Technical Note No 76 – supersedes TN52

Impact performance of building envelopes: method for impact testing of cladding panels

This Technical Note describes methods of testing cladding panels for impact. Technical Note TN 75 describes the requirements for impact testing of facades and gives guidance on specification and assessment of impact performance.

Introduction

The CWCT Standard test methods for building envelopes describes hard and soft body impact tests however the description of the tests does not give sufficient detail particularly in relation to the number and location of impacts and the design of the test specimen. This Technical Note provides this additional information.

The tests described in this Technical Note require an impactor to be suspended in front of the test specimen. The impactor is then raised and allowed to swing in pendulum manner so that it strikes the test sample. The severity of the test is given in terms of the impact energy which is given by the relationship:

E= mgh, where:

E is the impact energy in J (or Nm)
m is the mass of the impactor in kg
g is the acceleration due to gravity in ms^{-2}
h is the height through which the impactor falls in m

Tests may be carried out on a project basis or on a generic system made from standardised manufactured units.

The impact performance of a cladding panel may be influenced by many factors including the flexibility of the support structure (see TN 75). For a project test the test arrangement should represent the proposed construction as closely as possible. For a generic product test, the product manufacturer should specify the appropriate form of support structure. In the absence of alternative guidance it is recommended that a rigid support structure such as a concrete wall is used. This will normally be more onerous than a more flexible support structure but this may not always be the case. Manufacturers should be aware that tests may not satisfy all potential clients and additional tests may be required to satisfy specific project requirements.

The results of the tests described in this Technical Note allow the performance to be given in the form of a class for both serviceability and safety. These classes can be used by the specifier to assess acceptability for a particular purpose. The use of simple pass/fail criteria is not considered appropriate as the damage that is acceptable will depend on the location in which the product is used. Even fracture causing pieces of the sample to fall may be acceptable where the panel is readily replaceable and used at low level. In addition to the classification, the test report should accurately record the effects of the test as this may aid the specifier in the assessment of acceptable performance.

This Technical Note describes both hard and soft body tests. Hard body tests are carried out with a steel ball of 50 or 62.5mm diameter and soft body tests are carried out with a spheroconical bag containing glass spheres.

Scope

The test methods described in this Technical Note are applicable to the following:

- Rainscreen panels
- Spandrel panels in curtain walling
- Brick slip systems on a framed backing
- Insulated render systems
- Stone cladding.

Curtain wall framing members should be assessed using the method described in EN 14019. Impact tests to classify safety glass are given in EN12600. The tests in this Technical Note can be used to assess the impact performance of glass used as cladding panels.

Size of Test sample

The test specimen should either be large enough to allow all tests to be carried out on a single sample or allow damaged components to be replaced for subsequent tests.

Each test should normally be carried out on a fresh part of the sample however if a test at a low impact energy appears to cause no damage, the same location can be used for tests at higher impact energy. If the higher impact energy tests do not cause unacceptable damage the test can be considered valid. If the test at the higher impact energy causes unacceptable damage, the test can either be considered a fail or should be disregarded and a repeat test carried out on a new section of the sample or a new sample.

The number of test positions that is required will depend on the purpose of the test and the nature of its performance.

For a project test it may be sufficient to show that a particular design of panel can give a specified level of performance. For a system test it will often be required to establish the limit of performance for different sizes of panel.

Sufficient tests need to be carried out to give a reliable result taking account of variability of materials and test conditions. For materials that give a brittle failure causing cracking, there is often no indication how close to failure a test is when there is no apparent damage. It is therefore necessary to carry out a number of repeat tests on different panels to allow for variability. A minimum of four tests all giving consistent test results for a given impact energy at the most critical location is considered necessary. Where four tests give variable performance the lowest performance shall be taken as the appropriate value unless there is an identifiable reason for considering the low performance unrepresentative and repeat tests on a fresh sample give better performance.

Where failure results in a measurable response such as permanent deformation, it is often possible make a valid judgement on a smaller number of tests. This may take account of:

- How close the measured response is to the acceptable limit,
- The relationship between the measurable response and impact energy from tests at different impact energy
- The consequence of exceeding the limit on measured response where this is a subjective criterion.

Curtain wall samples generally provide relatively good resistance to impact so that sufficient tests can be carried out on a standard weathertightness sample.

Rainscreen systems often incorporate panels that are more easily damaged requiring more test points. They are also more likely to include brittle materials or thin gauge sheet materials which require a greater number of tests to give a reliable estimate of performance.

Impact locations

Cladding panels vary widely in construction method, size and means of support. The critical points for impact testing will therefore vary. Impacts close to support points will reduce the ability of the panel to absorb the impact energy by deflection, will tend to concentrate the resulting forces on a single fixing and may give a punching failure of the panel. Impacts well away from fixing locations will allow more of the impact energy to be absorbed by deflection and spread the resulting forces throughout the panel but may lead to flexural failure of the panel. The following guidance provides a basis for selecting suitable test locations but there may be additional considerations in specific circumstances.

Testing of a panel supported by fixings at its corners should normally include impacts applied at the:

- Centre of the panel
- Midpoint of panel edge
- Near to support

If panel edges differ in design, length or fixing method the panel should be impacted on each edge unless the edge giving the lowest performance is known.

For panels of more than one span, impacts should be applied at the following locations:

- Centre of panel bay
- Panel edge mid way between supports
- Near central support
- Near end support

It may be possible to show by preliminary tests or tests at one impact energy that a particular test location gives the lowest performance. In this case it may not be necessary to test all

locations at all impact energies. It should be noted that hard body tests and soft body tests often induce different failure modes so they need to be considered separately. For soft body tests there will be a significant contact area and it may not be practical to the test all locations on small format panels.

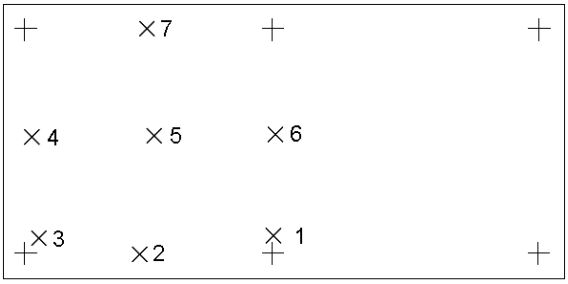

Figure 1 Possible impact test locations

During impact testing, panels can often deflect causing contact with, and transferring load to, adjacent panels. Where this may occur, it is necessary for any tested panel to be surrounded by other panels of the system.

Design of test sample

Testing of panels requires a suitable support structure. If the support structure moves or deflects during the test some of the impact energy will be absorbed and the impact energy transferred to the test panel will be reduced.

The support structure consists of two parts. There is generally a support rail system that provides the direct support to the panel which would normally be supplied as part of the cladding system. The support rail system should form part of the test sample. If the purpose of the test is to assess the performance of the panels, the support rails should be fixed with short spans to reduce deflection. If the test is required to check whether the support rails can withstand the impact, additional tests should be carried out with the rails installed at their maximum span.

The support rail system would normally be supported on a back wall and this needs to be simulated in an appropriate way in the test sample.

If the type of back wall to be used in practice is unknown or may vary, which will normally be the case for a system test, it is normally sufficient to carry out tests with the cladding supported by a rigid back wall such as a concrete wall. This will deflect less than a more flexible structure and ensures that the maximum amount of the impact energy is absorbed by the panel under test. Tests carried out in this way may give a conservative result.

For a project test, impact testing may be carried out on a sample of the proposed back wall using the same stiffness of structural members as for the proposed wall and connected to a rigid support structure. A sample used for weathertightness testing will normally satisfy this requirement.

Test conditions

Test samples will generally be constructed in an open test yard and may be used for weathertightness testing prior to impact. The condition of the specimen and the ambient conditions during the test shall be recorded.

Assessment criteria

Tests may be carried out to assess either serviceability or safety. For serviceability the criterion is that any damage should not require remedial action. This will be satisfied where there is no damage detectable however minor surface damage and small dents or deformations may be acceptable. In some cases a product that does not meet this criterion may be acceptable if it is readily repairable or replaceable. For most rainscreen systems replacement of a panel is possible but a client may prefer a more robust panel that is less likely to require replacement. Performance should be assessed in accordance with Table 1.

Class	Definition	Explanation/Examples
1	No damage	No damage visible from 1m, and Any damage visible from closer than 1m unlikely to lead to significant deterioration.
2	Surface damage of an aesthetic nature which is unlikely to require remedial action	Dents or distortion of panels not visible from more than 5m (note visibility of damage will depend on surface finish and lighting conditions. Damage will generally be more visible on reflective surfaces), and Any damage visible from closer than 5m

		unlikely to lead to significant deterioration

3	Damage that may require remedial action or replacement of components to maintain appearance or long term performance but does not require immediate action	Dents or distortion of panels visible from more than 5m, or Spalling of edges of panels of brittle materials, or Damage to surface finishes that could lead to deterioration of the substrate.
4	Damage requiring immediate action to maintain appearance or performance . Remedial action may include replacement of panel but does not require dismantling or replacement of supporting structure	Significant cracks in brittle materials eg cracks that may lead to parts of tile falling away subsequent to test, or Fracture of panels causing significant amounts of material to fall away during test.
5	Damage requiring more extensive replacement than 4	Buckling of support rails

Table 1 Classes for serviceability performance

For tests at the safety level the requirements are as follows:

- Ensuring that the structural stability of the building or parts of the building are not compromised
- Ensuring that the wall is not penetrated by the impact presenting a risk to people inside the building
- Ensuring that people outside the building are not put at risk from falling debris
- Ensuring that the failure mode of the cladding does not create risks to a person impacting the surface disproportionate to the impact for example severe cuts due to the formation of sharp edges.

The third of these requirements is normally the most relevant. Failure of cladding panels will rarely affect structural stability of components other than the panels themselves and even if the cladding panel is penetrated by the impact, the back wall will normally prevent risk to people inside the building. The fourth requirement may be applicable with some cladding materials that produce sharp edges on failure.

The risk to people outside the building from falling debris depends on the nature of the falling debris, how far it falls and whether it is likely to hit people when it falls. Where any damage more than simple surface damage occurs, the damage occurring during the test should be recorded to allow an assessment of suitability for a particular application. Careful dismantling will be required to assess the full extent of any damage. Relevant information that should be recorded would include

- Any cracking of brittle materials
- The size and mass of any pieces dislodged from the wall
- The size, mass and security of any fractured pieces and their risk of falling subsequently.

The performance should be assessed in accordance with Table 2.

Class	**Explanation/examples**
Negligible risk	No material dislodged during test, and No damage likely to lead to materials falling subsequent to test, and No sharp edges produced that would be likely to cause severe injury to a person during impact, and Cladding not penetrated by impactor
Low risk	Maximum mass of falling particle 50g, and Maximum mass of particle that may fall subsequent to impact 50g, and Cladding not penetrated by impact, and No sharp edges produced that would be likely to cause severe injury during impact
Moderate risk	Maximum mass of falling particle less than 500g, and Maximum mass of particle that may fall subsequent to impact less than 500g, and Cladding not penetrated by impact, and No sharp edges produced that would be likely to cause severe injury during impact

High risk	Maximum mass of falling particle greater than 500g, or Cladding penetrated by impact, or Sharp edges produced that would be likely to cause severe injury during impact.

Table 2 Classes for safety performance

Soft body impact test method

The test procedure described below is based on ISO 7892 which has been adopted for testing timber framed walls in EN 596 and internal partitions in BS 5234. This procedure was also used in BS 8200 which has now been withdrawn.

Equipment
The equipment is shown in Figures 2 and 3. The impactor is a coarse canvas bag containing a thin polyethylene bag of the same size which, when filled with hardened solid glass spheres each having a diameter of 3 ± 0.5 mm shall have a mass m of 50 ± 0.2 kg. The dimensions of the bag when filled are those of a volume composed of a sphere of 400 mm diameter inscribed in a cone, the top of which is located at a distance of 400 mm from the centre of the sphere. The bottom of the bag is strengthened by a circular piece of leather of 120 mm diameter sewn into it. The top of the bag is slightly truncated in order to make an opening of 80 mm diameter. This opening is strengthened by a leather strip sewn onto the bag, to which are fixed four equidistant rings held together by a suspension ring.

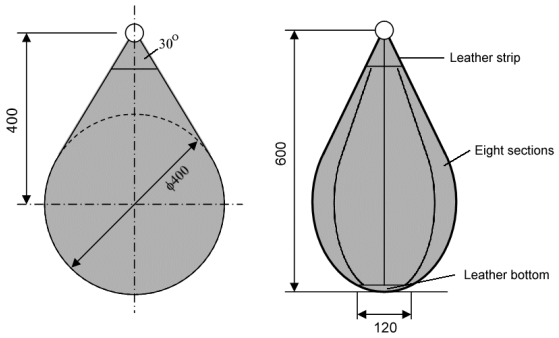

Figure 2 Spheroconical bag

The bag is suspended by a rope at least 3m long in such a way that, while vertically at rest, the bag is just touching the panel surface at the point of impact. The suspension point needs to be moveable to allow tests to be carried out at different locations on the sample.

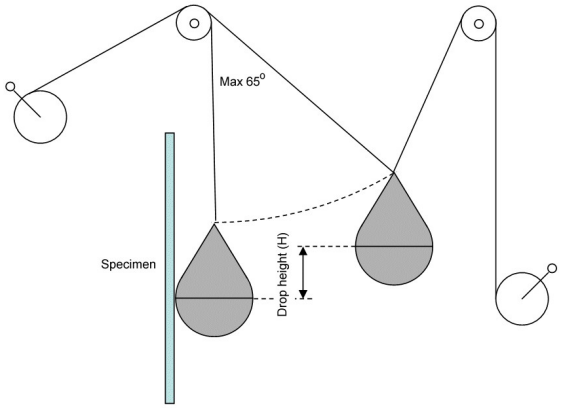

Figure 3 Soft body test arrangement

Devices are required for:

- Hoisting the impactor to give the required drop height; and
- Instantaneously releasing the bag.

To ensure that the drop height can be consistently maintained a mechanical means of holding the impactor before release is required. The method of holding the impactor immediately before release should be such that the centre of gravity of the bag is vertically below its connection to the suspension rope and with the suspension rope taut.

Procedure
Before an impact load is applied, the bag shall be rolled to loosen the spheres. The bag is placed at the impact point in such a way that, when it is suspended from the rope, it just touches the surface of the panel. The bag shall then be drawn away from the panel surface such that the maximum angle to the vertical subtended by the movement of the rope shall be not greater than 65°.

The bag shall be raised to the prescribed height of drop, h, measured vertically from the impact point. The bag is then released and allowed to swing freely in an arc onto the face of the panel.

Three standard levels of impact energy are 120J, 350J and 500J which require the following drop heights:

Impact energy (J)	**Drop height** (mm)
120	245
350	715
500	1020

The effect of the impact shall be described.

For serviceability impact tests three impacts at the same point shall constitute a single test. Damage shall be recorded after each impact. For safety impact tests a single impact is required.

Hard body impact test

The test procedure described below is based on that given in BS8200.

Equipment
Hard body tests are carried out with a steel ball of 50mm diameter with an approximate mass of 0.5kg or 62.5mm diameter with an approximate mass of 1kg. The ball is suspended from a cord at least 3m long. An eyebolt may be used to provide a connection between the steel ball and the suspension cord. The mass of the impactor shall be taken as the total mass of the ball and any connection rigidly fixed to it.

Procedure
The ball is placed at the impact point in such a way that, when it is suspended from the cord, it just touches the surface of the panel. The ball shall then be drawn away from the panel surface such that the maximum angle to the vertical subtended by the movement of the rope shall be not greater than 65°.

The ball shall be raised to the required height of drop h measured vertically from the impact point. The ball is then released and allowed to swing freely in an arc onto the face of the panel.

Three standard levels of impact energy are 3J, 6J and 10J. 3 and 6J impacts are carried out with the 50mm diameter impactor and 10J impacts are carried out with the 62,5mm diameter impactor. The drop height should be calculated based on the actual mass of the impactor including any hooks rigidly attached to it to allow connection to the suspension cord.

References

BS 5234-2: Partitions (including matching linings). Specification for performance requirements for strength and robustness including methods of test.

BS 8200: Code of practice for design of non-loadbearing external vertical enclosures of buildings.
BS EN 596: Timber structures. Test methods. Soft body impact test of timber framed walls.

BS EN 14019: Curtain walling - Impact resistance - Performance requirements.

BS EN 12600: Glass in building. Pendulum test. Impact test method and classification for flat glass. Pendulum test. Impact test method and classification for flat glass.

CWCT Standard test methods for building envelopes, CWCT, 2006, ISBN 1 874003 20 3.

CWCT
The Studio, Entry Hill, Bath, BA2 5LY

T: +44 (0) 1225 330945
cwct@cwct.co.uk
www.cwct.co.uk