

Australian/New Zealand Standard™

Testing of building facades



AS/NZS 4284:2008

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Australian Building Codes Board
Australian Glass and Glazing Association
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Building Research Association of New Zealand
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PREFACE

This Standard was prepared by the Joint Australia/New Zealand Standards Committee BD-080 on Curtain Walls to supersede AS/NZS 4284:1995.

The Standard is based on 'Specification for the performance testing of building facades by the SIROWET method' published by CSIRO, Division of Building, Construction and Engineering now it is known as Manufacturing and Infrastructure Technology.

This Standard is derived from publication by the CSIRO on the method of facade testing developed by the CSIRO and known as SIROWET. These publications are the following:

- (i) 'The SIROWET Rig, for testing weatherproofness of building facades' by N.G. Brown and E.R. Ballantyne, CSIRO Division of Building Research 1975.
- (ii) 'Specification for the performance Testing of Building Façade by the SIROWET Method', January 1990. Division of Building, Construction & Engineering, CSIRO—Australia.
- (iii) 'The SIROWET Method; Specification for the Performance Testing of Building Facades by the SIROWET Method', June 1992 ISBN 0 643 050930. This specification (TR92/6) is effective from 30 June 1992 and supersedes (TR 90/2) dated February 1990.

Consideration has been given to maintaining compatibility with NZS 4211:1985, *Specification for performance of windows* and with Amendment No. 3 which converts the earlier working stress basis to limit state design requirements. It should be noted that the water test pressure calculated in NZS 4211 Amendment No 3 is based on an alternative serviceability wind pressure definition and not equivalent to serviceability pressure determined in AS/NZS 1170.2.

The objective of this Standard is to provide those persons or organizations involved with the specification, design, purchasing and construction of building facades with a method for determining the performance of a building facade under wind and other optional loadings. This test method is applicable to complete facades and is intended to assess the overall system performance and interaction of the various facade components.

The Committee has made a number of significant changes and additions to the original SIROWET method and these include the following:

- (a) Change to limit state principles from working stress.
- (b) Addition of optional seal degradation, seismic and building maintenance unit (BMU) restraint tests.
- (c) Addition of several appendices, including a pro forma for test loads and limits.

Test pressures nominated in the Standard represent minimum default values that should be applied to the test sample; however, selection of pressure values should be based on the proposed usage of the structure, its exposure conditions and of the expected performance of the facade.

For high rise residential and commercial building facades (buildings typically greater than 25 m) or at particularly exposed sites that incorporate curtain wall, strip windows, opening window sashes, sliding doors, bifolding doors and the like, the methods of test described in this Standard are applicable to prove performance of the system. Facade elements in these situations can be subjected to the same environmental factors such as a continuous facade on an office building—particularly wind-driven rain. The non-uniform nature of wind-driven rain has led to the adoption in this Standard of the cyclic pressure water test and the SIROWET method before it. Appropriate additional testing parameters, such as those described in Table 2.2 of AS 2047—1999, *Windows in buildings—Selection and installation* and AS 4420.3—1996, *Windows—Methods of test*, Method 3: *Operating force test* as well as the torsional rigidity of building elements as covered in Clause 13 of NZS 4211:1985 *Specification for performance of windows*, should also be considered for relevant elements.

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard

Testing of building facades

1 SCOPE

This Standard sets out a method for determining the performance of a representative building facade under simulated conditions of loading. This Standard may be applied to all types of facades including low- and high-rise, commercial, industrial and residential buildings. Tests include displacement of the facade or prototype, water penetration and structural integrity at ultimate limit state as well as optional tests, including BMU restraint, seismic loading and seal degradation. This test method is applicable to prototype testing in a test facility and on-site testing.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- | | |
|--------|---------------------------|
| 1170 | Structural design actions |
| 1170.4 | Part 4: Earthquake loads |

AS/NZS

- | | |
|--------|--|
| 1170 | Structural design actions |
| 1170.0 | Part 0: General principles |
| 1170.1 | Part 1: Permanent, imposed and other actions |
| 1170.2 | Part 2: Wind actions |

NZS

- | | |
|--------|--|
| 1170 | Structural design actions |
| 1170.5 | Part 5: Earthquake actions—New Zealand |
| 4211 | Specification for performance of windows |

ISO/IEC

- | | |
|-------|---|
| 17025 | General requirements for the competence of testing and calibration laboratories |
|-------|---|

3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

3.1 BMU

Building maintenance unit.

3.2 Framing members

The elements, such as mullions and transoms that support facade panels.

3.3 Specifier

The person or party responsible for the facade Specification, nominating the use of this Standard, the test sample, sequence, pressures and performance criteria.

3.4 Test facility

Either a laboratory or any other facility registered by an accredited-testing agency in accordance with ISO/IEC 17025.

3.5 Uncontrolled water

Any leakage that is not contained and drained away during the water spray operation and for 5 min after the water spray has stopped during which time there is zero air pressure differential on the facade.

4 NOTATION

The following symbols are used in this Standard:

- D_e = average of net end displacements, in millimetres
- D_m = maximum displacement of member (generally at midspan), in millimetres
- d_s = seismic test displacement amplitude at the serviceability limit state, in millimetres
- d_u = seismic test displacement amplitude at the ultimate limit state, in millimetres
- K_d = deflection amplification factor, in millimetres
- M = overturning moment, in kilonewton metres
- n = number of cycles in the seismic test
- R_f = structural response factor
- S = span of member between points of support (transducers), in millimetres
- T = period of the seismic cycle, in seconds
- W_s = positive serviceability test pressure, in millimetres

5 PRINCIPLE

A sample of the building facade forms one face of an externally mounted chamber and is sealed at its perimeter and then successively subjected to a structural test, a water penetration test and a strength test.

NOTES:

- 1 Additional tests requested by the Specifier may include an air infiltration test, seismic loading by in-plane displacements, a simulated seal degradation test and a BMU restraint load test.
- 2 For information on sample preparation, see Appendix B.

6 APPARATUS

The following apparatus is required:

- (a) An externally mounted chamber of a size to fit to the test sample of the building facade. The fit shall be such as to seal the perimeter of the test sample against air and water penetration.
NOTE: The use of an internally mounted pressure box is suitable for all static pressure tests but may not adequately demonstrate water penetration in pressure-equalized systems in the cyclic pressure test.
- (b) A reversible air pump with controls to pressurize and depressurize the chamber.
- (c) Water sprays positioned so that when the sprays are in operation, the external face of the test sample is covered with water.
- (d) Displacement transducers capable of measuring deflections to an accuracy of ± 0.2 mm.
- (e) An orifice plate or laminar flow elements or other airflow measuring device calibrated to a traceable standard.

- (f) A manometer capable of measuring air pressure to an accuracy of $\pm 2\%$ of measuring range. The manometer used during the cyclic water test shall have a fast response time of at least 0.05 s.

7 SAMPLE PREPARATION

7.1 Test sample

The sample, with components, shall be representative both in size and shape of the facade of the building. Vertical and horizontal movement joints shall be included in the test sample. The joints shall be set on the sample within the design joint width including tolerances.

The materials of the test sample (glass, aluminium, stone, reinforced concrete, sealants, gaskets, etc.) shall be of the same type and size, have undergone the same method of construction, and have the same details, flashing and anchorage as the building facade.

If not an actual on-site representative sample of the wall of the building, the test sample shall be mounted and sealed into a simulated building frame in the same manner and by the same fixings that are intended to attach the facade to the building structure. The support frame shall be of similar stiffness to the supporting building structure.

NOTE: For discussion of the supporting structure, refer to Appendix B.

Simulated floor slabs and spandrel beams shall be to actual depth if, for example, in curtain walls, the air seal is connected to the slab. The internal finishes and linings shall be installed where they contribute to the air seal. The air seal of the test sample shall be continued to the air seal of the test chamber.

All framing members and other interconnected joints in the facade shall be sealed at the sample boundaries.

NOTE: This is to minimize the effects that the surrounding construction will have on the test performance of the sample.

All pressure equalization and drainage openings in the test sample shall be left open for the duration of testing.

NOTE: Transparent viewing panels (or other means of observation, such as an optical fibre probe) should be provided so that the performance of the test sample in areas that are not readily seen can be observed. They should be sized and sited to have a negligible minimal effect on the water and structural performance of the test sample.

7.2 Drawings

Shop drawings shall be supplied to the test facility before installation of the test sample. These drawings shall include the following:

- (a) Test sample elevation and vertical and horizontal sections.
- (b) Typical details of framing members and facade panels (including intersections of members).
- (c) All fixing brackets and support details.
- (d) Extent and type of sealants.
- (e) Size, position and number of pressure equalization and drainage openings.
- (f) Complete building in and blanking off details around the perimeter of the sample, including the chamber details where significant to sample performance.
- (g) Location of transparent viewing panels if used.
- (h) Method of installation.
- (i) Location of displacement transducers.

8 PROCEDURE

8.1 Test sequence

8.1.1 General

The sample shall be subjected to the tests in Items (a), (b), (d) and (g). The other tests shall be carried out only if specified. The test sequence shall be as follows:

- (a) Preliminary tests.
- (b) Structural test at serviceability limit state.
- (c) Air infiltration test.
- (d) Water penetration test by static pressure followed by cyclic pressure test.
- (e) Seismic test at serviceability limit state displacement (includes subsequent water penetration test).
- (f) BMU restraint test.
- (g) Strength test at ultimate limit state.
- (h) Seismic test at ultimate limit state displacement.
- (i) Seal degradation test.

8.1.2 Variation of test sequence or retesting

Where a variation of the test sequence is required, or if the test sample requires modification to gaskets, joint seals or drainage details to enable it to pass either the air infiltration or the water penetration test, both tests shall be repeated in full. Before retesting, the full positive and negative structural-test pressures (W_s) shall be applied to the test sample for 2 min each.

8.2 Preliminary tests

8.2.1 General

The tests in Clauses 8.2.2 and 8.2.3 shall be conducted before the structural test. Before prototype testing the information required in Appendix A shall be submitted by the Specifier.

8.2.2 Static pressure

The test sample shall be subjected to the positive and negative SLS design wind pressures. These pressures shall be maintained for 10 s at the positive requirement followed by 10 s at the negative requirement.

8.2.3 Water

Preliminary water tests shall be conducted under static and cyclic pressures in accordance with Clauses 8.5 and 8.6.

8.3 Structural test at serviceability limit state

8.3.1 Structural-test pressures

The structural-test pressures (W_s) are the positive and negative SLS design wind pressures. They shall be calculated in accordance with AS/NZS 1170.0 and AS/NZS 1170.2 and include all local pressure factors and internal pressures relevant to the location of the sample on the building.

The minimum serviceability requirements shall be for an annual probability of exceedance of 1/20 (0.05).

NOTE: Information on structural and strength test at ultimate limit state loading is given in Appendix C.

8.3.2 Location of the displacement transducers

The framework to support the displacement transducers shall be rigidly fixed independent of the test sample.

NOTE: The building frame (actual or simulated) is not part of the test sample.

Displacement readings shall be taken on the test sample at designated framing members, facade panels and window locations that would represent actual structural movement. Displacements shall be taken, at least, at the ends of the framing member or between fixings and at midspan, and also below and above (or to the left or right of) movement joints of framing members and across the shortest span of the largest panel or glass pane included in the test sample.

NOTE: Where members of facade framing systems are not simply supported over a single span, the points of maximum deflection are unlikely to fall midway between the support brackets connecting the facade to the building. In these cases the points of maximum deflection should be identified by structural analysis and displacement readings taken at these points.

Sufficient displacement transducers shall be located at the fixing brackets so that any differential movement between the various components and the support structure will be identified.

The location of all displacement transducers shall be nominated or approved by the Specifier.

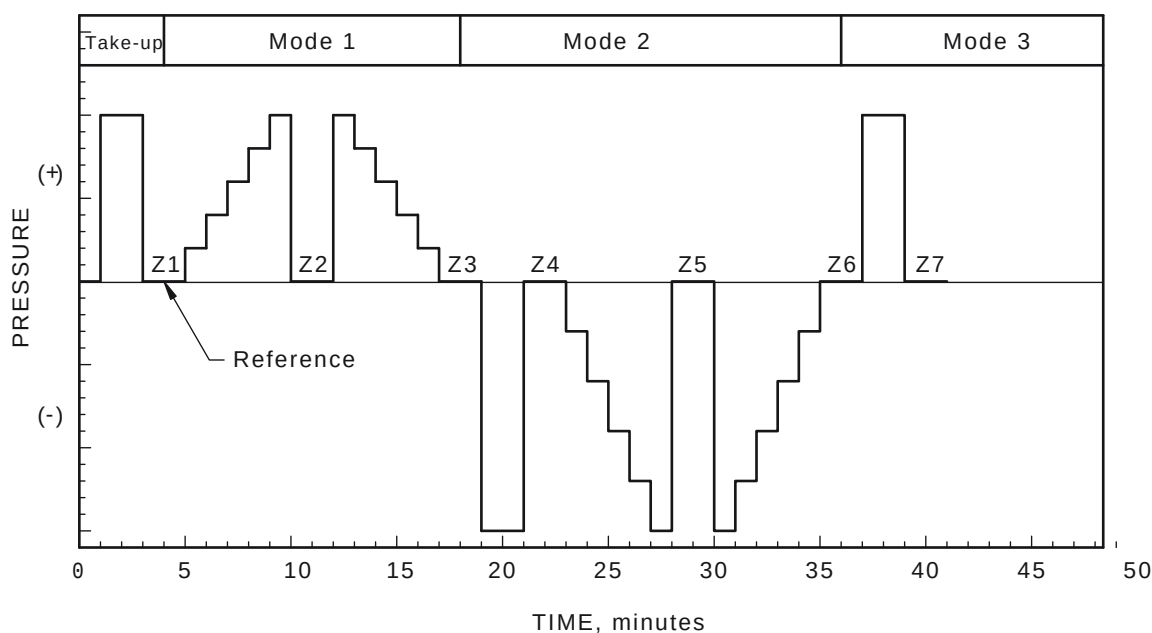
8.3.3 Pressure loading sequence

Displacements shall be measured at all pressure (positive) and suction (negative) sequence steps by calibrated displacement transducers.

The loading sequence during test (as shown in Figure 1) consists of three modes and shall be as follows:

- (a) An initial pressure differential equivalent to either the positive or the negative structural-test pressure shall be applied against the external face of the test sample for a period of 2 min which shall be taken as a settling/take-up period.
- (b) The differential pressure shall be removed and the zero position of the transducers recorded after 2 min of zero pressure (see Figure 1, zero stage Z1).
- (c) Differential pressures in the same direction as in Item (a) shall then be applied to the external face of the test sample in not less than five approximately equal steps, until the pressure reaches the structural test loading. The pressure shall be held at each step for at least 1 min before the displacements are recorded.
- (d) The differential pressure shall be removed and the zero position of transducers recorded after 2 min of zero pressure (see Figure 1, zero stage Z2).
- (e) The structural-test loading shall be applied again to the external face of the test sample and maintained for at least 1 min. The differential pressure shall then be reduced in the same number of steps as the increasing pressure regime ((see Item (c))). The pressure shall be held at each step for at least 1 min before the displacements are recorded. Also, the zero position of the transducers shall be recorded after 2 min of zero pressure (see Figure 1, zero stage Z3).
- (f) The procedure in Items (a) to (e), inclusive, shall be repeated using the opposite structural test design loading.
- (g) The procedure in Items (a) and (b) shall be repeated using the initial differential pressure.

NOTE: Items (b) to (e) are referred to as Mode 1, Item (f) as Mode 2 and Item (g) as Mode 3.



NOTE: The displacements used for deflection/span ratios are based on zero deflections at the reference stages Z1 and Z4. The reducing pressure steps from Z2 to Z3 and from Z5 to Z6 are optional.

FIGURE 1 TYPICAL STRUCTURAL TEST SEQUENCE

8.3.4 Displacement measurement of spandrel panels

If the facade specification requires displacement measurements of spandrel panels which form the exterior face of a spandrel box and the spandrel box is a pressure-equalizing design, a separate test is required.

Deflection measurements taken of the spandrel panels during the structural test sequence indicated above shall not be accepted as true readings of spandrel panel deflection, as the spandrel panels may not be under full test load, due to the extent of pressure equalization of the spandrel box chamber.

The spandrel panel measurement may be carried out immediately after the structural test sequence has been completed, or any other time before the strength test at ultimate limit state pressure.

Holes shall be installed in the prototype in a location agreed with the testing officer (usually in the back-pan), so that, when the test pressure is applied, the pressure difference will be across the spandrel panel. These holes may be installed before testing and covered for other tests.

Deflection transducers may be installed through the holes in the back-pan, to the internal surface of the spandrel panel or to the external surface of the spandrel panel.

The loading sequence of structural loadings shall be repeated as shown in Figure 1, taking deflection measurements of the spandrel panels. The test pressure for the spandrel panels may be reduced in accordance with the porosity provisions of AS/NZS 1170.2. During this test, pressure readings shall be taken both inboard and outboard of the spandrel panel(s) for which deflection measurements are being taken, to ensure that the pressure differential across the spandrel panel(s) is equal to the agreed spandrel test pressure.

When the spandrel deflection measurements have been taken and this test is complete, the holes shall be covered, so that the pressure difference in the spandrel box is applied across the back-pan and the prototype is effectively restored to the in-service condition. The hole covers shall be structurally continuous with the member to which they are attached and any sealant used in the covers is adequately cured before testing is resumed.

8.3.5 Calculation of deflection/span ratio

Where a framing member of the test sample is effectively supported at its ends only, its midspan deflection and resultant deflection/span ratio under load shall be calculated. The displacement for each transducer at the ends and midspan of the member and each mode (positive and negative) shall be reduced to a deflection and deflection/span ratio using the relationship—

$$\text{Deflection / span ratio is } 1 : \frac{S}{D_m - D_e}$$

where

S = span of member between points of support (transducers)

D_m = maximum displacement of member (generally at midspan)

D_e = average of net end displacements

The greater of the two deflections in positive and negative modes shall be used in the calculation of the deflection/span ratio for the members and panels. Significant variations in the ratios at the design pressure steps (that is either side of mid-mode steps) shall be noted in the final report.

Mode 1 deflection readings shall be referenced to Z1 and Mode 2 deflection readings shall be referenced to Z4.

NOTE: When stack joints are involved in the case of unitized curtain wall mullions, the maximum displacement may vary from the midspan between the support and the stack joint. In such instances it is recommended the transducer location for maximum displacement be checked with the aid of structural analysis software or design charts (see Figures C1 and C2).

8.3.6 Calculation of successive member displacement

The successive displacement of a member is the zero air pressure displacement (relative to the reading after initial take-up) measured during the structural performance test (refer to Figure 1)—

- (a) between maximum pressures in Mode 1 (stage Z2);
- (b) before take-up in Mode 2 (stage Z3);
- (c) after take-up in Mode 2 (stage Z4);
- (d) between maximum pressures in Mode 2 (stage Z5);
- (e) before take-up in Mode 3 (stage Z6); and
- (f) after take-up in Mode 3 (stage Z7).

8.3.7 Calculation of maximum displacement

The maximum displacement in Mode 1 shall be referenced to Z1 and maximum displacement in Mode 2 shall be referenced to Z4.

NOTE: Referencing of the mode of displacement to the Z4 zero values provides the equivalent member displacement as determined for Mode 1 while maintaining the successive member displacement values Z1 to Z7.

8.4 Air infiltration test

8.4.1 Test pressure

The air infiltration test pressure shall be as specified or taken as +150 Pa and –150 Pa.