CYCLONE
TESTING
STATION

DRAFT GUIDE TO LHL CYCLIC TESTING

(Version 1)

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Important Notice and Disclaimer

This draft Guide on Low-High-Low (LHL) Cyclic Testing (the Guide) is provided for general information and should not be taken as providing specific advice for any particular situation. In particular it is not mandatory or regulatory in nature. It is designed to assist in making information on this topic readily available.

The groups that have been involved in the development of this draft Guide

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1. Scope

This Guide covers the cyclic testing of metal roof assemblies, their connections and immediate supporting members to resist simulated wind loading. It includes the test method and the interpretation of test results.

Notes:

1. *This Guide was designed to facilitate and standardize the application of the Low-High-Low pressure sequence specified in the Building Code of Australia (BCA).*

2. *The cyclic loading sequence is the Low-High-Low cyclic testing regime specified in the BCA 2008. The same fatigue loading sequence is specified for Class 2 to 9 buildings (Specification B1.2, BCA 2008 Volume One) and for Class 1 & 10 buildings (Section 3.10.1, BCA 2008 Volume Two). For this test, their connections and immediate supporting members must be capable of remaining in position notwithstanding any permanent distortion, fracture or damage that sequence (see Section 4 of this Guide). The purpose of this Specification is to ensure the performance of roofing system is adequate under cyclonic conditions i.e. the cladding should not be detached from the framing and become wind-borne debris which might cause damage to the surrounding area as well as a threat to life safety.*

3. *It is important to differentiate between cyclic fatigue failure, associated with disengagement of cladding from its supports after repeated load applications and static failure which is associated with a strength capacity of a cladding system. Low cycle fatigue cracking of cladding, fixings, immediate supports and their fixings during tropical cyclones is a complex process where small changes in load, geometry or material properties can significantly affect the fatigue performance of the system. At present, there is no way to assess this type of performance apart from testing.*

4. *This Guide is applicable to all forms of testing such as air box, air bag, mechanical testing etc.*

2. Referenced Documents

The following documents are referred to in this Guide

Australian Building Codes Boara 0 0 1 107.9 265.13 Tm[n 16/0049>2804400560057004800

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(g) Determine appropriate factor k_t in accordance with Table B1. The ultimate strength design value to be adopted is (P_t/k_t).

Notes:

The selection of the target value of P_t for testing is critical for the success of the test. It should be less that the static load design capacity (i.e. test with sequence D only but to destruction). Therefore it might be convenient to establish the static design load capacity first (which is also required for non cyclonic design) and use it as an upper bound in deciding what the target test pressure for cyclic test should be.

5. Apparatus

5.1 General

The arrangement of equipment should be capable of performing the test procedure within the allowable tolerances and without influencing the performance of the specimen under test.

5.2 Loading System

The loading system should be capable of the following:

Pressure or loading equipment and their measuring devices shall be capable of delivering the maximum test pressure P_t to within 5% of the nominated value.

The upper limit of each pressure sequence shall not be less than the target value.

The lower limit is considered satisfactory even if it is not reduced to zero, provided that the lower limit does not exceed 10% of the upper load limit of the same load sequence.

The rate of load cycling must be less than 3 Hz.

The single load cycle (sequence D) must be held for a minimum of 10 seconds.

5.3 Set-up

Particular care should be taken at the edges of the test specimen to ensure that the specimen is not constrained in a manner that is significantly different to that which will occur in practice.

Notes:

1. *The high stress low cycle fatigue performance can depend on parameters such as the load per fastener, the bending moments in the cladding and the supporting member and the movements of the fastener, the cladding and the supporting member. The test apparatus should be able to deliver the**(en-US)>BDC BT/F2 12 T1 0*

2. *The method of load application should be selected depending on the purpose of the test. To obtain the static load capacity of a particular design a*

1901 1 453.12 736.66 TF0 1 Tm [ ] TJ ET BT/F8 1 Tf 8 0 0 8 453.12 736.66 Tm [(E699 (Pt t me31 0 0 1 453.me)]TBT/F7 12 Tf71 0 0 1 125.9 736.66 Tm[(The me 1 116.52 6

one test specimen can be counted.
be
counted.
Adopt a maximum of 10 replications, the upper limit in Table B1 of AS/NZS1170.0.

Notes:

The application of this Clause will require considerable engineering judgement. For example, for testing corrugated cladding, corrugated cladding under AS1455 could not generally be considered as the same because the Standard only specifies the height of the corrugation but not the radius of the corrugation. The latter is critical in the assessment of low cycle fatigue performance.

Features that may be critical in the determination of low cycle fatigue performance include bearing areas under the head of the fastener, thread conditions into the battens, distance between fastener head and supporting member, thickness and strength of the materials.

Fasteners that are specified similarly in AS3566 are considered to be equivalent for the purposes of this procedure.

When a batten or other supporting member is included in the test, the results may be considered to be applicable for other battens or supporting members that are equal or stronger and stiffer in all respects. In case of metal battens, for example, the results are applicable to cases with battens that have equal or greater base metal thickness (BMT) and yield strength.

On the basis of engineering judgement, it has been deemed prudent to be cautious when testing a single specimen. For example, a specimen may
tested,
two(2)
be
as large as eight(8).

6.3 Recommendations for Establishment of Design Load Tables

6.3.1 For establishing load tables for cladding or supporting members

Where load tables for the cladding, or supporting member such as a batten, are to be established from the results of the tests:

For any one cladding or member profile, thickness, single or continuous span type and fastener configuration, a minimum of three successful tests must be carried out for the full range of spans.

The spans chosen must include the lowest and highest spans and at least one value in between as shown in the Figure 1.

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Notes:

For tests carried out to establish load tables, consideration should be given to the following features to ensure the validity of the tests:

The width of the test specimen should be at least two cladding elements wide and include at least one cladding overlap. For cladding systems in which the interlocking of the edges of adjoining cladding elements is essential to their fastening, at least two sheet interlocks should be incorporated in the test specimen.

Continuous cladding should be supported by no fewer than three members to represent a double end span condition.

For non-continuous cladding elements where side overlaps and end overlaps are required for transferring fastener loads, such as roof tiles and clips, a minimum of four elements wide by four supporting members should be considered (e.g. sixteen cladding elements in total).

7. Interpretation of Test Results

7.1 General Principles

Interpolation of design capacities derived under test is acceptable but extrapolation of parameters outside the test range is not permitted.

Test results from one fastener (or cladding) may be considered as acceptable for another fastener (or cladding) in the same application if both fasteners (or both claddings) have the same critical features that will determine their cyclic load capacities.

All tests should show have similar potential failure modes or have no visible damage after the test to count as part of the same series. Where the potential failure mode changes for any of the tests, at least one further test must be carried out at a different span value, until a minimum of two span values have the same potential failure mode

If any test fails, further testing shall be carried out at the same span with a lower value of P_t until a pass is obtained as described in Section 4.2(f).

7.2 Recommended Acceptance Criteria

The test shall be considered as successful if the following conditions are met:

The specimen shall have sustained the full loading sequences as given in Section 4.1.

Annex A – Worked Examples

A1. Metal Roof Cladding

A metal roof cladding triple span test specimen with identical internal and end supports adopts a *(V_{sc}) of 10%* and uses two replications, giving $k_t = 1.38$. The test specimen passes a LHL cyclic test, (using a test pressure of 6.0 kPa) but with severe cracking around the screws. For this one test, the strength limit state design capacity will be 4.34 kPa (= 6.0/1.38).

If a second test specimen, using identical cladding, fasteners and supports, but with a different triple span length, also passes a LHL test (with the same potential mode of failure) then both test specimens can use a value of ($k_t = 1.30$, based on four replications). Now the first test specimen will have a higher strength limit state design capacity of 4.62 kPa (= 6.0/1.30).

A2. Roof Sheeting to Batten Connection Capacity

A manufacturer needs to determine the capacity of a roofing screw XXX fixed to the top flange of a 0.75mm thick batten when subjected to the LHL test. A test pullout value can be chosen and numerous small scale samples can be tested using mechanical means for the sequence of cycles shown in Table 1. Assume the first estimate of P_t is 2kN, and 3 tests are to be carried out using this value. The first two pass, the third fails by the screw pulling out of the batten before the test regime was completed. A further test is then done using a value of 1.9kN for Pt, and this passes the test.

The capacity of the connection can be based on the lower value of 1.9kN for P_t, with three replications, as there were three successful tests with Pt values either equal or higher. Hence the design capacity of the connection can be computed as follows.

V_{sc} for connection	= 15%
No of replications	= 3
k_t	=1.56 from Table B1

Hence the Strength Limit State design capacity of the connection using screw XXX in 0.75mm thick roof batten = 1.9/1.56 = 1.22kN.

If this screw is to be used to connect a roofing profile to the 0.75mm thick batten, the theoretical Strength Limit State design reaction value at each screw point should be limited to a maximum of 1.22kN.

Note: Instead of testing the connection on its own, if a test is carried out on the entire batten as described in Example 6, the value of V_{sc} could be reduced to 10% when

computing the capacity of the connections from the roofing screws to the top flange of the batten.

A3. Span Table for Roof Cladding

A manufacturer of a corrugated cladding profile requires pressure versus span tables for the cladding system fixed to pine battens. A cyclic load is applied to the cladding spans via an airbag loading system. Three different double span test configurations are chosen; 600/600, 900/900 and 1200/1200, each test specimen with no replications. All three test specimens do pass a LHL test and exhibit the same potential mode of failure. Therefore there are three replications for determining the factor for variability. The cladding span tables generated from this test program shall be constrained within the 600 to 1200 mm span limits**.**

A4. Roof Cladding Capacity

A manufacturer needs to determine the LHL capacity of a cladding XXX fixed to steel supports over a range of spans. (It is assumed the supports have adequate thickness to resist screw pull out.)

1. Estimate the initial "Target" test pressure (Pt) based upon previous data and or static testing results.
2. Conduct LHL testing at P_t.
3. If the roof cladding specimen fails the LHL test, then reduce P_t accordingly and retest.
4. If the roof cladding specimen passes, apply k_t using a Vsc of 10%, to calculate a design value.
5. **To determine the number of replications (based on Section 6.2 of this guide):** Each full sheet width (including both sidelaps) can be counted as a unit to be tested. Each different span tested using identical roof cladding, fixings and supports, with the same potential mode of failure, can be counted as replications.

   For example, suppose three different single spans are to be tested, to produce a load span curve for the cladding and the uplift test rig can test two full cladding sheet widths (including both sidelaps) test samples. (Note: All tests must have the same potential mode of failure)

   Number of replications = (No. of tests) (units per test) = 3x2 = 6.

   Reading from the table for 6 replications, we get $k_t = 1.27$

6. Say $P_t = 5$ kPa, for one of the spans tested. Then the design value becomes = 5/1.27 = 3.94 kPa.

Hence, the Strength Limit State design value for this span is 3.94 kPa.

NOTE: If one of the spans tested fails, P_t then must be reduced and the test repeated for this particular span. The failed result is discarded for the purposes of determining