Technical Note 4

(Draft Industry Standard)

Simulated Windborne Debris Impact Testing of Building Envelope Components

(Version 5 – Published 22 November 2023)

INTRODUCTION

AS/NZS 1170.2 Cl 2.5.8 gives mass and velocity of two classes of representative wind-borne debris; a timber member and spherical steel ball. It does not specify a test method, requirements for specimens or acceptance criteria.

A testing standard to implement the AS/NZS 1170.2 loadings for wind-borne debris is required. Acceptance criteria are associated with consequences for the building occupants or ramification for the safe design of the building. Using this draft standard, different building materials can be compared directly (providing a 'level playing field').

Version 4 of CTS Technical Note 4 (published 10/01/2017) has been rewritten as this draft Industry Standard that specifies test methods and acceptance criteria for evaluating debris impact resistance of building envelope components to debris loads specified in AS/NZS1170.2.

Principles:

- performance-based
- independent of the materials used in the specimen
- equipment used to project the debris – not specified, but velocity and mass must be measured within limits
- acceptance criteria to be stated objectively in terms of measurements taken during the test.

1. SCOPE

This Industry Standard sets out the requirements for evaluating the performance of building envelope elements, including protective screens, under debris loads specified in AS/NZS 1170.2. The Industry Standard details two tests:

- Test A using a timber debris item (debris item A, refer 4.2.1); and
- Test B using a spherical steel ball (debris item B, refer 4.2.2).

2. APPLICATION

This Industry Standard shall be read in conjunction with AS/NZS 1170.2 and is primarily intended for use by test facilities and manufacturers of building products. Debris testing is independent of any pressure testing of the specimen.

Test A is required for all debris impact tests. Test B is only required for panel elements behind screens with openings or perforations with a minimum dimension greater than 8 mm.

3. NORMATIVE REFERENCES

The normative reference used in this Industry Standard is AS/NZS 1170.2 Structural design actions, Part 2: Wind actions.

4. DEFINITIONS

Component

A single element that can exist alone or be combined with other elements to form a system. For example, plywood is a component that can be installed across openings as a temporary screen, or incorporated into a system such as a hinged shutter or a debris resistant wall system. Other examples of components include screen material or roof sheeting.

Debris item

A representative piece of wind-borne debris as described in AS/NZS 1170.2 Cl 2.5.8.

Debris Item A

A timber member of 4 kg mass, with a density of at least 600 kg/m^3, with a nominal cross-section of 100 mm x 50 mm.

Debris item B

A spherical steel ball, 8 mm in diameter (approximately 2 g mass).

Deformation/deflection

A change in shape or form; or movement from its original position.

Displacement

> ***Instantaneous displacement***
>
> The maximum displacement achieved at any stage in a debris impact test.
>
> Note: It is only a requirement to measure instantaneous displacement during tests on protective screens.
>
> ***Residual displacement***
>
> The maximum displacement of any part of the test specimen, measured after the test is finished.
>
> Note: It is only a requirement to measure residual displacement during tests on protective screens.

Hinge
A moveable mechanism that joins moving panel elements to a fixed frame and allows part of the system to swing open and closed.

Laboratory support frame
The frame on which the test component or test system is mounted.

Latch
A mechanism that attaches between moving panel elements and a fixed frame that can keep the moving elements closed or allow them to be opened.

Opening
An open part, hole, gap or aperture created by the impact of the debris item, either directly by the debris item or by tearing away from the frame; measured in the original plane of the test specimen.

Panel
A planar element within a system.

Penetration
The movement of the full cross-section of the debris item past the back of the test specimen. (i.e., beyond the face of the test specimen that is furthest from the wind-borne debris simulator).

Supporting element
An element in a test specimen that holds a component in place and carries load to the supports of the system.

System or assembly
A related set of components that work together; a group of interacting components that are marketed as a single product. Systems include any immediate supporting structures. Examples include:

- windows may consist of a frame, pane of glass mounted in a sash, and seals.
- a window protection screen may consist of a fixed frame, supporting elements that keep it a fixed distance from the window and attach to the wall, latches, hinges and a movable frame that incorporates some screen material.
- Wall panels may consist of cladding, fasteners and frame.

Test program
A series of impact tests to demonstrate impact resistance of a component or system.

Test specimen
A component, system or assembly on which a series of debris impact tests are performed.

5. TEST SPECIMEN

5.1. Representative specimens

The test specimen shall be manufactured to be representative of normal production. The specimen support conditions shall simulate conditions used in practice.

5.2. Component specimens

Where a component is tested, the fixing shall be specified and be representative of how it is fixed in service.
Note: The test report should only be quoted where the component is fixed as described in the test report.

5.3. System specimens

Where a system is tested, all components of the system shall be provided and assembled as specified for the marketed product.

Note: The test report should only be quoted where the system is fixed as described in the test report.

5.4. Size of specimen

Where a product is manufactured in a range of sizes, at least the following specimens shall be tested:

- The smallest size in the range;
- A representative large size from the range.

Note: The size of the laboratory support frame may limit the largest size that can be tested.

6. TEST EQUIPMENT

6.1. Wind-borne debris simulator

6.1.1. Performance requirements

The wind-borne debris simulator shall project the debris item so that it strikes the test specimen (within the relevant tolerances specified in this Industry Standard) at:

- the target velocity (see Clause 7.1).
- normal to the plane of the test specimen (additional tests at other angles may be conducted if required)
- the required test locations (see Clauses 7.2 or 7.3).

The test equipment shall measure:

- the speed of the debris item just before it hits the test specimen. (See Clause 6.1.2)
- the response of the test specimen shall be measured. (See Clause 7.5)

The equipment shall be calibrated to the requirements specified in Clause 6.4.

Different wind-borne debris simulators may be used for debris item A and debris tiem B.

Note: For example, a suitable wind-borne debris simulator could consist of:

(i) an air tank that is pressurised by an air compressor
(ii) a solenoid valve to instantaneously release the air from the tank
(iii) a barrel that allows the debris item to accelerate to the required velocity
(iv) a digital velocity meter at the exit of the barrel that measures the velocity of the debris item before they impact the target.

6.1.2. Velocity meter

A velocity meter shall measure the velocity of the debris item as close as possible to the test specimen and no greater than 1.5 m from the plane of the test specimen. The impact speed of the debris item must be measured to an accuracy of +/– 0.5 m/s.

The calibration method for the velocity measurement shall be in accordance with Clause 6.4.

6.2. Laboratory support frame

6.2.1. General

The test specimen shall be supported by a rigid laboratory support frame. The support frame shall be free from damage at the commencement and conclusion of each test program for the test program to be valid. The calibration requirements in Clause 6.4.1 shall be repeated if the support frame is repaired or changed.

6.2.2. Test specimen support

The connection of the test specimen to the support frame shall replicate the intended method of support of the specimen in service.

6.2.3. Rigidity of laboratory support frame

The rigidity of the support frame shall be checked during the calibration test described in Clause 6.4.1.

The method of assessing the rigidity of the support frame shall be:

a) Mount the test specimen described in Clause 6.4.1 directly on the support frame so it is supported on at least two opposite sides.
b) Mount a plate on a stand fixed directly to the laboratory floor and positioned behind the support frame at mid span of a vertical support frame member as shown in Figure 6.1. The stand shall be independent of the support frame and the plate shall be separated from the support frame by a distance of 0.0025 V^2 mm (with V = impact velocity in m/s). Refer to Figure 6.2.
c) Use an indicator to determine whether the plate makes contact with the frame during the test. Suitable indicators include wet paint, ink or plasticine.

The support frame shall be classified as rigid if the indicator shows that the support frame did not contact the plate during the test.

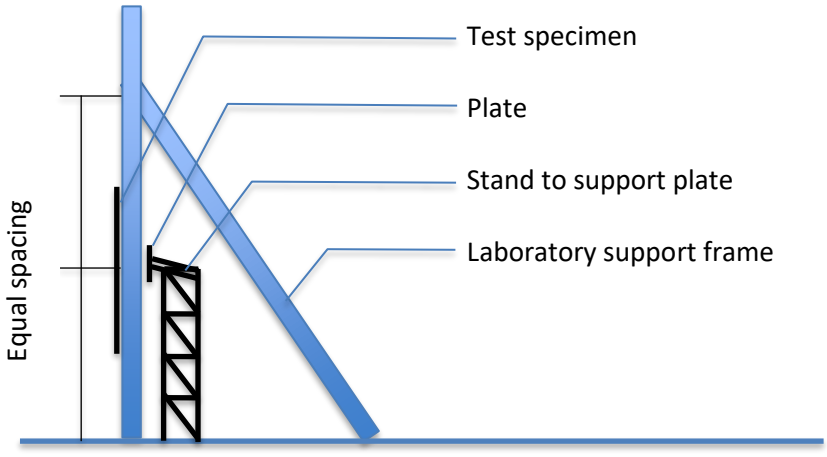

Figure 6.1 Configuration for the check for support frame displacement

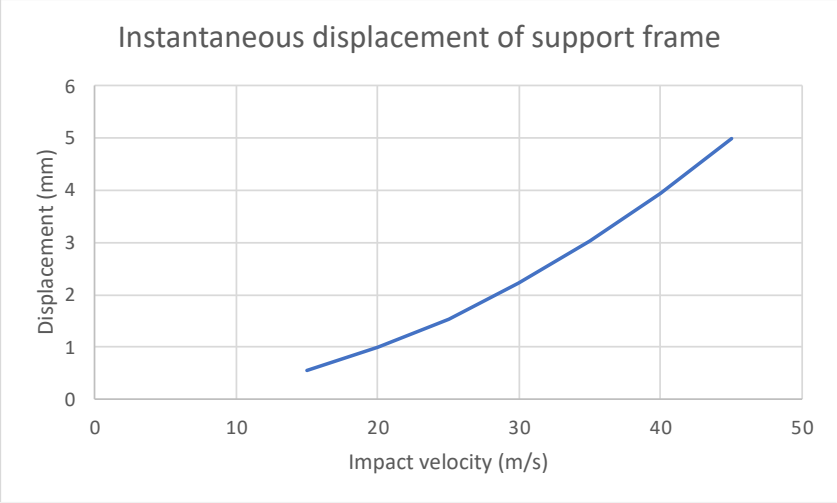

Figure 6.2 Relationship between displacement of the support frame and impact velocity

6.2.4. Measurement of test specimen displacement

For tests on protective screens, the instantaneous and residual displacement of the test specimen shall be measured relative to the support frame. The displacement of the test specimen at any stage of the test must be measured to an accuracy of +/– 2 mm.

6.3. Debris items

6.3.1. Debris item A

Debris item A shall comply with Clause 2.5.8(a) in AS/NZS 1170.2 and have:

- Total mass (including attachments for projecting debris item) of 4 kg (+0.12 kg, -0 kg)
- External nominal dimensions 100 x 50 mm (no larger than 100 x 50 mm and no smaller than 90 x 45 mm)

Note: Seasoned and dressed timber that is nominally 100 x 50 mm often has a cross-section of 90 x 45 mm.

- Density of timber (600 kg/m^3 to 1000 kg/m^3)
- Square cut end
- Radius of the arrises on the end that impacts the test specimen shall be no less than 2 mm anywhere, and no more than 4 mm, as illustrated in Figure 6.3.

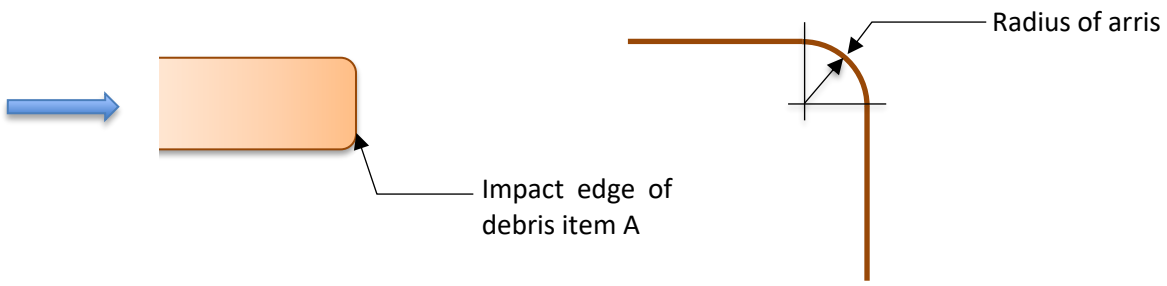

Figure 6.3 Arrises on the end of Debris item A

After each test, the debris item shall be examined for excessive wear or damage. If none of the end conditions below is observed, the debris item can be used for another test. The debris item shall be replaced if any of the following are observed:

- The radius of edge arises is greater than 4 mm
- Localised crushing to a depth > 2mm covers more than 30% of any edge
- Any segment larger than 10 mm is missing from any edge (including corners)
- Any cracking that connects two parallel edges
- Any indentation deeper than 5 mm that connects two parallel edges.

Notes:

1. It may be necessary to perform further tests using a new debris item if the debris item sustains substantial damage.
2. Refer to AS1720.2 for estimates of the density of timber species.
3. The mass of the timber item shall be checked regularly as moisture content may change and affect the mass of the item.
4. Dents in the end or on corners of the debris item are acceptable, provided high points on the arrises are within tolerances.

6.3.2. Debris item B – steel ball

Debris item B shall comply with Clause 2.5.8(b) in AS/NZS 1170.2 and have:

- Spherical shape (by visual inspection to exclude balls with sharp edges)
- Mass = 2 g (+/– 0.5 g)
- Average diameter 8 mm (+/– 0.2 mm)
- No visible cracking

6.4. Calibration of equipment

Each wind-borne debris simulator shall be calibrated at least six-monthly and whenever the wind-borne debris simulator or the support frame is modified.

6.4.1. Calibration using debris item A

A calibration test shall be conducted using a test specimen that will not be penetrated by the debris item and is anchored to the support frame on at least two opposite edges. The minimum calibration velocity shall be 28 m/sec and the debris item A used in the test must satisfy density and weight requirements (Clause 6.3.1), but the end condition assessment detailed in Clause 6.3.1 is not required.

The calibration test shall measure the debris item A velocity using the velocity meter (Clause 6.1.2) and an independent velocity measurement device traceable to NATA requirements. The support frame instantaneous deflection shall also be measured as described in Clause 6.2.3.

Calibration shall demonstrate:

a) The measured velocity from the velocity meter is within +/– 0.5 m/s of the velocity based on a calibrated reference velocity measurement traceable to NATA requirements.
b) The supporting frame instantaneous displacement in the direction of travel of the debris item is less than the requirements of Clause 6.2.3.
c) The measured position of impact is within +/– 50 mm of the target.

Notes:

1 Measurements for velocity and deflection may be taken on separate calibration tests.

2 Suitable methods for independent velocity measurement include high speed photographs (providing the frame speed can be shown to offer sufficient accuracy to capture the relevant information).

6.4.2. Calibration using debris item B

A calibration test shall be conducted by projecting the designated debris item B at any test specimen. The minimum calibration velocity shall be 28 m/sec and the debris item B used in the test must satisfy the requirements of Clause 6.3.2.

The calibration test shall measure the debris item B velocity using the velocity meter (Clause 6.1.2) and an independent velocity measurement device traceable to NATA requirements.

Calibration shall demonstrate:

a) The measured velocity from the velocity meter is within +/– 0.5 m/s of the velocity based on a calibrated reference velocity measurement traceable to NATA requirements.
b) The measured position of impact is within 100 mm of the target.

6.4.3. Calibration report

The results of the calibration shall be documented in a dated calibration report that includes:

(i) A summary of the configuration of the wind-borne debris simulator
(ii) Details of the debris items used – debris item A and/or debris item B
(iii) Velocities used in the calibration tests
(iv) Results of calibration

7. TESTS

The test method is applicable to tests with debris item A and debris item B. If both tests are required, tests using debris item A shall be performed first.

Debris item A shall be used on all specimens except glazing protected by an open screen with openings greater than 8 mm.

Debris item B shall be used on glazing protected by an open screen with openings greater than 8 mm. In these cases, Debris Item A is not used on the glass, but is used on the protective screen.

Tests shall be conducted on an undamaged portion of the specimen. A new test specimen can be used for each test location if required.

Debris items can be reused provided they remain within the tolerances specified in Clause 6.3.

The configuration of the wind-borne debris simulator shall be the same as for the calibration in Clause 6.4.

7.1. Test procedure

1. Fix the test specimen to the laboratory support frame in the same way as it will be installed in service.
2. Place the debris item into the wind-borne debris simulator.
3. Set the pressure at an appropriate value to project the debris test item at:
   - 0.4 V_R normal to vertical wall, door, screen, or window surfaces
   - 0.4 V_R x sine of the roof slope normal to roof surfaces for roof surfaces > 15° pitch
   - 0.1 V_R normal to the surface for horizontal surfaces and for roof surfaces < 15° pitch.

Notes:

1. Components tested in isolation shall be rigidly mounted to the laboratory supports. The results of a test on an isolated component cannot be used to represent the performance of the component within a system.
2. Normal means 90° +/-10° and relates to both horizontal and vertical angles with the face of the test specimen.

7.2. Position of impact for debris item A

For the following products and systems, a minimum of two impact tests shall be performed. The appropriate impact locations shall be chosen from those listed in this Clause and appropriate for the type of test specimen. For systems not listed below, the debris item shall be projected at locations that assess the potential failure modes by deformation or bending or punching through all layers. These locations shall be determined by testing all potential locations on one specimen of the type and identifying the critical ones for each failure mechanism for the remaining tests on the same type of specimen.

The tolerance on impact position is +/– 50 mm. “Adjacent to a feature” means within 150 mm of the feature. For example “Adjacent to a support” means within 150 mm of the support. “Adjacent to a corner” means within 150 mm of both supports that meet at the corner. The “centre” of a panel means where the diagonals across the panel intersect.

Note: While deflections may be greatest for impact in the centre of a panel, it is not acceptable to limit testing to one impact, or to only project, the debris item at the middle of the specimen. The worst penetration damage may occur when the debris item impacts the specimen close to its support. There is less opportunity for energy absorption with the specimen in this case, when compared to an impact in the centre of the specimen.

7.2.1. Wall or roof cladding on framing systems

Wall or roof cladding on framing is a system of cladding fixed to discrete framing members. Examples include wall cladding fixed to studs or girts, wall cladding fixed to battens on studs, and roofing fixed to battens or purlins.

The system shall be tested as a specimen consisting of a minimum of two sheets of horizontal cladding, fastenings and supporting members assembled as it will be in service as shown in Figure 7.1a; or a specimen consisting of a minimum of two sheets of vertical cladding, fastenings and supporting members assembled as it will be in service as shown in Figure 7.1b; or a specimen consisting of horizontal battens, a minimum of two sheets of vertical cladding, fastenings and supporting members assembled as it will be in service as shown in Figure 7.1c.

Impact tests shall be conducted at the following three locations shown in Figure 7.1:

(i) one test at either FS1 or FS2 (potential failure by deformation of the panel near the frame or punching through) AND

(ii) one test at either FS3 or FS4 (potential failure by deformation of the panel near the frame or punching through) AND

(iii) one test at FS5 (potential failure by bending of the panel or punching through.

For tests on horizontal cladding fixed to studs, the debris item shall be directed at the cladding from the outside as shown in Figure 7.1a, where:

- FS1 – adjacent to an end support midway between cladding edges
- FS2 – adjacent to an internal support midway between cladding edges
- FS3 – adjacent to the intersection of horizontal and vertical supports
- FS4 – adjacent to an end support with a lap or joint between sheets. If there is a lap, the impact shall be directed to the underlapped sheet
- FS5 – midspan between two supports, midway between cladding edges

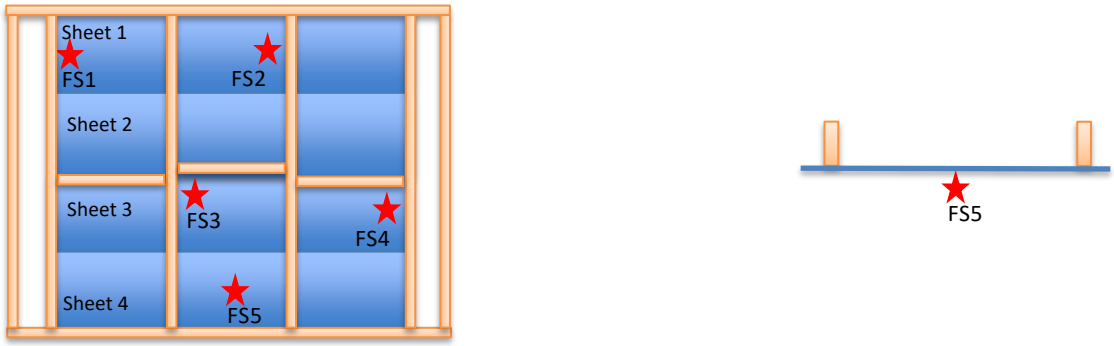

Figure 7.1a Locations of debris test impacts on horizontal wall cladding systems (view from inside)

For tests on vertical cladding fixed directly to studs, the debris item shall be directed at the cladding from the outside as shown in Figure 7.1b, where:

- FS1 – adjacent to an end support midway between horizontal supports
- FS2 – adjacent to an internal support midway between horizontal supports
- FS3 – adjacent to the intersection of horizontal and vertical supports
- FS4 – adjacent to a support with a lap or joint between sheets. If there is a lap, the impact shall be directed to the underlapped sheet
- FS5 – midway between horizontal and vertical supports

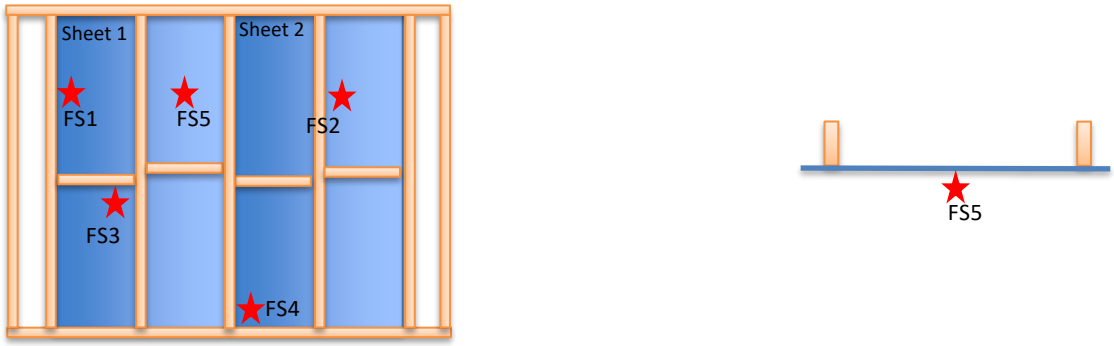

Figure 7.1b Locations of debris test impacts on vertical wall cladding systems (view from inside)

For tests on vertical cladding fixed directly to battens, the debris item shall be directed at the cladding from the outside as shown in Figure 7.1c, where:

- FS1 – adjacent to an end support midway between horizontal supports
- FS2 – adjacent to an internal support midway between horizontal supports
- FS3 – adjacent to the intersection of horizontal and vertical supports
- FS4 – adjacent to a support with a lap or joint between sheets. If there is a lap, the impact shall be directed to the underlapped sheet
- FS5 – midway between horizontal and vertical supports

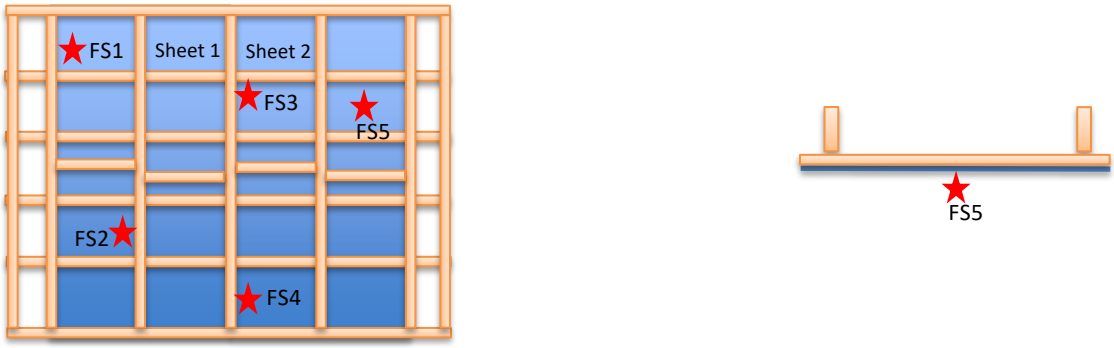

Figure 7.1c Locations of debris test impacts on battened vertical wall cladding systems (view from inside)

Notes:

1. The above impact locations refer to a uniform cladding profile. Additional test locations may be included depending on the cladding type. For example, weather boards may require additional tests that differentiate impact on a single board from impact on the overlapping portion of the board.
2. Cladding systems are typically installed in various span types (single, multi) and over a range of span lengths. Therefore, additional tests may be required to determine which span conditions have the most adverse results.
3. Impact tests where there is a potential failure by deformation of the panel, should be conducted with cladding spanning the shorting distance within a span range. Impact tests where there is a potential failure by bending should be conducted with cladding spanning the largest distance within a span range.
4. One specimen may be able to be used for a number of test locations.

7.2.2. Wall or roof panel systems

Roof and wall panel systems are prefabricated systems that include the external skin and the structural elements within the panel. Examples include sandwich panels, Structural Insulated Panels (SIPs), Cross Laminated Timber (CLT).

They are tested as a system consisting of two joined panel sections, the fastenings and supporting members, which are assembled as the system will be in practice.

Impact tests shall be conducted at the following three locations shown in Figure 7.2:

(i) One test at either PS1 or PS2 (potential failure by bending of the panels or punching through) AND

(ii) One test at either PS3 or PS4 (potential failure by shear near an edge or punching through) AND

(iii) One test at PS5 (potential failure by damage to the lap between panels)

The critical impact locations are:

- PS1 – Centre of one panel adjacent to an internal support (where internal supports are used in the panel)
- PS2 – Centre of one panel defined by supporting elements
- PS3 – Directly on the panel-to-panel interface joint at midspan
- PS4 – Adjacent to the connection between the panel and the floor
- PS5 – Near the panel-to-panel interface joint at midspan (if lapped, on the under-lapped panel with respect to the travel direction of the debris item)

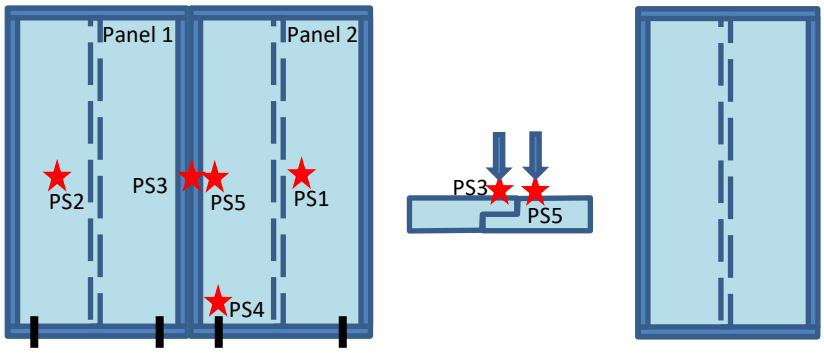

Figure 7.2 Locations of debris test impacts on wall panel systems

7.2.3. Door systems

Doors shall be tested as an assembly consisting of the door and its frame including hinges, locks, and latches. The reaction frame shall only support the door frame. The impact tests shall be conducted at the following two locations shown in Figure 7.3:

(i) One test at either DS1, DS2 or DS3 (potential failure by damage to door hardware – latches or hinges) AND

(ii) One test at either DS4 or DS5 (potential failure by bending)

Impact tests shall be conducted at the following locations:

- DS1 – Near the primary latch or handle
- DS2 – Near the hinge joint
- DS3 – Near an upper latch point (if present)
- DS4 – In the centre of the door panel
- DS5 – Near any unsupported corner of the door panel, if any

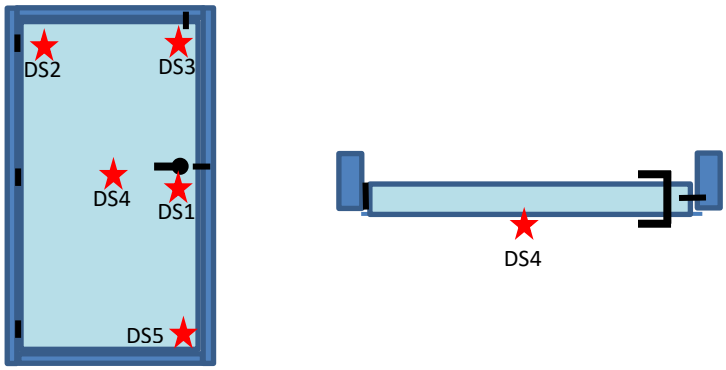

Figure 7.3 Locations of debris test impacts on door systems

7.2.4. Window systems

Window systems shall be tested as an assembly consisting of the window and its frame including any hinges, sliders, mullions, locks, and latches. The reaction frame shall only support the window frame. The test shall use a minimum of two impacts at the locations listed below and shown in Figure 7.4.

Impact tests shall be conducted at the following two locations:

a) For small glazing elements (both sides less than 1 m) WS1 and WS4 AND

b) For tests on any panel with a dimension greater than 1 m,

(i) one test at either WS1, WS2 or WS3 (potential failure by deformation of the glass at the seal) AND

(ii) one test at either WS4 or WS5 (potential failure by bending of the frame or glazing).

The critical impact locations are:

- WS1 – Near the primary latch
- WS2 – Near any hinge joint or slider
- WS3 – On or near an upper or lower latch point (if present)
- WS4 – In the centre of the window panel
- WS5 – On or near any unsupported corner of the window panel, if any

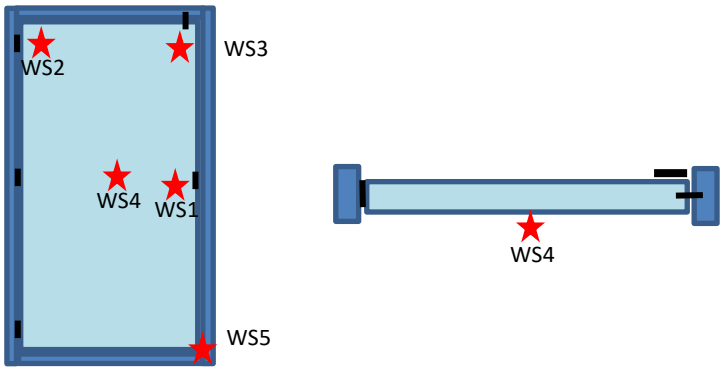

Figure 7.4 Locations of debris test impacts on window systems (casement shown)

7.2.5. Debris-rated screens or shutters

Shutters or screens shall be tested as an assembly consisting of the shutter or screen and its frame, including any accessories if applicable.

The instantaneous or peak deflection of the shutter or screen shall be measured. Options include:

- using imprintable material (e.g., plasticine) to record the peak instantaneous deflection of the rear face of the shutter or screen at the target impact location.
- Mounting a visual deflection indicator on the back of the test specimen and using a high-speed video to determine the maximum shutter or screen deflection.

Impact tests shall be conducted at the following locations shown in Figure 7.5:

(i) One test at either SS1 or SS2 (potential failure by detachment of the screen near a support point, AND

(ii) One test at either SS3 or SS4 (potential failure by deformation of the screen)

The critical impact locations are:

- SS1 – Near a corner
- SS2 – Near an edge at a support point
- SS3 – Near an edge between support points
- SS4 – At the centre between support points

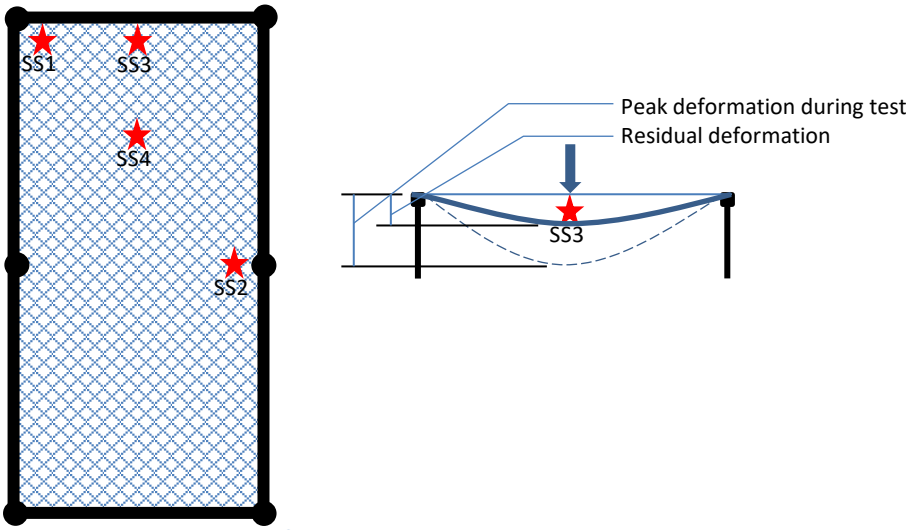

Figure 7. 5 Locations of debris test impacts on shutters and screens

7.2.6. Garage doors

Garage doors shall be tested as an assembly of a number of segments spanning between guides. Guides shall be fixed to building frames with the specified connections. The building frames shall be fully supported by the laboratory support frames.

Impact tests shall be conducted at the following locations shown in Figure 7.6:

(i) One test at either GS1 or GS2 (potential failure by deformation of the door or failure of the wind lock) AND

(ii) One test at either of GS3 if appropriate or GS4 (potential failure by bending of the door)

The critical impact locations are:

- GS1 – near a wind lock at a guide lug or track fixing
- GS2 – between wind locks at a guide lug or track fixing
- GS3 – if the wind locks are not at every segment, at the centre of a segment that does not have a wind lock
- GS4 – at the centre of a segment

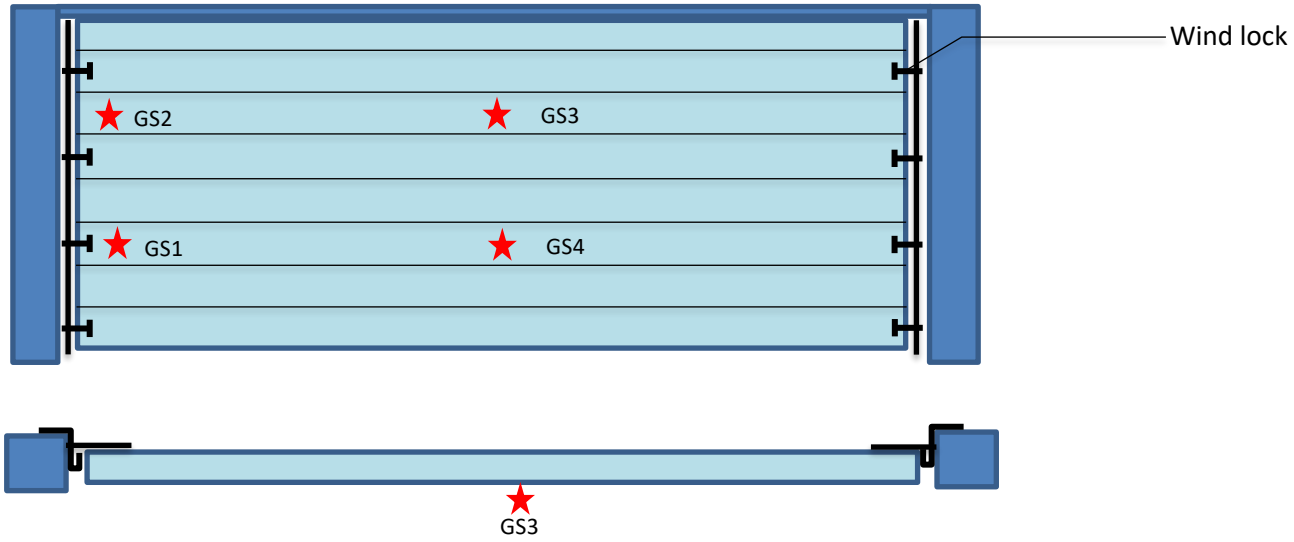

Figure 7.6 Locations of debris test impacts on garage doors

7.3. Position of impact for debris item B

Debris item B shall be separately projected five times at the specimen.
The five projected items should impact the specimen within a 300 mm circle.

7.4. Valid impact velocity

For the test to be valid, the impact of the debris item with the test specimen shall be at an impact velocity measured within 1.5 m of the specimen that is (+5%, - 0) of the target velocity calculated from V_R as specified in Clause 7.1.

7.4.1. Target velocity

The target velocity shall be calculated from the regional wind speed (V_R) in accordance with AS/NZS 1170.2. V_R is a function of:

(i) Wind region in which the product is used
(ii) The annual probability of exceedance, which is a function of the building type.
(iii) The angle of inclination of the test specimen as detailed in Clause 7.1.

Note: Most importance level II structures use V_{500}, but structures with higher importance levels may use velocities up to and including $V_{10,000}$.

7.5. Test specimen measurements

After impact, the test specimen shall be measured to record:

(i) Maximum and minimum dimensions of openings (defined in Clause 4.7) (+/– 5 mm).
(ii) Total area of any openings (defined in Clause 4) created in the test either directly by the debris item or by tearing away from the frame (+/– 100 mm^2).
(iii) Check whether there is sufficient spalling from the non-impact face of the specimen to cause injury. i.e., would you have been prepared to have stood behind the specimen and let the spalling hit you while wearing no protective equipment.

Where the test specimen is a screen and deformation of the screen is a reportable finding from the test, also measure:

(iv) Maximum instantaneous displacement at any time in the test (+/– 1 mm).
(v) Maximum residual displacement after test completed (+/– 1 mm).

8. ACCEPTANCE CRITERIA

Acceptance criteria are independent of the material of the test specimen.

The results of each test program consisting of a number of impacts shall be reported against the appropriate acceptance criteria. The outcome reported shall be the worst of any assessment of all the tests at that wind speed:

- Criteria 'E' (Entry) – To prevent entry of debris – appropriate for protection of occupants from wind-borne debris
- Criteria 'P' (Pressure) – To indicate the effectiveness of an element in restricting internal pressures for the design of the rest of the structure.
- Criteria 'S' (Screen or shutter) – To protect a fragile opening (e.g., a window) from wind-borne debris

The test results for a test program are deemed a 'pass' if all the relevant acceptance criteria as indicated in Table 8.1 are satisfied by all of the test impact positions as specified in Clauses 7.2 and 7.3.

Note: Appendix A provides some examples of test results for different categories.

Table 8.1 Acceptance criteria

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**	**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit	Not sufficient to cause disengagement of any part of the system	Less than 0.8 times the standoff distance
2. Max permanent deformation of specimen – debris item A	No limit	Not sufficient to cause disengagement of any part of the system	Less than 0.8 times the standoff distance
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris item.	No limit	Penetration of less than 100% of debris item cross-section
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm.	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening.	No opening larger than the debris item cross-section was measured.
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants	No limit	No limit
6. Fracturing of surface – debris item B	Glass does not break or crack	No limit	Not applicable

Note: Debris item B is only used on glass that is to be protected by a screen with an aperture of more than 8 mm and in those cases, Debris item A is not used.

9. REPORT

The report shall include the following:

1. Name of the company that requested the tests
2. Detailed description of the test specimen including
    a. dimensions
    b. materials
    c. fixing methods
    d. commercial name and model descriptor
    e. name of manufacturer and date of manufacture.
3. Description of the test equipment, including the debris simulator, laboratory support frame and measurement devices.
4. The regional wind speed (V_R) used in the tests
5. Method and date of calibration and results of calibration of the configuration of the wind-borne debris simulator used in the tests
6. Detail of debris items (A or B)
7. Test locations
8. Indicate any variations in the tests e.g., additional tests at different impact angles or at different locations
9. Measurements taken of the velocity, mass and shape of the debris item for each test
10. Measured deformations of the test specimen (appropriate for screens)
11. Description of any spalling from the surface of the specimen furthest from the wind-borne debris simulator
12. Observations of the performance of the test specimen including measurements of any openings or description of any disengagement within the tested system
13. Performance of the test specimen against the acceptance criteria (pass or fail)
14. Details of test procedures used and reference to this industry standard
15. Name and affiliation of the author of the report
16. Date of the tests and report

10. REFERENCES

Department of Energy and Public Works (2021) “QDC for Queensland Public Cyclone Shelters”, DEPW, Brisbane (2021)

Standards Australia (2021a) AS/NZS 1170.2:2021 “Structural design actions, Part 2: Wind actions”, Standards Australia, Sydney NSW

Standards Australia (2021b) AS 4055:2021 “Wind loads on housing”, Standards Australia, Sydney NSW

Standards Australia (2012) AS/NZS 4505:2012 “Garage doors and other large access doors”, Standards Australia, Sydney NSW

APPENDIX A – EXAMPLES OF TEST RESULTS FOR DIFFERENT PRODUCTS AND TESTS

A test on a debris protection screen for a window (Test S1)

- The screen is tested using only debris item A and it is pushed back by the debris item, but does not break. It was installed with 200 mm standoffs.
- The maximum instantaneous deformation was 140 mm (0.7 times standoff) and the permanent deformation at the end of the test was 90 mm (0.45 times standoff).
- The only appropriate acceptance criteria for this product is Criteria S.

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**		**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit **NA**	Not sufficient to cause disengagement of any part of the system **NA**		Less than 0.8 times the standoff distance **Pass**
2. Max permanent deformation of specimen – debris item A	No limit **NA**	Not sufficient to cause disengagement of any part of the system **NA**		Less than 0.8 times the standoff distance **Pass**
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris. **NA**	No limit **NA**		Penetration less than 100% of debris cross-section **Pass**
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm. **NA**	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening. **NA**		No opening larger than the debris cross-section was measured. **Pass**
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants **NA**	No limit **NA**		No limit **NA**
6. Fracturing of surface – debris item B	Glass does not break or crack **NA**	No limit **NA**		Not applicable **NA**

The result of this test is a **PASS** against criteria S.

A test on a debris protection screen for a window (Test S2)

- The screen is tested using only debris item A and it is pushed back by the debris item, but does not break. It was installed with 200 mm standoffs.
- The maximum instantaneous deformation was 190 mm (0.95 times standoff) and the permanent deformation at the end of the test was 150 mm (0.75 times standoff).
- The only appropriate acceptance criteria for this product is Criteria S.

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**		**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit **NA**	Not sufficient to cause disengagement of any part of the system **NA**		Less than 0.8 times the standoff distance **Fail**
2. Max permanent deformation of specimen – debris item A	No limit **NA**	Not sufficient to cause disengagement of any part of the system **NA**		Less than 0.8 times the standoff distance **Pass**
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris. **NA**	No limit **NA**		Penetration less than 100% of debris cross-section **Pass**
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm. **NA**	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening. **NA**		No opening larger than the debris cross-section was measured. **Pass**
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants **NA**	No limit **NA**		No limit **NA**
6. Fracturing of surface – debris item B	Glass does not break or crack **NA**	No limit **NA**		Not applicable **NA**

The result of this test is a **FAIL** against criteria S.

A test on debris resistance of a wall panel system (P1)

- The panel system is tested using only debris item A and the debris item does not penetrate the non-impact face of the specimen. Some small particles come off the non-impact face but would not cause injury.
- There is no disengagement in any part of the system during the test. No displacements were measured in the tests as it was not a test on a debris screen.
- The only appropriate acceptance criteria for this product are Criteria E and P.

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**		**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit **Pass**	Not sufficient to cause disengagement of any part of the system **Pass**		Less than 0.8 times the standoff distance **NA**
2. Max permanent deformation of specimen – debris item A	No limit **Pass**	Not sufficient to cause disengagement of any part of the system **Pass**		Less than 0.8 times the standoff distance **NA**
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris. **Pass**	No limit **Pass**		Penetration less than 100% of debris cross-section **NA**
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm. **Pass**	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening. **0mm^2**		No opening larger than the debris cross-section was measured. **NA**
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants **Pass**	No limit **Pass**		No limit **NA**
6. Fracturing of surface – debris item B	Glass does not break or crack **NA**	No limit **NA**		Not applicable **NA**

The result of this test is a **PASS** against criteria E and **PASS** against criteria P (0mm^2).

A test on debris resistance of a wall panel system (P2)

- The panel system is tested using only debris item A and the debris item penetrates the non-impact face of the specimen and causes a hole 50 mm x 100 mm. Some small particles including a plug of wall 50 mm x 100 mm come off the non-impact face. The spalling has the potential to cause injury.
- There is no disengagement in any part of the system during the test. No displacements were measured in the tests as it was not a test on a debris screen.
- The only appropriate acceptance criteria for this product are Criteria E and P.

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**		**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit **Pass**	Not sufficient to cause disengagement of any part of the system **Pass**		Less than 0.8 times the standoff distance **NA**
2. Max permanent deformation of specimen – debris item A	No limit **Pass**	Not sufficient to cause disengagement of any part of the system **Pass**		Less than 0.8 times the standoff distance **NA**
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris. **Fail**	No limit **Pass**		Penetration less than 100% of debris cross-section **NA**
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm. **Fail**	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening. **5000mm^2**		No opening larger than the debris cross-section was measured. **NA**
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants **Fail**	No limit **Pass**		No limit **NA**
6. Fracturing of surface – debris item B	Glass does not break or crack **NA**	No limit **NA**		Not applicable **NA**

The result of this test is a **FAIL** against criteria E and **PASS** against criteria P (5000mm^2).

A test on debris resistance of a window system designed to be used behind any rated debris screen (W1)

- Because the window could be used behind any debris screen, the aperture of the screen may have been greater than 8 mm. It is therefore tested using only debris item B.
- None of the debris item B impacts cracks or breaks the glass and no penetration or spalling is observed.
- The only appropriate acceptance criteria for this product are Criteria E and P.

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**		**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit **NA**	Not sufficient to cause disengagement of any part of the system **NA**		Less than 0.8 times the standoff distance **NA**
2. Max permanent deformation of specimen – debris item A	No limit **NA**	Not sufficient to cause disengagement of any part of the system **NA**		Less than 0.8 times the standoff distance **NA**
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris. **Pass**	No limit **Pass**		Penetration less than 100% of debris cross-section **NA**
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm. **NA**	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening. **0mm^2**		No opening larger than the debris cross-section was measured. **NA**
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants **Pass**	No limit **Pass**		No limit **NA**
6. Fracturing of surface – debris item B	Glass does not break or crack **Pass**	No limit **Pass**		Not applicable **NA**

The result of this test is a **PASS** against criteria E and **PASS** against criteria P (0mm^2).

A test on debris resistance of a wall cladding system (C1)

- The cladding system consists of cladding, and girts and is tested using only debris item A and the debris completely penetrates the non-impact face of the specimen and rips out cladding between two adjacent girts causing a hole 1200 mm x 570 mm. The damaged cladding has the potential to cause injury.
- There is significant disengagement of the system during the test. No displacements were measured in the tests as it was not a test on a debris screen.
- The only appropriate acceptance criteria for this product are Criteria E and P.

	Criteria E – Test for prevention of debris entry	**Criteria P – Test to investigate openings in envelope for internal pressure calculations**		**Criteria S – Test for protection of a fragile opening**
1. Max temporary deformation of specimen – debris item A	No limit **Pass**	Not sufficient to cause disengagement of any part of the system **Fail**		Less than 0.8 times the standoff distance **NA**
2. Max permanent deformation of specimen – debris item A	No limit **Pass**	Not sufficient to cause disengagement of any part of the system **Fail**		Less than 0.8 times the standoff distance **NA**
3. Penetration of debris through specimen – debris item A or debris item B	No penetration of debris **Fail**	No limit **Pass**		Penetration less than 100% of debris cross-section **NA**
4. Area of opening in the specimen created by debris– debris item A	No opening larger than 8 mm. **Fail**	Measure and report the size of any openings created in the specimen to nearest 1000 mm^2 If there is any disengagement within the tested system, report the full size of the specimen as the opening. **684,000mm^2**		No opening larger than the debris cross-section was measured. **NA**
5. Detection of spalling from the non-impact face – debris item A or debris item B	No spalling that is large enough to cause injury to occupants **Fail**	No limit **Pass**		No limit **NA**
6. Fracturing of surface – debris item B	Glass does not break or crack **NA**	No limit **NA**		Not applicable **NA**

The result of this test is a **FAIL** against criteria E and **FAIL** against criteria P (684,000mm^2). Note that the size of opening created could have a serious impact on internal pressure calculations.