Evaluation Method

BRANZ EM7 [version 3, June 2020]

Performance of mid-rise cladding systems

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BRANZ Evaluation Method EM7 (version 3)

Reference

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Abstract

This evaluation method (EM7) provides a means of assessing the weathertightness performance of generic domestic-oriented external wall cladding systems for use on buildings between 10 m and 25 m in height. It expects that a drained and ventilated cavity is used as part of the cladding construction. EM7 applies a series of tests from AS/NZS 4284:2008 *Testing of building facades*, with specific nominated values for the performance levels, and allows the addition of other tests from AS/NZS 4284:2008. The aim is to provide a flexible test with a consistent set of parameters for use in design, verification of NZBC clause E2 compliance and consenting of claddings for mid-rise buildings.

Keywords

Façade testing, mid-rise buildings, weathertightness, air infiltration, seismic racking.

Key parameters

- Building height of 25 m
- Serviceability limit state (SLS) design air pressure up to 2.25 kPa.
- Air leakage test 1 at 75 Pa stable air pressure difference with < 0.3 L/m².s air leakage.
- Seismic SLS lateral displacement of ±span/200 (minimum of ±15 mm) with 15 cycles, each at a period of 15 seconds.
- Air leakage test 2 at 75 Pa stable air pressure difference with < 0.6 L/m².s air leakage.
- Static water penetration test with water application rate of 0.05 L/m².s at 675 Pa air pressure difference for 15 minutes.
- Cyclic water penetration tests with water application rate of 0.05 L/m².s with 4 second cycles at air pressures from 338–675 Pa, 450–900 Pa and 675–1350 Pa for 5 minutes each.
- Cavity water management tests with 6 mm cladding holes (defects) with water and air pressure tests above repeated.
- Wetwall tests at 75 Pa air pressure difference with water application rate of 0.05 L/m².s for 15 minutes.

Note: This version of EM7 has been revised for usability, clarity and readability in line with comments received, particularly with respect to the following:

- EM7 being part of a compliance path for specific claddings on specific buildings.

- EM7 supporting consenting of details that may be new, altered from those tested or outside the scope of the test.
- To allow an EM7 test that fails due to water on a 'peel and stick' membrane to still be used by a façade engineer to support a consent application.
- Better alignment with the Auckland Council façade guidance document.
- Removal of some stringent conditions that made the test less usable.
- Inclusion of details more relevant to mid-rise construction.

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1. General

This evaluation method (EM7) provides a means of assessing the weathertightness performance of generic domestic-oriented external wall cladding systems for use on buildings between 10 m and 25 m in height. It expects that a drained and ventilated cavity is used as part of the cladding design.

EM7 applies a series of tests from AS/NZS 4284:2008 *Testing of building facades*, with specific nominated values for performance levels forming the performance verification. For flexibility, EM7 allows these values to be increased (but not reduced) to allow specific design criteria to be investigated while maintaining compliance with the test.

The aim is to provide a test with a consistent minimum set of parameters for use in weathertight design, verification of compliance with New Zealand Building Code (NZBC) clause E2 *External moisture* and consenting of claddings for specific mid-rise buildings. The parameters have been developed from research funded by the Building Research Levy and engagement with a variety of industry stakeholders.

For buildings less than 10 m in height, Verification Method E2/VM1 provides a simpler method of determining whether a cladding system complies with NZBC clause E2.3.2, although EM7 could also be used. Compared with E2/VM1, this procedure has the following differences:

- Greater emphasis on the air barrier, where the air barrier resists the air pressure and the exterior cladding sheds the water.
- A requirement for the cladding system to provide a specific amount of airtightness.
- Increased test pressures to reflect the change in height of the buildings and the greater significance of local and internal pressure factors on larger buildings.
- The use of seismic racking to verify performance following an earthquake (or other factors) causing building movement.
- Specimen details that are more representative of mid-rise construction.

1.1 Use

The tests in this evaluation method shall be undertaken in a test facility with IANZ or equivalent accreditation for testing to the procedures of AS/NZS 4284, including the seismic requirements.

This test is not applicable to a monolithic cladding that is completely sealed, and expects the incorporation of a drained and ventilated cavity.

It is intended for this evaluation method to provide higher levels of security for all stakeholders regarding the weathertightness performance of generic cladding systems used on mid-rise buildings.

As for AS/NZS 4284:2008, EM7 may also be used as part of a weathertightness compliance path for specific claddings on specific buildings.

1.1.1 Compliance

Further to demonstrating compliance with NZBC clause E2.3.2, other aspects of NZBC compliance may be identified during use of EM7 – for example, this can contribute to NZBC clause B1 *Structure* clause B1.3.2.

EM7 does not require the following mandatory parts of AS/NZS 4284:2008:

- Preliminary water tests at serviceability limit state (SLS).
- Structural test (and deflection measurement) at SLS.
- Structural test at ultimate limit state (ULS).

Test sections cannot be removed, and values of the parameters[1] in EM7 cannot be reduced. However, a specifier may request that the mandatory parts (or other tests from AS/NZS 4284:2008) be included in the EM7 test with the same or increased parameter values. In this case, the test becomes an "EM7 test, with additions (and extensions) from AS/NZS 4284:2008" where the additions and extensions must be clearly indicated.[2]

It is anticipated that this test (EM7) will assist façade engineers to verify compliance of the details tested as well as some new or altered details that are not included in the test, potentially using on-site weather testing as verification.

It must be noted that water on the air barrier during this test constitutes an EM7 test fail. However, if the air barrier is appropriately covered with a 'peel and stick' (or similar) membrane, a test failing for this reason could still be used as part of the E2 compliance path for the façade. Consideration must be given to avoiding trapping water within the cavity.

1.1.2 Window system compliance

This test (EM7) is not intended to replace NZS 4211:2008 *Specification for performance of windows* to verify the weathertightness of window systems but may be used to test the building-in details of windows within the cladding system.

However, it is proposed that NZS 4211:2008 be revised to include this test for windows used in mid-rise claddings with pressures beyond 2.25 kPa and seismic action.

[1] For example, pressures, times, deflections, air leakages, water flow rates, cycles (water or seismic).
[2] Note that, if a specifier does increase test parameter values, there is a risk that a failure at an early part of the test may prevent the base EM7 requirements from being completed.

2. Scope

The scope of EM7 is restricted[3] to claddings on buildings that:

- have a height measured from the lowest ground level adjacent to the building to the highest point of the roof (except for chimneys, aerials and the like) of 25 m or less
- have cladding systems exposed to a specific peak positive SLS air pressure of up to 2.25 kPa (ULS 3.2 kPa)
- have claddings that include a drained and ventilated cavity of 20 mm nominal depth with an inter-storey horizontal drainage joint every 2 floors (or within 7.0 vertical metres), including minimum ventilation openings of 1000 mm^2/m
- include window and door units that are manufactured to comply with the relevant pressures and inter-storey deflections
- have inter-storey deflections designed for ±height/200 horizontal in-plane lateral movement during seismic SLS events (±15 mm for a 3 m inter-storey height)[4]
- have cladding supported on lightweight framing (expected to be timber or light steel framing) with studs at centres no greater than 600 mm that are connected to the floor at each level of the building, possibly including a movement joint
- have an air barrier system including rigid building underlay affixed to the framing, which may include a 'peel and stick' membrane.

Comment

AS/NZS 1170.2:2011 *Structural design actions – Part 2: Wind actions* could be used to calculate the increase in SLS pressure above and beyond the 1515 Pa associated with E2/VM1. Table 4.1 in that standard can be used to calculate a worst-case increase in wind speed of 17%. This corresponds to an increase in pressure of 37%, which would give an SLS of 2.075 kPa and a ULS of 2.9 kPa. This does not represent much increase over the 2.5 kPa ULS limit stated in E2/VM1. Instead, the approach taken has been to approximately increase the pressures associated with E2/VM1 by 50%. This scope will allow the inclusion of buildings on which the effects of local pressure factors and internal pressures are more significant than expected by E2/VM1.

[3] Note that the scope may be increased (but not decreased) as in clause 1.1.1.
[4] For specific applications, any greater requirements of AS/NZS 1170.2:2011 may be used here.

3. Specimen details

The minimum size of the wall cladding specimen to be tested shall be 3.0 m high by 3.0 m wide including a fixed window of 1800 mm high x 800 mm wide. The air barrier shall include removable inspection ports but otherwise will be installed as per the manufacturer's details. The removable ports allow inspection of the wall cavity with cameras and other recording devices and permit the wetwall test to be performed more easily. BRANZ research shows that circular inspection ports will not significantly alter the general behaviour of the air barrier in the air, water or seismic test if sized and located as specified. The construction of the specimen shall also permit small holes to be formed in the air barrier during testing to undertake the second airtightness test.

3.1 Included details

The wall cladding details that shall be included, as a minimum, for any test specimen using EM7 are:

- typical vertical joint(s)
- typical (vertical) external corner
- typical (vertical) internal corner
- cladding detail at the bottom of the cladding (footer)
- cladding detail at the top of the cladding (soffit)
- cladding detail at floor level balcony penetration or cladding penetration for balcony support structure
- typical inter-storey/tenancy horizontal drainage joint
- typical horizontal control joint (if different from inter-storey joint)
- typical vertical control joint
- typical window head detail
- typical window sill detail
- typical window jamb detail
- typical round plumbing or service pipe penetration of between 10 and 22 mm external diameter
- typical round ventilation pipe of between 140 and 240 mm external diameter
- vertical cladding termination.

Test specimens must include all cladding details or junctions for which compliance with this evaluation method is intended to be demonstrated. All details must be drawn up 'as tested' and included in the test report. Additional details may be included, provided they are documented as beyond minimum EM7 requirements.

3.2 Inspection ports

To enable inspection of the drainage cavity during testing and to facilitate the wetwall test, inspection ports shall be installed through the rigid air barrier.[5]

The ports shall be approximately 150 mm diameter round screw-in marine access hatches. These are to be installed into the specimen using screws, with silicone sealant used to provide an air seal. The cut-out hole will be approximately 165 mm, and the distance from the edge of this hole to the edge of the sheet shall be no less than

[5] Access for photographs (and other recording devices) needs to be considered at this point.

115 mm. To reduce the spattering of water at the foot of the cladding, these port holes shall be no closer than 400 mm to the base of the cladding.

Sufficient ports shall be installed to ensure that, when open, most of the air pressure is held across the wetwall, which may require up to 20 ports in a 3 x 3 m specimen.

3.3 Pressure measurement

As well as measuring the booth pressure, a pressure tap shall be available in each significant cavity compartment to enable the average pressure difference across the wetwall (and air barrier) to be measured.[6]

[6] A single pressure tap could be moved around the cavity under constant conditions to achieve this, or multiple tappings could be read with a single transducer to provide an average pressure.

4. Test procedure

EM7 comprises the following test methodologies (and extensions) from AS/NZS 4284:2008, where requirements for uncertainties are provided in AS/NZS 4284:2008:

1. Preliminary test at differential SLS pressure of +2.25 kPa and then -2.25 kPa.[7]
2. Air infiltration test 1 at -75 Pa and then +75 Pa above (below) atmospheric pressure.
3. Lateral building seismic movement test at SLS displacement of ±span[8]/200 (i.e. ±15 mm for a height of 3.0 m).
4. Air infiltration test 2 at +75 Pa and then -75 Pa above (below) atmospheric pressure, followed by air leak standardisation.
5. Water penetration test – static pressure test at 675 Pa above atmospheric pressure and three-stage cyclic test at 338–675 Pa, 450–900 Pa and 675–1350 Pa with water applied at 0.05 L/m².s.
6. Water management tests with simulated gaps in the wetwall (static and cyclic).
7. Wetwall test – seal degradation at static pressure of 75 Pa across the wetwall.

It is possible that some modifications to the specimen will be required to reach the acceptance criteria. These modifications must be documented in the test report,[9] noting the restrictions in AS/NZS 4284:2008 clause 8.1.2 where the air and water tests must be repeated if changes are made that affect these factors. If there are water-sensitive materials or elements used in the system that are wetted by the water tests, these must be dried adequately before retesting.

These modifications should then be incorporated into the product literature, consent documents and/or cladding design so that construction on site matches the specimen as modified.[10]

If changes to the specimen are still necessary after modifications to four different areas, the test cannot claim a pass to EM7 but may be used as a development test "to the method of AS/NZS 4284:2008". It can be retested (or a new specimen tested) after appropriate design changes have been made.

4.1 Preliminary test at SLS pressure

Apply a preconditioning pressure to the external face of the test specimen for a period of at least 1 minute of positive pressure followed by a period of at least 1 minute of negative pressure (suction). The pressures shall be +2.25 kPa and -2.25 kPa (±2%) and are applied to ensure the air barrier will hold this pressure and confirm the system is unlikely to physically endanger the health and safety of test operators.

4.2 Air infiltration test 1

Unlike AS/NZS 4284:2008, it is necessary in this method to determine the air leakage through the specimen itself, not just the total leakage through the test specimen and test enclosure. Measurements of air leakage are performed in both directions

[7] The preliminary water tests (and SLS deflection tests) are not a mandatory part of the EM7 test process. However, they can be included in EM7 as noted previously.
[8] Where the span is typically the height of the specimen between floor slabs/connections.
[9] A full set of as-built drawings shall be used to document the test specimen.
[10] A façade engineer may be engaged to verify any differences.

(exfiltration and infiltration) at a pressure difference magnitude of 75 Pa (±2 Pa). These pressure have been chosen to align with the air infiltration/exfiltration with the ASTM E1677-11 value for an undamaged air barrier and the AAMA 508-14 interpretation of a damaged air barrier after the seismic racking test.

4.2.1 Method

Seal the face of the specimen in the manner described in AS/NZS 4284:2008 clause 8.4.2 paragraph 2. Record the volumetric air flow rate at -75 Pa and +75 Pa (±2 Pa) air pressure difference. The results provide a measure of the airtightness of the test enclosure. If two separated samples are being tested in the same specimen, each sample must be sealed independently to obtain the appropriate measurements.

Unseal the specimen and then repeat the above measurements. The results provide a measurement of the combined airtightness of the total specimen and enclosure.

Subtract the enclosure air leakage results from the total leakage to determine the specimen air leakage.

It is required that unintentional air leakage through the specimen perimeter and enclosure in the air leakage measurement be minimised and the leakage be quoted with its expanded uncertainty. If the enclosure leakage is more than 20% different from the typical enclosure leakage in previous tests and the reason for the difference cannot be identified, the test must be repeated.

4.2.2 Criteria

The specimen air leakage at an air pressure difference magnitude of 75 Pa must not exceed 0.3 L/s.m² (in either direction), including the measurement uncertainty.[11]

4.2.3 Testing leakage at other pressures

If desired for comparison purposes, airtightness tests at other pressures (for example, ±150 Pa) may also be performed after the tests at ±75 Pa and noted in the report.

4.3 Seismic test at SLS displacement

The purpose of the seismic test is to verify the test specimen can accommodate a reasonable amount of inter-storey drift or racking while remaining serviceable. In AS/NZS 4284:2008, a water penetration test is subsequently used to assess the severity of any damage. In this method, an air infiltration test is used as a metric of damage and performed prior to the water penetration test so that the specimen airtightness is not altered due to the presence of water in any materials.

4.3.1 Method

Using the procedure in AS/NZS 4284:2008 clause 8.9, perform 15 cycles of inter-storey movement of span/200 (±10%) in each direction, with a period of 15 ±5 seconds per cycle.

Inspect and report the condition of the specimen after the completion of the cycles.

[11] This means that a reading of less than 0.28 L/s.m² must be achieved for the complete area of the specimen at the relevant orientation of pressure difference across the specimen.

The deflection shall be measured on a significant piece of structure such as a floor slab/or ribbon plate/joist in the plane of the air barrier and not the cladding, ram or reaction frame. The measurement point shall be as close as practicable to the attachment of the ram to the structure.[12]

Comment

The seismic deflection specified in this test is based on what is typically used in a AS/NZS 4284:2008 test. There has not been sufficient research into the effect of different loading periods, so these are not specified. It is assumed that the deflection will be generated by some kind of hydraulic actuator.

Note that the water penetration tests from AS/NZS 4284:2008 are not undertaken at this stage.

4.4 Air infiltration test 2

4.4.1 Method

See 4.2.1.

4.4.2 Criteria

The magnitude of the specimen air leakage at a pressure difference of 75 Pa must not exceed 0.6 L/s.m² including the measurement uncertainty.[13] This is double the air leakage measured in air infiltration test 1. It is required that unintentional leakage through the specimen perimeter and enclosure in the air leakage measurement be minimised and the air leakage be quoted with its expanded uncertainty.

If the magnitude of the air leakage plus measurement uncertainty exceeds 0.6 L/s.m^2, the specimen fails the test.

4.4.3 Airtightness standardisation

Following the completion of air infiltration test 2, bring the specimen air leakage up to 0.60 ±0.04 L/s.m^2 at +75 (±2) Pa[14] by drilling holes in the air barrier of 3–6 mm diameter such that they are evenly distributed across the test specimen. (Note: The airtightness at 75 Pa below atmospheric pressure may be different.) This is to ensure EM7 specimens have a standardised airtightness prior to water penetration testing and that this airtightness corresponds to a non-perfect air barrier.

Comment

Dozens of 3 mm diameter holes have been used, but fewer holes of up to 6mm diameter may be used where a thick or tortuous air barrier makes large numbers of 3 mm holes impracticable. It is typically necessary to form the holes while the test is in progress to achieve the correct airtightness level.

[12] This is to ensure that the structure is racked by the correct amount, with any movement in the cladding being dependent upon the transfer of movement through the fixings of the cladding to the structure. It is useful if the connections used to install the specimen mirror the connections intended to be used in the proposed construction.
[13] This means an air leakage of less than 0.56 (or greater than -0.56) L/s.m².
[14] Where positive pressure refers to the pressure in the booth being higher than atmospheric pressure outside the booth, with the exterior face of the cladding inside the booth.

4.5 Water penetration tests – static and cyclic

Undertake water penetration tests in accordance with AS/NZS 4284:2008 clauses 8.5 and 8.6.

4.5.1 Static pressure water penetration test

The water penetration test by static pressure shall be conducted in accordance with AS/NZS 4284:2008 clause 8.5 at a test pressure of 675 ±15 Pa.

4.5.2 Cyclic pressure water penetration test

The water penetration test by cyclic pressure shall be conducted in accordance with AS/NZS 4284:2008 clause 8.6 using the default multipliers of the positive serviceability pressure of 2.25 kPa. The three stages of the test involve pressures varying from 338–675 Pa, 450–900 Pa and 675–1350 Pa above atmospheric pressure.

This test shall commence within 30 minutes of the completion of the static pressure water test, otherwise the specimen shall be re-wet for a minimum of 5 minutes at the standard water application rate.

4.5.3 Criteria

Water that can penetrate to the back of the wetwall through introduced defects and joints shall be controlled. Water may contact battens and other cavity surfaces, but no water shall be transferred to the plane of the air barrier (irrespective of its water-handling ability), cavity air sealing or structural framing due to a design or systemic failure. Water that may arrive on the rigid underlay due to an isolated blemish may be disregarded. No water may drip through an air space within the cavity where it is possible for water to impact on a surface in the cavity and splash onto the unprotected air barrier. However, any spattering of water across the cavity through the introduced defects shall be ignored. During the wetwall test, water can spatter up from the footer flashing, provided it is not held above any cavity obstruction where it may cause damage or deterioration.

The inspection ports in the air barrier shall be opened to assess most of the construction. In addition, within 30 minutes of the completion of the water penetration tests, the air seal from around the windows shall be removed and also inspected for non-compliance.

4.6 Water management tests– static and cyclic

The procedures in section 4.5 shall be repeated following the closure of the 150 mm inspection ports and the introduction of 6 mm diameter holes through the wetwall as permitted by AS/NZS 4284:2008 clause 9.9.

The intent is to confirm the cavity can manage leakage water by simulating potential leaks where sealant could get missed, cladding cover could be low or overlapping joints may have openings.

These water leakage holes shall be formed in the following places:

- Through the window/wall joint at three-quarter height of both jambs of the window(s).
- Immediately above the window head flashing(s).

- Through the external sealing of the horizontal and vertical joints – for example, at their ends.
- Through the external and internal corners.
- Through the pipe and duct penetration external seals.
- Above any other wetwall penetration details.

The introduction of defects must only penetrate to the plane of the back of the wetwall so the water management of the cavity can be assessed.

4.6.1 Criteria

See 4.5.3.

4.7 Wetwall test – seal degradation

4.7.1 Method

Remove the air seal from around the window(s) and open enough of the inspection ports (evenly spaced) across the air barrier to obtain an air pressure of 75 Pa across the wetwall. The air pressure across the air barrier shall be less than 75 Pa.[15] Perform the static pressure water penetration test (see 4.5.1) with an air pressure of 75 ±2 Pa across the wetwall for at least 15 minutes.

4.7.2 Criteria

See 4.5.3.

[15] If the air pressure across the air barrier is not less than 75 Pa, this may be achieved by opening more ports in the air barrier. It is the difference between the average pressure in the test booth and the average pressure in the cavity that must create the pressure drop of 75 ±2 Pa across the wetwall. Likewise, it is the difference between the average pressure in the cavity and the average pressure on the inside of the air barrier that creates the pressure drop of 75 Pa across the air barrier.

5. Reporting

The test report shall contain the following:

- Test date(s) and report number.
- Confirmation that this is an EM7 test, including a statement of whether additional tests from AS/NZS 4284:2008 have been included, the test order and test parameters
- Testing agency, contact details and IANZ accreditation number (for the AS/NZS 4284:2008 test procedures).
- Identification of IANZ-accredited test officer and other persons attending the test.
- Name of client and specifier.
- Name of specimen designer/manufacturer and installer.
- Detailed specimen description, including as-built shop drawings, with 1:2 scale details at junctions, fully dimensioned with all materials identified.
- Any changes made during testing. All materials must be uniquely identified and not described generically.
- Results of each test and relevant observations on the behaviour or performance of the test specimens with a summary of each test result as compliant or non-compliant. This shall include the pressure drop across the air barrier during the wetwall test.
- Photographs of the system under test.
- A summary statement of overall compliance or non-compliance.
- Any other relevant requirements from the AS/NZS 4284:2008 test method.

6. Referenced documents

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