



Quality Control Considerations for Developing Structural Glued- laminated Timber (glulam) for U.S. Markets Using South American Wood Species

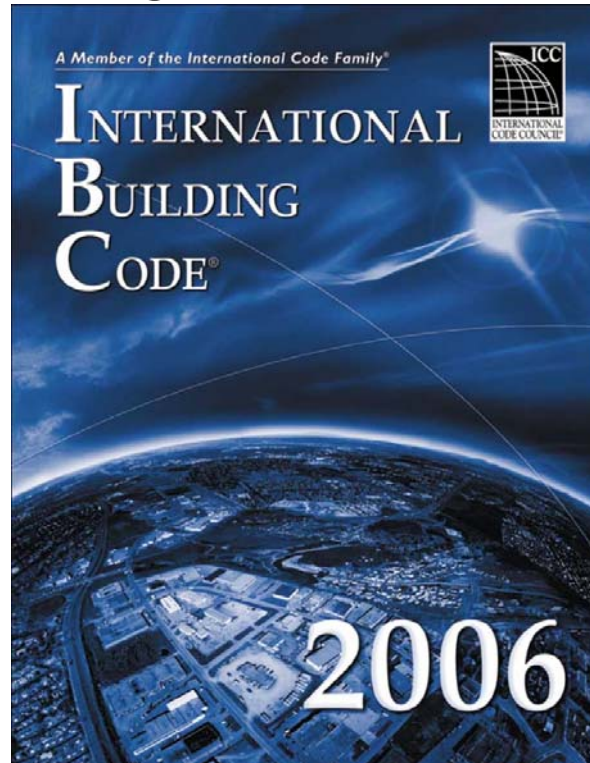
**Presented By:
Roland Hernandez
Senior Engineer
11/10/08**

Objectives of this presentation

- Understand the system of codes and standards for glued-laminated timber (glulam) in the United States.
- Review details of the standards and how they apply to U.S. wood species.
- Review details of how those same standards can be applied to South American wood species.

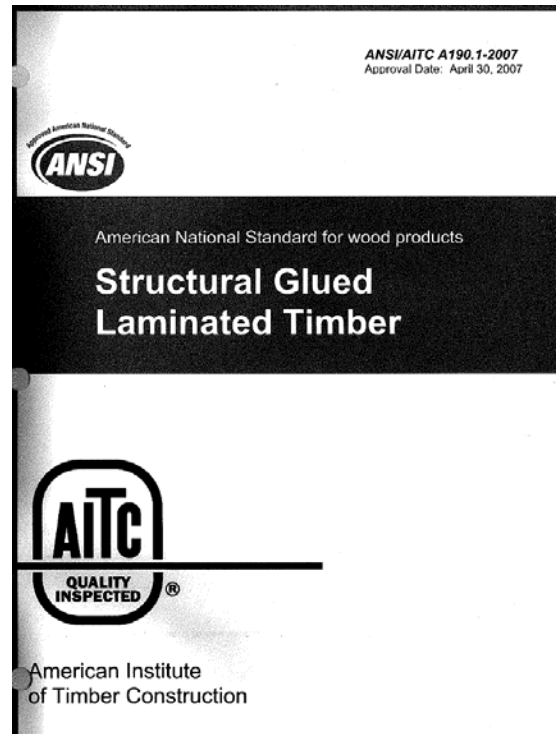
Use of Glulam in U.S. Buildings

- All wood products used as structural members in the United States must follow the 2006 International Building Code requirements.



- **2303.1.3 Structural glued-laminated timber.**
Glued-laminated timbers shall be manufactured and identified as required in AITC A190.1 and ASTM D 3737.

- American National Standard for wood products.
Structural Glued Laminated Timber.



- To established nationally recognized requirements for...
 - Production
 - Inspection
 - Testing, and
 - Certification
- ...of structural glued laminated timber

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- Production requirements
 - Sizes and tolerances
 - Lumber requirements
 - Laminating and Adhesive requirements
 - Manufacture

- * If highlighted in red, this requires special consideration when using a species of wood not currently included in the U.S. standard.

- Production requirements
 - Lumber requirements
 - Species
 - Moisture Content
 - Grading (Visual, Mechanical, SCL)

- Production requirements
 - Laminating and Adhesive requirements
 - Surface quality for bonding
 - Adhesive strength
 - Surface Bonding: Test T107
 - End-Joint Bonding: Test T119;
 - Durability of adhesive: Test T110

- Production requirements
 - Sizes and tolerances
 - Lumber requirements
 - Laminating and Adhesive requirements
 - Manufacture
 - Lamination preparation
 - Adhesive Curing
 - The use of End Joints (finger, scarf)
 - Assembly (e.g. Spacing of End Joints)

- To established nationally recognized requirements for...
 - Production
 - **Inspection**
 - Testing, and
 - Certification
- ...of structural glued laminated timber

- Inspection requirements
 - Plant manuals (production, quality control)
 - Quality control records (5 years)
 - Inspection and test procedures
 - Plant qualification
 - Daily quality control

- **Inspection requirements**
 - Plant manuals (production, quality control)
 - Quality control records
 - **Inspection and test procedures**
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Table 1—SUMMARY OF QUALIFICATION TESTS

Test Performed On	Minimum Number of Samples	Minimum Number of Specimens per Sample	AITC Test Number and Type of Test	Requirements or Limitations for	References Within this Standard
Face and Edge Joints	2 beams ^{a, b}	10	T107 Shear	Strength and Wood Failure	5.5.2, 4.5.4.1
	2 beams ^{a, b}	3	T110 Cyclic Delamination	Bond Line Openings	5.5.2 4.5.4.3
End Joints	1 ^a	30	T119 Tension	Strength and Wood Failure	5.5.1 4.5.4.2,
	1 ^{a, c}	5	T110 Cyclic Delamination	Bond Line Openings	5.5.2 4.5.4.3
The following tests are required in addition to the above requirements when these processes and/or materials are used in the plant.					
Proof Loaded End Joints	2	30	T118 Bending -or- T121 Tension	Strength Strength	5.5.1.4
End Joints for Repair	10 Repairs	2	T119 (Modified) Tension	Strength and Wood Failure	5.5.1.3 5.5.1.5
	1 ^d	5	Beam Test		AITC 403
Manufactured Lumber	1	102	T123 Tensile Properties	Strength	4.3.4 5.5.4 AITC 401
SCL	Per Applicable Requirements in ASTM D5456 and AITC 402	Per Applicable Requirements in ASTM D5456 and AITC 402	T123 Tension Plus Referenced ASTM Tests T107, T110	Strength SCL/SCL plus SCL/Wood	4.3.5 5.5.3 ASTM D5456 AITC 402
			T116	Long Span E	AITC 402
Radially Reinforced Curved Members	1	10			AITC 404
Proof Graded Lumber	1	102	T123 Tensile Properties	Strength	4.3.3.3 AITC 406
			T116	Long Span E	AITC 406

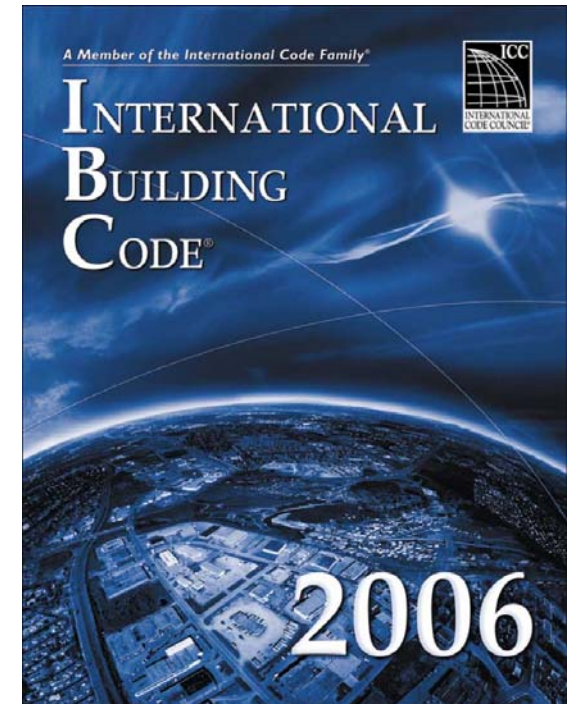
- **Inspection requirements**
 - Plant manuals (production, quality control)
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- Plant qualification
 - End-joints
 - Must meet required strength levels
 - Adhesives
 - Must pass ASTM standard tests for durability
 - SCL and Manufactured Lumber
 - Wood species
 - U.S. glulam standards primarily cover North American species.

- **Inspection requirements**
 - Plant manuals (production, quality control)
 - Quality control records
 - Inspection and test procedures
 - Plant qualification
 - **Daily quality control**

- Daily Quality Control
 - In-Line Tests
 - moisture content
 - adhesive spread
 - Assembly parameters (pressure, temperature)
 - Physical Tests
 - Parallel to the plant qualification tests
 - To assure that the plant is maintaining performance

- **2303.1.3 Structural glued-laminated timber.**
Glued-laminated timbers shall be manufactured and identified as required in AITC A190.1 and ASTM D 3737.



- Standard Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)
 - Analysis method
 - Lamination requirements and properties
 - Determining glulam properties when made from visually-graded lumber
 - Determining glulam properties when made from E-rated lumber
 - End-use adjustment factors



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- D3737 Analysis method
 - Developed in 1950s
 - Clear wood stress of lumber is reduced by the strength-reducing effect of knots in a glulam beam.
 - Referred to as the I_k/I_g Method
 - I_k is the moment of inertia of knots
 - Knots farther away from the neutral axis have larger effect
 - Requires properties of clear wood and properties of knot size
 - Many evolutions since the 1950s



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- Lamination requirements
 - Thickness requirements
 - Grade requirements
 - Visually- or E-rated lumber
 - Primarily, limitations on strength-reducing characteristics
 - Moisture content requirements
 - Cannot exceed 16% (bonding)
 - Cannot vary by more than 5% (residual stresses)

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- Glulam made with visually-graded lumber
 - Clear wood and knot size properties provided for
 - Douglas Fir-Larch
 - Southern Pine
 - Hem-Fir
 - For other visually-graded species, properties can be derived from ASTM D2555
 - Standard Practice for Establishing Clear Wood Strength Values
 - Primarily includes commercial species that grow in the United States and Canada.
 - Knot data is often proprietary information.



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- Glulam made with E-rated lumber
 - E-rated lumber assures
 - An average modulus of elasticity for the grade
 - Visual Quality Level (VQL)
 - Edge knot characteristic (1/6, 1/4, 1/3, 1/2)
 - Wood properties are determined based on E-rated grade level, not specifically for a species
 - Higher E is assigned higher clear wood stress properties
 - VQL determines the knot properties used for the analysis.

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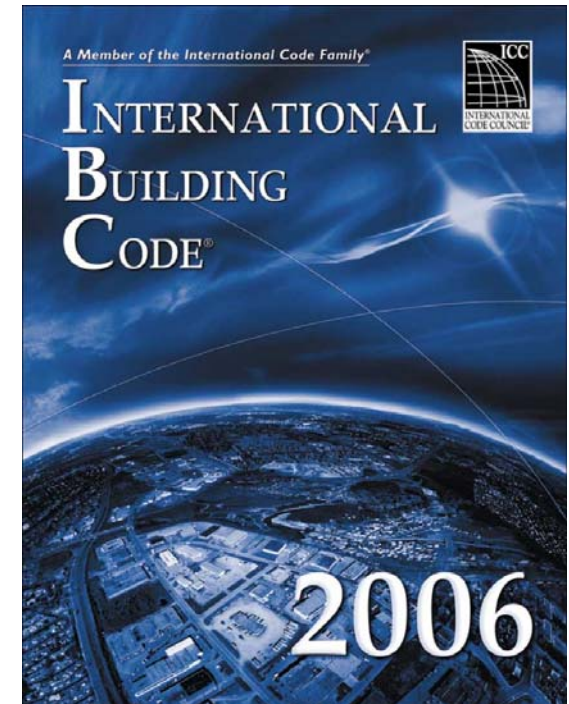


- End-use adjustment factors
 - Moisture content
 - Duration of load
 - Volume effect (???)
 - Curvature
 - Treatment (chemical or incising)
 - Shear deflection

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- Developing glulam using South American species for acceptance in U.S. markets.
 - Must be manufactured according to ANSI A190.1
 - Must be analyzed using ASTM D3737,
 - Must be confirmed with testing

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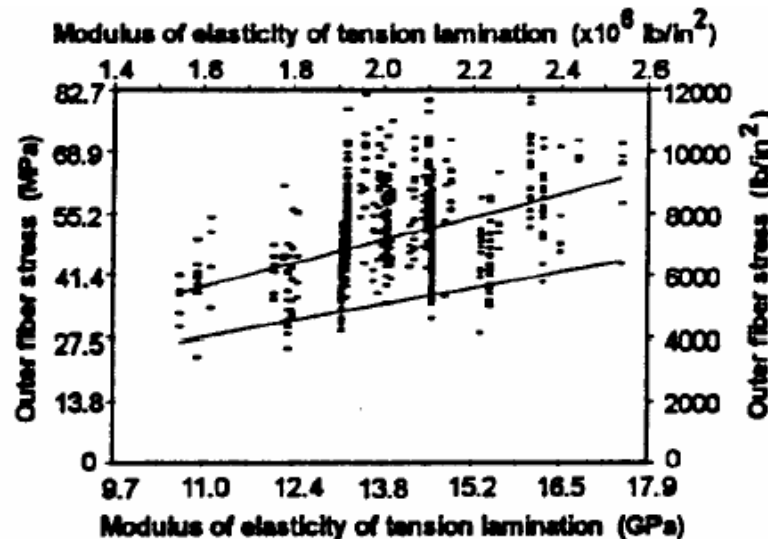
- Analyzing South American glulam using ASTM D3737
 - E-rated lumber approach

Analysis of Glulam Timber Beams with Mechanically Graded (E-rated) Outer Laminations

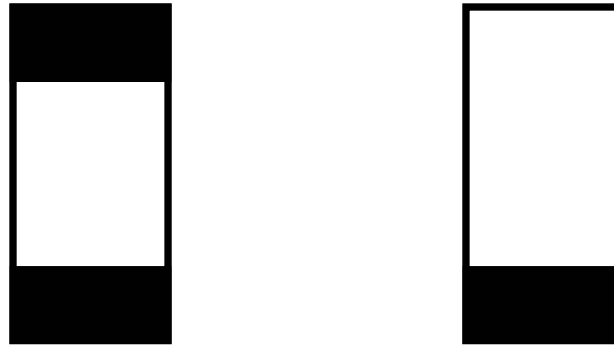
Roland Hernandez and Russell C. Moody, USDA Forest Service,
Forest Products Laboratory, Madison, WI USA

» <http://www.fpl.fs.fed.us/>

- Analyzing South American glulam using ASTM D3737
 - A study of 771 glulam beams made from E-Rated lumber, from various species, was conducted.



- Analyzing South American glulam using ASTM D3737
 - Balanced and Unbalanced glulam combinations were studied, and found to have similar performance.



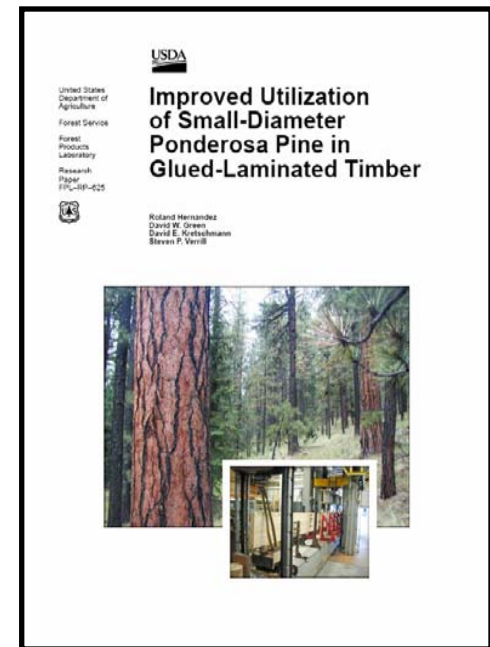
- Increasing E-rated lumber grades in the tension lamination showed similar increases in final glulam performance.

- Analyzing South American glulam using ASTM D3737
 - The conclusion of the Hernandez & Moody (1996) study: *“Species, species group, and country of origin of the lumber have a minimum effect on glulam beam strength properties”*
 - Using E-rated lumber allows for non-North American species to be analyzed using ASTM D3737, and past research shows that these beams have predictable performance regardless of species.

- Developing glulam using South American species for acceptance in U.S. markets.
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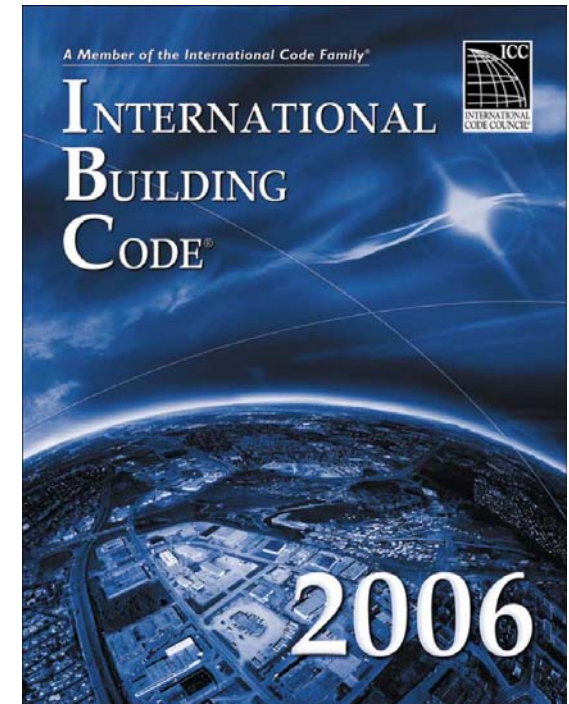
- A study was conducted using North American Ponderosa pine forest thinnings (small-diameter trees).

- Low properties
- Visual graded data not available
- Utilized E-rated lumber
- Conducted D3737 analysis
- Glulam beam testing
- Glulam combination was adopted



- Good example of tests and procedures necessary for developing South American glulam for U.S. markets.

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Thank you!

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