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Guide for
Evaluating System Effects in Repetitive-Member Wood Assemblies[1]

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INTRODUCTION

The apparent stiffness and strength of repetitive-member wood assemblies is generally greater than the stiffness and strength of the members in the assembly acting alone. The enhanced performance is a result of load sharing, partial composite action, and residual capacity obtained through the joining of members with sheathing or cladding, or by connections directly. The contributions of these effects are quantified by comparing the response of a particular assembly under an applied load to the response of the members of the assembly under the same load. This guide defines the individual effects responsible for enhanced repetitive-member performance and provides general information on the variables that should be considered in the evaluation of the magnitude of such performance.

The influence of load sharing, composite action and residual capacity on assembly performance varies with assembly configuration and individual member properties, as well as other variables. The relationship between such variables and the effects of load sharing and composite action is discussed in engineering literature. Consensus committees have recognized design stress increases for assemblies based on the contribution of these effects individually or on their combined effect.

The development of a standardized approach to recognize "system effects" in the design of repetitive-member assemblies requires standardized analyses of the effects of assembly construction and performance.

1. Scope

1.1 This guide identifies variables to consider when evaluating repetitive-member assembly performance for parallel framing systems.

1.2 This guide defines terms commonly used to describe interaction mechanisms.

1.3 This guide discusses general approaches to quantifying an assembly adjustment including limitations of methods and materials when evaluating repetitive-member assembly performance.

1.4 This guide does not detail the techniques for modeling or testing repetitive-member assembly performance.

1.5 The analysis and discussion presented in this guideline are based on the assumption that a means exists for distributing applied loads among adjacent, parallel supporting members of the system.

1.6 Evaluation of creep effects is beyond the scope of this guide.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 245 Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber[2]
D 1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens[2]
D 2915 Practice for Evaluating Allowable Properties for Grades of Structural Lumber[2]
D 5055 Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists[2]

3. Terminology

3.1 *Definitions:*

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[2] *Annual Book of ASTM Standards*, Vol 04.10.

3.1.1 *composite action*, *n*—interaction of two or more connected wood members that increases the effective section properties over that determined for the individual members.

3.1.2 *element*, *n*—a discrete physical piece of a member such as a truss chord.

3.1.3 *global correlation*, *n*—correlation of member properties based on analysis of property data representative of the species or species group for a large defined area or region rather than mill-by-mill or lot-by-lot data. The area represented may be defined by political, ecological, or other boundaries.

3.1.4 *load sharing*, *n*—distribution of load among adjacent, parallel members in proportion to relative member stiffness.

3.1.5 *member*, *n*—a structural wood element or elements such as studs, joists, rafters, tresses, that carry load directly to assembly supports. A member may consist of one element or multiple elements.

3.1.6 *parallel framing system*, *n*—a system of parallel framing members.

3.1.7 *repetitive-member wood assembly*, *n*—a system in which three or more members are joined using a transverse load-distributing element.

3.1.7.1 *Discussion*—Exception: Two-ply assemblies can be considered repetitive-member assemblies when the members are in direct side-by-side contact and are joined together by mechanical connections or adhesives, or both, to distribute load.

3.1.8 *residual capacity*, *n*—ratio of the maximum assembly capacity to the assembly capacity at first failure of an individual member or connection.

3.1.9 *sheathing gaps*, *n*—interruptions in the continuity of a load-distributing element such as joints in sheathing or decking.

3.1.10 *transverse load-distributing elements*, *n*—structural components such as sheathing, siding and decking that support and distribute load to members. Other components such as cross bridging, solid blocking, distributed ceiling strapping, strongbacks, and connection systems may also distribute load among members.

4. Significance and Use

4.1 This guide covers variables to be considered in the evaluation of the performance of repetitive-member wood assemblies. System performance is attributable to one or more of the following effects:

4.1.1 load sharing,

4.1.2 composite action, or

4.1.3 residual capacity.

4.2 This guide is intended for use where design stress adjustments for repetitive-member assemblies are being developed.

4.3 This guide serves as a basis to evaluate design stress adjustments developed using analytical or empirical procedures.

NOTE 1—Enhanced assembly performance due to intentional overdesign or the contribution of elements not considered in the design are beyond the scope of this guide.

5. Load-Sharing

5.1 *Explanation of Load-Sharing:*

5.1.1 Load sharing reduces apparent stiffness variability of members within a given assembly. In general, member stiffness variability results in a distribution of load that increases load on stiffer members and reduces load on more flexible members.

5.1.2 A positive strength-stiffness correlation for members results in load sharing increases, which give the appearance of higher strength for minimum strength members in an assembly under uniform loads.

NOTE 2—Positive correlations between modulus of elasticity and strength are generally observed in samples of "mill run" dimension lumber; however, no process is currently in place to ensure or improve the correlation of these relationships on a grade-by-grade or lot-by-lot basis. Where design values for a member grade are based on global values, global correlations may be used with that grade when variability in the stiffness of production lots is taken into account.

5.1.3 Load sharing tends to increase as member stiffness variability increases and as transverse load-distributing element stiffness increases. Assembly capacity at first member failure is increased as member strength-stiffness correlation increases.

NOTE 3—From a practical standpoint, the system performance due to load sharing is bounded by the minimum performance when the minimum member in the assembly acts alone and by the maximum performance when all members in the assembly achieve average performance.

5.2 Variables affecting Load Sharing Effects on Stiffness include:

5.2.1 Loading conditions,

5.2.2 Member span, end conditions and support conditions,

5.2.3 Member spacing,

5.2.4 Variability of member stiffness,

5.2.5 Ratio of average transverse load-distributing element stiffness to average member stiffness,

5.2.6 Sheathing gaps,

5.2.7 Number of members,

5.2.8 Load-distributing element end conditions,

5.2.9 Lateral bracing, and

5.2.10 Attachment between members.

5.3 Variables affecting Load Sharing Effects on Strength include:

5.3.1 Load sharing for stiffness (5.2),

5.3.2 Level of member strength-stiffness correlation.

6. Composite Action

6.1 *Explanation of Composite Action:*

6.1.1 For bending members, composite action results in increased flexural rigidity by increasing the effective moment of inertia of the combined cross-section. The increased flexural rigidity results in a redistribution of stresses which usually results in increased strength.

6.1.2 Partial composite action is the result of a non-rigid connection between elements which allows interlayer slip under load.

6.1.3 Composite action decreases as the rigidity of the connection between the transverse load-distributing element and the member decreases.

6.2 Variables affecting Composite Action Effects on Stiffness include:

6.2.1 Loading conditions,

6.2.2 Load magnitude,

6.2.3 Member span,

6.2.4 Member spacing,

6.2.5 Connection type and stiffness,

6.2.6 Sheathing gap stiffness and location in transverse load-distributing elements, and

6.2.7 Stiffness of members and transverse load-distributing elements (see 3.1.5).

6.3 Variables affecting Composite Action Effects on Strength include:

6.3.1 Composite action for stiffness (6.2),

6.3.2 Location of sheathing gaps along members.

7. Residual Capacity of the Assembly

7.1 *Explanation of Residual Capacity*

7.1.1 Residual capacity is a function of load sharing and composite action which occur after first member failure. As a result, actual capacity of an assembly can be higher than capacity at first member failure.

NOTE 4—Residual capacity theoretically reduces the probability that a "weak-link" failure will propagate into progressive collapse of the assembly. However, an initial failure under a gravity or similar type loading may precipitate dynamic effects resulting in instantaneous collapse.

7.1.2 Residual capacity does not reduce the probability of failure of a single member. In fact, the increased number of members in an assembly reduces the expected load at which first member failure (FMF) will occur (see Note 5). For some specific assemblies, residual capacity from load sharing after FMF may reduce the probability of progressive collapse or catastrophic failure of the assembly.

NOTE 5—Conventional engineering design criteria do not include factors for residual capacity after FMF in the design of single structural members. The increased probability of FMF with increased number of members can be derived using probability theory and is not unique to wood. The contribution of residual capacity should not be included in the development of system factors unless it can be combined with load sharing beyond FMF and assembly performance criteria which take into account general structural integrity requirements such as avoidance of progressive collapse (that is, increased safety factor, load factor, or reliability index). Development of acceptable assembly criteria should consider the desired reliability of the assembly.

7.2 Variables affecting Residual Capacity Effects on Strength include:

7.2.1 Loading conditions,

7.2.2 Load sharing,

7.2.3 Composite action,

7.2.4 Number and type of members,

7.2.5 Member ductility (brittle versus ductile),

7.2.6 Connection system,

7.2.7 Contribution from structural or nonstructural elements not considered in design, and

7.2.8 Contribution from structural redundancy.

8. Quantifying Repetitive-Member Effects

8.1 *General*—This section describes procedures for evaluating the system effects in repetitive-member wood assemblies using either analytical or empirical methods. Analysis of the results for either method shall follow the requirements of 8.4.

8.2 *Analytical Method*:

8.2.1 System effects in repetitive-member wood assemblies shall be quantified using methods of mechanics and statistics.

8.2.2 Each component of the system factor shall be considered.

8.2.3 Confirmation tests shall be conducted to verify adequacy of the derivation in 8.2.1 to compute force distributions. Tests shall cover the range of conditions (that is, variables listed in 5.2, 5.3, 6.2, 6.3 and 7.2) anticipated in use. If it is not possible to test the full range of conditions anticipated in use, the results of limited confirmation tests shall be so reported and the application of such test results clearly limited to the range of conditions represented by the tests. Confirmation tests shall reflect the statistical assumptions of 8.2.1.

NOTE 6—When analyzing the results of confirmation tests, the user is cautioned to differentiate between system effects in repetitive-member wood assemblies that occur prior to first member failure and system effects which occur after first member failure as a result of residual capacity in the test assembly (See Section 7).

8.2.4 If increased performance is to be based on material property variability, the effects of the property variability shall be included in the analysis.

8.2.4.1 For material properties which are assigned using global ingrade test data, the effects of the property variability, including lot-by-lot variation, shall be accounted for through Monte Carlo simulation using validated property distributions based on global ingrade test data (Practice D 1990).

8.2.4.2 For material properties that are assigned using mill specific data, the effects of the property variability shall be accounted for using criteria upon which ongoing evaluation of the material properties under consideration are based.

8.2.5 Extrapolation of results beyond the limitations assigned to the analysis of 8.2.1 is not permitted.

8.3 *Empirical Method*:

8.3.1 System effects in repetitive-member wood assemblies quantified using empirical test results shall be subject to the following limitations:

8.3.1.1 For qualification, a minimum of 28 assembly specimens shall be tested for a reference condition. Additional samples containing 28 assembly specimens shall be tested for additional loading and test conditions.

Exception: When system factors are limited to serviceability, the number of assembly tests need not exceed that required to estimate the mean within ±5 % with 75 % confidence.

NOTE 7—The minimum sample size of 28 was selected from Table 2 of Practice D 2915.

8.3.1.2 Extrapolation of results to other loading and test conditions is not permitted.

8.3.1.3 Interpolation of results between test conditions is limited to one variable.

8.3.1.4 Additional sampling for each of the elements in the assembly shall be selected and tested to ensure that the elements in the test assemblies are representative of the population.

8.3.1.5 An ongoing procedure for quality control of the assembly, including material properties, fabrication quality, and proper field application limits, shall be developed and maintained.

8.4 *Evaluation*—In the absence of a more detailed analysis, the methods in 8.4.1 and 8.4.2 shall be used to evaluate system effects in repetitive-member wood assemblies.

NOTE 8—Assemblies exhibiting atypical creep or assemblies exhibiting failure modes that differ from individual member tests require additional consideration to account for differences between short-term and long-term performance.

8.4.1 *System Factors for Strength (including Buckling)*:

8.4.1.1 The system strength factor for a repetitive-member assembly shall be computed as the ratio of load at first member failure (FMF) in the assembly to load at FMF for the same number of members not in an assembly.

8.4.1.2 The assigned system strength factor, C_r, shall be evaluated at the 5th-percentile load ratio.

8.4.2 *System Factors for Stiffness*:

8.4.2.1 The system stiffness factor for a repetitive-member assembly shall be computed as the inverse ratio of the maximum deflection of the assembly to the maximum deflection of the same members not in an assembly. The deflection ratio shall be calculated at a constant load level.

8.4.2.2 The assigned system stiffness factor, C_E, shall be evaluated at the average deflection ratio.

8.5 *Default System Factors*:

8.5.1 In lieu of the more rigorous methods required by 8.2-8.4, system strength factors defined in Table 1 shall be permitted to be used for repetitive-member assemblies. These factors are applied by multiplying the single member allowable design stress by the applicable factor.

TABLE 1 Default System Strength Factors, C_r, for Repetitive-Member Assemblies

1.15	Bending stress of solid sawn wood members (3 or more members spaced not more than 24 in. o.c.)
	Axial stress of visually-graded solid sawn I-joist flanges (3 or more I-joist members spaced not more than 24 in. o.c.)
1.10	Bending stress of 2–ply solid sawn beams or headers (2 members in direct contact)
	Axial stress of solid sawn truss chords (3 or more trusses spaced not more than 24 in. o.c.)
1.07	Axial stress of machine-graded solid sawn I-joist flanges (3 or more I-joist members spaced not more than 24 in. o.c.)
1.04	Axial stress of structural composite lumber I-joist flanges (3 or more I-joist members spaced not more than 24 in. o.c.)

APPENDIXES

(Nonmandatory Information)

X1. BACKGROUND OF ASTM REPETITIVE-MEMBER FACTORS

X1.1 A repetitive-member bending stress increase factor has been provided in Practice D 245 for many years. Development and use of new prefabricated structural components and emphasis on reliability-based design formats have focused attention on the basis for this repetitive-member adjustment.

X1.2 The 1.15 repetitive-member bending stress increase factor, referenced in Practice D 245, has its root in a short-lived tentative ASTM standard (ASTM D 2018-62T). The procedures in D 2018 were intended to provide increases in allowable design stresses for any established grade or specific group of framing lumber used as joists, truss chords, rafters, studs, planks, decking or similar members which are in contact or spaced not more than 24 in. on centers, are not less than three in number and are joined by floor, roof or other load distributing elements adequate to support the design load.

X1.3 Appendix X1 of Specification D 5055 provides repetitive-member factors for wood I-joists bending stresses based on the 1.15 factor from Practice D 245 for solid sawn lumber. The rationalization for these factors assumes that the 1.15 factor is proportional to the assumed stiffness coefficient of variation (COV) of visually-graded solid sawn lumber. For I-joists which use visually graded solid sawn lumber flanges, the repetitive-member factor for bending was set to 1.15. For flange material with lower COV, factors were derived proportionally using the ratio of flange material COV. The following assumptions and factors were developed (Table X1.1):

TABLE X1.1 Assumed COV and Repetitive-Member Factors for I-Joist Flange Materials (Specification D 5055)

I-Joist Flange Material	Assumed Stiffness COV	Repetitive-Member Bending Stress Factor
Visually graded solid-sawn lumber	0.25	1.15
Machine stress-rated lumber	0.11	1.07
Structural composite lumber	0.07	1.04

X2. COMMENTARY

X2.1 Introduction

X2.1.1 This commentary was developed to assist users in their interpretations regarding the intent of the provisions of the guide. In its broadest sense, this guide is the first step on the journey toward developing a common understanding of what we mean by "repetitive member factor" or "system factor." Historically, the repetitive member factor has been described mostly in terms of the deflection-averaging effects of load-distributing elements in a system with varying stiffnesses among its flexural members. This effect is defined as the "load sharing" effect in the terminology of this guide; however, as these concepts have evolved over time, the concept of "system effects" has been extended to include the structural interactions between sheathing and framing and even to include any and all increases, whether by test or analysis, in system performance that exceed some measure of member performance.

X2.1.2 The developing committee encourages work that leads toward quantifying beneficial system effects, but only when presented in the proper context, in which discrepancies between "reference" systems and actual applications are minimized. As this guide gains exposure and use, the developing committee hopes that it could be refined and upgraded from a guide to a practice.

X2.1.3 This guide does not include a list of references for several reasons. First, other than the source documents for ASTM-based repetitive member factors (provided in Appendix X2.1), there are few comprehensive references that deal with the issue of system factors in the same context as this guide. The developing committee believed that selective referencing of documents with differing treatments of system effects would prove to be confusing rather than enlightening for the user. As researchers begin to apply the standardized concepts outlined in this guide, the committee expects to add such references to future versions of this commentary.

X2.2 Scope

X2.2.1 This guide was developed to fill an evolving need for engineered wood products and systems but is equally applicable to systems that use traditional wood products. Over the years, as methods for assessing system effects have become more sophisticated, it has become evident to those in this field that there were no common terminologies or reporting protocols by which one study could be related to another. Standards writers attempted to reconcile large differences in reported results between apparently similar studies. This guide provides a set of definitions that attempt to reflect the state-of-the-art in this field in a manner that is easily translated into useful information for standards writers and engineering designers.

X2.3. Terminology

X2.3.1 *Definitions*—Early committee discussions focused on whether there was a need to separate the various contributing mechanisms that collectively result in system benefits. The arguments against separating these mechanisms were that, for example, in a test it might be impossible to distinguish the benefits of one mechanism relative to another. The arguments in favor of separating the mechanisms were that only after a complete understanding of the source of the system benefits could one determine the applicability and limitations of any proposed system factor. An additional argument in favor of separating the factors was that engineers and designers increasingly are computing member performance based on composite-section calculations. For these cases, only a segmented set of system factors would prevent the designer from "double-dipping" the benefits due to composite action.

X2.3.1.1 *Member*—One difficulty in providing standardized definitions is in covering a broad range of system applications under a single definition. The definition of "member" is a good example. While this definition is straightforward for simple joist/sheathing systems, it becomes more complex in trussed systems. In a trussed system, the individual pieces of the truss are called "elements" while an assembly of truss elements is called a "member." See Fig. X2.1. These definitions were chosen in an attempt to characterize the common performance attributes of flexural members (whether joists or trusses) while preserving the ability to model "sub-member" characteristics, such as element behavior. As noted later, in X2.6, these definitions require the user to apply judgment when assessing characteristics, such as" first member failure."

X2.3.1.2 *Repetitive Member Wood Assembly*—This basic definition is identical to that traditionally used in wood design standards with the exception that the 24-in. spacing limitation has been removed from this definition. The rationale in removing the spacing limitation was that it does not define the magnitude of repetitive member factors and, thus, should not

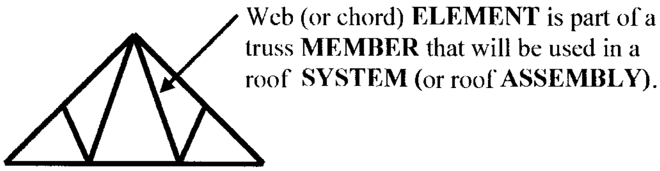

FIG. X2.1 Truss Elements and Members

restrict the research assessment of repetitive member effects to a single spacing criterion.

X2.4 Load-sharing

X2.4.1 The benefits of load-sharing within a structural assembly have been discussed widely in the literature; however, only recently have questions begun to arise regarding the assumptions underlying prior research. In general, beneficial load-sharing is highest in systems built from members that exhibit a strong positive strength-stiffness correlation, and are configured such that relative deflections, from one member to the next, are appreciable. The published studies on floor joists often focus on uniformly loaded, simple span members made of visually-graded solid sawn lumber. Section 5 of this guide reminds users that such a configuration will likely give an upper bound on estimates of system effects. Other span conditions, continuous or cantilevered, will exhibit smaller relative joist deflections and result in smaller system benefits. Other materials, particularly those with nearly identical flexural stiffnesses, may exhibit no relative member deflections and therefore no load-sharing prior to initial member failure. Conversely, other load configurations, such as concentrated loads, will show higher load sharing effects. Section 5 instructs users to explore the limitations of their models and to limit applicability of their proposed system factors appropriately.

X2.5 Composite Action

X2.5.1 Section 6 of this guide similarly reminds users to limit applicability appropriately based on the range of tested or modeled systems. Due to the nonlinearities that are common in nailed wood assemblies, the section separates the determination of stiffness effects from strength effects.

X2.6 Residual Capacity of the Assembly

X2.6.1 The computed benefits of residual capacity of an assembly are often very large. It is not uncommon to compute system capacities that are two to five times greater than the capacity of the weakest member in the system. Early committee discussions focused on whether it was appropriate to include this contribution in a proposed system factor. Arguments in favor generally stated that "if it really exists, we should take advantage of it." Arguments opposed restated the point that empirically-based factors often have limitations that are not obvious without detailed analysis. Data in support of the latter viewpoint showed that high residual capacity was often based on a set of assumptions that severely limited the structural configurations and assumed a constant set of material properties over time. In addition, as stated in this guide, the increasing number of members as a system becomes large and increases the probability of failure. The committee chose to discourage the use of residual capacity in system factor calculations based on the premise that traditional "safety factors" are calibrated to a member-based design system. The committee believes that it is inappropriate to extend these same safety factors to entire systems. In other words, engineers should not design entire systems that have the same computed probability of failure as individual members in today's designs. This guide proposes that users work toward the establishment of alternative design criteria for assemblies (reflecting judgment on acceptable probabilities of assembly failure and the benefits of reduced probability of progressive collapse in some systems) prior to including residual capacity in the overall system factor.

X2.7 Quantifying Repetitive-Member Effects

X2.7.1 Section 8 proposes that system factors be computed by separately accounting for load-sharing and composite action effects. It encourages the use of mechanics-based derivations to compute force distributions in the components of the assembly. It reiterates that users must separate their results into pre-failure and post-failure results. This maximizes the utility of the results, in which pre-failure system effects can be built into system factors today and post-failure effects can be studied for incorporation into future factors that will include residual capacity effects. This section warns that analyses must realistically account for variations in material properties, either through sensitivity studies or through ongoing material property characterization, that is, quality assurance testing. While this section permits the determination of system effects based on empirical testing (without mechanics-based force computations), it limits the application of such results to the configuration (structure, materials, etc.) that was tested. It further requires ongoing monitoring of system variables to verify continued compliance with underlying assumptions.

X2.8 Example 1—Empirical Method for Trussed-Roof Assembly

X2.8.1 Assume that a manufacturer produces a single truss configuration (always the same shape and span, always the same lumber grades and plate sizes). Hypothetically, the trusses are designed to support an allowable design load of 30 lb/ft^2(psf). Assume that testing of many replications of a roof system comprised of a series of trusses shows first member failures (at the appropriate 5th percentile tolerance limit) at 70 psf and entire roof system capacity (in comparable terms) of 95 psf. What is an appropriate system factor?

X2.8.2 *Discussion*—Since the configuration of this assembly is very specific, assume that the testing adequately reflects all potential application variables. Assume also that the manufacturer has a quality assurance system that proves that the quality of the test material is representative of production material on an ongoing basis. Unless the trusses have been specifically designed with internal redundancies, tabulations of first member failure for each assembly should represent the first failure of any element or connection in any of the trusses in the assembly. On this basis, this guide would lead the user to compute the following:

X2.8.2.1 In accordance with Section 5, the user would examine the load sharing in the system. For trusses with low stiffness variability, load sharing effects are minimal. In addition, since the test configuration is identical to the application configuration, no value is derived from separate characterization of the load sharing effect.

X2.8.2.2 In accordance with Section 6, the user would examine the composite action in the system. As noted above, unless the user intends to modify any variables in application, that is, sheathing, or fastening, or both, the only value derived from separate characterization of the composite action would be for design stiffness calculations.

X2.8.2.3 In accordance with Section 8, the system factor would be computed as the characteristic value for the roof assemblies (70 psf) divided by the characteristic value for the trusses (30 psf × 2.1 = 63). Thus, the system factor would be 1.11.

X2.8.2.4 Note that the system factor is *not* computed based on the assembly collapse information (95/63 = 1.51) unless and until standardized methods are available for establishing target safety levels for ultimate strength of assemblies.

X2.9 Example 2—Analytical Method for Rafter (Hip) Roof Assembly

X2.9.1 Assume that a manufacturer has generated an engineering analysis procedure to quantify the state of stresses in a broad range of roof configurations. The method must be verified, most likely be confirming tests, to assess the effects of application variables including configuration, spans, connection variables, material variables, etc. Hypothetically, the roof rafters are designed to support an allowable design load of 30 psf. Assume that testing of a variety of configurations of this assembly type prove that individual connections begin to yield at 20 psf, first member failures (at the appropriate 5th percentile tolerance limit) are at 65 psf and that the entire assembly withstands (in comparable terms) 80 psf. What is an appropriate system factor?

X2.9.1.1 *Discussion*—The additional complexity in this example is the discrepancy in which one potential limit state is reached at load levels that are *below* those used in traditional member design. In this case, the user must determine whether this initial limit state should be characterized as a strength limit state or a serviceability limit state. If it is a strength limit state, the system factor would be less than unity, with the magnitude determined by computations similar to those in Example 1. If characterized as a serviceability limit state, it generally would not be considered in the development of a strength-based system factor. All other calculations are as described in Example 1.

X2.10 Appendix X1

X2.10.1 Appendix X1 discusses the background of repetitive-member factors currently in use. The factors that are included in this appendix are those that are widely used by designers and have a consistent set of assumptions as their basis. Other factors are used by various product groups, many of which are based solely on limited empirical testing. The committee did not include these factors in this compilation at this time. If proponents of these factors submit their derivations to this committee and the committee believes that they have been generated in a manner consistent with this guide,they will be added to future versions.