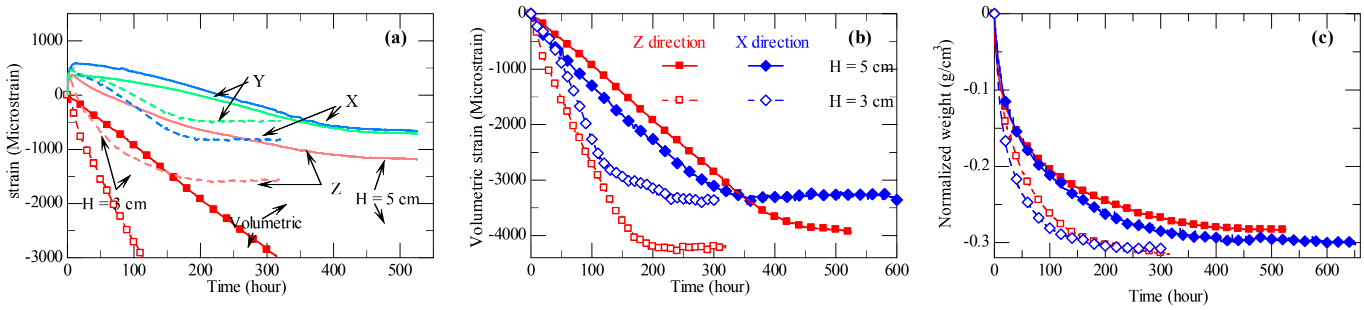

Fig.2 (a) Drying-induced deformation of different height specimens; (b) Volumetric strain evolution with time; (c) Normalized weight against drying time for strain measured specimens [H: Specimen height]

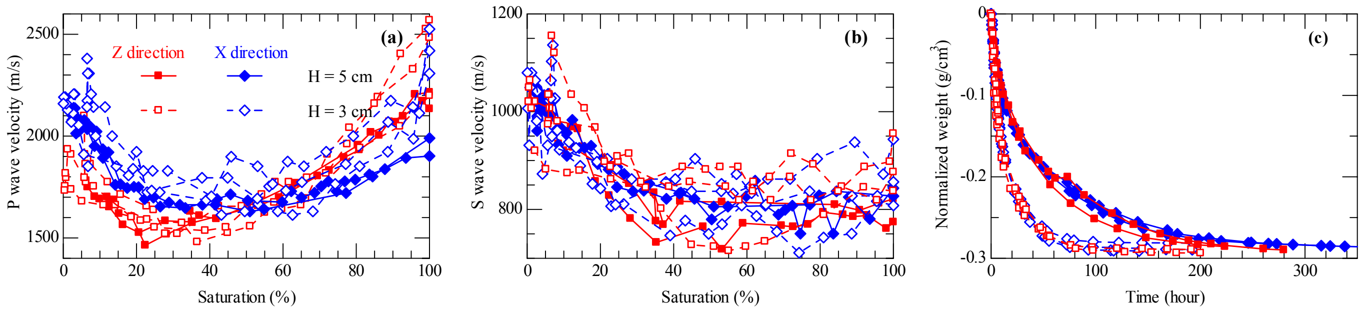

Fig.3 (a) & (b) ultrasonic wave velocity variation with saturation; (c) Normalized weight against drying time for wave velocity measured specimens [H: Specimen height]

According to Fig. 3(a), it is obvious that P wave velocity vary with two distinct trends depending on the two main textural directions in which it was measured. This feature was related to the orientation of water filled pore spaces inside the specimen, since such a trend was not observed with S wave velocity, which is theoretically less sensitive to water content changes (Fig. 3(b)). Higher level of pore connectivity in the direction parallel to the bedding revealed the presence of pore volumes filled with water is higher in X direction assist to explain this behaviour. Significant increase in S wave velocity in saturation less than 30% indicate the desiccation driven hardening of specimens (Ghorbani et al., 2009).

The normalized weight in Fig. 2(c) and Fig. 3(c) was calculated as the change in weight (g) of specimens during drying to its original volume (cm^3). Figures clearly indicate that the rate of change in weight is higher in 3 cm high specimens; hence approach to equilibrium state more rapidly irrespective of drying direction. Normalized weigh of all specimens equilibrate to a value of -0.3, which equals to the apparent porosity of Tage Tuff.

4. CONCLUSIONS

There is no effect of specimen height on final shrinkage strain on same direction dried specimens. But there is an effect of drying direction on final shrinkage strain. Similarly, there is no effect of the specimen height on ultrasonic wave velocity. Strain anisotropy and P wave velocity variation pattern according to the textural direction confirmed the presence of anisotropy in Tage Tuff.

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