Allowable Stress Design

Review of National Design Specification (NDS) for Wood Construction
Structural Design for Wood Construction

- Allowable Stress Design (ASD) uses the National Design Specification (NDS) for Wood Construction
  - ANSI / AF&PA NDS-2001
  - Published by American Forest and Paper Association - American Wood Council

NDS and Wood Design References

- 2001 Allowable Stress Design Manual for Engineered Wood Construction
  - ASD Manual
  - NDS
  - NDS Supplement: Design Values for Wood Construction
  - Additional Supplements
  - Guidelines
  - Special Design Provisions for Wind and Seismic
NDS and Wood Design
References

• Supplements
  • Structural Lumber
  • Structural Glued-Laminated Timber
  • Timber Poles and Piles
  • Wood Structural Panels
  • Wood Structural Panel Shear Wall and Diaphragm

• Guidelines
  • Wood I-Joists
  • Structural Composite Lumber
  • Metal Plate Connected Wood Trusses
  • Pre-Engineered Metal Connectors
NDS and Wood Design
Additional References

- Wood Frame Construction Manual for One- and Two-Family Dwellings
- Commentary on the Wood Frame Construction Manual

NDS and Wood Design

- The NDS is one of two accepted standards of practice for structural wood design in the U.S.
- All model building codes have adopted the NDS
- Minimum design loads and load combinations for design are from building codes
NDS and Wood Design

- The NDS defines the methods to be followed for design of:
  - visually graded lumber
  - mechanically graded lumber
  - structural glued-laminated timber
  - timber piles
  - single and multiple fastener connections
- Design specifications for panel products are not included in the NDS - see APA's Plywood Design Specification

ASD Manual

- ASD Manual Contents
  - Intro and Case Studies
  - Member Design (checklists and examples)
    - Tension Members
    - Compression Members
    - Bending Members
    - Bending plus Axial Loads
ASD Manual

- ASD Manual Contents
  - Mechanical Connectors
  - Wood Structural Panels
  - Shear Walls and Diaphragms
  - Reference Information (beam tables, etc.)

NDS Organization

- NDS Contents
  - General requirements for design
  - Discussion of design values for structural members
  - Design provisions for structural members
  - Provisions for sawn lumber, glulam, round timber piles
NDS Organization

• NDS Contents, continued
  • General design provisions for:
    • Wood I-joists
    • Structural Composite Lumber
    • Wood Structural Panels

NDS Organization

• NDS Contents, continued
  • General mechanical connection design provisions
  • Provisions for Dowel-type fasteners:
    • bolts, lag screws, wood screws, nails and spikes, drift bolts and drift pins
  • Provisions for Split ring and Shear plate fasteners
  • Provisions for Timber Rivets
NDS Organization

- NDS Contents, continued
  - Provisions for shear walls and diaphragms
  - Special loading conditions (spaced columns, built-up columns, etc.)
  - Fire Design of wood members
  - Appendices

NDS Supplements

- Main NDS Supplement Contents
  - Sawn lumber species combinations and grading agencies
  - Section properties for sawn lumber and glued-laminated timbers
  - All design values for:
    - visually-graded dimension lumber
    - mechanically-graded dimension lumber
    - visually-graded timbers
    - visually-graded decking
    - structural glued-laminated timbers
NDS Supplements

- Other Specific Supplements
  - Structural Lumber - contains simplified design procedures, adjustment factors, and selection tables
  - Structural Glued-Laminated Timber - contains adjustment factors, selection tables, and examples
  - Timber Poles and Piles - adjustment factors, design values, selection tables
  - Wood Structural Panels - design capacities, adjustment factors, section properties, selection tables, examples
  - Wood Structural Panel Shear Wall and Diaphragm – use of design tables and design considerations

ASD Guidelines

- Guidelines provide additional information
  - Wood I-Joists
  - Structural Composite Lumber
  - Metal Plate Connected Wood Trusses
  - Pre-Engineered Metal Connectors
  - Design capacities
  - Adjustment factors
  - Design examples
  - Other design and installation considerations
Special Provisions for Wind and Seismic

• Terminology
• Special provisions for designing members and connections
• Special provisions for shear walls and diaphragms

ASD Format

• Allowable stress design format:

\[ f \leq F' \]

\[ f = \text{actual stress} \quad F' = \text{allowable design value} \]

\[ F' = FC_i \]

\( F = \text{tabulated design value (from NDS Supplement)} \)
\( C_i = \text{adjustment factors for use conditions} \)
ASD Format

- Example: Tensile stress \( f_t \leq F_t' \)

\[
f_t = \frac{P}{A}
\]

\[
F_t' = F_t C_D C_M C_t C_F C_i
\]

Alternate Format

- Example: Tensile capacity \( T \leq T' \)
  - \( T = \) actual tensile force
  - \( T' = \) allowable tensile capacity

\[
T' = F_t' A \quad (lbs)
\]

\[
F_t' = F_t C_D C_M C_t C_F C_i
\]
**ASD Format**

- Example: Bending stress \( f_b \leq F_b' \)
  - \( f_b \) = actual bending stress
  - \( F_b' \) = allowable bending stress

\[
 f_b = \frac{M}{S}
\]

\[
 F_{b'} = F_b C_D C_M C_t C_L C_F C_V C_{fu} C_1 C_r C_c C_f
\]

**Alternate Format**

- Example: Moment capacity \( M \leq M' \)
  - \( M \) = actual bending moment
  - \( M' \) = allowable bending moment

\[
 M' = F_b' S \quad \text{(in – lbs)}
\]

\[
 F_{t'} = F_t C_D C_M C_t C_F C_i
\]
General Notation in NDS

A = cross section area
C = adjustment factors
D = diameter
E, E' = tabulated and allowable value of modulus of elasticity

General Notation in NDS

\( F_b, F'_b \) = tabulated and allowable bending design values
\( F_t, F'_t \) = tabulated and allowable tension parallel-to-grain design values
\( F_v, F'_v \) = tabulated and allowable shear parallel-to-grain design values
\( F_c, F'_c \) = tabulated and allowable compression parallel-to-grain design values
General Notation in NDS

\[ F_{\perp}, F'_{\perp} = \text{tabulated and allowable compression perpendicular-to-grain design values} \]

I = moment of inertia

K = various coefficients

M = bending moment

General Notation in NDS

P = concentrated load

S = section modulus

V = shear force

b = width of rectangular member

c = distance from neutral axis to extreme outer fiber of beams

d = depth of beams
General Notation in NDS

\begin{align*}
\sigma_b &= \text{actual bending stress} \\
\sigma_t &= \text{actual tension stress parallel-to-grain} \\
\tau_v &= \text{actual shear stress parallel-to-grain} \\
\sigma_c &= \text{actual compression stress parallel-to-grain} \\
\sigma_{c,\perp} &= \text{actual compression stress perpendicular-to-grain}
\end{align*}