EFFECT OF DRYING PROCESS ON DEFORMATION BEHAVIOR IN MUDSTONE

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1. INTRODUCTION

Drying experiments have been conducted by researches with aim to characterized deformational behavior on mudstones (Pham et al., 2007).It is a vital requirement to examine how moisture transfer process vary in saturated rock mass with th e effect of drying process with respect to nuclear waste repositories. Most previous work concern with steady state drying with constant temperature and step wise decreasing humidity convinced by range of saline solutions. Few experiments ca n be counted as transient drying, since the drying method utilize constant temperature and constant low humidity .The present drying experiment was performed using decreasing stepwise relative humidity in controlled environment to compare with the previously done drying experiment for similar rock formation using relatively constant low humidity environment with constant temperature of 40^{0}C. Both experiments performed inside controlled climatic chamber with continuous air flow which reflects real ventilated tunnel environment. This paper, presents the comparison made between the results obtained by two methods with aim to find the deformation behavior in two drying procedures.

2. MATERIAL

The rock specimens extracted from diatomaceous sandy mudstone part of Koetoi Formation of vertical borehole named H DB-10 in Horonobe Underground Research Laboratory site situated in the Neogene- Quaternary sedimentary basin (Ishii et al., 2011). The petrographic analysis showed that Koetoi Formation mainly composed of; 40%-50% Opal A, 17%-25% Clay, 7%-10% Quartz and 5%-10% Feldspar with diatom supported matrix (Ishii E., 2011). Koetoi Formation show unimodal pore size distribution which has similar size pores comparatively and more than 90% of total pores are macro pores in tested samples of koetoi formation.

3. EXPERIMENTAL PROCEDURE

Experimental work has been conducted in a laboratory scale by using cylindrical specimens obtained from a core sample of the Koetoi Formation. Firstly, four strain gauges were attached at 90° to each other centrally on the periphery of the specimens denoted as HDB10KO-1 and HDBKO-5 to monitor the deformation. Then periphery of samples covered by silicon rubber to allow evaporation only from top and bottom surfaces of the specimen. Once the samples were prepared, leading wire terminals of the strain gauges were connected to the data logger for continuous monitoring of deformation. Samples which attached to the strain gauges were placed on electrical balance kept inside two different climatic chamber as illustrated in fig 1. During the steady state drying, relative humidity decreased step wisely throughout the drying process. When the strains and weight changes became stabilized the current relative humidity step terminated and continue to the next RH step (Table.1). Another four samples were used to measure physical properties at the end of each humidity step. The temperature inside the climatic chamber environment was maintained at 40 °C. Transient state drying experiment has been conducted for the specimen denoted as HDB10KO-1. In this test procedure the climatic chamber environment was conserved at 40 °C with constant low humidity level of 50%.

Table 1. Relative Humidity (RH) steps used in steady state drying.

RH%	98	90	80	70	60	50
Suction(MPa)	2.89	15.10	31.98	56.11	73.21	99.34

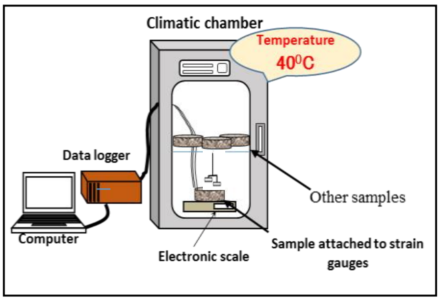

Fig.1 Experimental Setup

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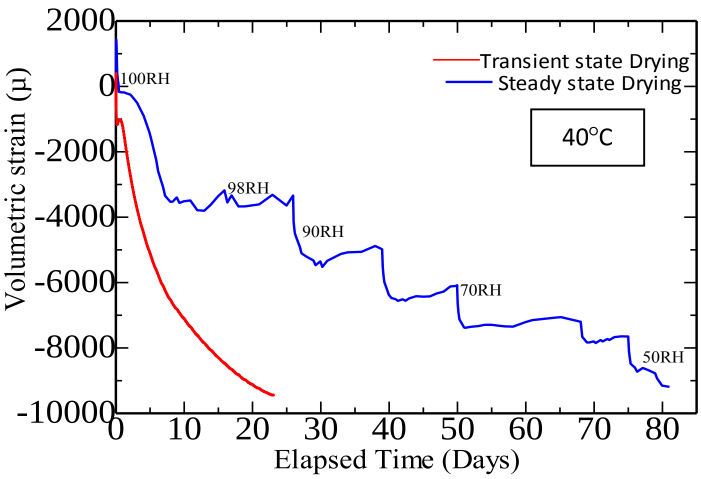
The test conducted to measure the weight loss, evaporation rate and shrinkage strain as a function of time. The weight of other four samples was measured time to time taken outside of the chamber until the weight stabilized in each step. Automated recording of weight strain, temperature and relative humidity via a data logger at 2 minute intervals.

3. RESULTS AND DISCUSSION

For the purpose of interpretation and analysis of measured strains, a negative value was taken to represent shrinkage while a positive value represented expansion. The fig.2 indicates the evolution of shrinkage with time progress in two drying processes. In both drying procedures, the magnitude of acquired strains showed almost equal values (nearly up to -9000μ) and the steady state method consumed more than 80 days whereas the specimen reached equilibrium in 23 days in transient drying method. The shrinkage variation with respect to degree of saturation in specimens illustrated in fig.3. It can be observed that the shrinkage not developed much until the saturation value drops from 100% to nearly to 70% and gradually increased with decreasing saturation in both methods. In initial stage of drying, specimen dried under constant humidity (transient method) showed slight higher shrinkage values.



Fg.2 Strain Variation with Time during Drying

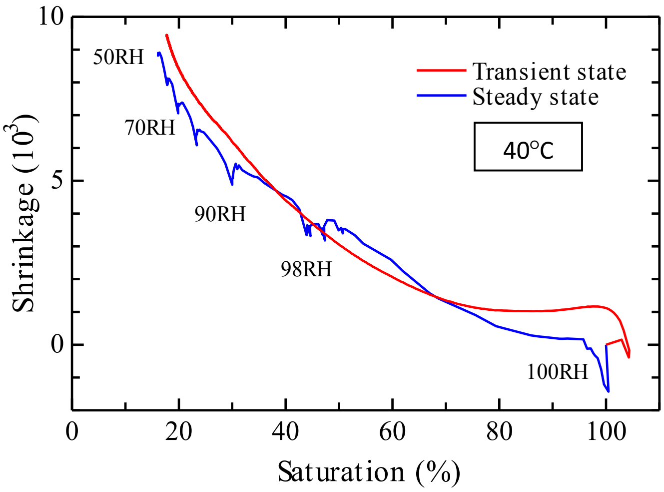


Fig.3 Strain Variation with saturation during Drying

The figures designates that volumetric reduction is mostly depend on amount of water retain in specimens during both drying procedures. It is obvious that moisture discharge from macrospores did not contribute considerable strain magnitude and water expel from mesopores can generate higher shrinkage as seen in figures.

4. CONCLUSION

Two drying methods were used to investigate the deformation based on controlling the drying environment. The results obtained by two drying methods revealed that the deformational behavior is not effected by the two drying processes for Koetoi formation samples. The steady state drying procedure is more time consuming method compare to simple transient drying method. Therefore it is meaningful to apply simple transient state drying (using constant low humidity) method to evaluate deformational behavior of low permeable mudstones with the effect of drying. Moreover it was observed that the pore structure can contribute much consequence on moisture exchange process during drying. However further testing is needed to verify the observation for different formation samples.

REFERENCES

Illankoon, T.N., Suu, M. Y., Osada, M., Maekawa, K., Tada, H. and Kumasaka, H., 2013, Drying induced deformation of Horonobe sedimentary rock in the Koetoi and Wakkanai formations, 6th Japan-Korea Joint Sym. on Rock Eng., JCRM, Japan, 899-904.

Ishii E, Sanada H, Iwatsuki T, Sugita Y, Kurikami H. Mechanical strength of the transition zone at the boundary between opal- A and opal- CT zones in siliceous rocks. Eng Geol 2011; 122:215–21.

Pham QT, Vales F, Malinsky L, Minh DN, Gharbi H. Effects of desaturation–resaturation on mudstone. Phys Chem Earth 2007; 32:646- 55.