

Australian/New Zealand Standard™

**Masonry units, segmental pavers and flags—
Methods of test****Method 11: Determining coefficients of
expansion**

This Standard incorporates Amendment No. 1 (August 2004). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

1 SCOPE

This Standard sets out the methods for determining the coefficients of expansion of masonry units, segmental pavers and flags. The coefficients of expansion estimated by these tests represent the total 15 year expansion of either kiln-fresh or non-kiln-fresh fired clay units. Provision is also included for the estimation of past expansion and of residual expansion to 15 years, of units of any age.

2 REFERENCED DOCUMENTS

The following document is referred to in this Standard:

AS/NZS

4456	Masonry units, segmental pavers and flags—Methods of test
4456.0	Part 0: General introduction and list of methods
4456.1	Method 1: Sampling for testing
4456.2	Method 2: Assessment of mean and standard deviation

3 DEFINITIONS

For the purpose of this Standard, the definitions given in AS/NZS 4456.0 apply.

4 NOTATION

The following symbols are used in this Standard:

L	= overall length of unit, in millimetres
Z_i	= initial gauge reading of reference bar (average of two readings), in millimetres = $(Z_1 + Z_2)/2$
Z_f	= final gauge reading of reference bar (average of two readings), in millimetres = $(Z_3 + Z_4)/2$
Y_i	= initial gauge reading of unit before steaming or refiring, in millimetres
Y_f	= final gauge reading of unit after steaming or refiring, in millimetres
dL	= change in length of the specimen due to steaming or refiring, in millimetres
dZ	= differences between final and initial gauge reading ($Z_i - Z_f$) of the reference bar, in millimetres
ΔL	= percentage change in length of each unit due to steaming or refiring

$\overline{\Delta L}$	=	mean percentage change in length of the sample due to steaming or refiring
e_m	=	coefficient of expansion of the specimen, in millimetres per metre
$\overline{e_m}$	=	mean coefficient of expansion of the sample, in millimetres per metre
e_p	=	past expansion of the specimen, in millimetres per metre
$\overline{e_p}$	=	mean past expansion of the sample, in millimetres per metre
e_r	=	coefficient of residual expansion of the specimen, in millimetres per metre
$\overline{e_r}$	=	mean coefficient of residual expansion of the sample, in millimetres per metre
e_t	=	coefficient of expansion after 't' months, in millimetres per metre
$\overline{e_t}$	=	mean coefficient of expansion of the sample after 't' months, in millimetres per metre

5 COEFFICIENT OF EXPANSION OF FRESH UNITS

5.1 Principle

A sample of 5 units is used. (For burnt clay building bricks, they represent the range of the firing treatments of the product. They are taken either from the kiln or from the packaging line and their temperature allowed to equilibrate).

Reference points are established in the ends of the units and the distances between the points are measured between 24 h and 32 h after the units are drawn from the kiln (see Note 1). The units are then exposed to saturated steam at 100°C (see Note 2) for 4 h, after which they are cooled and re-measured when their temperature is within 2°C of the temperature at which they were first measured and within 100 h of the taking of that first measurement. The difference in length multiplied by an appropriate factor gives the coefficient of expansion – the ' e_m ' value.

NOTES:

- 1 Because at least one day will have elapsed between the end of firing and the first possible occasion when they can be sampled, fired bricks from batch kilns should have their first measurement taken as soon as temperature equilibration has occurred.
- 2 See Clause 5.8 for corrections for locations where water boils at temperatures less than 100°C.

5.2 Apparatus

The following is required:

- (a) Temperature-controlled space in which the temperature does not differ by more than 2°C between the taking of the initial and final gauge readings of the units.
- (b) Measuring frame, of a suitable type, fitted with a micrometer or dial gauge that is capable of being read to the nearest 0.002 mm or better (see Figure 1).
- (c) Flat-ended reference bar of invar steel rod fitted with an insulated grip and approximately equal in length to the test specimens.
- (d) Two steel balls of 6.5 mm diameter.
- (e) Two steel-ball adaptors that can be attached to the reference bar (see Figure 2).
- (f) Calliper capable of being read to 0.5 mm over the length of the units being tested.
- (g) Well-insulated, loosely covered boiler capable of holding at least 5 units without them touching each other. It shall be complete with a grid to support units clear of the boiling water and be large enough to hold sufficient water to last for the duration of the test. A thermometer shall be fitted to measure the temperature close to and at the top of the units.

- (h) Tungsten carbide drill, 6.5 mm diameter.
- (i) Suitable still brush

5.3 Preparation of test specimens

Specimens accumulated from continuous sampling shall be deemed to meet the requirements of this method, provided that the number of specimens accumulated is at least five. For assessment of an individual lot, select 5 units in accordance with AS/NZS 4456.1.

After the test specimens have been received in the laboratory, they shall be kept for a minimum of 3 h in the controlled temperature space for equilibration. During this time the units may be briefly moved to a different space where, by means of the tungsten carbide drill, a conical depression shall be formed in the centre of each end of each unit to provide reference point seats for the steel balls. All dust shall be brushed from the conical depressions.

Where difficulty is encountered in making smooth conical depressions in coarse-textured or friable units, it shall be permissible, after initial drilling, to fill the depression with a moisture-stable, epoxy-based filler, for which the dimensional stability has been checked under the test conditions before it is adopted for use.

When the filler is cured, it shall be redrilled to re-expose the unit surface.

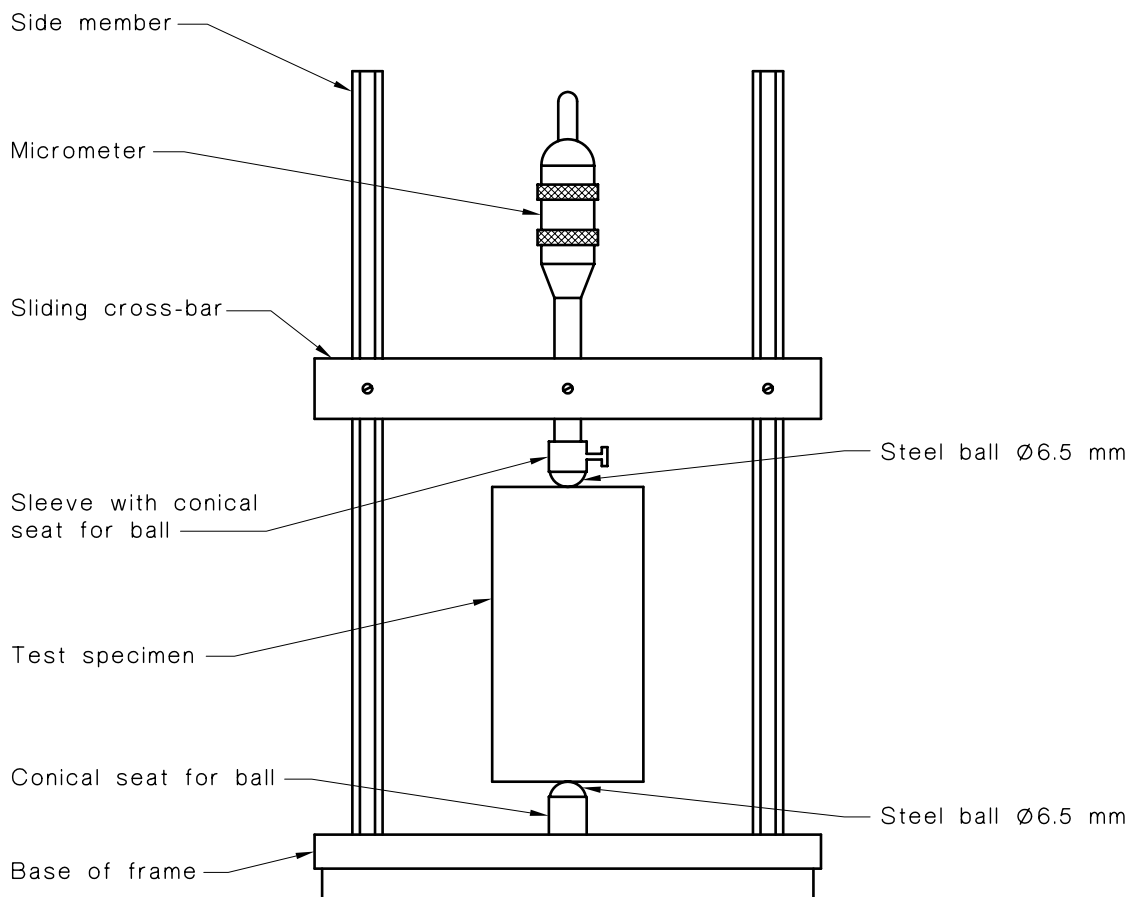


FIGURE 1 TYPICAL MEASURING FRAME

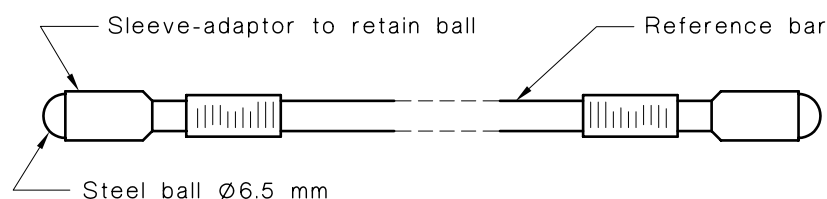


FIGURE 2 TYPICAL REFERENCE BAR WITH STEEL-BALL ADAPTORS

5.4 Procedure

The procedure shall be as follows, with all steps being completed within 100 h of the time of taking the first measurement:

- Using the calliper, measure the overall length of each specimen to the nearest 1 mm and record as L .
- Attach one steel ball adaptor to each end of the reference bar and with the balls in position measure the length of the reference bar supported vertically in the measuring frame with the micrometer to the nearest 0.002 mm. Record the result as Z_1 .
- Support the test specimen between the steel balls in the measuring frame. Take care that the unit is properly seated on the steel balls and read the micrometer to the nearest 0.002 mm. Record the result as Y_i . Repeat this procedure for all other test specimens.
- Remeasure the length of the reference bar as in Step (b) and record the result as Z_2 .
- Heat the water in the boiler until the steam temperature at the top of the vessel reaches 100°C. Reduce the heat input while the units are placed in position and then slowly increase it until the steam temperature near the top of the units returns to 100°C (see Note). Maintain this temperature for 4 h.

NOTE: See Clause 4.8 for details of steaming time adjustments in locations where water boils at temperatures less than 100°C.

- Remove the specimens from the steamer and, after the specimens have stopped steaming (about 30 min), place them in the controlled temperature space with the measuring frame. Allow a minimum of 12 h for temperature equilibration to take place and then remeasure the reference bar and the specimens as in Steps (b) to (d) and record these results as Z_3 , Y_f and Z_4 .

NOTE: Ideally, all steps should be completed in the shortest possible time, but the accuracy of the results will not be impaired significantly if a 2 day break, e.g., Saturday and Sunday, interrupts the procedure between either Steps (d) and (e) or Steps (e) and (f).

5.5 Calculation of coefficients of expansion

The following calculations shall be made:

- $Z_i = \frac{Z_1 + Z_2}{2}$ and $Z_f = \frac{Z_3 + Z_4}{2}$
- $dZ = Z_i - Z_f$
- $dL = (Y_f + dZ) - Y_i$
- $\Delta L = \frac{dL}{L} \times 100 (\%)$
- $e_m = 10 \left(4.53 \Delta L - 23.25 \Delta L^2 \right) \text{ mm/m}$

NOTE: This formula has been based on information for values of $\Delta L < 0.09\%$. For all greater values, the results may not necessarily be reliable.

- Calculate the mean coefficient of expansion in accordance with AS/NZS 4456.2 to one decimal place, in millimetres per metre.

5.6 Recording

The following information shall be recorded:

- (a) Reference to this test method, i.e., AS/NZS 4456.11.
- (b) Description of the marking, location and identification of the lot.
- (c) Sample and specimen identification.
- (d) Date of sample and test.
- (e) Work sizes for the lot.
- (f) Time of the removal of the units from the kiln.
- (g) Dates and times of the initial and final gauge readings.
- (h) All measurements taken.
- (i) Percentage change in length of each specimen due to steaming (ΔL).
- (j) Coefficient of expansion (e_m) of each specimen to two decimal places, in millimetres per metre.
- (k) The mean coefficient of expansion to one decimal place, in millimetres per metre.

5.7 Report

If a report is prepared, it shall include the following information:

- (a) Reference to this test method, i.e., AS/NZS 4456.11.
- (b) Description of mark and identification of the lot and of each specimen.
- (c) Sample and specimen identification.
- (d) Date of sample and test.
- (e) Work sizes for the lot.
- (f) Initial length of each specimen.
- (g) Coefficient of expansion (e_m) of each specimen, to two decimal places, in millimetres per metre.
- (h) Mean coefficient of expansion ($\bar{e}_m$), to one decimal place, in millimetres per metre.

5.8 Steaming time adjustments at elevations 100 m and above

The steaming time shall be increased where testing is done at altitudes greater than 100 m to compensate for the reduced reaction rate caused by water boiling at temperatures lower than 100°C at higher altitudes.

The adjusted steaming times shall be calculated from the following equation:

$$\text{Total steaming time (hours)} = 4 \times 10^{\{0.02553(100 - T_w)\}}$$

where

T_w = local boiling point of water, in degrees Celsius

NOTE: It follows from this equation that for small reductions in the boiling point, for every 1°C decrease in the boiling point of water, the time for steaming has to be increased by 15 min.

6 COEFFICIENT OF EXPANSION OF NON-KILN-FRESH UNITS

6.1 Principle

A sample of 5 specimens is taken. When situations allow, specimens represent the range of firing treatments or, if this cannot be determined, the lot from which the product was taken. The sample is returned to a kiln-fresh state by refiring in a laboratory kiln at $915 \pm 15^\circ\text{C}$, after which the procedures given in Clause 5, to determine the coefficient of expansion, are used.