Learning Objectives

• Participants will gain understanding of building code requirements for construction products not covered by the code.
• The development process for evaluation criteria will be detailed to help participants understand criteria development and their opportunities to participate in the processes.
• An overview of several evaluation criteria used to load rate products for the wood construction industry will be given, with a focus on critical testing requirements.
• Recent testing of connectors for cross-laminated timber will be discussed as a case study in how manufacturers may test in the absence of a specific evaluation criteria.
What do you do when you see something like this?

Can its capacity be tested?
Which capacity? Shear? Uplift?
What tests?
Who does the tests?
Any other way to “approve”?

104.11 Alternative materials, design and methods of construction and equipment.
The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved.
An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Definition of “Approved” - 2012

- **IBC**: “Acceptable to the building official or authority having jurisdiction.”
- **IRC**: “Acceptable to the building official.”

104.11.1 Research reports

- Supporting data, where necessary to assist in the approval of materials or assemblies not specifically provided for in this code, shall consist of valid research reports from approved sources.
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Benefits of Accreditation

- Agencies must have policies & processes in place
- Annual audits to
Accredited Product Certification Bodies

**Directory Details**

- **Organization**: Accredited Product Certification Bodies
- **Letter Code**: ARCHIVE
- **Website**: http://www.archtest.com
- **Accreditation Certificate**: To be uploaded soon

**ACCRREDITED SCOPES**

- **Headquarters**: 100 Barry Court, York, PA 17402 USA
  - **Address**: 100 Barry Court, York, PA 17402 USA
  - **Phone**: (717) 764-7700

**ARCHITECTURAL TESTING INC.**

- **Evaluates reports on alternative materials and methods.**
- **Design and construction codes.**
- **recognized and accepted test methods.**
- **Building officials shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction.**
- **Test methods shall be as specified in this code or by other recognized test standards.**
- **Approved testing procedures.**
- **Reports of such tests shall be retained by the building official for the period required for retention of public records.**

**IBC: 104.11**

**Alternative materials, design and methods of construction and equipment.**

104.11.2 **Tests.** Whenever there is insufficient evidence of compliance with the provisions of this code, or evidence that a material or method does not conform to the requirements of this code, or in order to substantiate claims for alternative materials or methods, the building official shall have the authority to require tests as evidence of compliance to be made at no expense to the jurisdiction.

Test methods shall be as specified in this code or by other recognized test standards. In the absence of recognized and accepted test methods, the building official shall approve the testing procedures.

**Tests shall be performed by an approved agency.**

Reports of such tests shall be retained by the building official for the period required for retention of public records.
Summary of Code Requirements

The code allows alternate materials and methods

Justify performance with:

- Calculations
- Research Reports
- Testing

Subject to approval of building official

Research Reports provided by accredited agencies

Testing performed in accredited test labs

Learning Objectives

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Evaluation Report Process

Acceptance Criteria Development

1. AC Proposal sent to ICC-ES Staff
2. Staff prepares AC draft for internal review
3. ICC-ES posts to website for public comment

Acceptance Criteria Development


Acceptance Criteria Development

October 1, 2012

TO: PARTIES INTERESTED IN SHRINKAGE COMPENSATING DEVICES

SUBJECT: Proposed Revisions to the Acceptance Criteria for Shrinkage Compensating Devices, Subject: 251E-091 RT (BAR5)

Dear Colleague:

We are seeking your comments on proposed revisions to the subject acceptance criteria, as presented in the enclosed draft. The revisions, which are being posted on the ICC-ES web site for 30 days of public comment, affect Section 4.2.1.4(d) for tests on tension-controlled shrinkage compensating devices (TCCCDs). In order to assure that the steel used in these tests is identical to the steel used in connection tests with the TCCCDs, all processes and test requirements shall be in accordance with the test direction guidelines.

Acceptance Criteria Development

1. AC Proposal sent to ICC-ES Staff
2. Staff prepares AC draft for internal review
3. ICC-ES posts to website for public comment
4. Public comments received
5. Staff posts public comments to website
6. Staff posts AC memos and final drafts to Evaluation Committee to website
7. ICC-ES Evaluation Committee and Staff hear public testimony
8. ICC-ES Evaluation Committee decides whether to hold for Approve, Approve with Revisions, or hold for Further Study

Acceptance Criteria Completed – Now What?

Evaluation Report Process

Acceptance Criteria established through public process, expert input, BO Committee
Test Lab performs test
Independent Agency witnesses test
Independent Agency issues test report
Test report & Calculations submitted to Evaluation Agency
Evaluation Agency issues Code Report
Evaluation Agency performs ongoing audits of manufacturer
Building Official confident in product evaluation

Other Process

Lab does test
Lab issues Report
Learning Objectives

- Participants will gain understanding of building code requirements for construction products not covered by the code.
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Using Evaluation Criteria

Examine requirements for a few choice criteria:
- AC13 – Acceptance Criteria for Joist Hangers and Similar Devices
- AC155 – Acceptance Criteria for Hold-Downs (Tie-Downs) Attached to Wood Members
- AC233 – Acceptance Criteria for Alternate Dowel Type Threaded Fasteners
- AC116 – Acceptance Criteria for Nails and Spikes

Evaluation Report Process

1. Test Lab performs test
2. Test report & Calculations submitted to Evaluation Agency
3. Independent Agency witnesses test
4. Independent Agency issues test report
5. Test report & Calculations submitted to Evaluation Agency
7. Evaluation Agency establishes minimum QA and QC requirements
8. Evaluation Agency performs ongoing audits
9. Acceptance Criteria established through public process, expert input, BO Committee

AC 13 Criteria

Option to test per either:
- ASTM D1761
- ASTM D7147

Both standards require:
- 3 (or 6) tests
- ¾” Deflection Limit
- Ultimate Load ÷ 3x Safety Factor
- Calculation Limit

3.6 TEST AND PERFORMANCE REQUIREMENTS

3.1 General: Every device shall be tested for direct (vertical) capacity under Allowable Stress Design (ASD) in accordance with Section 3.2 or 3.3 of this criteria. Joist hangers also shall be rated for tensional moment capacity in accordance with Section 3.4 of this criteria.

3.2 Direct (Vertical) Load Capacity Tests: The testing procedure to establish direct load capacity shall be in accordance with ASTM D 1761 and conform to the following provisions:

- Ultimate Load ÷ 3x Safety Factor
- Calculation Limit

3.3 Alternative Test Method for Direct (Vertical) Load Capacity Testing: As an alternative to ASTM D 1761, the provisions of ASTM D 7147 may be followed to establish direct load capacity, provided that analysis of test data and derivation of allowable loads are in accordance with Sections 15, 14 and 15 of ASTM D 7147.
ASTM D7147

AC13 References D7147
Additional Requirements:
Mill Certificates (or coupon tests)
Base Metal Thickness
Specific Gravity Reductions

13.5.7 The design value determined in 13.3.1 shall be reduced by multiplying it by a steel ratio \( R_s \) as defined below.

\[
R_s = \left( \frac{S_{seam}}{S_{ew}} \right) \left( \frac{F_{u,seam}}{F_{u,ew}} \right) \leq 1.0
\]  

Test Criteria – Simple Setups

Face mount hangers generally governed by calculations

AC 13 Criteria – Simple Setups

Top flange hangers generally governed by calculations
AC 13 Criteria – Not Simple Setups

AC155 - Holdowns
Developed in 2005
Previously used AC13
Better Addresses:
  Boundary Conditions
  Deflection Limits
  Post tension limits

Pre-AC155 Bolted Holdown Tests
- Steel jig test
- 3.0 Safety factor
- NDS Bolt Calculation
- Report deflection at allowable load
AC155 - Holdowns

Pre-AC155 Screw/Nailed Holdowns
- Tested on wood
- 3.0 Safety factor
- Fastener Calculation
- Report deflection at allowable load

Photo 1: View of the Test Set-Up

AC155 - Holdowns

Steel Jig Testing
Wood Post Testing
Required to load post in Tension
Holdown raised 1” off test bed
Deflection based on wood assembly

AC155 – Holdown Test Setup

AC155 – Holdown Load Ratings

Nailed/Screwed Holdowns:
- Fastener Calculation
- Deflection Limits:
  - ¼” Deflection Limit on Wood Post
  - 0.185” Deflection Limit on Steel Jig
- Deflection Limits at Strength Levels
  - Ultimate Load Limit
    - Wood Assembly Test + 3.0

Bolted Holdowns:
- Fastener Calculation
- Deflection Limits:
  - ¼” Deflection Limit on Wood Post
  - 0.185” Deflection Limit on Steel Jig
- Deflection Limits at Strength Levels
  - Ultimate Load Limit
    - Steel Jig Test + 2.5
AC233 Criteria – Wood Screws

Steel-to-Wood Connections
Wood-to-Wood Connections
Fastener Shear & Tensile Strength:
  • Average Ultimate ÷ 3x Safety Factor
  • No Duration of Load Increase
Wood Connection Strength:
  • Average Ultimate ÷ 5x Safety Factor
  • Load Duration Increase per NDS Allowed
  • 10 to 15 tests minimum per configuration
  • 5% precision at 75% to 95% confidence

AC233 Criteria – Wood Screws

Adjustments
Steel Strength & Thickness

\[
\sigma_{n} = \frac{3.0}{\sigma_{u} \text{ NDS Value}} \leq 1.0
\]

Specific Gravity (SG)
Tested SG ≤ NDS Value
IE, use Douglas Fir with SG ≤ 0.50

AC233 Criteria – Wood Screws

Tensile Test  Shear Test

AC233 Criteria – Wood Screws

Wood Shear Test  Failure Mode
Test Criteria Review
AC13 – Hangers & Similar
ASTM D7147
AC155 – Holdowns (Tension Ties)
AC233 – Threaded Fasteners
AC116 – Nails (similar to AC233)

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Cross Laminated Timber Testing
Overview
North American Manufacturers
Connector Testing Program

What is Cross Laminated Timber
Plywood?
Used in Europe for last 15-20 years
  – Approx. half dozen manufacturers
New to North America
  – 3 Manufacturers
Why use Cross Laminated Timber

Can be an economical alternative to concrete and steel construction
High level of pre-fabrication
Computer Numerical Control (CNC)
  - Wall/Floor openings
  - Mechanical
Quick building erection times
Starting to be embraced in North America

Cross Laminated Timber References


CLT in North America

APA Product Standard
Design Standard
  - American Wood Council (NDS)
  - CSA-O86
Code adoption of Design Standard
Code reference targeted
  - 2018 IBC
  - 2015 NBCC

ANSI/APA PRG320-2011

Manufacturing Standards
  - Dimensions
  - Tolerances
  - Performance Requirements
  - Test methods
  - Quality assurance
  - Trademarking
APA Product Reports®
Currently One CLT Report
Others in development

CLT Handbook
FPInnovations
- CLT Background
- Manufacturing
- Structural/Seismic
- Duration of load
- Connections
- Vibration/Acoustic
- Fire
- Enclosure
- Environmental

CLT Manufacturers
- KLH in Europe
- Structurlam – CrossLam™
- Nordic – X-Lam
- CST Innovations – Just CLT

Connection Details
CLT Testing Project Overview

Objectives – To Support CLT

Test Program
- Connector
- Fastener
- US (AC13) & Canadian (CCMC) Test Standards
- CCMC similar to AC13, has additional requirement that test setups be conditioned for at least 7 days prior to testing

Results

Literature

CLT Connector Tests

- Three Connectors
  - ABR9020
  - ABR105
  - AE116

- Two Fastener Types
  - CNA4 x 60
  - SD10212

CLT Connector Tests

- Four Loading directions
  - F₁
  - F₂ (F₂T for toward)
  - F₃ (F₂A for away)
  - F₄ (Uplift)
Connector Test Matrix

<table>
<thead>
<tr>
<th>Connector</th>
<th>Fastener Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLT Fastener Tests</td>
<td></td>
</tr>
<tr>
<td>CNA4 x 60</td>
<td></td>
</tr>
<tr>
<td>- Withdrawal</td>
<td></td>
</tr>
<tr>
<td>- Shear parallel to outer lambs</td>
<td></td>
</tr>
<tr>
<td>- Shear perpendicular to outer lambs</td>
<td></td>
</tr>
</tbody>
</table>

ABR9020 with CNA4x60 in F₃ (Uplift)

ABR105 with CNA4x60 in F₁
ABR9020 with CNA4x60 in F₂

ABR105 with CNA4x60 in F₃ (F₂A away)

ABR105 with CNA4x60 in F₂

AE116 with CNA4x60 in F₃ (F₂A away)
Shear Test of CNA4x60

Withdrawal Test of CNA4x60

CLT Test Results

Test results
- Fasteners
- Connectors

CLT Summary
Although in infancy in North America, CLT is here
Evaluated performance of several connectors with CLT
Testing followed US & Canada Connector Test Standards
Seismic test criteria may be needed
CLT panels rigid – no ductility
Ductility achieved through connections
Current connector standards do not address ductility
Thank you!

Paul McEntee, PE, SE
Manager of Engineering Research & Development
Simpson Strong-Tie
pmcentee@strongtie.com