ICC EVALUATION SERVICE

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August 18, 2020

TO: **PARTIES INTERESTED IN DOWEL-TYPE THREADED FASTENERS USED IN WOOD**

SUBJECT: Proposed Revisions to the Acceptance Criteria for Dowel-type Threaded Fasteners Used in Wood, Subject AC233-1020-R2 (EL/MG/TE)

Hearing Information:
WebEx Event Meetings
Tuesday, October 6, 2020
Wednesday, October 7, 2020
8:00 am Central Daylight Time
Click each date above to register.
Please register for *both* days

Dear Colleague:

You are invited to comment on [proposed revisions to AC233 which will be discussed at the Evaluation Committee hearing noted above.

Revisions are being proposed to address several issues. Preliminary revision proposals were posted on the June 2020 Alternate Agenda for comment only. As a result, we received input from several interested parties. These comments are included with this posting. We have considered the input we received, and this is reflected in the enclosed criteria draft.

The proposed revisions address four separate concerns, as detailed below and keyed to the numbered comments in our letter dated June 1, 2020:

1. Revisions are proposed on behalf of the proponent, Simpson Strong-Tie Company Inc. (SST) to address qualification requirements for the use of screws to resist end grain withdrawal in Sections 3.3.2 and 4.2.3.2 of the enclosed criteria draft. The proposed revisions are based on recommendations from the American Wood Council (AWC). The comments we received were favorable, with a few suggestions. Based on these suggestions, we have modified our proposed revisions.

   One comment asked for information regarding the requirement to test 48 hours after installation. This is based on a recommendation from AWC and is intended to address the potential for relaxation of the wood fibers and the possible effect this could have on end-grain withdrawal capacity.

2. Revisions are proposed on behalf of proponent Simpson Strong-Tie Company Inc. to address lateral capacity of fasteners installed into the edge of CLT panels in Section 3.4.4 of the proposed criteria. Initially, a method to determine an CLT edge factor, $C_{eg\text{-}clt}$, was proposed. No comments requesting technical changes were received. However, further study by staff has found that it is not possible to provide clear guidance at this time as to what the baseline test assembly should be for the purpose of comparison to testing in the edge of CLT panels. The proposed revision for Section 3.4.4 has been significantly revised to rely only on testing in the applicable CLT material, without trying to establish a factor that would be applied to other connections.

3. Staff is proposing several revisions based on staff experience and expanded knowledge, including review of standards used in the European Union (EU) for design of wood connections using dowel-type threaded fasteners. These revisions are needed to address a broader range of screw sizes and lengths, which may extend up to $^1/_2$ inch in diameter and over 3 feet in length. The proposed revisions, along with a summary of the comments received and our response, are detailed below:

   a. Revisions to Section 3.1.2 are proposed regarding acceptable wood test materials and applicability to other types of wood members. The comments we received on this proposal were supportive.

      An additional revision to Section 3.1.2 is proposed, limiting applicability of the provisions in AC233 to softwood species combinations. This is in response to a comment we received indicating that withdrawal and pull-through test results will depend not only on the specific gravity of the wood member, but also on the species. The proposed limitation is based on the understanding that species specific effects are more likely in hardwood species.

   b. Revisions to Section 3.2.1 and associated sections are proposed, allowing shear testing of fasteners used in wood-to-wood connections to be at the applicant's option, rather than being required in all cases. The comments we received on this proposal were supportive.

   c. Revisions to Section 3.2.1 are proposed to provide guidance on how to determine design fastener strengths for use in LRFD. While Appendix N of the NDS addresses conversion of NDS design values from ASD to LRFD, the proposed revision is needed because neither the body nor Appendix N of the NDS address determination of fastener strength. Note that an associated revision to Section 6.1.1 is proposed.

   d. Revisions to Section 3.2.2 are proposed requiring the holes used in steel side members to comply with the fastener manufacturer's requirements. The comments we received on this proposal were supportive.

   e. New Sections 3.3.1 and 3.3.2 are proposed to distinguish requirements for withdrawal of fasteners installed into the face of the wood member from those proposed for fasteners installed into the end of the wood member. Associated revisions to Section 4.2.3.1 are also proposed.

   f. We propose moving the requirements for bending yield strength determination from Section 3.4.1 to Section 3.2.1. We are also proposing new language regarding which fasteners need to be tested for bending yield strength.

g. Revisions to Section 3.4 are proposed regarding determination of reference lateral design values in accordance with the NDS. Associated revisions to Sections 6.1.3 and 6.3 are proposed to standardize how lateral design is addressed in the evaluation report. Also, a revision to Table 1 is proposed to require the reported bending yield strength, F_{yb}, to be the minimum specified F_{yb} for use in calculations in accordance with the NDS. The comments we received on this proposal were generally supportive, and our proposed revisions remain the same as what was proposed in June 2020.

h. Revisions to Section 3.7 and a replacement Table 6 are proposed to more clearly and comprehensively address requirements for connection geometry. We have considered comments received on this proposal, as follows:

   i. We have clarified that the provisions in the proposed Table 6 are only applicable to fasteners installed perpendicular to the face of the wood members.

   ii. We are aware that Table C12.1.5.7 of the Commentary to the 2018 NDS provides some distinct recommendations for steel-to-wood connections. We do not see that using a steel side member makes splitting of the wood less likely. This is why we consider the provisions in Table 6 to be applicable for both wood-to-wood and steel-to-wood connections, unless test data is submitted supporting alternate provisions.

   An additional condition is proposed in Section 3.7 to prevent splitting. The condition requires testing fasteners with diameter larger than 3/8 inch to determine the connection geometry. Section 12.1.4.3 of the 2018 NDS indicates that wood splitting may occur for lag screws with diameter larger than 3/8 inch.

   iii. Figures have been added to the proposed criteria draft for clarity.

   iv. We are aware of other concerns regarding the proposed Table 6, but did not receive clear suggestions for how these should be addressed within the table.

i. Revisions to the following sections of the criteria draft are proposed to address use of test data based on European standards to meet the requirements of AC233: 4.1.1, 4.2.1.2, 4.2.2, 4.2.3.1, 4.2.3.2, 4.2.5. The proposed revisions take into account comments received.

j. Revisions to Table 2 are proposed to remove wood structural panels from the footnotes, since assigned specific gravities applicable to withdrawal design are not given in the NDS for these products.

k. A standardized term is proposed to describe a common design feature of proprietary fasteners located between the threads and the smooth shank of the fastener and intended to facilitate installation by creating a hole in the wood members that is slightly larger than the diameter of the smooth shank. Based on input we received, the term we are proposing is “reamer knurl”, as shown in Section 1.4.4 of the proposed criteria.

l. A new index, Table 1.2, is proposed. We have modified this table from what was originally proposed, based on a comment we received.

m. (New comment) In addition to the sections of the criteria mentioned above, staff is proposing revisions to other sections, as follows:

i. Section 1.2.4: We are proposing a revision to make clear that provisions in Annex C are for connections that cannot be designed in accordance with the NDS.

ii. Sections 1.4.5, 3.3, 3.4.2, 3.5.2 and 4.2.2: Revisions are proposed to clarify that the factors applied to test values to determine reference design values are not purely safety factors, but also account for duration of load considerations.

iii. Addition of Sections 1.4.8 through 1.4.11, and associated revisions throughout, to standardize terminology used in the criteria.

iv. Section 2.1.4: An editorial revision to be consistent with ICC-ES policies.

v. Section 4.1.2.3: A revision is proposed to document guidance given to clients regarding bending yield strength testing. Since the test load is applied at the transition or threaded portion of the fastener, the fastener root diameter was set for the span length determination for the test.

vi. Section 4.2.3.1: Revisions are proposed to address fasteners installed at an angle other than 90 degrees to the face of the wood member.

vii. Section 4.2.3.1 and 4.2.5: Based on input we received, revisions are proposed to clarify that test member dimensions can deviate from the applicable ASTM and EN standards so that they are representative of member sizes that are intended for use with the proprietary fasteners.

viii. Section 4.2.3.1 and 4.2.5: Revisions are proposed to provide guidance regarding what to do when wood members split during installation and/or testing of the fasteners.

ix. A new Section 6.4 is proposed in response to comment received.

4. A new Sub-Annex CB is being proposed by ES Staff to standardize requirements for determining required spacing of dowel-type threaded fasteners used to attach deck ledgers to rim boards. Currently, Section R507.9.1.3(1) of the 2018 IRC prescribes maximum spacing for lag screws and bolts used for this purpose. This table was originally added to the 2009 IRC pursuant to code change proposal RB159-06/07.

   Since we are aiming to evaluate dowel-type threaded fasteners as alternates to the fasteners prescribed in Section R507.9.1.3 of the 2018 IRC, the test set-up and testing methods proposed are meant to provide comparable results to the testing used to support the requirements in the code.

   We have adjusted the proposed revisions for Sub-Annex CB compared to what was proposed in June 2020, based on the comments we have received.

Should the committee approve the proposed revisions to the criteria, the ICC-ES staff will not recommend a mandatory compliance date. Compliance with the revised criteria will be required for the following cases:

- Current applicants for new and revised reports.

- Future revisions to address the 2021 *International Building Code*® (IBC) and *International Residential Code*® (IRC). Changes in current evaluation reports are expected to include the following:
    - In many cases, the reported F_{yb} has been the strength measured by the testing laboratory. This will need to be adjusted to reflect the minimum specified F_{yb}. We will review quality documentation to determine the specified bending yield strength, and adjust the reported F_{yb} accordingly.
    - When connection geometry requirements in current reports differ from what is prescribed in Table 6 of the revised criteria, we will need to re-examine data on file to confirm that lesser dimensions have been adequately substantiated. If such substantiation is not found, the report holder will have the option to submit new data or we will revise the connection geometry in the ESR to agree with Table 6 of the revised criteria.
    - Editorial revisions will be made to address connection design in accordance with the NDS in a consistent manner.

You are invited to submit written comments on this or any other agenda item, or to attend the Evaluation Committee hearing and present your views in person. If you wish to contribute to the discussion, please note the following:

1. Regarding written comments and presentations:

    a. You should submit these via e-mail to es@icc-es.org to be received by the applicable due date.

    b. Comments are to be received by **September 10, 2020.** These written comments will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site shortly after the deadline for submission. Written comments that are not submitted by this deadline will not be considered at the meeting.

    c. For itemized concerns 1 and 2, rebuttal comments, from the proponent noted in this letter, are to be received by **September 22, 2020**. They will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site shortly after the deadline for submission. Written rebuttal comments that are not submitted by the deadline will not be considered at the meeting.

    d. If you want to make a visual presentation at the hearing, it must be received in PowerPoint format. Please identify the applicable itemized concern(s), to allow for efficient organization of presentations. The presentation is to be received by **October 2, 2020.** These will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site after the deadline for submission. Presentations that are not submitted by the deadline cannot be presented at the meeting. **Note:** Videos will not be posted on the web site.

    Presentations will be retained with other records of the meeting.

e. ICC-ES will post to the web site, on **October 2, 2020**, memos by the ICC-ES staff, responding to the previously received public comments.

f. If you miss the deadlines for submission of written comments and visual presentations, your verbal comments can be presented at the Webex Event meeting.

g. Proposed criteria, written public comments, visual presentations, and responses by ICC-ES staff for this agenda item are all available on our website.

2. Regarding verbal comments and presentations:

   Please plan to speak for not more than ten minutes. As noted above, visuals are to be in PowerPoint format and will be shown during the Webex Event meeting.

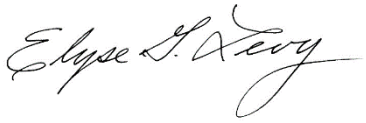
3. Keep in mind that all materials submitted for committee consideration are part of the public record and will not be treated as confidential. It is the presenter's responsibility to certify to ICC-ES staff that no materials infringe copyright.

4. Please do not communicate with committee members before the meeting about any items on the agenda.

We appreciate your interest in the work of the Evaluation Committee. If you have any questions, please contact me at (800) 423-6587, extension 4315, Mohamed Gallow, PhD., P.E., Staff Engineer, at extension 5333, or Thomas Engleder, PhD., Product Evaluation Specialist, at +49 175 6909260. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

Elyse G. Levy, S.E.
Senior Staff Engineer



EL/MG/ls

Encl.

cc: Evaluation Committee

Laurie Spandle

From: ICC-ES Website <no-reply@icc-es.org>
Sent: Wednesday, July 1, 2020 1:38 PM
To: Rosalind Fazel
Subject: A Comment has been received

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A Comment has been received.

The details submitted are as follows:

Field Name	Field Value
Criteria Number	AC233
Email	henry.schniedermeier@itwresidential.com
Name	Henry
Company	Schniedermeier
Phone	847-247-4984
Comments	1. ASTM D1761 guidance/requirements for wood specimen sizes seem to be inadequate for large diameter fasteners (maybe 3/16" and up). I such situations, failure mode may be restricted by inherent limitations of small wood specimens. 2. The AC should offer guidance instructing users to narrow the SG of the wood that they're using. Often, fasteners are evaluating in species groups rather than focusing more heavily on similar species groups, but narrowing the SG requirements within the groups. A given wood species can have a wide range of specific gravities variance from board to board. Section 3.3.2, end-grain testing, calls out wood species. NDS formulas for withdrawal are based on specific gravity.

June 29, 2020

Ms. Elyse G. Levy S.E.
Senior Staff Engineer
ICC Evaluation Service, LLC
Birmingham Regional Office
900 Montclair Road, Suite A
Birmingham, AL 35213

RE: AC233-0620-R1(EL/MG/TE)
Proposed Revisions to the Acceptance Criteria for Dowel-type Threaded Fasteners Used in Wood

Dear Ms. Levy:

In response to your June 1, 2020 posting of the Proposed Revisions to the Acceptance Criteria for Dowel-type Threaded Fasteners Used in Wood, AC233, MiTek would like to share the following general comments.

Proposed Revision 1, End-grain Withdrawal of Screws

The Commentary in the NDS mentions the erratic results in the withdrawal testing of screws in the end-grain and, because of the irregularity, structural loading of screws in withdrawal from the end-grain has been prohibited. With the splitting issue in mind, MiTek can understand this when a traditional screw is being used in this application. With the AWC NDS allowing structural applications of lag screws loaded in end-grain withdrawal, MiTek recommends limiting the testing and application to screws with a self-drilling tip.

Proposed Revision 3

3a. MiTek agrees that test results from using solid sawn or glulam lumber can be applied to CLT.

3b. MiTek agrees that shear testing of the fastener is not the limiting factor when determining the lateral load capacity of dowel fasteners and, therefore, this testing and published value can be optional.

3c. Appendix N of the AWC NDS addresses LRFD conversion of connection design values which is mandatory. MiTek is unsure as to why ICC-ES is addressing this issue.

3d. MiTek agrees. Additionally, the size of the fastener hole in the steel side plate used during testing should be listed in the Evaluation Report.

3e. MiTek has no additional comment.

3f. MiTek has no additional comment.

3g. Our response is in reference to Proposed Revison 3.g.iii. MiTek has investigated the use of the AWC TR12 analysis and found no appreciable difference in the calculated capacity compared to using the simplified equations in the AWC NDS. As such, the reference to AWC TR12 can be removed.

3h. MiTek agrees that a table clearly defining the geometry requirements would be beneficial. As per the comments below, values for both wood and steel side plates should be listed.

3hi. MiTek finds the proposed geometry listed in this section acceptable with the exception of the comparison with Eurocode 5. The current published geometry listed in the NDS was derived from testing in the US.

3hii. There should be a maximum diameter on the self-drilling screws before switching to NDS Section 12.5.1. The NDS does not require lead holes for lag screws 3/8 inch diameter and smaller when loaded in withdrawal. MiTek believes that this may be a reasonable maximum.

3hiii. These lesser values when using steel side plates were determined thru testing in the US by T.E. McLain and published in 1981.

3i. There were a number of compromises made when bringing the European Yield Mode equations to the US (see Bolted Connection Design Values Based on European Yield Model, Journal of Structural Engineering/Volume 119 Issue 7 - July 1993). For connections with wood side members, the agreed upon R_d reduction term (calibration factor) resulted in generally higher design values (over NDS table values) for fasteners loaded parallel to grain while the opposite was true for steel side member connections. For loading perpendicular to grain, using the EYM mode equations with the calibration factor generally resulted in higher design values for both wood and steel side members. As such, care must be taken when trying to establish the appropriate conversion factor.

3j. MiTek has no additional comment.

3k. MiTek has no additional comment.

3l. MiTek has no additional comment.

Proposed Revision 4

MiTek's comments regarding Sub-Annex CB will be addressed later in this response letter.

AC233 Section 3.1.2

Does the term "side grain", as opposed to end-grain, include both the wide face and narrow face of sawn lumber and glulams?

AC233 Section 3.4.1

Should the second sentence include the possible variations in steel side member thickness?

AC233 Section 3.4.4

It would be greatly beneficial to have illustrations to clarify each test setup.

Table 6

Revise this table based upon the MiTek comments listed for Proposed Revision 3h.

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Sub-Annex CB Section CB2.0

The term “wet condition” needs to be defined. Since typical rain events do not constitute a “wet service” condition, it should be defined what the minimum moisture content should be at the time of testing and at what depth within the ledger this measurement should be made.

The “dry condition” of the rim board should also be defined by a minimum moisture content.

Regarding Sub-Annex CB Section CB3.0

It should probably be clarified that the displacement is relative to the rim board.

Regards,

Steven A. Brekke, P.E.
Sr. Engineer – Product Scientist
MiTek - USP Structural Connectors

June 29, 2020

Ms. Elyse Levy
International Code Council – Evaluation Service
4951 Flossmoor Road
Country Club Hills, IL 60478

RE: AC233-0620-R1

Dear Ms. Levy;
Simpson Strong-Tie has reviewed AC233-0620-R1. We offer the following comments to further the criteria development. Inasmuch as this is an Alternate Agenda, some of our comments are made to be informative and do not include proposed alternate language. Rather than offering section-by-section comments, this letter poses comments referenced to item numbers in the staff letter of June 1, 2020.

ITEM 1. End-grain withdrawal

1a. This methodology arose from our attempt to assign end-grain withdrawal design values for CLT, glulam, and lumber because we receive requests for this information from design engineers. It is appropriate to conduct the evaluation over the specific gravity range of commercial wood species combinations as recommended in section 3.3.2.1. The specification low specific gravity species combinations Redwood and Western Woods is western centric and these species combinations may not be available in all parts of the country. Any wood species combination with assigned specific gravity that is less than or equal to 0.36 could be used. A wood species combination such as SPF-South would be an acceptable alternate, however, naming a specific species combination imposes problems of procurement. Recommended revised sentence: Douglas Fir-Larch, Spruce-Pine-Fir, and an approved wood species combination with assigned specific gravity less than 0.37.
1b. In section 4.2.3.2 (3), the objective is not apparent for the test 48hrs after assembly; and it is not consistent with other test practice. It is assumed that this is one of the end-grain withdrawal tests referenced in the second to last paragraph in this section.
1c. No comment at this time.
1d. No comment at this time.

ITEM 2. Qualification of end-grain factor for fasteners installed in narrow face of CLT and laterally loaded

Connection testing with wood members oriented parallel and perpendicular to loading direction have been standard practice for many years. The request for this assessment arose from our work to assign design values for loading conditions illustrated in NDS, Figure 12I. Table 6 that is being removed, required tests for connection geometry that comply with the referenced NDS Figure, and the new Table 6 includes connection geometry requirements that require test method guidance. The section would benefit from some figures that illustrate the test as described in subsections 1-4. We agree that the factor 0.67 is a reasonable limitation.

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ITEM 3. Revisions based on Staff information and EU standards

3a. We agree with this decision.

3b. The shear test can be awkward for screws with coarse threads. However, for fully threaded screws used with steel side plates, screw shear strength can be a limit state. Shear strength of the fastener should be retained at least as an optional property.

3c. No comment at this time.

3d. We agree with this assessment.

3e. No comment at this time.

3f. We find it acceptable to move required Bending yield strength from 3.4.1 to 3.2.1 with testing as described in 4.1.2. At the same time, the proposed revision of 3.2.1 that includes specified "mechanical properties (e.g., hardness)" is not acceptable. We are open to publishing engineering mechanical properties that can be used by the design engineer, however, hardness profile is a proprietary feature; is not useable in engineering design; and should not be published in the evaluation report. Other engineering properties, such as tension, shear, and bending are appropriate and useful to the engineering community.

3g.i. We agree with this analysis.

3g.ii. We agree that some limited demonstration of performance is appropriate. It seems that the sections 3.4.1.3 and 3.4.1.6 could be viewed as in conflict with Section 3.1.2. Section 3.1.2 requires the specimens have specific gravities equal to or less than the NDS. However, section 3.4.1.6 requires that the wood complies with the NDS meaning that the average of the specimens complies with the NDS. The new section 3.4.1.3 requires the use of wood properties of the wood members tested, which is appropriate when comparing calculated and tested performance.

3g.iii. In section 3.4.1, it is assumed that the average tested bending yield strength from 3.2.1 is used for calculations of each connection. TR12 may have some value as a calculation method depending on the connection geometry. However, we concede that deleting the applicable section is acceptable given that it has not been imposed by any proponent as of this time.

3h. The table revisions need some further explanation from Staff. Are these applicable to fasteners that are installed normal to the surface as well as fasteners that are installed at an angle to the surface that is other than normal? Is the intent that these configurations would be assigned specific load values? The table is extremely difficult to decipher with respect to orientation of the members in the connection. We would welcome an opportunity to discuss the table.

3i.i It is acceptable to include the named EN standards as alternates to ASTM standards. In section 1.3.17, 1.3.18, and 1.3.19, the references to EN standards can be without the prefix DIN as the DIN indicates the German version of the harmonized EN standard. The copyright and publication information then belongs to the European Committee for Standardization, Brussels, The Netherlands rather than the Deutsches Institut für Normung. Also, the most recent revision of EN 1383 is 2016.

3i.ii. We agree with this assessment.

3i.iii. We agree with this assessment.

3i.iv. Is there a precedence for the use of 6.0 as a safety factor for reduced testing? Is the safety factor still subject to short-term DOL adjustments? With a factor of 6.0 and a short-term DOL adjustment, the safety factor moves from 3.12 to 3.75. In other standards with minimum numbers of tests, the allowable is often based on the first-order statistic rather than the average. If the intent is to base the allowable on the average, the proposed language needs a minimum number of tests that is sufficient to reasonably approximate the average. It is recommended to add this or similar language to the section: At least 8 samples shall be required.

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3i.v. The proposed adjustment factor of 1.2 adjusts the density data value from the characteristic value (5th percentile) to the mean of the distribution. However, the moisture condition must also be adjusted because the reference condition for density in EN 338 is weight and volume at 12% moisture content while the reference condition of specific gravity in the NDS is oven-dry weight and volume. The methods of ASTM D2395 should be specified for the moisture condition adjustment of specific gravity and density.

3j. It is acceptable to remove the general reference to WSP from the Table 2 notes for the reasons given. It might be acceptable for a proponent to use the equivalent specific gravity values from APA *Panel Design Specification* D510, Table 4 as a default. Then, if proponents want to get higher values they can test for them. It would be good to determine a specific characteristic of wood panels to use as a guide to material strengths so applicants can test one manufacturer's panel and rate all of them that have that characteristic as a minimum. At the same time, we do not understand the removal of reference to WSP and NDS Table 12.3.3B from the notes of Table 4.

3k. The proposed terminology fails to reflect the function of some geometries of shank knurls. Twisted knurls with sharp edges may be designed to cut, however, knurls that are not sharp and are aligned with the shank axis are designed to ream. It is preferred to refine the terminology to "reaming knurl," which is more universal and appropriately describes the knurl function.

3l. Inclusion of the table is helpful. However, each section should either have all sections included (analysis and testing) or just one section included (analysis), which then contains references to the required test sections. To be consistent, annexes should include all possible testing an analysis sections from Sections 2 through 6 even if they are referenced in the annex.

ITEM 4. Proposed new Sub-Annex CB for fastening deck ledgers to rim boards

We have reservations related to this part of the proposed revisions. Simpson Strong-Tie has conducted hundreds of ledger-to-rim tests for the purpose of assigning design values to screws for the ledger-to-rim connection. It is appropriate that there is a common practice for this test. At the same time, the proposed annex addresses a specific connection, and this departs from the objective of the AC. The objective of the AC is to demonstrate that the proponent fastener meets the intent of the codes. In other cases where specific uses and issues are considered, the user first demonstrates that the fastener is a structural fastener and then demonstrates that the fastener complies with the specific requirements of the code. The new index illustrates this point where the proponent is directed to AC257 for corrosion resistance and AC120 for shear walls and diaphragms. The same practice should be implemented for ledger-to-rim connections. It is difficult to imagine a reason that this is not an ASTM test method rather than an AC. Our comments related to this as an annex are made with the intent that ledger-to-rim fastening is moved to a separate criteria rather than an Annex of AC 233.

a. In the General Section the subsections are misnumbered; CB2.1 should be CB1.1 and CB2.2 should be CB1.2.
b. In CB2.2, remove the requirement that the tip must penetrate beyond the rim member. A screw that has a tip that penetrates just beyond a 2x rim should also be allowed for use in a 4x rim.
c. In CB2.0, the tip penetration requirement should be removed. See previous comment. This requirement might be applicable to lag screws but not wood screws as the tips are addressed differently for lags and screws in the NDS.

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d. In CB2.0, a number of items need clarification regarding the test set up:
    1. The set up should be symmetrical. Although the original testing used a solid support on the non-tested side of the set-up, symmetry in the test assembly removes stiffness differences that can lead to uneven load distribution. A single load cell does not capture this load difference.
    2. Is the minimum moisture content requirement for the ledger > 19% like in the original testing or > 25% per Section 3.6?
    3. Clarification is needed on the minimum grade of sheathing that is included in the test as opposed to that identified in the evaluation report.
    4. How is the sheathing attached to the rim? There should be a specific fastener size and minimum spacing to simulate the code required attachment. We recommend using 6d nails at the corners and 6-in o.c. minimum.
    5. There should be at least two test fasteners per ledger. Having one fastener near the bottom of the ledger does not capture the very great potential for cross grain tension action by having some of the joist load delivered below the top fasteners.
    6. The AC needs clarification on the relative positions of the tested fastener to the load applying joists. If the fastener is in between the joists, how can end distances be tested? The test set up could have the joists on the inside and fasteners on the outside.
    7. How far away do the fasteners need to be from the joist hanger fasteners? The AC should state that the hanger fasteners must not penetrate through the ledger thickness.
    8. The set-up should allow for horizontal bracing of the rim material similar to the support given to headers in an AC13 joist test.
    9. The AC should have a drawing showing the test set up, including the required dimensions and the variable dimensions. This will eliminate variations between applicants that could have an effect on the final allowable loads.
e. In CB3.0, the language should clarify the ultimate load is the average ultimate load. In addition, there should be a limitation that the fastener used in the ledger shall not have a higher allowable load than the fastener when used in a similar two-member lateral shear connection. Also, add a statement permitting load adjustments for load duration.
f. For test assemblies that use more than one fastener, the sample quantity requirement should be similar to that of Section CA3.3 that allows for using the lowest ultimate of five tests or the average ultimate of six or more tests.
g. In CB6.0, the evaluation report should report that the reference allowable load includes the effect of elevated moisture content and no further adjustment is needed for elevated moisture content.

Section 3.1.2 on wood members indicates that reference design values are developed for species combinations listed in NDS Table 12.3.3A. The European strength classes are not species centric. When evaluating test data from Europe, how will the EN strength classes be integrated into the species combinations requirement of the criteria? Are European data from strength classes to be held to the same specific gravity criteria, that is the criteria being equal to or less than the assigned NDS value?

During the course of review, we identified several other editorial revisions in the revision text, and we will send an annotated pdf to Staff with those editorial revisions.

Simpson Strong-Tie Company Inc. 5956 W. Las Positas Boulevard Pleasanton, CA 94588 Phone: 925.560.9000 Fax: 925.847.1605 www.strongtie.com

We appreciate the opportunity to review and comment on this important revision. We are available for discussion as needed. I can be reached at rleichti@strongtie.com.

Sincerely,
SIMPSON STRONG-TIE COMPANY INC.

Robert Leichti
Engineering Manager, Fastening

Cc: N. Tapata
S. Yim
A. Khachadourian
J. Ellis

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SWG: Comments on the proposed revisions to AC233-0620-R1

Division Production

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Please also see these comments from SWG directly in the pdf file, next to the text.

1. SWG Comment, on page 1:
   We are of the opinion, that there should be a kind of protection/preservation for the existing SWG reports (our status quo), e.g. in relation to the edge distances.
   This should mean that we would not have to prove the regulations in our reports again with additional tests for future renewals.

2. SWG Comment, on page 5:
   Regardless of a possible acceptance of the European test standards, we assume that the tests must continue to be carried out by an accredited test laboratory.
   Test reports that were carried out before accreditation of a test laboratory should not be accepted as the basis for an ICC report.

3. SWG Comment, on page 5:
   Test such as thread extraction or head pull are significantly influenced by the wood species used.
   For this reason, wood species that correspond to the local conditions should continue to be used, e.g. north American Douglas Fir, SPF, etc.

4. SWG Comment, on page 4:
   Root diameter is not the conservative case in all instances.

   When testing bending yield strength the smaller diameter will result in an increased bending yield strength.

   A method taking into account the actual diameter of the wood screw in the shear plane should be looked at.

   Partially threaded screws can have either shank or minor diameter in the shear plane and yield different results.

   Fully threaded screws can only have the minor diameter in the shear, unless, a steel to wood connection is designed, then, a shank diameter may also be in the shear plane.

5. SWG Comment, on page 8 of 21:
   In section 4.1.1, EN 1383:1999 is cited.
   Timber structures - Test methods
   Pull through resistance of timber fasteners.

   Is this norm really appropriate/suitable in this case?
   Also, the current edition is from July 2016. Does this need to be adjusted?

ICC EVALUATION SERVICE, LLC, RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE

1.0 PURPOSE

The purpose of the Evaluation Committee is to review and approve acceptance criteria on which evaluation reports may be based.

2.0 MEMBERSHIP

2.1 The Evaluation Committee has a membership of not fewer than nine, with one of the members named by the ICC-ES president each year to serve as the chairman–moderator.

2.2 All members of the committee shall be representatives of a body enforcing regulations related to the built environment.

2.3 Persons are appointed to the committee by the ICC-ES president, from among individuals who have formally applied for membership.

2.4 The ICC-ES Board of Managers, using simple majority vote, shall ratify the nominations of the president.

2.5 Committee membership is for one year, coinciding with the calendar year. Members may be renominated and reappointed, but no person shall serve for more than five consecutive terms.

2.6 In the event that a member is unable to attend a committee meeting or complete a term on the committee, the ICC-ES president may appoint a replacement to fill in at the meeting or for the remainder of the member's term. Any replacement appointed for only one meeting must have prior experience as a member of the Evaluation Committee. Appointments under this section (Section 2.6) are subject to ratification as noted in Section 2.4.

3.0 MEETINGS

3.1 The Evaluation Committee shall schedule meetings that are open to the public in discharging its duties under Section 1.0, subject to Section 3.0.

3.2 All scheduled meetings shall be publicly announced. There shall be three meetings per year.

3.3 More than half of the Evaluation Committee members, counting the chairman, shall constitute a quorum. A majority vote of members present is required on any action. To avoid any tie vote, the chairman may choose to exercise or not exercise, as necessary, his or her right to vote.

3.4 In the absence of the chairman–moderator, Evaluation Committee members present shall elect an alternate chairman from the committee for that meeting. The alternate chairman shall be counted as a voting committee member for purposes of maintaining a committee quorum and to cast a tie-breaking vote of the committee.

3.5 Minutes shall be kept and shall be the official record of each meeting.

3.6 An electronic record of meetings may be made by ICC-ES if deemed necessary; no other audio, video, electronic recordings of the meetings will be permitted. Visual aids (including, but not limited to, charts, slides, videos, or presentation software) viewed at meetings shall be permitted only if the presenter provides ICC-ES before the presentation with a copy of the visual aid in a medium which can be retained by ICC-ES with its record of the meeting and which can also be provided to interested parties requesting a copy.

3.7 Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members regarding agenda items. All written communications and submissions regarding agenda items must be delivered to ICC-ES and shall be considered nonconfidential and available for discussion in open session of an Evaluation Committee meeting. Such materials will be posted on the ICC-ES web site (www.icc-es.org) prior to the meeting. Comments and submissions not meeting the following deadlines will not be considered at the meeting:

- Initial comments on agenda items shall be submitted at least 28 days before the scheduled meeting.
- A rebuttal comment period shall follow, whereby rebuttal comments to the initial comments may be submitted by the proponent at least 21 days before the scheduled meeting.
- Those planning on giving a visual presentation at the meeting must submit their presentation, in PowerPoint format only, at least 10 days before the scheduled meeting.

The committee reserves the right to refuse recognition of communications which do not comply with the provisions of this section.

4.0 CLOSED SESSIONS

Evaluation Committee meetings shall be open except that at the discretion of the chairman, staff counsel may be necessary. Also, matters related to clients or potential clients covered by confidentiality requirements of ICC-ES Rules of Procedure for Evaluation Reports are discussed only during closed meetings.

5.0 ACCEPTANCE CRITERIA

5.1 Acceptance criteria are established by the committee to provide a basis for issuing ICC-ES evaluation reports on products and systems under codes referenced in Section 2.0 of the Rules of Procedure for Evaluation Reports. They also clarify conditions of acceptance for products and systems specifically regulated by the codes.

Acceptance criteria may involve a product, material, or method of construction. Consideration of any acceptance criteria must be in conjunction with a current and valid application for an ICC-ES evaluation report, an existing ICC-ES evaluation report, or as otherwise determined by the ICC-ES President.

EXCEPTIONS: The following acceptance criteria are controlled by the ICC-ES executive staff and are not subject to committee approval:

- The Acceptance Criteria for Quality Documentation (AC10)
- The Acceptance Criteria for Test Reports (AC85)
- The Acceptance Criteria for Inspections and Inspection Agencies (AC304)

5.2 Procedure:

5.2.1 Proposed acceptance criteria shall be developed by the ICC-ES staff and discussed in open session with the Evaluation Committee during a scheduled meeting, except as permitted in Section 4.0 of these rules.

5.2.2 Proposed acceptance criteria shall be available to interested parties at least 30 days before discussion at the committee meeting.

5.2.3 The committee shall be informed of all pertinent written communications received by ICC-ES.

5.2.4 Attendees at Evaluation Committee meetings shall have the opportunity to speak on acceptance criteria listed on the meeting agenda, to provide information to committee members. In the interest of fairness, each person requesting to testify on a proposed acceptance criteria or proposed changes to an existing acceptance criteria will be given the same amount of time. The following time limits are established:

a. For entities offering their first testimony on any item, a 10-minute limit applies. This time limit applies to both verbal testimony and/or visual presentations.

b. Each person offering testimony may return to the microphone for one five-minute period to offer additional testimony and/or to rebut testimony given by others.

c. Each person offering testimony on the staff recommendation, on each criteria, is allowed one, two-minute trip to the microphone.

Time limits do not include time needed to answer questions from the staff and/or committee members. The chairman–moderator shall have limited authority to modify time limitations on testimony. The chairman–moderator shall also have the authority to adjust time limits as necessary in order to get through the hearing agenda.

Keeping of time for testimony by an individual will be by an automatic timing device. The time remaining shall be evident to the person testifying. Interruptions during testimony will not be tolerated. It is the responsibility of the chairman–moderator to maintain decorum and order during all testimony.

5.3 Approval of any action on an acceptance criteria shall be as specified in Section 3.3 of these rules. Possible actions made by the Evaluation Committee include: Approval; Approval with Revisions; Disapproval; or Further Study. The Evaluation Committee must give the reason(s) for any Disapproval or Further Study actions with specific recommendations.

5.4 Actions of the Evaluation Committee may be appealed in accordance with the ICC-ES Rules of Procedure for Appeal of Acceptance Criteria or the ICC-ES Rules of Procedure for Appeals of Evaluation Committee Technical Decisions.

6.0 COMMITTEE BALLOTING FOR ACCEPTANCE CRITERIA

6.1 Acceptance criteria may be revised without a public hearing following a 30-day public comment period and a majority vote for approval by the Evaluation Committee, when at the discretion of the ICC-ES executive staff, the subject is a revision that requires formal action by the Evaluation Committee.

6.2 Negative votes must be based upon one or more of the following, for the ballots to be considered valid and require resolution:

a. *Lack of clarity*: There is insufficient explanation of the scope of the acceptance criteria or insufficient description of the intended use of the product or system; or the acceptance criteria is so unclear as to be unacceptable. (The areas where greater clarity is required must be specifically identified.)

b. *Insufficiency*: The criteria is insufficient for proper evaluation of the product or system. (The provisions of the criteria that are in question must be specifically identified.)

c. *The subject of the acceptance criteria is not within the scope of the applicable codes*: A report issued by ICC-ES is intended to provide a basis for approval under the codes. If the subject of the acceptance criteria is not regulated by the codes, there is no basis for issuing a report, or a criteria. (Specifics must be provided concerning the inapplicability of the code.)

d. *The subject of the acceptance criteria needs to be discussed in public hearings*. The committee member requests additional input from other committee members, staff or industry.

6.3 An Evaluation Committee member, in voting on an acceptance criteria, may only cast the following ballots:

- Approved
- Approved with Comments
- Negative: Do Not Proceed

7.0 COMMITTEE COMMUNICATION

Direct communication between committee members, and between committee members and an applicant or concerned party, with regard to the processing of a particular acceptance criteria or evaluation report, shall take place only in a public hearing of the Evaluation Committee. Accordingly:

7.1 Committee members receiving an electronic ballot should respond only to the sender (ICC-ES staff). Committee members who wish to discuss a particular matter with other committee members, before reaching a decision, should ballot accordingly and bring the matter to

the attention of ICC-ES staff, so the issue can be placed on the agenda of a future committee meeting.

7.2 Committee members who are contacted by an applicant or concerned party on a particular matter that will be brought to the committee will refrain from private communication and will encourage the applicant or concerned party to forward their concerns through the ICC-ES staff in writing, and/or make their concerns known by addressing the committee at a public hearing, so that their concerns can receive the attention of all committee members.■

Revised August 2020

ICC EVALUATION SERVICE

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PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR DOWEL-TYPE THREADED FASTENERS USED IN WOOD

AC233

Proposed August 2020

Previously approved February 2020, October 2019, October 2018, April 2015, June 2014, June 2012, June 2011, June 2010, October 2009, February 2007, October 2006, February 2006, October 2005, June 2005, June 2004

(Previously editorially revised August 2015, August 2013)

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the *International Building Code*® reads as follows:

> **The provisions of this code are not intended to prevent the installation of any materials 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.**

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

Acceptance criteria are developed for use solely by ICC-ES for purposes of issuing ICC-ES evaluation reports

PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR DOWEL-TYPE THREADED FASTENERS USED IN WOOD (AC233)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for dowel-type threaded fasteners (standard and alternate) addressed in an ICC Evaluation Service, LLC (ICC-ES), evaluation report under the 2018, 2015, 2012, 2009 and 2006 *International Building Code*® (IBC) and the 2018, 2015, 2012, 2009 and 2006 *International Residential Code*® (IRC). Bases of evaluation are IBC Section 104.11 and IRC Section R104.11. The reason for development of this criteria is to provide guidelines for the evaluation of fasteners, held in place by threaded anchorage in the main member, which are alternates to those addressed by the code or the code reference, the NDS, as well as use of standard and alternate dowel-type threaded fasteners which are used in assemblies that are not addressed in the code.

1.2 Scope: Requirements for evaluation of dowel-type threaded fasteners intended for use in various applications are addressed within this criteria, as follows, and as indexed in Table 1.2:

1.2.1 Evaluation of fastener strength and single-fastener reference lateral, withdrawal and pull-through design values for alternate dowel-type threaded fasteners used for connections between wood (sawn lumber) members, engineered wood members and/or steel members where at least one of the members is wood or engineered wood shall be in accordance with Sections 2.0 through 6.0.

1.2.2 Use of dowel-type threaded fasteners (both standard and alternates) which are intended to attach wood structural panel sheathing to wood framing for use in diaphragms, shear walls and braced walls shall be evaluated in accordance with Annex A.

1.2.3 Dowel-type threaded fasteners used to attach miscellaneous building materials to wood shall be evaluated in accordance with Annex B.

1.2.4 Load capacities of wood connection configurations that cannot be designed in accordance with the NDS shall be evaluated in accordance with Annex C. ~~See Section C1.0 for a description of wood connection types which are currently addressed in this criteria.~~

TABLE 1.2—CRITERIA INDEX

Type of qualification	Location of Requirements	Design Characteristic	Section Addressing Test and Performance Requirements
Alternate dowel-type threaded fastener used in two-member tension and/or lateral connections	Sections 2.0 through 6.0	Fastener shear, tension and bending yield strength	3.2.1
		Reference withdrawal design values	3.3
		Withdrawal from face of member	3.3.1
		Withdrawal from end grain of member (for self-drilling fasteners)	3.3.2
		Reference lateral design values	3.4
		Determined in accordance with NDS	3.4.1
		Determined by testing	3.4.2
		Narrow edge of CLT	3.4.4
		Reference pull-through design values	3.5
		Wet service use	3.6
		Minimum connection geometry	3.7
		Prescriptive fastening designs as alternates to nails prescribed in the code	3.8
Dowel-type threaded fasteners used to fasten wood structural panel sheathing to wood framing for use in diaphragms, shear walls and braced walls	Annex A	Qualification as substitute for code prescribed nails	AC120
Dowel-type threaded fasteners used to attach miscellaneous materials to wood, and for wood-to-wood connections not directly addressed in Sections 2.0 through 6.0.	Annex B	Fastener shear, tension and bending yield strength	3.2.1
		Reference withdrawal design values	3.3
		Minimum connection geometry	3.7
Assemblies constructed with dowel-type threaded fasteners, which are not addressed in the NDS	Annex C	Lateral design values for Wood-to-wood and Steel-to-wood connections with fasteners installed at an angle to the surface of the members	Sub-Annex CA
		Lateral design values for fasteners used to attach deck ledgers to rim board.	Sub-Annex CB

1.3 Codes and Referenced Standards: For the applicable editions of the referenced standards, see the table at the end of Section 1.3.

1.3.1 2018, 2015, 2012, 2009 and 2006 *International Building Code*® (IBC), International Code Council.

1.3.2 2018, 2015, 2012, 2009 and 2006 *International Residential Code*® (IRC), International Code Council.

1.3.3 AISC 360, Specifications for Structural Steel Buildings, American Institute of Steel Construction.

1.3.4 AISI S100, North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute.

1.3.5 AISI S904, Standard Test Methods for Determining the Tensile and Shear Strength of Screws, American Iron and Steel Institute.

1.3.6 ANSI/AWC (ANSI/AF&PA) National Design Specification for Wood Construction (NDS), American Wood Council (American Forest & Paper Association).

~~**1.3.7** AWC Technical Report 12, General Dowel Equations for Calculating Lateral Connection Values, American Wood Council.~~

~~**1.3.8**~~**1.3.7** ANSI/ASME Standard B18.2.1, Square and Hex Bolts and Screws (Inch Series), American Society of Mechanical Engineers.

~~**1.3.9**~~**1.3.8** ANSI/ASME Standard B18.6.1, Wood Screws (Inch Series), American Society of Mechanical Engineers.

~~**1.3.10**~~**1.3.9** ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

~~**1.3.11**~~**1.3.10** ASTM D1037, Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials, ASTM International.

~~**1.3.12**~~**1.3.11** ASTM D1761, Test Method for Mechanical Fasteners in Wood, ASTM International.

~~**1.3.13**~~**1.3.12** ASTM D2395, Standard Test Method for Specific Gravity of Wood and Wood-Based Materials, ASTM International.

~~**1.3.14**~~**1.3.13** ASTM D2915, Standard Practice for Evaluating Allowable Properties for Grades of Structural Lumber, ASTM International.

~~**1.3.15**~~**1.3.14** ASTM D4442, Standard Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials, ASTM International.

~~**1.3.16**~~**1.3.15** ASTM D4444, Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters, ASTM International.

~~**1.3.17**~~**1.3.16** ASTM F1575, Standard Test Method for Determining Bending Yield Moment of Nails, ASTM International.

1.3.17 EN 1382:2016, Timber Structures – Test Methods – Withdrawal Capacity of Timber Fasteners, European Committee for Standardization.

1.3.18 EN 1383:2016, Timber Structures – Test Methods – Pull Through Resistance of Timber Fasteners, European Committee for Standardization.

~~**1.3.18**~~**1.3.19** NASM1312-20, National Aerospace Standard Practice for Fastener Test Methods, Method 20, Single Shear; Aerospace Industries Association of America, Inc.

TABLE 1.3—APPLICABLE EDITIONS OF REFERENCED STANDARDS[1,2]
(continued on next page)

STANDARD	2018 IBC & IRC	2015 IBC & IRC	2012 IBC & IRC	2009 IBC & IRC	2006 IBC & IRC
AISC 360	2016	2010		2005	
AISI S100	-16	-12	-07/S2-10	-07	AISI-NAS
AISI S904	-08 and -13				
AWC (AF&PA) NDS	-18				
~~AWC Technical Report 12~~	~~2014~~				
ANSI/ASME B18.2.1	1996 through 2012				
ANSI/ASME B18.6.1	1981 (reaffirmed 2008)				
ASTM A370	-11a				
ASTM D1037	-06a				
ASTM D1761	-06				
ASTM D2395	-07a through -17				
ASTM D2915	-03 through -10				
ASTM D4442	-07				
ASTM D4444	-08				
ASTM F1575	-03 (2013)				
NASM1312-20	1997				

[1]When multiple editions of a standard are listed above, this criteria is written using the applicable section numbers for the latest edition, unless otherwise noted.

[2]When a range of editions of a standard is listed above, the editions within the range are deemed to be technically equivalent for the purposes of this criteria. New report applicants are expected to use the latest edition referenced. Current report holders, whose evaluation reports are based on data required by one of the earlier editions of the standard, will not need to submit new data to demonstrate compliance with the latest edition of the referenced standard.

1.4 Definitions:

1.4.1 Alternate Dowel-type Threaded Fastener: A fastener which is self-drilling and/or has dimensions which differ from those specified in ANSI Standard B18.2.1 (for lag screws) and ANSI Standard B18.6.1 (for wood screws).

1.4.2 Engineered Wood: For purposes of this criteria, engineered wood includes products such as structural glued-laminated timber, wood structural panels, and structural composite lumber, complying with IBC Section 2303.

1.4.3 Fastener Class: A group of fastener products from the same manufacturer which have the same raw material specifications and manufacturing processes. Fasteners within the fastener class can differ in diameter, head style and length, but have similar thread design.

1.4.4 Reamer Knurl: A shank deformation located between the fastener threads and the smooth shank of the fastener, used to facilitate installation in wood. The knurls may be straight or twisted and may be designed to cut or ream the wood.

1.4.5 Reference Factor: A factor applied to test values to determine reference design values. This factor accounts for a safety factor and for duration of load.

~~1.4.4~~**1.4.6 Specific Gravity (G):** For purposes of this criteria, specific gravity means the physical specific gravity of sawn lumber as determined in accordance with ASTM D2395 or the equivalent specific gravity for engineered wood products reported in an ICC-ES evaluation report, as applicable.

~~1.4.5~~**1.4.7 Standard Dowel-type Threaded Fastener:** A lag screw or wood screw complying with ANSI Standard B18.2.1 or B18.6.1, respectively.

1.4.8 Test Specimen: One tested assembly.

1.4.9 Test Sample: A grouping of replicate test specimens or comparative test sets.

1.4.10 Comparative Test Set: A grouping of one test specimen each of assemblies with distinct features or test procedures.

1.4.11 Wood Member:

1.4.11.1 Face: A surface of the wood member which is parallel to the grain of the wood.

1.4.11.2 End: A surface of the wood member which is cut perpendicular to the grain of the wood.

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted to ICC-ES:

2.1.1 Product Description: Complete information concerning material specifications (including steel specifications, specified minimum bending yield strength, F_{yb}, etc.), diameters (shank, outside thread and root), thread type (cut or rolled), size, and the manufacturing process.

2.1.2 Intended Use: A description of the intended uses of the fasteners, including types of building materials to be connected with the fasteners.

2.1.3 Installation Instructions: Installation details and limitations. The installation details shall be similar to the installation details provided within the submitted test reports. The installation instructions shall address any requirements for pilot holes that need to be followed when installing the fasteners, including diameter and depth. If pilot hole requirements for fasteners subjected to lateral loads are different than the pilot hole requirements for fasteners subjected to withdrawal loads, the evaluation report will limit use of the fasteners to those subjected to lateral loads only or withdrawal loads only.

2.1.4 Packaging and Identification: Product identification shall be in accordance with the product identification provisions of the ICC-ES Rules of Procedure for Evaluation Reports. A description of the method of packaging and field identification of the fasteners shall be submitted. Where practical with respect to available space on the fastener head, each fastener shall be identified by the manufacturer's identifying mark or logo and the length designation. Each container of fasteners shall have a label noting ~~the evaluation report holder's name and address, the evaluation report number~~, ~~name of the inspection agency and~~ the fastener type, size and finish, as applicable.

2.1.5 Qualification Test Plan: A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted. Plans shall address variations of fasteners within a fastener class, such as diameter, and variables of intended installation, including member material strength (specific gravity for wood members, tensile strength for steel members), member thicknesses, fastener orientation to the wood grain and the presence or absence of threads near the shear plane.

2.2 Testing Laboratories: Testing laboratories shall comply with Section 2.0 of the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.3 Test Reports: Test reports shall comply with AC85.

2.4 Product Sampling: Sampling of the fastener(s) for tests under this criteria shall comply with Section 3.2 of AC85.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 General: When evaluation of alternate dowel-type threaded fasteners is sought in accordance with Section 1.2.1, the fasteners shall be evaluated for fastener strength, including bending yield strength, and for reference lateral, withdrawal and pull-through design strengths for wood-to-wood and/or steel-to-wood connections, as applicable, in accordance with Section 3.0.

3.1.1 Regression Analysis with Respect to Specific Gravity: Reference design values may be interpolated between tested specific gravity values using a best-fit regression function fitted to tests of connections when all of the following conditions are met: (1) Only specific gravity is allowed to vary in the test series, a minimum of three specific gravity ranges approximately equally spaced are tested, and the average tested specific gravities must be within 10 percent of the respective assigned specific gravities given in NDS Table 12.3.3A~~.~~; (2) A sufficient number of tests is conducted to result in a coefficient of determination greater than or equal to 0.90, and a percentage standard error of estimate of less than 10 percent~~.~~; (3) In lateral load testing, a regression line shall pertain to tests exhibiting a common failure mode. Regression analysis shall consider linear, polynomial, exponential, power, and logarithmic functions, and the best fitting function shall be used for the purposes of interpolating reference design values. Regression equations shall not be used for extrapolations to specific gravity ranges greater than or less than the maximum and minimum specific gravity ranges tested.

3.1.2 Wood Members: Reference design values ~~for connections with wood members~~that are indexed to assigned specific gravity values may be derived for softwood species combinations identified in NDS Table 12.3.3A. For hardwood species, testing will be applicable to the test species only. Members of target species used in test ~~connections~~ specimens shall have a specific gravity determined on an oven-dry weight and volume basis ~~equal to or lower than the NDS table values~~, and shall have a moisture content complying with Section 4.2.1.3. Testing of specific gravity and moisture content shall be in accordance with Sections 4.2.1.2 and 4.2.1.3, respectively. Individual

wood members shall have a specific gravity of ± 6 percent of the assigned specific gravity for the species combination, with the average specific gravity for the wood members used in the test specimens being no greater than the assigned specific gravity for the species combination.

Unless otherwise noted, results from testing in the face of sawn lumber or structural glued laminated timber (GL) of a single wood species shall be applicable to installation in the face of sawn lumber, the face of GL or the face of cross laminated timber (CLT) panels having the same assigned specific gravity. Testing in the ends of sawn lumber or GL or in the edge of CLT, shall only be applicable to the type of wood product tested.

3.1.3 Applicability of Test Results to Wood with Higher Specific Gravity: Reference design values derived from connection tests may be assigned to like connections with wood species having a higher specific gravity than tested. However, reference design values for connections with wood species exceeding a specific gravity of 0.50 shall be evaluated if predrilled holes meeting the requirements of NDS Section 12.1.5 are not used.

3.1.4 Engineered Wood: In order for installation in engineered wood to be addressed in the evaluation report, the fasteners must be tested in engineered wood products (EWPs) addressed in an ICC-ES evaluation report and in sawn lumber. A test plan shall be submitted to ICC-ES prior to commencement of testing, outlining the desired scope of evaluation and the proposed testing, considering the guidance in Sections 3.1.4.1 and 3.1.4.2, as applicable.

3.1.4.1 For Reference Withdrawal Design Values and Reference Lateral Design Values Determined by Testing: The fasteners shall be tested in both EWP and in sawn lumber for the purpose of comparison. The equivalent specific gravity specified in the evaluation report on the EWP, and the measured specific gravity of the sawn lumber, shall be the same. The grade of EWP selected for testing shall be the lowest grade assigned the chosen equivalent specific gravity. If the fasteners installed in the EWP are determined to have reference design values that are at least 95 percent of those of the fasteners installed in the comparable sawn lumber, use in EWPs with the same or higher equivalent specific gravity has been qualified. Conversely, if the fasteners installed in the EWP do not meet this condition of acceptance, only use in the tested type of EWP (LVL, PSL, etc.) has been qualified.

3.1.4.2 For Reference Lateral Design Values Determined by Calculation and Confirmed by Testing: The reference lateral design values for the alternative fastener shall be determined by calculation in accordance with Section ~~3.4.2~~3.4.1, using the equivalent specific gravity specified in the evaluation report on the EWP to determine the bearing stress in accordance with ASTM D5456. The fastener shall be tested in an EWP to confirm the validity of the calculation approach, in accordance with Section ~~3.4.2~~3.4.1.

3.2 Design of Metal Fasteners and Steel Side Plates: Fastener material and steel side plate material specifications shall conform to a national industry standard. Design of metal fasteners and steel side plates shall comply with Section 11.2.3 of the NDS. The strength of the fasteners shall be qualified in accordance with Section 3.2.1, the tensile strength of the steel side plates shall be qualified in accordance with Section 3.2.2, and use of the NDS adjustment factors shall be limited in accordance with Section 3.2.3.

3.2.1 Fastener Strength: Tensile tests and shear tests (optional for fasteners used in wood-to-wood connections only) shall be performed on each combination of fastener root diameter and fastener steel type in accordance with Section 4.1.1 of this criteria. The allowable tensile or shear design load of a fastener for use in ASD shall be taken as the average maximum load from the tests divided by a safety factor of 3.0. The design tensile or shear strength of a fastener for use in LRFD shall be taken as the average maximum load from the tests multiplied by a resistance factor of 0.50.

Bending yield strength ~~must~~shall be determined by tests in accordance with Section ~~3.4.1~~4.1.2. At a minimum, one length for each combination of fastener root diameter and fastener steel type shall be tested to confirm compliance with the manufacturer's specification. Bending yield strength shall be determined for fasteners from the same lots as those used in lateral connection testing. The average bending yield strength of these fasteners shall not exceed the specified minimum bending yield strength by more than 10 percent.

3.2.2 Steel Side Plates: The tensile strength, F_u, of the steel side plate shall be determined using coupons from the same steel sheet or plate used to make the side member or by mill certification. Tensile testing shall comply with ASTM A370. Base-metal thickness shall be determined by measuring the base-metal thickness of representative steel side plates. The shape and diameter of pre-punched or pre-drilled holes must comply with the fastener manufacturer's installation instructions, to ensure that shaped fastener heads bear on the steel side plate as intended.

3.2.3 Limits on Use of NDS Adjustment Factors: When the reference design value of a tested connection is controlled by fastener tensile or shear strength or steel side plate metal strength, rather than wood strength or fastener bending yield strength, the resulting reference design value shall not be permitted to be multiplied by the adjustment factors specified in the NDS.

3.3 Reference Withdrawal Design Values: If the thread and/or point geometry of the alternate dowel-type fastener does not conform to ANSI Standard B18.2.1 or ANSI Standard B18.6.1, withdrawal tests shall be performed in accordance with Sections 4.2.1, 4.2.2 and 4.2.3. The tested reference withdrawal capacity shall be the average maximum test value divided by a reference factor of 5.0 and divided by the length of the embedded thread in the wood. For fasteners with threads and points which fully comply with ANSI Standard B18.2.1 or ANSI Standard B18.6.1, withdrawal design values shall be determined in accordance with the NDS.

3.3.1 Withdrawal from Wood Member Face: Reference withdrawal design values shall be determined for dowel-type threaded fasteners installed perpendicular to the face of the wood member, in accordance with Section 3.3. Reference withdrawal design values for dowel-type threaded fasteners installed at other angles to the face of the wood member may also be qualified by testing in accordance with Section 3.3.

3.3.2 Withdrawal from Wood Member End: This section addresses qualification of withdrawal performance

for self-drilling fasteners installed into the end of a sawn wood member. The scope is limited to use in dry wood members which are maintained in a dry service condition, to resist short term load duration, such as for wind or seismic loading. Use of fasteners to resist combined withdrawal and lateral loads is outside the scope of this criteria.

An end-grain withdrawal factor, $C_{eg\text{-}w}$, shall be qualified for each fastener class, as follows:

1. The largest and the smallest diameter within the fastener class shall be tested. The more conservative edge distance and embedment depth used in testing, in terms of multiples of outside thread diameter, shall be applicable to all intermediate diameters within the fastener class.
2. For each fastener size, three test samples shall be investigated for each fastener class, one in each of the following wood species or species groups: Douglas Fir, Spruce-Pine-Fir, and a wood species combination addressed in Table 12.3.3A of the 2018 NDS which has an assigned specific gravity of 0.37 or less.
3. Testing shall be in accordance with Section 4.2.3.2. The end-grain withdrawal reduction ratio for each test sample shall be reported.
4. The lowest reduction ratio from each of the three test samples shall be the end-grain withdrawal factor, $C_{eg\text{-}w.}$ but this factor shall not exceed 0.65. The resulting allowable end grain withdrawal values for wood species addressed in the evaluation report shall not exceed the allowable end-grain withdrawal values determined from the testing in accordance with Section 4.2.3.2.
5. Results from testing in sawn lumber shall also apply to fasteners installed in the edges of cross-laminated timber panels. The applicable edge distance shall apply to the distance to the edge of the CLT panel, not the individual lamination.
6. When spacing is not addressed in testing, the minimum spacing requirement shall be twice the minimum edge distance used in testing.

3.4 Reference Lateral Design Values: Reference lateral design values for fasteners installed perpendicular to the face of wood members shall be determined in accordance with this section. Lateral load tests shall be performed in accordance with Sections 4.2.1, 4.2.2 and 4.2.4. ~~Bending yield strength shall be determined in accordance with Section 3.4.1. Reference lateral design values~~ Applicability of the NDS provisions for lateral connection design shall be determined in accordance with Section 3.4.~~2~~1 ~~(for a calculated and confirmation testing evaluation approach) or Section 3.4.3 of this criteria~~. When applicability of the NDS provisions cannot be validated in accordance with Section 3.4.1, or at the applicant's option, reference lateral design values for alternate dowel-type threaded fasteners shall be determined in accordance with Section 3.4.2.

Applicability of the end-grain factor specified in Section 12.5.2.3 of the NDS for lateral connections for alternative dowel-type fasteners used in CLT shall be validated in accordance with Section 3.4.4.

~~**3.4.1 Bending Yield Strength:** Bending yield strength for all fastener diameters shall be determined by tests in accordance with Section 4.1.2. The average bending yield strength of the tested fasteners shall not exceed the specified minimum bending yield strength by more than 10 percent.~~

~~3.4.2~~3.4.1 Reference Lateral Design Values Determined ~~by Calculation and Confirmed by Testing~~in Accordance with the NDS: At least one wood-to-wood connection configuration for each fastener class shall be tested in accordance with Section 3.4. At least one steel-to-wood connection configuration shall be tested for each fastener head style within a fastener class, when the fasteners are intended to be used with steel side members. The fastener penetration into the main member must be a minimum of 6 times the shank diameter for partially threaded screws or a minimum of 6 times the outside thread diameter for fully-threaded screws, as applicable. ~~This section is applicable to connections where the side member is wood, engineered wood or steel and where the reference lateral design values are determined by calculation and confirmed by testing.~~ The calculated reference lateral design value shall be compared to the tested reference lateral design value. If the tested reference lateral design value is equal to or greater than the calculated reference lateral design value, the NDS provisions may be used to determine reference lateral design values for all conditions addressed in the NDS. If the tested reference lateral design value is less than the calculated reference lateral design value, the reported reference lateral design value shall be determined in accordance with Section 3.4.2. For purposes of ~~this~~ comparison, the tested reference lateral design value shall be the average ultimate test value divided by 3.2 and reduced by R_s (defined in Section ~~3.4.4~~3.4.3), as applicable. ~~If the tested reference lateral design value is less than the calculated reference lateral design value, the reported reference lateral design value shall be determined in accordance with Section 3.4.3~~.

For the purposes of comparison, ~~T~~the calculated reference lateral design value shall be determined using the yield limit equations found in NDS Section 12.3.1 ~~or the general dowel equations in the AWC Technical Report 12, Table 1-1~~, using the following assumptions:

1. ~~The following fastener diameters shall be used:~~The root diameter at the threads shall be used as the applicable diameter in the calculations.
   - ~~Equations found in the NDS shall assume a diameter equal to the root diameter at the threads.~~
   - ~~Equations found in Technical Report 12 shall assume a diameter equal to the root diameter at the threads except for the diameter used to calculate q_s in Table 1-1. This diameter can be either the shank diameter or the root diameter at the threads as evaluated. If the shear plane is in the threads, the root diameter shall be used.~~
2. The measured bending yield strength of the fasteners determined in accordance with Section 3.2.1 shall be used.
3. The measured specific gravities of the wood test members shall be used.

~~2~~4. For steel side plate connections, the calculated Mode IV yield value shall be permitted to be used to determine the calculated reference lateral design value, regardless of which yield mode governs the calculation, provided Mode IV yielding is consistently observed during the test and the specified steel side plate is at least as thick as the tested steel side plate.

~~3~~5. For steel side plate connections, the steel dowel bearing strength, F_{es}, shall be permitted to be taken as $2.4F_u/1.6$ for hot rolled steel plate specified in AISC 360, or $2.2F_u/1.6$ for cold-formed steel specified in AISI S100.

~~4~~6. Wood properties shall be in accordance with the NDS.

~~5~~7. The dowel bearing length shall be determined per Section 12.3.5 of the NDS. *D* shall be taken as the shank diameter.

~~3.4.3~~3.4.2 Reference Lateral Design Values Determined by Testing: This section is applicable to connections where the side member is wood, engineered wood or steel and where the reference lateral design values are determined solely by testing. The reported reference lateral design value shall be the average ultimate test value divided by a reference factor of 5.0 and reduced by R_s (defined in Section ~~3.4.4~~3.4.3), as applicable.

~~3.4.4~~3.4.3 Adjustment of Lateral Test Values Based on Steel Side Plate Properties: Test values for connections where the side member is a steel side plate shall be adjusted to account for the measured or mill certified tensile strength and base metal thickness of the steel. The adjustment factor, R_s, shall be determined from the following equation:

$$R_s = \left(\frac{3.0}{2.5}\right)\left(\frac{Fu-spec}{Fu-tested}\right)\left(\frac{t-spec}{t-tested}\right) \leq 1.0$$

where:

($F_{u\sim spec}$) = Minimum specified tensile strength of the side plate steel, psi.

($F_{u\sim tested}$) = Measured tensile strength of the side plate steel used in the test, psi.

(t_{spec}) = Specified minimum side plate base metal thickness, inch.

(t_{tested}) = Measured base metal thickness of tested side plate, inch.

3.4.4 Lateral Connections with Fasteners Installed into the Narrow Edge of CLT Panels: Reference lateral design values for fasteners installed into the edge of CLT panels may be determined in accordance with Section 3.4.4.1 or 3.4.4.2, based on testing in accordance with Sections 4.2.1, 4.2.2 and 4.2.4.

3.4.4.1 Design in accordance with the NDS: Design in accordance with the provisions of the NDS, including application of C_{eg} = 0.67, may be validated in accordance with Section 3.4.1, which relies on a reference factor of 3.2. If the average ultimate test result divided by a reference factor of 5.0 exceeds the value determined in accordance with the NDS, using C_{eg} = 1.0, then use of NDS provisions with C_{eg} = 1.0 has been qualified.

3.4.4.2 Empirical Approach: Reference lateral design values for fasteners installed into the edge of CLT panels may be determined directly through testing. A proposal shall be submitted showing how use of the fasteners installed into the edge of the CLT will be addressed in the evaluation report, together with a proposal for supportive testing. At a minimum, these proposals shall address the following:

1. The applicable materials for the connection. The main member is expected to be CLT, but the side member may be CLT, sawn lumber or GL as applicable.
2. Tested conditions such as fastener penetration into the main member and connection geometry shall be considered minimum limits for connections addressed in the evaluation report.
3. Testing will apply to larger diameter fasteners within the fastener class, as long as penetration depth and connection geometry ratios are maintained and no splitting is allowed.
4. For each load orientation under evaluation, testing shall consider installation into both the end grain and the side grain of the CLT lamination. See Figure 4.
5. Reference lateral design values shall be determined in accordance with Section 3.4.2.

3.5 Reference Fastener Pull-through Values: Reference fastener pull-through values shall be based on provisions in the NDS or on test results, as described in Sections 3.5.1 and 3.5.2, respectively.

Exception: For fasteners which are fully threaded, reference pull-through values shall be based on the reference withdrawal capacity of the embedded threads in the wood side member.

3.5.1 Values Based on the NDS: Reference head pull-through shall be determined in accordance with Section 12.2.5 of the 2018 NDS, when all of the following conditions are applicable:

1. The fastener heads are round and the underside of the head is flat.
2. The fastener shank diameter is no more than two-thirds of the head diameter.
3. The head diameter, D_H, is within the range of 0.234 inch to 0.500 inch (5.94 to 12.7 mm).
4. The wood thickness is between $^5/_{16}$ and $1^1/_2$ inches (7.94 to 38 mm).
5. The wood member is sawn lumber or wood structural panel sheathing.

3.5.2 Values determined by Testing: When Section 3.5.1 is not applicable, fastener head pull-through testing shall be conducted in accordance with Sections 4.2.1, 4.2.2 and 4.2.5. If the fastener is to be used with sheathing, the applicable sheathing types shall also be tested for pull-through. The reference fastener head pull-through design value shall be taken as the average ultimate load for each tested configuration, divided by a reference factor of 5.0.

3.6 Determination of Wet Service Factor:

For fasteners intended for connections in wood that is unseasoned or partially seasoned, or for connections that are exposed to wet service conditions in use, wet service factors, C_M, for the connections shall be established by comparing the results of withdrawal and lateral fastener

tests specified in Sections 4.2.3 and 4.2.4, respectively, for wet (greater than 25 percent moisture content) versus dry (10 to 14 percent moisture content) wood samples. When the evaluation addresses use in wet service conditions, withdrawal tests shall be performed using fasteners having the minimum thread length and diameter, in wood members having the minimum and maximum specific gravity; and lateral load tests shall be performed using the minimum fastener length and diameter, with wood members of the minimum and maximum specific gravity ranges, and the minimum baseline side member thickness. The wet service factor shall be determined as the ratio of average test values of wet and dry samples for each specific gravity. The wet service factor determined for withdrawal shall also be considered applicable to head pull-through values. In no case shall the wet service factor be greater than what is specified in Table 11.3.3 of the NDS.

3.7 Minimum Spacing, Edge and End Distance: ~~Minimum spacing, end and edge distances in units of length (i.e., inches) shall be derived from the load tests of Section 3.4. Alternatively, confirmatory lateral tests may be run to establish end and edge distance criteria. These tests shall be performed in accordance with Section 3.4 on connection configurations having maximum fastener diameter, minimum baseline side member thickness, minimum main member thickness, and minimum and maximum specific gravity. A comparison of the results from the confirmatory tests (i.e., with minimum end and edge distances) to those of the corresponding configurations tested under Section 3.4 shall indicate that the former are greater than or equal to the latter. In no case shall the spacing, edge and end distances be less than specified in Table C12.1.5.7 of the 2018 and 2015 NDS Commentary for fasteners with shank diameters less than 0.250 inch, or less than minimum values specified in NDS Tables 12.5.1A through G for fasteners with shank diameters equal to or greater than 0.250 inch.~~ For fasteners installed perpendicular to the face of the wood members (in wood-to-wood and steel-to-wood connections), minimum spacing, end and edge distances in multiples of outside thread diameter, D, shall be in accordance with Table 6, for applicable conditions. For fasteners installed into SCL, geometry limitations in the applicable evaluation report must be considered. Lesser dimensions may be qualified for use in all connections addressed in the evaluation report (including those calculated in accordance with the NDS) based on comparative testing. These tests shall be performed in accordance with Sections 3.3 and 3.4, as applicable, on connection configurations having the maximum fastener diameter within the fastener class, the minimum applicable side member thickness, the minimum applicable main member thickness, and minimum and maximum specific gravity. A comparison of the capacity results from the confirmatory tests (i.e., with minimum end and edge distances) to those with connection geometry as prescribed in Table 6 shall indicate no reduction in capacity. Lesser dimensions for specific conditions shall be based directly on testing in accordance with Sections 3.3 and 3.4, as applicable.

For fasteners installed at an angle other than 90 degrees to the face of the wood member, and fasteners installed into the end of the wood member, connection geometry shall be based on testing in accordance with Sections 3.3. and 3.4.

3.8 Qualification of Alternative Prescriptive Fastening Designs (Optional): Multiple dowel-type threaded fasteners may be qualified as alternates to the nails prescribed for framing connections in IBC Table 2304.10.1 and IRC Table R602.3(1), based on calculations using the single-fastener reference design values determined in accordance with this criteria. At a minimum, the evaluation shall consider the lateral and withdrawal strength of the connection prescribed in the code, the required spacing and other connection geometry requirements of the dowel-type threaded fasteners, and the minimum number of fasteners needed.

Dowel-type threaded fasteners used as alternates to the nails and staples prescribed in the code for attachment of wood structural panel sheathing to framing shall be evaluated in accordance with AC120.

4.0 TEST METHODS

4.1 Fastener Strength Tests:

4.1.1 Shear and Tensile Strength: Tensile and shear tests of fasteners shall be conducted in accordance with AISI S904 or EN 1383. Alternatively, shear tests of fasteners may be conducted in accordance with NASM1312-20. A minimum number of ~~samples~~ specimens shall be tested to achieve a precision of 5 percent at a 95 percent confidence interval, with a minimum sample size of 10 (refer to ASTM D2915).

4.1.2 Bending Yield Strength: The bending yield strength of fasteners shall be determined in accordance with ASTM F1575, and the following:

4.1.2.1 The 5 percent diameter offset bending yield strength shall be defined by the section at the root diameter.

4.1.2.2 The fastener shall be placed on the cylindrical bearing points for testing so that the transition zone between shank and thread is as close as possible to the midpoint between the bearing points, with the load applied at the transition or in the threaded section.

4.1.2.3 Determination of the applicable span in accordance with Table 1 of ASTM F1575 shall be based on the root diameter.

~~**4.1.2.3**~~**4.1.2.4** The fastener designation, overall length, length of thread, root diameter, and bending yield strengths shall be recorded.

~~**4.1.2.4**~~**4.1.2.5** A minimum of ten ~~samples~~ specimens shall be tested.

4.2 Connection Tests:

4.2.1 Wood Test Member Requirements:

4.2.1.1 Growth Characteristics: In the immediate vicinity of the location in which the fastener is driven, each wood member shall be free of knots, sloped grain and other growth characteristics that may affect the test results.

4.2.1.2 Specific Gravity: The specific gravity of each wood member used in the connection tests shall be determined in accordance with Test Method A of ASTM D2395, on an oven-dry weight and volume basis. One sample specific gravity calculation shall be provided within the submitted test reports.

The measured characteristic density reported in accordance with EN 1382 and EN 1383 shall be adjusted to determine the applicable assigned specific gravity, as follows:

1. Multiply by a factor of 1.2 to convert from the characteristic value to the mean value.

2. Determine the specific gravity at the tested moisture content in accordance with Section 15.4.1 of ASTM D2395.

3. Determine the oven-dry specific gravity in accordance with Section X2.1.3 of ASTM D2395.

4.2.1.3 Moisture Content: Wood ~~samples~~ members shall be conditioned to reach equilibrium with a moisture content of 10 to 14 percent when testing for dry in-service conditions. When testing for wet in-service conditions, wood ~~samples~~ members shall have a moisture content greater than 25 percent. The moisture content of the wood ~~samples~~ members shall be determined in accordance with ASTM D4442 or D4444 (handheld moisture meters). One sample moisture content calculation shall be provided within the submitted test reports.

4.2.2 Sample Size: Unless otherwise noted, ~~A~~a minimum number of ~~samples~~ specimens shall be tested to achieve a precision of 5 percent at a 75 percent confidence interval, with a minimum sample size of 15 specimens and a maximum sample size of 40 specimens. There is an implied limit on the COV of 27 percent. If 40 specimens are tested with a COV above 27 percent, the product has failed the test. Alternatively, a minimum of 10 specimens may be tested, provided a precision of 5 percent at a 95 percent confidence interval is achieved. In this case, there is no limit on the maximum sample size.

For withdrawal and pull-through tests conducted in accordance with EN 1382 and EN 1383 with fewer than 15 but at least 10 specimens, if a precision of 5 percent at a 95 percent confidence interval is not achieved, but a precision of 5 percent at a 75 percent confidence interval is achieved, the reference factor of 5.0 shall be applied to the lowest test value. If fewer than 15 specimens are tested but a precision of 5 percent at a 75 percent confidence interval is not achieved or if the test specimens are less than 10 specimens, the test results will not be relied upon.

4.2.3 Withdrawal Load Testing:

4.2.3.1 Withdrawal from Wood Member Face: Fastener pullout strength shall be tested in general accordance with ASTM D1761 or EN 1382 and this section. The size of the wood test members shall be representative of the wood members which will be addressed in the evaluation report, which may be larger than those prescribed in the standard test methods. The use of pilot holes for installation of the fasteners shall be in accordance with the manufacturer's instructions submitted in accordance with Section 2.1.2. When splitting is observed during fastener installation or testing, test member size shall be adjusted as needed to preclude splitting, and installation or testing shall be repeated with no splitting observed.

For fastener designs with one available thread length, the size of the wood test member shall be representative of the minimum wood member thickness intended to be connected with the fastener. Each ~~sample~~ specimen shall have the same fastener embedment length, which shall be equal to the length of the threaded portion of the shank for partially threaded fasteners and two-thirds of the shank length for fasteners that are threaded along the entire shank.

For fastener designs which are available with a variety of thread lengths, multiple thread lengths shall be tested in withdrawal. The minimum intended thread penetration shall be tested. The testing shall also include either the longest intended thread embedment or a thread embedment where the fastener breaks before it withdraws, along with an intermediate thread embedment. ~~Samples~~ Specimens within each test ~~set~~ sample shall have the same embedment length, which shall not exceed the thread length.

When fasteners are to be qualified for installation at angles other than 90 degrees to the face of the wood member, the test plan shall specify the least angle to the wood surface, the minimum penetration depth (measured along the axis of the fastener) and the dimensions of the wood test members, including the minimum length of the wood member beyond the tip of the fastener. Multiple embedded thread lengths shall be addressed as noted above.

4.2.3.2 Withdrawal from Wood Member End: Comparative tests shall be made between fasteners installed into the face of a wood test member and fasteners installed into the end of a wood test member. Testing shall be in general accordance with ASTM D1761 or EN 1382 and this section. The use of pilot holes for installation of the fasteners shall be in accordance with the manufacturer's instructions.

Each test sample shall include a minimum of 15 replicate comparative test sets. Each comparative test set shall be tested using a different piece of lumber. The wood members used for each of the tests within a comparative test set shall be cut from the same piece of wood.

Each comparative test set shall include one specimen of each of the following:

1. A fastener installed into the face of the wood member, with testing commencing within 1 hour of assembly fabrication.
2. A fastener installed into the center of the end of the wood member, with testing commencing within 1 hour of assembly fabrication.
3. A fastener installed into the center of the end of the wood member with testing commencing a minimum of 48 hours after fabrication.

The thread penetration into the wood member shall be the same for all specimens within the test sample and shall represent the minimum penetration depth/fastener diameter ratio addressed in the evaluation report for the fastener class.

For fasteners installed into the face of the wood member, splitting shall be precluded. At a minimum, comply with the end and edge distance requirements of Table 6.

For fasteners installed in the end of the wood member, splitting shall be precluded. At a minimum, the fastener manufacturer's minimum edge distance requirements shall be followed.

For each comparative test set, the lower result from the two withdrawal tests for fasteners installed in the end of the

member shall be the governing reduction ratio for the test set.

The governing reduction ratio for the test sample shall be the average of the governing reduction ratios for the test sets.

4.2.4 Lateral Load Testing: Lateral resistance and fastener slip shall be tested in accordance with ASTM D1761, and the following:

1. Friction between the main and side members shall be minimized by the use of a friction-reducing barrier. Alternatively, fasteners shall be inserted to a "tightness" that permits the wood members of the test assembly to rotate relative to each other with only mild pressure. To avoid separation of the connected members when fully threaded fasteners are tested, partially threaded fasteners may be used to hold the members together while driving the fully threaded fasteners. The partially threaded fasteners shall be removed prior to testing the connection.

2. The failure mode shall be reported for each ~~test~~specimen. Typical failure modes for lateral load testing include fastener withdrawal, head pull-through, side member splitting, bearing failure in the main or side member, and fastener fracture.

3. The size of the wood test members shall be representative of the connection configurations which will be addressed in the evaluation report. Similar connection configurations, having larger main members and/or longer fastener penetration than those tested, may also be addressed when an analysis providing justification is submitted.

4. For fasteners which are intended to be installed without pilot holes, the pilot holes described in ASTM D1761 shall not be used.

4.2.5 Pull-through Load Testing: Fastener head pull-through capacity shall be tested by means of a test setup in which the fastener installed in the side member is pulled through. ~~Modifications of the test procedure for fastener withdrawal described in ASTM D1037 may be used.~~ Testing shall be in accordance with Section 15 of ASTM D1037, modified as needed to represent the intended installation. As an alternative, testing may be performed in accordance with EN 1383. The size of the wood test member shall be representative of the wood members which will be addressed in the evaluation report, and may be larger than that prescribed in the standard test methods. The use of pilot holes for installation of the fasteners shall be in accordance with the manufacturer's instructions submitted in accordance with Section 2.1.2. When splitting is observed during fastener installation or testing, test member size shall be adjusted as needed to preclude splitting, and installation or testing shall be repeated with no splitting observed.

5.0 QUALITY CONTROL

5.1 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted. The quality documentation shall include technical drawings for each fastener and the specifications required by Section 2.1.1.

5.2 The manufacturing and/or labeling facilities shall be subject to a qualifying inspection and regular, ongoing follow-up inspections under an approved quality control program with inspections by ICC-ES. These inspections shall also be in accordance with Section 9.0 of the ICC-ES Rules of Procedure for Evaluation Reports.

6.0 EVALUATION REPORT REQUIREMENTS

6.1 The evaluation report shall include tables similar to those shown in this acceptance criteria, as required by Sections 6.1.1 through 6.1.5. Tables shall be prepared by a registered design professional in accordance with the ICC-ES Rules of Procedure for Evaluation Reports.

6.1.1 There shall be a table providing fastener dimensions, specified bending yield strength and ~~allowable~~available fastener shear and tension strengths determined in accordance with Section 4.1.1. Refer to Table 1 for an example.

6.1.2 There shall be a table providing reference withdrawal design values (*W*). Refer to Table 2 for an example.

6.1.3 When lateral design values have been determined by testing in accordance with Section 3.4.2, ~~T~~there shall be a table providing reference lateral design values (*Z*) for single shear (two-member) connections. Refer to Table 3 for connections consisting of two wood members having identical specific gravity, and Table 4 for connections consisting of one wood member and one steel side plate member.

6.1.4 There shall be a table providing reference fastener head pull-through design values. Refer to Table 5 for an example.

EXCEPTION: In cases where it can be demonstrated that withdrawal values will always control for connections having the minimum specified side member thickness and the maximum thread penetration into the main member, the head pull-through design value table may be omitted from the evaluation report.

6.1.5 There shall be a table providing the minimum fastener end and edge distances and spacing as determined in accordance with Section 3.7, based on the intended use. Refer to Table 6 for an example.

6.2 The evaluation report shall include statements similar to the following, as applicable:

6.2.1 "The allowable load for a single-fastener connection in which the fastener is subject to tension is the least of: (a) the reference withdrawal design value given in Table #, multiplied by the embedded thread length in the wood and adjusted by all applicable adjustment factors; (b) the reference head pull-through design value given in Table #, adjusted by all applicable adjustment factors; and (c) the allowable fastener tension strength given in Table #."

6.2.2 "The allowable lateral load for a single-fastener connection is the lesser of: (a) the reference lateral design value given in Table #, adjusted by all applicable adjustment factors, and (b) the allowable fastener shear strength given in Table #."

6.2.3 "Connections containing multiple fasteners must be designed in accordance with Sections 11.2.2 and 12.6 of the NDS."

6.2.4 "Where the fasteners are subjected to combined lateral and withdrawal loads, connections shall be designed in accordance with Section 12.4.1 of the NDS."

6.2.5 "Design of connections having steel side plates shall comply with Section 11.2.3 of the NDS."

6.2.6 "When designing a connection, the structural members must be checked for load-carrying capacity in accordance with Section 11.1.2 of the NDS, and local stresses within the connection must be checked against Appendix E in the NDS to ensure the capacity of the connection and fastener group."

6.2.7 "When use is in engineered wood products, the minimum fastener end and edge distances and spacing must be in accordance with Table _# of this report or in accordance with the recommendations of the engineered wood product manufacturer, whichever is more restrictive."

6.3 If use of the NDS provisions for determining reference lateral design values has been validated in accordance with Section 3.4.1, the evaluation report shall indicate that lateral design values may be determined in accordance with the NDS. Reference shall be made to applicable parameters such as diameter to use in calculations, specified bending yield strength, recommended minimum member thicknesses and connection geometry requirements.

6.4 When steel side plates are addressed in the evaluation, the fastener manufacturer's requirements for the hole size and shape shall be reported.

~~6.3~~6.5 The evaluation report shall include guidance regarding pilot hole requirements, based on the installation methods used in the lateral and withdrawal testing. When the installation methods used for the two types of tests are not the same, use of fasteners subjected to both lateral and withdrawal loads shall be outside the scope of the evaluation report. ■

TABLE 1—FASTENER DIMENSIONS AND STRENGTHS

FASTENER DESIGNATION	OVERALL LENGTH[1] (inches)	THREAD LENGTH[2] (inches)	ROOT DIAMETER, D_r (inch)	SHANK DIAMETER, D_s (inch)	OUTSIDE THREAD DIAMETER, D (inch)	HEAD DIAMETER, D_H (inch)	DRIVE TYPE AND SIZE	SPECIFIED BENDING YIELD STRENGTH[3], F_{yb} (psi)	ALLOWABLE FASTENER STRENGTH Tension (lbf)	ALLOWABLE FASTENER STRENGTH Shear (lbf)

For **SI:** 1 inch = 25.4 mm; 1 lbf = 4.4 N; 1 psi = 6.9 kPa.

[1]For fasteners with countersinking type heads, overall fastener length is measured from top of head to bottom of tip. For fasteners with washer type heads, overall length is measured from underside of head to bottom of tip.
[2]*Length of thread includes tip. **Length of thread excludes tip. (Choose applicable statement.) See detailed illustration.
[3]Bending yield strength determined in accordance with ASTM F1575 using the root diameter.

TABLE 2— REFERENCE WITHDRAWAL DESIGN VALUES (*W*)[1]
Tabulated Withdrawal Design Values (*W*) Are in Pounds per Inch of Thread Penetration into ~~Side Grain~~the Wood Member Face ~~of Main Member~~

FASTENER DESIGNATION	THREAD LENGTH[2], *L* (inches)	*W* (lbf/in.) FOR SPECIFIC GRAVITIES[3] OF: 0.67	0.55	0.5	0.46	0.43	0.36	0.31

For **SI:** 1 inch = 25.4 mm; 1 lbf/in = 175 N/m.

[1]Values shall be multiplied by all applicable adjustment factors (see NDS). **(OR if fastener strength controls connection strength:** Values must **not** be multiplied by any adjustment factors.)
[2]Reference withdrawal design values must be multiplied by the length of thread penetration in the main member. *Length includes tapered tip. **Length excludes tapered tip.
[3]Specific gravity must be the assigned specific gravity for sawn lumber ~~or wood structural panels~~ per NDS Table 12.3.3A ~~or 12.3.3B, respectively~~, the specific gravity for fastener design (addressed in Tables 5A through 5D of the NDS Supplement) for glued laminated timber, or the engineered wood product equivalent specific gravity given in the applicable ICC-ES evaluation report.

TABLE 3— REFERENCE LATERAL DESIGN VALUES (*Z*) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS[1]
For Sawn Lumber or Engineered Wood Products with Both Members of Identical Specific Gravity

FASTENER DESIGNATION	SIDE MEMBER THICKNESS, t_s (inch)	FASTENER PENETRATION, p (inch)	REFERENCE LATERAL DESIGN VALUE (*Z*) FOR SPECIFIC GRAVITIES[2] OF: (lbf) 0.67	0.55	0.5	0.46	0.43	0.36	0.31
			$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$	$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$	$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$	$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$	$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$	$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$	$Z_\parallel$ $Z_{\perp s}$ $Z_{\perp m}$ $Z_\perp$

For **SI:** 1 inch = 25.4 mm; 1 lbf = 4.4 N.

[1]Values must be multiplied by all applicable adjustment factors (see NDS). **(OR if fastener strength controls connection strength:)** Values must **not** be multiplied by any adjustment factors.
[2]Specific gravity must be the assigned specific gravity for sawn lumber or wood structural panels per NDS Table 12.3.3A or 12.3.3B, respectively, or the engineered wood product equivalent specific gravity given in the applicable ICC-ES evaluation report.

TABLE 4—REFERENCE LATERAL DESIGN VALUES (*Z*) FOR SINGLE SHEAR (TWO-MEMBER) CONNECTIONS[1, 2] with Steel Side Plate

FASTENER DESIGNATION	SIDE MEMBER THICKNESS, t_s (inch)	FASTENER PENETRATION, p (inch)	REFERENCE LATERAL DESIGN VALUE (Z) FOR SPECIFIC GRAVITIES[3] OF: (lbf)[3]						
			0.67	0.55	0.5	0.46	0.43	0.36	0.31
			$Z_\parallel$ $Z_\perp$	$Z_\parallel$ $Z_\perp$	$Z_\parallel$ $Z_\perp$	$Z_\parallel$ $Z_\perp$	$Z_\parallel$ $Z_\perp$	$Z_\parallel$ $Z_\perp$	$Z_\parallel$ $Z_\perp$

For **SI:** 1 inch = 25.4 mm; 1 lbf = 4.4 N.

[1]Values must be multiplied by all applicable adjustment factors (see NDS). **(OR if steel side plate strength or fastener strength controls connection strength:)** Values must **not** be multiplied by any adjustment factors.
[2]Minimum steel side plate tensile strength F_u = ksi.
[3] Specific gravity must be the assigned specific gravity for sawn lumber or wood structural panels per NDS Table 12.3.3A or 12.3.3.B, respectively, or the engineered wood product equivalent specific gravity given in the applicable ICC-ES evaluation report.

TABLE 5—REFERENCE PULL-THROUGH DESIGN VALUES (~~*P*~~W_H) [1]

FASTENER DESIGNATION	MINIMUM SIDE MEMBER THICKNESS (inches)	~~*P*~~W_H (lbf) FOR SPECIFIC GRAVITIES[2] OF:						
		0.67	0.55	0.5	0.46	0.43	0.36	0.31

For **SI:** 1 inch = 25.4 mm; 1 lbf = 4.4 N.

[1]Values shall be multiplied by all adjustment factors, as applicable to reference withdrawal design values, W, in accordance with the NDS. **(OR if fastener strength controls connection strength:)** Values must **not** be multiplied by any adjustment factors.
[2]Specific gravity must be the assigned specific gravity for sawn lumber or wood structural panels per NDS Table 12.3.3A or 12.3.3B, respectively, or the engineered wood product equivalent specific gravity for fastener withdrawal, as given in the applicable ICC-ES evaluation report.

~~**TABLE 6—CONNECTION GEOMETRY REQUIREMENTS[1]**~~

~~CONDITION~~			~~MINIMUM DISTANCE OR SPACING (inches)~~		
			~~(Fastener Diameter 1)~~	~~(Fastener Diameter 2)~~	~~(Fastener Diameter 3)~~
~~**For installation into sawn lumber and SCL**~~					
~~End distance~~	~~Loading parallel to grain, tension (fastener bearing toward end)~~				
	~~Loading parallel to grain, compression (fastener bearing away from end)~~				
	~~Loading perpendicular to grain~~				
~~Edge distance~~	~~Loading parallel to grain~~				
	~~Loading perpendicular to grain, loaded edge~~				
	~~Loading perpendicular to grain, unloaded edge~~				
~~Spacing between fasteners in a row~~	~~Loading parallel to grain~~				
	~~Loading perpendicular to grain~~				
~~Spacing between rows~~	~~Loading parallel to grain~~	~~In-line rows~~			
		~~Staggered rows[2]~~			
	~~Loading perpendicular to grain~~	~~In-line rows~~			
		~~Staggered rows[2]~~			
~~**For installation into Cross Laminated Timber (CLT)**~~					
~~End Distance~~	~~Loading perpendicular to plane of CLT~~				
	~~Loading parallel to plane of CLT, tension (fastener bearing toward end)~~				
	~~Loading parallel to plane of CLT, compression (fastener bearing away from end)~~				
~~Edge Distance~~	~~Loading parallel or perpendicular to plane of CLT~~				
~~Spacing for Fasteners in a Row~~	~~Loading parallel or perpendicular to plane of CLT~~				

TABLE 6—CONNECTION GEOMETRY REQUIREMENTS FOR FASTENERS INSTALLED PERPENDICULAR TO THE FACE OF WOOD MEMBERS[1,2,3,5]

CONDITION			MINIMUM DISTANCE OR SPACING		
			Self-drilled		Predrilled Hole
			G < 0.50	0.50 ≤ G	
For alternate dowel-type threaded fasteners with a shank diameter of less than $^1/_4$ inch, installed into sawn lumber, structural glued laminated timber (GL) and cross laminated timber (CLT) panels					
End distance (see Figure 1)	Tension loading parallel to grain (fastener bearing toward end)		15D	20D	12D
	Compression loading parallel to grain (fastener bearing away from end)		10D	15D	7D
	Loading perpendicular to grain		10D	15D	7D
	Axial loading (fastener withdrawal or pull-through)		10D	10D	7D
Edge distance (see Figure 2)	Loading parallel to grain		5D	7D	3D
	Loading perpendicular to grain	Load toward edge	10D	12D	7D
		Load away from edge	5D	7D	3D
	Axial Loading		4D	4D	3D
Spacing between fasteners in a row (parallel to grain of main member) (see Figure 3)	Loading parallel to grain		15D	15D	10D
	Loading perpendicular to grain		12D	15D	5D
	Axial loading		7D	7D	7D
Spacing between rows (perpendicular to grain of main member) (see Figure 3)	Lateral loading	In-line rows	5D	7D	4D
		Staggered rows[4]	2.5D	3D	2.5D
	Axial loading		4D	4D	3D
For alternate dowel-type threaded fasteners with a shank diameter equal to or greater than $^1/_4$ inch, installed into sawn lumber, structural glued laminated timber (GL) and cross laminated timber (CLT) panels					
End distance (see Figure 1)	Tension loading parallel to grain (fastener bearing toward end)		15D	20D	7D
	Compression loading parallel to grain (fastener bearing away from end)		10D	15D	4D
	Loading perpendicular to grain		10D	15D	4D
	Axial loading		10D	10D	4D
Edge distance (see Figure 2)	Loading parallel to grain		5D	7D	3D
	Loading perpendicular to grain	Load toward edge	10D	12D	4D
		Load away from edge	5D	7D	3D
	Axial Loading		4D	4D	3D
Spacing between fasteners in a row (parallel to grain of main member) (see Figure 3)	Loading parallel to grain		15D	15D	5D
	Loading perpendicular to grain		12D	15D	5D
	Axial loading		7D	7D	5D
Spacing between rows (perpendicular to grain of main member) (see Figure 3)	Loading parallel to grain		5D	7D	5D
	Loading perpendicular to grain		5D	5D	5D
	Axial loading		5D	5D	5D

For **SI:** 1 inch = 25.4 mm.

[1] End distances, edge distances and fastener spacing must be sufficient to prevent splitting of the wood, or as required by this table, whichever is the more restrictive.

[2] Wood member stresses must be checked in accordance with Section 11.1.2 and Appendix E of the NDS, and end distances, edge distances and fastener spacing may need to be increased accordingly.

[3] D refers to the outside thread diameter.

[24] Values for spacing between staggered rows apply where fasteners in adjacent rows are offset by half of the spacing between fasteners in a row.

[5] Values in Table 6 are applicable for both wood-to-wood and steel-to-wood connections, unless test data is submitted supporting alternative values.

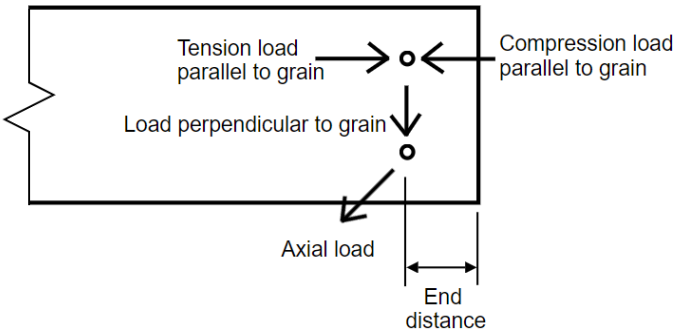


FIGURE 1—END DISTANCE DEFINITIONS

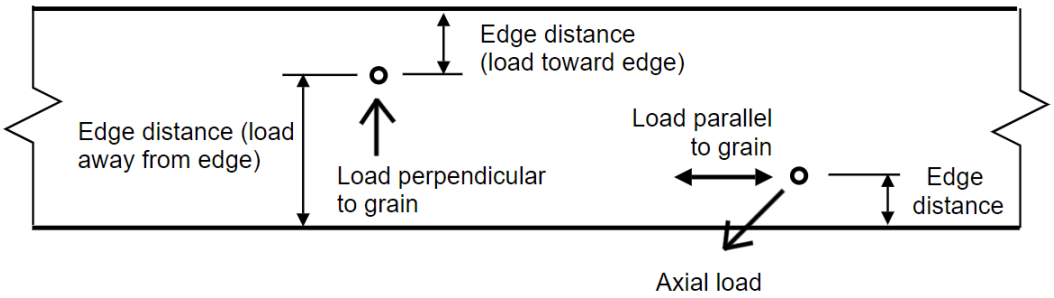


FIGURE 2—EDGE DISTANCE DEFINITIONS

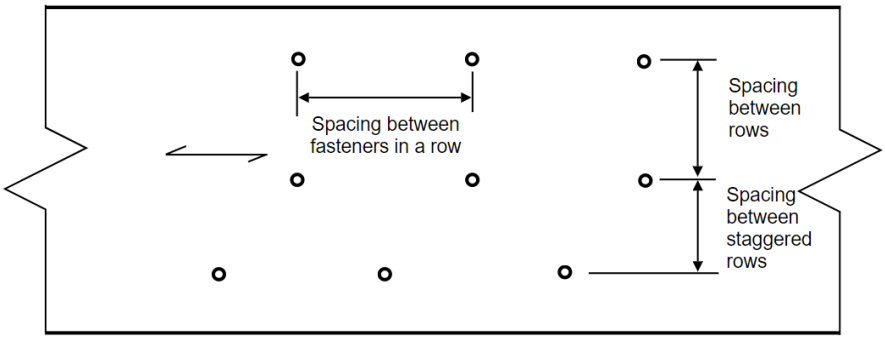
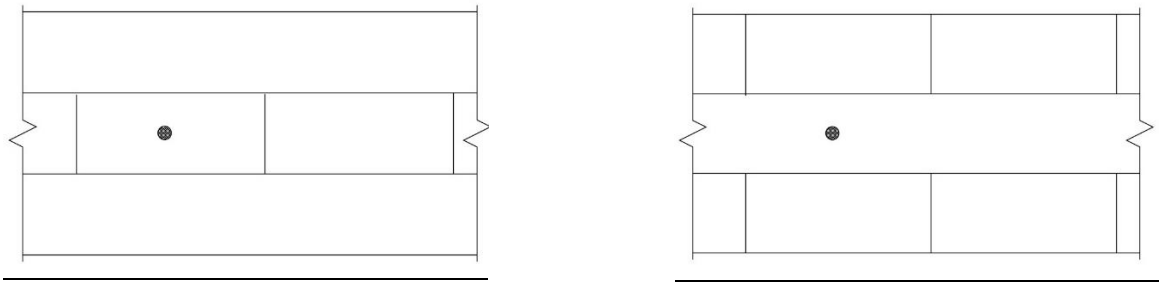


FIGURE 3—SPACING DEFINITIONS



Fastener Installed into End Grain of Lamination at CLT Edge **Fastener installed into Side Grain of Lamination at CLT Edge**

FIGURE 4—CLT EDGE INSTALLATION FOR TESTING

Annex A
Evaluation of Dowel-type Threaded Fasteners Used as Substitutes for Code-prescribed Nails in Diaphragms, Shear Walls and Braced Walls

A1.0 Introduction

The purpose of this Annex to provide procedures for evaluation of dowel-type threaded fasteners used as substitutes for nails prescribed in the codes referenced in Section 1.1 for attaching wood structural panel sheathing to wood framing for use in engineered diaphragms and shear walls and for use in prescriptive attachment of wood structural panel sheathing to wood framing in prescriptive diaphragms and braced wall construction.

See Sections 1.3 and 1.4 for references and definitions.

A2.0 Basic Information:

See Section 2.0.

A3.0 Test and Performance Requirements

See the Acceptance Criteria for Wood-frame Horizontal Diaphragms, Vertical Shear Walls and Braced Walls with Alternative Fasteners (AC120).

A4.0 Test Methods

See AC120.

A5.0 Quality Control

See Section 5.0.

A6.0 Evaluation Report Requirements

The report shall include descriptions of the fasteners including dimensions. See AC120 for additional requirements.

Annex B
Evaluation of Dowel-type Threaded Fasteners Used to Attach Miscellaneous Building Materials to Wood

B1.0 Introduction

The purpose of this Annex to provide procedures for evaluation of dowel-type threaded fasteners for use in attaching miscellaneous building materials to wood base material (sawn lumber or engineered wood). Fastener tension, shear and bending yield strengths and withdrawal values shall be addressed. These values are to be used in the determination of the connection capacity as part of the determination of building strength, in accordance with IBC Section 1604.2 and IRC Section R301.1.3.

See Sections 1.3 and 1.4 for references and definitions.

B2.0 Basic Information:

See Section 2.0.

B3.0 Test and Performance Requirements

See Section 3.2.1 for determination of fastener tension, shear and bending yield strengths. Fasteners which are too short to be tested for bending yield strength shall be tested for shear and tension strength only.

See Sections 3.3 for determination of reference withdrawal design values.

See Section 3.7 for determination of minimum spacing, edge and end distance based on the limitations of the supporting wood material.

B4.0 Test Methods

As referenced in Section 3.2.1 and 3.3, as applicable.

B5.0 Quality Control

See Section 5.0.

B6.0 Evaluation Report Requirements

B6.1 The report shall include descriptions of the fasteners including dimensions.

B6.2 There shall be a table providing fastener dimensions and allowable fastener strengths. Refer to Table 1 for an example.

B6.3 There shall be a table providing reference withdrawal design values (*W*). Refer to Table 2 for an example.

B6.4 There shall be a table providing the minimum fastener end and edge distances and spacing for installation in the wood member. Refer to Table 6 for an example.

B6.5 There shall be a description of the types of building products that are intended to be attached to the wood material.

B6.6 The following statements shall appear in the report:

1. The design values in this report for the (applicable products) are intended to aid the designer in meeting the requirements of IBC Section 1604.2.
2. Determination of the suitability of the (applicable products) for the specific application is the responsibility of the designer and is outside of the scope of this report.
3. The designer is responsible for determining the available strengths for the connection, considering all applicable limit states, and for considering serviceability issues.
4. The designer is responsible for determining the required spacing, edge distance and end distance for the fasteners, based on the characteristics of the wood material and the attached building material.

Annex C
Evaluation of Load Capacities of Connection Configurations with Dowel-type Threaded Fasteners

C1.0 Introduction

The purpose of this Annex to provide procedures for evaluation of specific connection configurations with dowel-type threaded fasteners.

See Sections 1.3 and 1.4 for references and definitions.

The following types of connections are currently addressed:

1. Lateral Connections with Dowel-type Threaded Fasteners Installed at an Angle to the Grain. See Sub-Annex CA.
2. Ledger Board Attachment to Rim Board. See Sub-Annex CB.

C2.0 Basic Information:

See Section 2.0.

C3.0 Test and Performance Requirements and Test Methods

C3.1. Wood Test Member Requirements: See Section 4.2.1, and applicable requirements in each Sub-Annex.

C3.2. Sample Size: See Section 4.2.2.

C3.3. See the applicable Sub-Annex for additional requirements.

C4.0 Analysis Requirements

C4.1. Limiting Values: Determination of allowable load capacities must consider tested strength and limits on displacement of the connected parts as required by the applicable Sub-Annex. The allowable load capacity shall not be increased to account for duration of load. For fasteners complying with the standards addressed in the NDS, allowable load capacities must not exceed applicable capacities determined in accordance with the NDS.

C4.2. Factor to Adjust Tested Values to Allowable Stress Design: The factor to adjust tested values to an Allowable Stress Design normal load duration basis shall be 5.0.

C4.3. Adjustment of Test Values for Test Member Overstrength: Test values shall be adjusted for test member overstrength in accordance with Section~~s~~ 3.0~~3.3.3, 3.4.3 and 3.5.2~~, as applicable.

C4.4. Connection Stiffness or Slip: Connection stiffness or slip shall be addressed as required by the applicable Sub-Annex.

C5.0 Quality Control

See Section 5.0.

C6.0 Evaluation Report Requirements

The report shall include descriptions of the fasteners including dimensions and strengths. See the applicable Sub-Annex for additional requirements.

Sub-Annex CA
Lateral Connections Made with Dowel-type Threaded Fasteners Installed at an Angle of Less than 90 Degrees from the Surface of the Wood.

CA1.0 General:

CA1.1 Scope: This sub-annex provides two approaches to qualifying lateral connections between wood members or between steel side members and a wood main member when dowel-type threaded fasteners are installed in a manner other than at 90 degrees to the surface of the connected wood members. The lateral load being considered is parallel to the surface of the wood member(s), but the fastener axis is at an angle less than 90 degrees with respect to the wood member surface, such that the fasteners transfer load through shear only or a combination of tension and shear. Applicable connections include two-member connections (single shear) and three-member connections (double shear).

Connections used to resist dead and live loads (normal duration of load) and connections used to resist wind and/or seismic loads have been considered. Testing is considered to be representative of short-term loading.

CA1.2 Qualification and Testing Plan: Prior to commencement of testing, a testing and analysis proposal shall be submitted to ICC-ES for approval. The Qualification Approach that will be followed (Section CA2.0 or Section CA3.0) shall be identified. The proposal shall indicate the types of connections for which evaluation is sought, and shall provide the applicable range of all parameters such as specific gravity, moisture content, minimum and maximum side member thickness, fastener orientation, minimum penetration into the main member, direction of applied load etc. Fasteners intended for installation in EWP shall be limited to use with the specific EWP that is tested.

CA1.3 Test Member and Test Setup Requirements: Wood members used in testing shall comply with the requirements in Section 4.2.1. Lateral load testing of single fasteners shall be in Section 4.2.4 of this criteria, except free rotation of the connected members is not required. As an option, a three-member setup may be used whereby two lateral connections are tested at the same time. The proposed three-member setup shall be included in the qualification test plan submitted to ICC-ES for review.

CA2.0 Qualification Approach No. 1 - Design Methodology Based on Tested Design Characteristics:

CA2.1. General: A design methodology shall be described in the evaluation report, based on single-fastener design characteristics which are qualified through testing and which shall also appear in the evaluation report. Currently, the only design methodology considered in this annex is a design methodology using the design characteristics of withdrawal and pull-through when the fasteners are installed at an angle between 30 degrees and 90 degrees to the wood grain, to determine lateral connection strength.

CA2.2. Description of Design Methodology: The design methodology shall be fully described. The applicant shall indicate if the design methodology is applicable to single fastener connections and/or to connections comprised of multiple fasteners. The design methodology shall address the required edge and end distances, as well as the required spacing between rows of fasteners and between fasteners in a row. The design methodology shall address how to determine the stiffness of the connection or the amount of slip in the connection at the allowable load level.

CA2.3. Qualification of Applicable Single Fastener Design Characteristics: Single fastener design characteristics that are not able to be qualified in accordance with Sections 3.0 through 4.0 of this criteria shall be qualified through additional single fastener testing. Test methods shall follow the requirements noted in Section 4.0 as much as possible, and shall be representative of the expected installation in the field. Sample size shall comply with Section 4.2.2 of this criteria. The determined design characteristics, such as withdrawal of ~~screws~~ fasteners installed at an angle to the wood surface, must not exceed the relevant fastener strength.

CA2.4. Confirmation Testing of Connections: Connections representative of those designed using the proposed methodology shall be tested for lateral connection capacity as follows:

1. A variety of connection configurations shall be tested to verify the design methodology. The selected configurations must address the extreme conditions for which the design methodology is considered applicable. Relevant characteristics to be considered include, but are not limited to, fastener type, angle of fastener installation relative to the grain of both the side and main members, fastener penetration in the main member, side member material and thickness, assigned specific gravity of wood members, types of applicable EWP, moisture content of wood members, mechanical properties of steel members, etc.
2. When confirming a design methodology for single fastener connections, confirmation tests shall be conducted on single fasteners. When confirming a design methodology for multiple fastener connections, confirmation tests shall be conducted on assemblies that represent the range of connections designed using the proposed methodology.
3. For each connection configuration, a minimum of three replicate two-member or three-member assemblies shall be tested. If the ultimate load for any one of the test assemblies within a set of replicates varies more than 20 percent from the average, three additional replicate assemblies shall be tested.

4. The specific gravity and moisture content of the wood members shall be determined and reported in accordance with Sections 4.2.1.2 and 4.2.1.3.
5. The lateral slip of the side member(s) in the direction of the applied load with respect to the main member shall be measured for each test assembly and the load-deflection diagrams shall be included in the test report.

CA2.5. Conditions of Acceptance: The design methodology shall be qualified when the following conditions have been met:. If the design methodology cannot be validated~~substantiated~~, the design methodology may be adjusted or the tested connections shall be evaluated in accordance with Section CA3.0.

1. For each configuration that is tested, a comparison shall be made between the test results and the expected results determined by calculation in accordance with the proposed design methodology. Both strength and stiffness or slip shall be considered.
2. The tested connection strength for each configuration shall be compared to the expected connection strength, as follows:
    a. The expected reference allowable connection strength for each assembly configuration shall be based on the applicable dimensions, material properties, etc. of the components used in the test assemblies.
    b. When three-member test setups are used, the ultimate test load divided by two shall be compared to the expected connection strength.
    c. When three to five replicate assemblies are tested, the lowest ultimate test load shall be used in the comparison to the expected connection strength. When six or more replicate assemblies are tested, the average ultimate test load shall be used in the comparison to the expected connection strength.
    d. For connections intended to resist wind and/or seismic loads, the tested connection strength for each configuration shall be at least three times the reference allowable connection strength determined in accordance with the design methodology, multiplied by a load duration factor of 1.6.
    e. For connections intended for use under normal load durations, the tested connection strength for each configuration, divided by a duration of load factor of 1.6, shall be at least three times the expected reference allowable connection strength.
3. The stiffness of each test assembly shall be determined as the secant modulus or the slope of a line from the origin (zero point) to the reference allowable design load on the load-deflection diagram. An average stiffness for the connection configuration shall be determined for the test series. The measured stiffness of the connection shall be greater than or equal to 80 percent of the expected stiffness, or the measured slip of the connection at the reference allowable design values shall be no more than $^{1}/_{16}$ inch (1.6 mm) more than expected, whichever is less severe.

CA2.6. Evaluation Report: The evaluation report shall address the following:

1. The intended use of the connections and whether or not they are expected to transfer wind and/or seismic loads.
2. Fastener descriptions and applicable single fastener design values in accordance with Sections 6.1.1 through 6.1.4 and CA2.3 of this acceptance criteria.
3. Detailed descriptions of the applicable connection configurations showing connection geometry, fastener orientation with respect to the wood surface and orientation of design load. Figures shall be included as needed to aid in the understanding of the connection geometry.
4. The design methodology, including the following:
    a. Limits on applicable parameters, based on the range of conditions addressed in the confirmatory testing.
    b. Expected load duration and adjustments required for alternative load duration.
    c. A requirement for adjustment of design values due to moisture content or elevated temperature in accordance with the NDS.
    d. The expected connection stiffness or amount of slip.
5. The evaluation report shall include reference lateral design values for specific connection configurations, determined using the qualified design methodology.
6. The evaluation report shall include the statements in Sections 6.2.5, 6.2.6, 6.2.7 and 6.3 of this acceptance criteria, as applicable.

CA3.0 Qualification Approach No. 2 - Empirical Qualification of Connection Strength:

CA3.1. General: Specific single or multiple fastener connection configurations shall be qualified through testing.

CA3.2. Reporting Requirements: Connection characteristics that shall be reported include fastener type and dimensions, number of fasteners, edge and end distances, spacing of fasteners, angle of fastener installation relative to the grain of both the side and main members, fastener penetration in the main member, side member material and thickness, assigned specific

gravity of wood members, moisture content of wood members, mechanical properties of steel members, pre-drilling of wood (pilot holes), etc.

CA3.3. Testing Requirements: For single-fastener connections, sample size and lateral testing shall follow Sections 4.2.2 and 4.2.4 of this criteria, respectively. For connections with two or more fasteners, a minimum of five replicate two-member or three-member assemblies of each configuration shall be tested. Additionally, for connections with two or more fasteners, if the ultimate load for any one of the test assemblies within a set of replicates varies more than 20 percent from the average, three additional replicate specimens shall be tested. The lateral slip of the side member with respect to the main member shall be measured for each test assembly and the load-deflection diagram of each test assembly shall be included in test report.

CA3.4. Reference Allowable Lateral Design Load: The reference allowable lateral design value for the connection shall be determined as follows:

1. When three-member test setups are used, the resulting ultimate test load shall be divided by two.
2. The average ultimate test load result shall be used in the determination of the reference allowable connection strength.
3. For connections intended to resist wind and/or seismic loads, the reference allowable connection strength shall be the average ultimate test load for each configuration divided by a safety factor of 3.0.
4. For connections intended for use under normal load durations, the reference allowable load shall be the average ultimate test load, divided by the product of a duration of load factor of 1.6 and a safety factor of 3.0.

CA3.5. Evaluation Report: The evaluation report shall address the following:

1. The intended use of the connections and whether or not they are expected to transfer wind and/or seismic loads.
2. Fastener descriptions and applicable single fastener design values in accordance with Sections 6.1.1 through 6.1.4 of this acceptance criteria.
3. Detailed descriptions of the applicable connection configurations showing connection geometry, fastener orientation with respect to the wood surface and orientation of design load. Figures shall be included as needed to aid in the understanding of the connection geometry.
4. Requirements for the connected members including assigned specific gravity and moisture content, based on the test member characteristics.
5. The reference lateral design value for the connection.
6. Expected load duration and adjustments required for alternative load duration.
7. A requirement for adjustment of design values due to moisture content or elevated temperature in accordance with the NDS.
8. The evaluation report shall include the statements in Sections 6.2.4, 6.2.5, 6.2.6~~, 6.2.7~~ and 6.3 of this acceptance criteria, as applicable.

Sub-Annex CB
Ledger Board Attachment to Rim Board

CB1.0 General:

CB1.1 Scope: This sub-annex addresses qualification requirements for determining spacing of dowel-type threaded fasteners used to fasten deck ledger boards to rim boards as alternates to the bolts and lag screws prescribed in 2018 IRC Table R507.9.1.3(1). Dowel-type threaded fasteners with outside (major) thread diameter of up to $^1/_2$ inch (12.7 mm) have been considered. Only loads due to dead load, live load and snow load have been considered.

CB1.2 Qualification and Testing Plan: Prior to commencement of testing, a testing and analysis proposal shall be submitted to ICC-ES for approval. The proposal shall identify the wood species or products used for the ledger board and rim board; the thickness of the sheathing and any gap between the ledger board and the rim board; the minimum edge distance applicable for both the ledger board and the rim board; the moisture content for the wood members; the minimum member dimensions; and the applicable fastener, including the minimum fastener length.

CB2.0 Test Member and Test Setup Requirements:

As much as possible, the test setup shall replicate the intended installation. Wood members used in testing shall comply with the requirements in Section 4.2.1 and the additional requirements of this section. See Figure CB1. The number of replicate specimens shall comply with Section 4.2.2.

The deck side of the connection shall be represented by two joist members and a ledger board. The joist members shall be spaced 16 inches (406 mm) on center and shall be attached to the ledger board using joist hangers. Fasteners used with the joist hangers shall not penetrate through the ledger board. A sufficient size and quantity of fasteners shall be used to ensure that the tested assembly fails at the connection of the ledger board to the rim board. The ledger board shall be treated lumber tested in a wet condition, in accordance with Section 4.2.1.3.

Sheathing used in testing shall be of the thickness intended for installation in the field. Use of rated sheathing will qualify use with rated sheathing and with Structural I sheathing. Use of Structural I sheathing will only qualify installation through Structural I sheathing. Sheathing shall be fastened to the rim board using 6d common nails at each corner and at 6 inches (152 mm) o.c. along each edge. When a gap is intended between the sheathing and the ledger board, steel washers or shims shall be used as spacers.

On the side of the connection representing the residential structure, only the rim board (not the sheathing) shall bear on the support. Horizontal bracing of the rim board shall be used to prevent rotation of the rim board during testing. The rim board shall be tested in a dry condition, in accordance with Section 4.2.1.3.

The fastener connecting the ledger board to the rim board shall be long enough to penetrate the rim board member a minimum of 6D, where D is the shank diameter. If this is not possible due to the dimension of the rim board, the fastener tip shall fully penetrate past the inside face of the rim board. Self-drilling fasteners are to be installed without a predrilled hole. The fastener shall be centered between the two joist members. The distance from the center of the fastener to the loaded edge of the ledger board shall represent the minimum intended edge distance, and shall not be less than 2 inches (51 mm).

The loading rate shall be 0.5 inch (12.7 mm) per minute. Vertical displacement of the ledger board relative to the rim board shall be recorded.

CB3.0 Reference Allowable Lateral Design Load:

The reference allowable lateral design load for a single fastener shall be the least of the following: 1) the average ultimate test load divided by a reference factor of 5; 2) the maximum load at which the ledger board displacement relative to the rim board does not exceed $^1/_8$ inch (3.2 mm); and 3) the qualified reference design value for the fastener size and type when used to connect two 2-by [$1^1/_2$ inch (38.1 mm) thick] members of the same specific gravity as the ledger board.

CB4.0 Determination of Required Spacing of Fasteners:

The maximum spacing of the fasteners along the ledger board shall be based on the reference allowable lateral design load, and the capacity of the ledger board to span between fasteners. Tabulated spacings shall be supported by calculations which are signed and sealed by a registered design professional, taking into account a minimum uniform live load of 40 psf (195 kg/m^2) and a minimum uniform dead load of 10 psf (49 kg/m^2) together with the span of the joists. Spacing between rows of fasteners shall not be less than $1^5/_8$ inches (41 mm) nor more than 5 inches (127 mm).). Fasteners spacing within the staggered rows shall not be less than what is required by Table 6.

CB5.0 Corrosion Resistance of Fasteners:

The fasteners must comply with IRC Sections R317.3.1 and R507.9.1.3 of the 2018 IRC or shall be qualified as alternates to hot-dipped galvanized fasteners in accordance with the ICC-ES Acceptance Criteria for Corrosion-resistant Fasteners and Evaluation of Corrosion Effects of Wood Treatments (AC257), as documented in an ICC-ES evaluation report.

CB6.0 Evaluation Report:

The evaluation report shall include the following:

1. A statement that the prescribed use of the fasteners is intended as an alternate to Table R507.9.1.3(1) of the 2018 IBC, and that only dead load, live load and snow load have been considered.
2. A description of the applicable wood species combination, incising condition and minimum dimension of the ledger board.
3. A description of the applicable wood species combination or engineered wood product for the rim board, as well as the minimum thickness.
4. The applicable fastener designation including the minimum applicable length.
5. A table showing maximum allowable fastener spacing for applicable combinations of uniform load and joist span.
6. Minimum edge distance, end distance and spacing requirements, including a figure depicting staggered fasteners, similar to Figure R507.9.1.3 of the 2018 IRC.
7. A statement regarding the required fastener penetration into or through the rim board member.
8. A statement indicating that wet-service conditions for the ledger board have been considered in determining the prescribed spacing requirements.
9. The location of the deck joist relative to the ledger board screws based on the tested assembly.

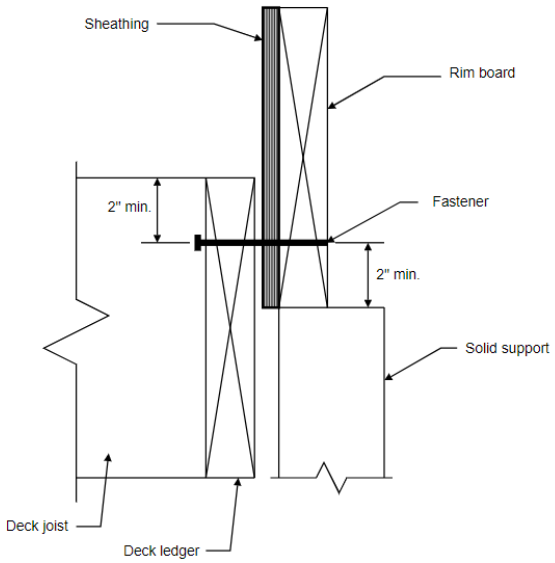


FIGURE CB1—LEDGER TO RIM BOARD TEST SETUP