THE EVALUATION OF RECOMMENDED ALLOWABLE DESIGN PROPERTIES FOR EXISTING STRUCTURES (DES160)

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DESCRIPTION

Throughout the world there are great examples of historic wood structures that have withstood the test of time and exposure to various climates. One of the challenges that code officials and designers face for modifying existing wood structures is determining what design properties to use. This webinar will address methods used to establish recommended allowable design properties for structural wood members in existing buildings. Examples from several interesting projects will be presented including buildings under renovation and waterfront structures such as piers.
LEARNING OBJECTIVES

1. Understand methods used to identify wood species used as structural members in existing buildings.

2. Understand methods used to visually grade structural wood members in existing buildings.

3. Understand methods used to establish allowable design properties for visually graded lumber in existing buildings.

4. Understand methods used for condition assessment of in-service wood including quasi-nondestructive evaluation methods and equipment.

Outline

- Species Identification
- Visual Grading of In-situ Members
- Methods to Determine Allowable Design Properties for Wood Members
- Condition Assessment
- Examples (Existing Buildings & Waterfront Structures)
Polling Question

What is your profession?

a) Architect
b) Engineer
c) Code Official
d) Builder/Building Designer
e) Other
After My “As-built“ Where Do I Begin?

- Basement
- 1st & 2nd Levels
- Attic

Typical New York City Basement
Painted Columns & Beams

Unique Attic Design
# 31 Species Combinations

## 2.1 List of Seven Lumber Species Combinations

<table>
<thead>
<tr>
<th>Species Classification</th>
<th>Species Name</th>
<th>Design Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Douglas Fir (B)</td>
<td>Douglas Fir</td>
<td>2.05, 2.05, 1.40</td>
</tr>
<tr>
<td>Hemlock (B)</td>
<td>Hemlock</td>
<td>1.75, 1.75, 1.10</td>
</tr>
<tr>
<td>Spruce (B)</td>
<td>Spruce</td>
<td>2.05, 2.05, 1.40</td>
</tr>
<tr>
<td>Redwood (B)</td>
<td>Redwood</td>
<td>2.05, 2.05, 1.40</td>
</tr>
<tr>
<td>Southern Pine (B)</td>
<td>Southern Pine</td>
<td>1.75, 1.75, 1.10</td>
</tr>
<tr>
<td>White Oak (B)</td>
<td>White Oak</td>
<td>2.05, 2.05, 1.40</td>
</tr>
<tr>
<td>Northern Hardwood (B)</td>
<td>Northern Hardwood</td>
<td>1.75, 1.75, 1.10</td>
</tr>
<tr>
<td>Western Hardwood (B)</td>
<td>Western Hardwood</td>
<td>1.75, 1.75, 1.10</td>
</tr>
</tbody>
</table>

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### Table 28
Reference Design Values for Visually Graded Southern Pine Glu-Laminated Lumber
**Lumber Grades:**\footnote{Southern Pine lumber is graded according to \textit{American Lumber Standards Association} (ASA) specifications.} 
**Foil:**\footnote{Design values are based on a specific moisture content of 19% for glue-laminated lumber and 15% for structural lumber.} 
**Grades:**\footnote{Grades are determined based on the size and shape of the lumber.} 
**Table Notes:**\footnote{Design values are intended for use in structural design and are based on the assumption that the lumber is properly designed and installed.} 

<table>
<thead>
<tr>
<th>Species and Commercial Grade</th>
<th>Design Value</th>
<th>Lumber Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal 2&quot; Thick, 5&quot; &amp; Wider</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Southern Pine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 Size/Grade Combinations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Table 30
Reference Design Values for Visually Gradated Heavy 5" x 5" and Larger \footnote{Design values are based on a specific moisture content of 19% for glue-laminated lumber and 15% for structural lumber.} 
**Grades:**\footnote{Grades are determined based on the size and shape of the lumber.} 
**Table Notes:**\footnote{Design values are intended for use in structural design and are based on the assumption that the lumber is properly designed and installed.} 

<table>
<thead>
<tr>
<th>Species and Commercial Grade</th>
<th>Design Value</th>
<th>Lumber Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Beams, Girts &amp; Columns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timbers - 5&quot; x 5&quot; &amp; Larger</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Southern Pine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between 5x5 and 14x14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36 Size/Grade Combinations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
First - Identify The Species

Macroscopic Identification Using Gross Features
Microscopic Identification Using Microscopic Features

Southern Pine  Douglas-fir

Purchase Microscopic Equipment
Recommendation

Hire an Expert

Polling Question

Knowing the wood species is not required to determine design values?

True
False
Second - Determine the Grade
(Grade Stamps Would Be Nice)

Typically to grade a wood member you must:

- Look at each member full length – close up
- Look at all 4 sides and at least 1 end (typically not possible in a building)

TYPICAL BUILDING IN THE NORTHEAST

7-10 POTENTIAL SPECIES
4-6 POTENTIAL RAFTER OR JOIST SIZES
10-16 POTENTIAL COLUMN, BEAM OR GIRT SIZES
Knots are the most frequently encountered characteristic. Illustrated here are the more common types as they appear on the lumber face in cross-section:

- Round knot hole through two wide faces.
- Sound, encased knot through two wide faces.
- Sound, star-checked, intergrown knot through two wide faces.
- Sound, intergrown knot through two narrow faces.
- Sound, intergrown knot through all four faces.
- Sound, intergrown knot through three faces.
Measuring Slope of Grain

Grain Reasonably Parallel

Slope of Grain = 1 in X

Wane: the presence of blank or lack of wood from any cause on the edge or corner of a piece of lumber.

Shake: a lengthwise separation of the wood which usually occurs between or through the annual growth rings.

White Speck and Honeycomb: are caused by a fungus in the living tree. White speck is small white pits or spots. Honeycomb is similar but the pits are deeper or larger. Neither is subject to further decay unless caused by wet conditions.

Decay: the deterioration of the wood substance due to action of wood-decaying fungi. It also may be called dry rot or unsound wood.

Splits: are similar to checks except the separations of the wood fibers extend completely through a piece, usually at the ends.

Bow: a deviation from a flat plane of the wide face of a piece of lumber from end to end.

Crook: a deviation from a flat plane of the narrow face of a piece of lumber from end to end.

Twist: a deviation from the flat planes of all four faces by separating or torsional action, usually the result of seasoning.
A Reasonable Process

Grade Each Column, Beam and Girt
(Heavy timbers are easier to grade than joists & rafters and there are generally fewer of them than joists & rafters)

(Generally more structurally significant than joists & rafters)
(Provide a map showing the grade of each member)

Grade a representative sample of rafters and floor joists
(A percentage on each level and a general overview of the remainder looking for major problems)
Recommendation

Hire an Expert

Polling Question

Which of the following is not required to determine the lumber grade?

a. Viewing all 4 sides of a member
b. Location and size of knots
c. Slope of grain
d. Moisture content
### Allowable Design Stresses for Visual Grades

Lumber – ASTM D-245  (Small Clear Specimen Testing)

(Prior to 1991 all Design Stresses)

ASTM D-1990 (In Grade testing of Full Size Lumber)

(Initiated in 1977 at WWPA – Adopted 1n 1991)

Round Timber Piles – ASTM D-2899  (Small Specimen Testing)

(Some Adjustments Based on Large Tests)
Recommended Allowable Properties Based on Small Clears

Recommended Allowable Properties Based on Testing Full Size, In-Grade Lumber
Recommended Allowable Bending Strength from Ultimate Bending Strength Test Data

2.1 = Duration of Load & Safety Factor
DOL = 1.6, Safety = 1.3
(1.6 x 1.3 = 2.1)

Fourth - Don’t Forget the Condition Assessment
Condition Assessment Tools
Evaluation of Decay
Incipient, Intermediate & Advanced Decay

1. Visual assessment - Intermediate and advanced decay
2. Moisture Meter - Potential for decay
3. Hammering - advanced internal decay
4. Pick test - Surface - incipient, intermediate and advanced decay
5. Resistograph - Internal intermediate and advanced decay
6. Core boring - All levels of decay

Visual Identification of Decay
Moisture Meter

Pick Test - Pass & Fail
What the Resistograph Chart Tells Us
Interpreting Resistograph Charts
They Can Be Really Weird

Resistograph Testing Through a Copper Covering into a Wood Column
Resistograph Testing Through Floor Boards

Increment Borer
Increment Core Boring (0.2” diameter) & Resistograph Chart

Brown Rot Decay
Effects of Decay on Strength (from Wilcox)
(If Decay is present, Visual Grades are Invalid)

Post & Beam Style Buildings
Solid Timber Trusses

Lattice Web Bowstring Trusses
These Bowstring Trusses Can Be Up to 100’ Span

Polling Question

Recommended strength design values are derived from the 5th percentile of tested values?

True
False
Pier & Foundation Pile Structures:

Determine Current Structural Capacity & Future Utility

Pier & Foundation Piles

Unlike buildings we do not visually grade piles

We Test Them!
Similar Approach Applied to Waterfront Structures & Foundation Piles

Waterfront Structures & Foundation Piles
**Limnoria**

![Image of Limnoria]

**Limnoria** Damage – Hour-glassing

![Image of Limnoria damage]

© PA
Teredo

Teredo Damage
"Wood Destroying Fungi " (Wood Rot)

- "Submerged wood will not rot or decay because of lack of air"
  - Wrong, Wrong, Wrong, Wrong !!!!!

- Over the last 30 years Wood Advisory Services, Inc developed a procedure to test pier & foundation piles to:
  - Determine Current Structural Capacity & Future Utility

Sample and Store Under water Pile Sections
Pile Sample Cutting Diagram

Loss of Test Samples
First Cut Through a Pile

Second Cut Through a Pile
Test Specimens from Preceding Pile

Bending Test for MOR (Strength) & MOE (Stiffness)
Compression Parallel to Grain Testing

Example of Small Specimen Test Results Within a Pile
The Cellular Structure of Wood

Soft Rot
Advanced Soft Rot

Side Grain View of Soft Rot
Soft Rot and Brown Rot Co-existing

Effects of Decay on Strength (from Wilcox)
Two Methods of Modifying Recommended Allowable Design Values for Piles from the NDS

<table>
<thead>
<tr>
<th>Property</th>
<th>NDS Table 6A</th>
<th>Method #1 ASTM D-2899</th>
<th>Method #2 Residual Values / NDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$F_c$</td>
<td>1250 psi</td>
<td>375 psi</td>
<td>500 psi</td>
</tr>
<tr>
<td>$F_b$</td>
<td>1950 psi</td>
<td>600 psi</td>
<td>1200 psi</td>
</tr>
<tr>
<td>MOE</td>
<td>1.5 x $10^6$ psi</td>
<td>0.8 x $10^6$ psi</td>
<td>0.9 x $10^6$ psi</td>
</tr>
<tr>
<td>MOE$_{0.5}$</td>
<td>0.6 x $10^6$ psi</td>
<td>0.4 x $10^6$ psi</td>
<td>0.5 x $10^6$ psi</td>
</tr>
</tbody>
</table>

Method 1 – Use ASTM D 2899 from Test Data.
Method 2 – Adjust NDS Table 6A Values by % Strength Loss (Test Data / Published Data).

Future Serviceability

[Diagram showing the future serviceability with data points for the years 2013 and 2042]
Surprise – Sodium Hydroxide Leaking

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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