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Publisher's version / Version de l'éditeur:

Journal of Testing and Evaluation, 6, 2, pp. 144-147, 1978-03

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MEASUREMENT OF LINEAR EXPANSION IN BRICKS
DUE TO FREEZING

by J. I. Davison and P. J. Sereda

ANALYZED

Reprinted from
Journal of Testing and Evaluation
Vol. 6, No. 2, March 1978
p. 144-147

DBR Paper No. 766
Division of Building Research

Price 10 cents

OTTAWA

NRCC 16593

SOMMAIRE

L'extensomètre linéaire décrit peut être employé pour mesurer les dilatations, causées par le gel, dans les matériaux de construction inorganiques, poreux et saturés. Les courbes de gel typiques illustrent les dilatations réversibles et irréversibles. Le procédé peut avoir une application dans une méthode d'essai simple pour estimer la durabilité des briques ou d'autres matériaux de construction inorganiques et poreux.

J. I. Davison¹ and P. J. Sereda²

Measurement of Linear Expansion in Bricks Due to Freezing

REFERENCE: Davison, J. I. and Sereda, P. J., "Measurement of Linear Expansion in Bricks Due to Freezing," *Journal of Testing and Evaluation*, Vol. 6, No. 2, March 1978, pp. 144-147.

ABSTRACT: A linear extensometer is described that can be used to measure expansions resulting from freezing in saturated porous inorganic building materials. Typical freezing curves illustrate reversible and irreversible expansions. The procedure may have application as a simple test method for assessing the durability of bricks or other porous inorganic building materials.

KEY WORDS: thermal expansion, bricks, freezing

The destruction of saturated clay bricks by frost action is a continuing problem in spite of many attempts to develop a reliable method of assessing durability under these conditions.

Present criteria in Canadian Standards Association (CSA) Standard A82.1, Burned Clay Bricks, and in ASTM Specifications for Building Brick (Solid Masonry Units Made from Clay or Shale) (C 62-75a) establish durability on the basis of either compliance with a combination of requirements for strength, absorption and saturation coefficient, or freezing and thawing tests described in CSA Standard A82.2 and in ASTM Methods of Sampling and Testing Brick and Structural Clay Tile (C 67-73). Both methods are suspect because they do not always accurately predict the performance of bricks in service. Litvan [1] has discussed this aspect in detail. The freeze-thaw cycling test is also time-consuming (consisting of 50 cycles each of 24-h duration) and unreal in terms of in-situ conditions.

Tray and cemetery tests [2] have been used extensively but they also are time-consuming and severe. In the 1930s Thomas [3] conducted an extensive study of freezing in building materials in which a linear extensometer was used to measure dimensional changes on freezing. More recently Litvan [1] has examined the relation between surface area and frost durability in clay bricks. The present paper describes a linear extensometer, a modified version of the Thomas extensometer, that may be useful in predicting the performance of clay bricks and other building materials under the influence of frost action.

Presented at the Masonry Symposium, ASTM Annual Meeting, Chicago, Ill., June 1976.

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Apparatus

The extensometer is shown in Fig. 1. It consists of a mounting frame with the top attached to the cover of a brass cylinder in which the frame and sample are suspended. Invar posts within the mounting frame support a 76-mm (3-in.) sample³ by means of stainless steel mounting cups epoxied to the ends of the sample. The lower mounting post can be adjusted by a screw; the upper post extends through the top of the cylinder to a dial gage that records movement in the sample. Temperature is measured in a stainless steel tube extending through the cylinder top. Figure 2 shows the extensometer with a sample ready for measurement, and Fig. 3 the extensometer in place in the cylinder. The cylinder in turn is placed in a bath cooled by a refrigeration system capable of maintaining a temperature of -30°C . Figure 4 shows the bath with two cylinders installed plus an immersion heater and tem-

FIG. 1—Detail of extensometer.

³Original experimental data were measured in English customary units.

FIG. 2—Sample mounted in extensometer.

perature-sensing element. Bath temperature is controlled by a precision temperature controller, and temperatures are measured by means of a copper-constantan thermocouple inserted in the thermometer tube.

FIG. 3—Complete assembly of extensometer.

FIG. 4—Two extensometers mounted in cooling bath as during test.

Experimental Procedure

Specimens 13 by 13 by 76 mm ($\frac{1}{2}$ by $\frac{1}{2}$ by 3 in.) are cut from bricks and dried, and the mounting cups are epoxied to the ends. Samples are evacuated in a desiccator with a high vacuum pump for $3\frac{1}{2}$ h and saturated by admitting water and leaving the specimen submerged for 18 to 20 h. Saturated samples are mounted in the extensometer, which is then placed in the brass cylinder filled with water-saturated kerosene to ensure no water loss from the sample. The cylinder in turn is placed in the bath, which has been raised to ambient temperature. The bath temperature is then lowered, the rate of temperature drop regulated by the control setting.

Linear changes are followed on the dial gage [1 division = $1.27 \mu\text{m}$ (0.00005 in.)] at regular intervals. In a typical experiment, readings indicate shrinkage with dropping temperature. When freezing occurs in the sample the needle on the gage reverses direction, indicating expansion. Upon completion of freezing the needle resumes the original behavior, indicating shrinkage. Usually temperatures were dropped to -15 or -18°C and then the bath temperature was raised to its original level, at which point the run was discontinued. It is possible to do successive freezings before removing the sample from the cylinder.

During early experiments temperature readings indicated the temperature in the kerosene surrounding the sample. In some a slight rise in temperature was recorded when freezing occurred. In order to clarify this behavior, temperatures on the surface and in the center of the specimen were recorded during later exper-

iments. A thermocouple wire was placed in the sample in a hole drilled with a 1.6-mm ($1/16$ -in.) drill, at the center of one end, to a depth of 38.1 mm ($1\frac{1}{2}$ in.) (half the length of the sample). After inserting the thermocouple, the hole was filled with fine sand and sealed with epoxy. A second thermocouple wire was epoxied to the side of the sample to measure surface temperature. The thermometer tube was removed from the cylinder top to accommodate the thermocouple wires.

Results

Typical freezing curves are shown in Figs. 5, 6, and 8 and a temperature profile is shown in Fig. 7. Figure 5 depicts the results for a slow freezing experiment on a sandstone sample; Fig. 6 shows the result of a fast freezing experiment on a dry press brick; and Fig. 8 shows decreasing expansions resulting from repeated freezings of an extruded clay brick. Figure 7 shows the temperature rise that occurs when freezing starts and the temperature behavior during melting. The temperature differential between the center and the surface of the sample during freezing and melting is clearly defined.

FIG. 5—Results for slow freezing of a sandstone sample.

FIG. 6—Results for fast freezing of a dry press brick.

Concluding Remarks

Linear expansions occurring in porous inorganic building materials as a result of freezing can be measured with ease by the method described. Correlation of expansion values, either reversible or irreversible, with known field performance or other properties can provide a basis for predicting the durability of bricks and other inorganic building materials.

Measurement of only the irreversible deformation occurring at the end of one freezing cycle can eliminate the labor-intensive factor in the test method. Deformation simply determined by observing the difference between initial and final dial readings could be used as an indication of durability. The freezing and melting stages can be automatically controlled and the intermediate readings eliminated. Subsequent papers will present data collected with this apparatus.

Acknowledgments

The authors gratefully acknowledge the contribution of Roger Tetu and H. F. Slade to the design, fabrication, and assembly of the extensometer. This paper is a contribution from the Division of Building Research, National Research Council of Canada, and is published with the approval of the Director of the Division.

FIG. 7—Plot of temperatures in sample and cylinder with time of experiment.

Sample No.	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>
Expansion	$365 \times 10^{-5}''$	$+190 \times 10^{-5}''$	$152 \times 10^{-5}''$	$108 \times 10^{-5}''$	$98 \times 10^{-5}''$	$78 \times 10^{-5}''$	$62 \times 10^{-5}''$
Final Set	$144 \times 10^{-5}''$	$20 \times 10^{-5}''$	$8 \times 10^{-5}''$	NIL	$5 \times 10^{-5}''$	$6 \times 10^{-5}''$	$10 \times 10^{-5}''$
Temp. Drop	40°/HR.	40°/HR.	38°/HR.	36°/HR.	36°/HR.	+2°/HR.	36°/HR.
Freezing Temp.	-7.5°C.	-6.2°C.	-6.7°C.	-5.5°C.	-6.5°C.	-6.6°C.	-6.3°C.

FIG. 8—Results of repeated freezing of an extruded clay brick.

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