ARCHITECTURE 544
WOOD FRAMING

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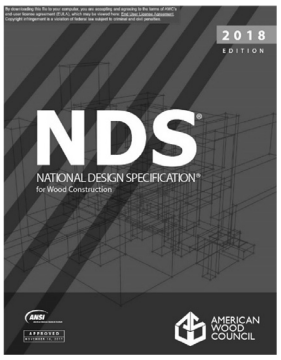
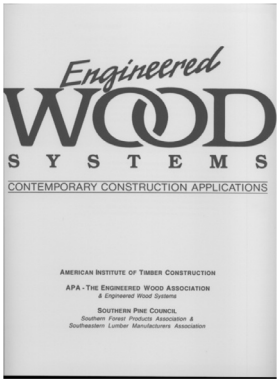
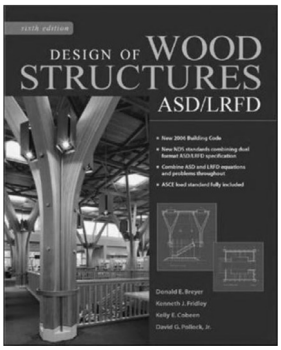
Office hours:
by appointment

Lecture Topics :

- Course Structure
- Codes
- Course Website
- Sawn Lumber
- Engineering Properties
- Engineered Wood Products







Course Syllabus

Organization

- Lecture – Tuesday & Thursday
- HW Problems – on web
- Project with STAAD

Evaluation

• Topic Quizzes	330
• HW Problems	840
• STAAD Project	200
• Class Project	200

Text

- NDS 2018
- Canvas
- Web site:
  https://www.umich.edu/~arch544

Wood Framing (3)
Syllabus

CATALOG DESCRIPTION
Timber as material, properties. Framing with wood (light wood framing, heavy timber framing, laminated timbers). Design and selection of components. Connections of elements (nailing, bolting, timber connectors). Lateral loads and response thereto are also studied. Prerequisite: Arch 324 or equivalent.

OBJECTIVES
Students are familiarized with analysis and design of wood structures using the NDS-ASD code as well as load calculation based on ASCE – 7 (including dead, live, wind and snow load calculation). In addition techniques used to design with modern wood engineered products are explored. Topics covered include: sawn lumber, Glulam, LVL, I-joists, CLT, plywood panels, and stressed skin elements. The students will also explore architectural examples of contemporary wood design using case studies.

ORGANIZATION
The course is lecture based, and the concepts and procedures are taught in this context with classroom and homework problems solved by the students. The presentation is hybrid. Physical presents is not required. All lectures and material will be posted on the course website and Canvas. Computer facilities, including software, are available for supporting computational work in the BT-Lab. Testing equipment and tools are also available for the construction project.

EVALUATION
Evaluation is based on a series of online problems (approximately one per week); Weekly quizzes on Canvas; a group computer analysis project using STAAD.Pro; and a special project (student's choice). Grades are assigned according to the number of points achieved during the semester:

11 topic quizzes 30pts each	330
11 homework problems, 5pts/ question	840
STAAD project	200
Class project	200
TOTAL	1570

The point scale relates to a full range of letter grades assigned as follows:

A+	1518	A	1465	A-	1413
B+	1361	B	1308	B-	1256
C+	1204	C	1151	C-	1099
D+	1047	D	994	D-	942
		E	941 and below		

By University policy the minimum passing grade is a D (994). The highest recorded grade in Architecture is an A. For graduate students C- (1099) is required to pass.

HOMEWORK PROBLEMS
A set of homework problems covering the primary aspects of the course is given to each student. Each student will have a unique set of problems to solve. Students submit solutions online for scoring. Each problem may be worked up to 2 times (2 different data sets) for credit. The best score from **one** of the 2 trials will be recorded. Late problems will be penalized at -5% per day up to a maximum of -35%. Problems are accessed through the course web site. A FAQ which explains the policy concerning the problems is also posted on the problem page.

TEXTS
The required text is the *NDS-2018* code, available at http://www.awc.org/Standards/nds.html (student price) In addition, a copy of *Design of Wood Structures* by Donald Breyer is available in electronic format on Canvas. Another good resource is *The APA Engineered Wood Handbook* also posted on our Canvas site.

Course Schedule

Lectures

Tuesday & Thursday

8:30 – 10:00

Recoded and posted

Homework

on website

Weekly Quiz

Canvas

Projects

STAAD FEA analysis

Group Project
- Physical Testing
- Case Study
- Structure Analysis

Architecture 544 Winter 2022

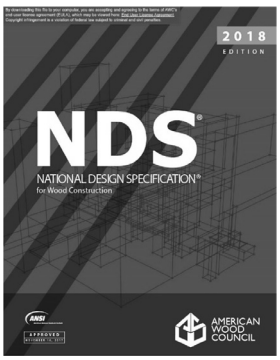
Wood Framing (3)
Lecture and Exercise Schedule

DATE	TOPIC	ASSIGNMENT (due dates online)	REFERENCE
JAN 6	Wood Properties-ASD approach		Breyer-Ch.1&4
JAN 11	ASCE-7 – Load Cases and C_D		Breyer-Ch.2 / ASCE7-3&4
JAN 13	Sawn Lumber: Flexure		Breyer-Ch.4 / NDS-3&4
		HW1 – Floor Loads	
JAN 18	Sawn Lumber: Flexure		Breyer-Ch.4 / NDS-3&4
JAN 20	Analysis of Beams		Breyer-Ch.6 / NDS-3&4
		HW2 – Sawn Lumber Rafters	
JAN 25	Design of Beams		Breyer-Ch.6 / NDS-3&4
JAN 27	Grid Shells		
		HW3 – Sawn Lumber Joists	
FEB 1	LVL, PSL, LSL, I-Joists – pt1		APA Lit. / NDS 7&8
FEB 3	LVL, PSL, LSL, I-Joists – pt2		APA Lit. / NDS 7&8
		HW4 – Sawn Lumber Beams	APA Lit.
FEB 8	Sawn Lumber: Columns		Breyer-Ch.7 / NDS-3&4
FEB 10	Box Beams		
		HW5 – Sawn Lumber Columns	
FEB 15	Glulam Beams		Breyer-Ch.5 / NDS-5
FEB 17	CLT floor plates		CLT Handbook
		HW6 – Glulam Beams	
FEB 22	Intro to FEA and STAAD		
FEB 24	STAAD project in BT Lab (room 1221)		
MAR 1	Winter Break ***** Winter Break ***** Winter Break ***** Winter Break ***** Winter Break *****		
MAR 3	Winter Break ***** Winter Break ***** Winter Break ***** Winter Break ***** Winter Break *****		
MAR 8	Composite (Flitch) Beams		
MAR 10	Five Column Types		Breyer-Ch.7 / NDS-15
		HW7 – Flitch Beams	
MAR 15	Combined Stresses		Breyer-Ch.7 / NDS-3&4
MAR 17	Panels – Plywood & OSB		Breyer-Ch.8 / NDS-9
		HW8 – Combined Stresses	
MAR 22	Diaphragms		Breyer-Ch.9 / NDS-9
MAR 24	Shear Walls		Breyer-Ch.10 / NDS-9
		HW9 – Diaphragms	
MAR 29	Mechanical Connectors		Breyer-Ch.11-14 / NDS-11-14
MAR 31	Mechanical Connectors		Breyer-Ch.11-14 / NDS-11-14
		HW10 - Connectors	
APR 5	Timber Frame		AWC-DCA5-Post Frame
APR 7	Graphic Statics		
APR 12	student reports		
APR 14	student reports		
APR 19	student reports		

National Design Specification for Wood Construction (NDS 2018)

Order at student price $65

or use pdf on Canvas



Minimum Design Loads for Buildings and Other Structures (ASCE 7-16)

Use pdf on Canvas

National Design Specification for Wood Construction (NDS 2018)

Order online:

Register as student with American Wood Council

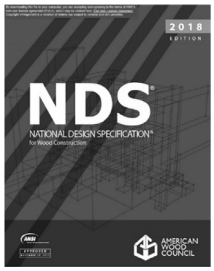
https://www.awc.org/membership

Publications for Students

Student hard copies of all publications can be ordered by you, your instructor, or your institution's bookstore at publications@awc.org, 800-890-7732, or 412-741-1579. Electronic (PDF) versions of AWC publications are also available at a discount for students. Students receive a 50% discount off the list price of publications.

Then place order at student price:

https://www.awc.org/codes-standards/publications/nds-2018

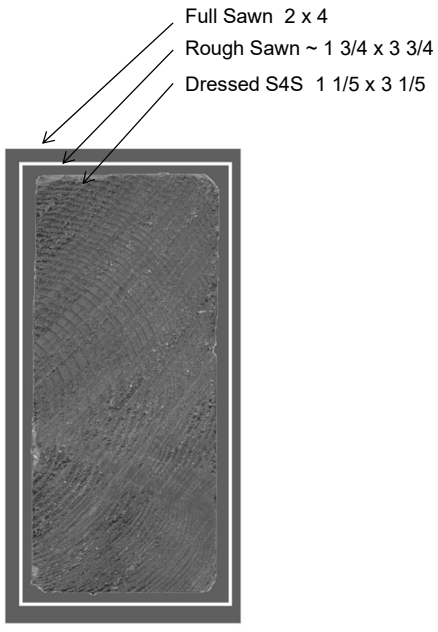


SIZE NOMINCLATURE

Full Sawn
- The size delivered is the full nominal size before shrinkage
- Not generally available

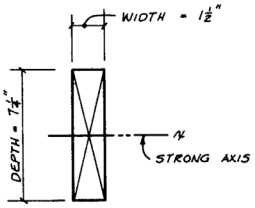
Rough Sawn
- Rough sawn condition with no surface planing
- Because no surfaces are planed, sizes are approximately 1/8" larger than S4S

Dressed
- The size after shrinkage from drying and surface planing
- Typically dressed on all 4 sides S4S

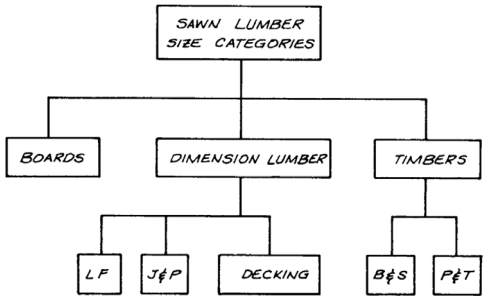


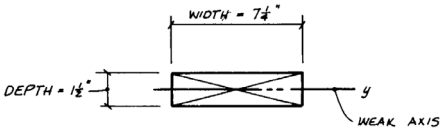
SIZE CATAGORIES

Boards	1 to 1½ in. thick 2 in. and wider
Dimension lumber	2 to 4 in. thick 2 in. and wider
Timbers	5 in. and thicker 5 in. and wider



2 x 8 SECTION





8 x 2 SECTION

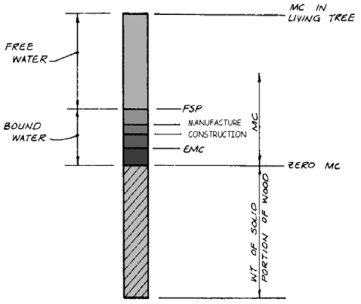
SIZE CATAGORIES

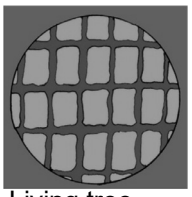
Symbol	Name	Nominal dimensions: Thickness	Nominal dimensions: Width	Examples of sizes
LF SLF	Light Framing and Structural Light Framing	2 to 4 in.	2 to 4 in.	2 × 2, 2 × 4, 4 × 4
SJ&P	Structural Joist and Plank	2 to 4 in.	5 in. and wider	2 × 6, 2 × 14, 4 × 10
	Stud	2 to 4 in.	2 to 6 in.	2 × 4, 2 × 6, 4 × 6 (lengths limited to 10 ft and shorter)
	Decking*	2 to 4 in.	4 in. and wider	2 × 4, 2 × 8, 4 × 6
B&S	Beams and Stringers	5 in. and thicker	More than 2 in. greater than thickness	6 × 10, 6 × 14, 12 × 16
P&T	Posts and Timbers	5 in. and thicker	Not more than 2 in. greater than thickness	6 × 6, 6 × 8, 12 × 14

*Decking is normally stressed about its minor axis. In this book, all other bending members are assumed to be stressed about the major axis of the cross section, unless otherwise noted.

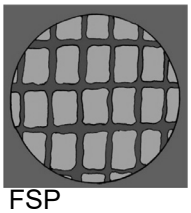
Moisture Content

- MC = %water to oven dry wood
- In a living tree, MC can be 200%
- “free water” is contained in cell cavity
- “bound water” is within the cell wall
- Fiber Saturation Point (FSP) is the MC at 0% free and 100% bound water FSP is about 30%
- Equilibrium Moisture Content (EMC) is reached in service

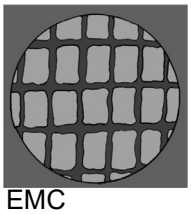




Living tree



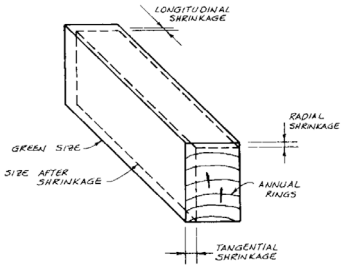
FSP



EMC

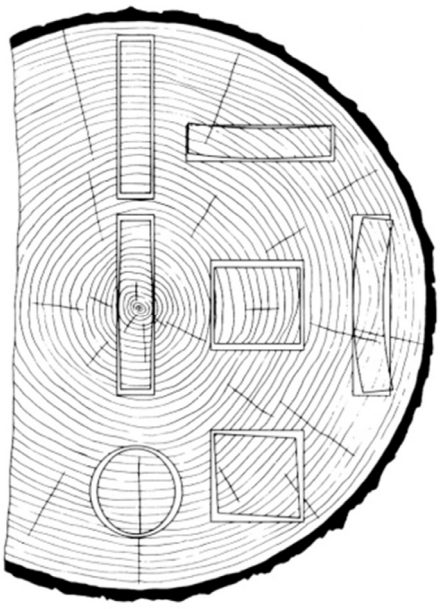
Shrinkage

- Shrinkage begins once MC<FSP
- Shrinkage is not the same in each direction
- Uncontrolled shrinkage results in splits



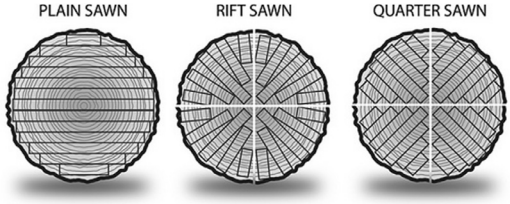
Shrinkage

- Is different in different directions
- Longitudinal is the least
- Across the grain is more
- Circumferential is greatest



Cut

- Plain Sawn – most economical and common
- Quarter Sawn – less warping
- Rift Sawn – least warping but more waste



Yard Dry

- Initial free water is removed
- Air dried outdoors or under cover
- Dry rate depends on humidity and circulation
- Coating the ends reduces splitting
- Takes ~ weeks to months

Kiln Dry - KD

- Enclosed in humidity controlled chamber
- Introduction of controlled heat
- Air circulation
- Dried to < %18

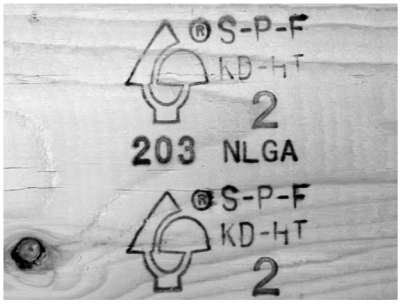
Heat Treated - HT

- temperature raised to 53° C (127° F) for 30 min.
- kills organisms
- requirement for imports

GRADING

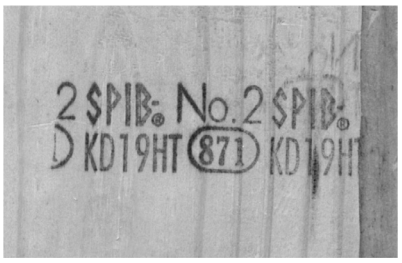
Visual Grading

Each member is assessed for visual defects. (splits, knots, density, etc.)



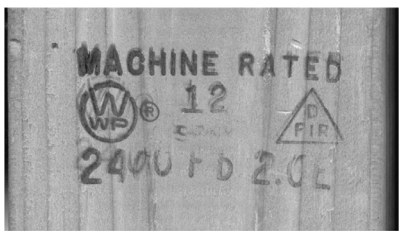
Machine Evaluated Lumber (MEL)

Each member is assessed for density using x-ray technology.



Machine Stress Rated (MSR)

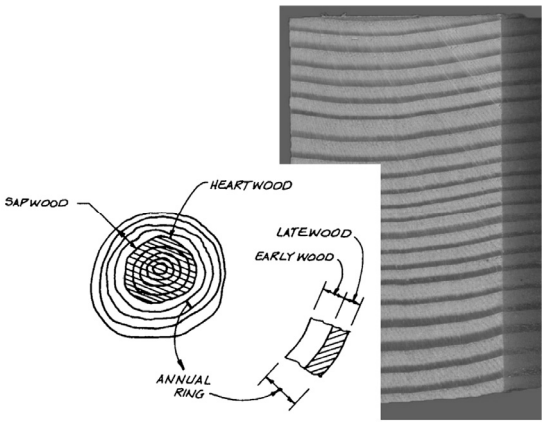
Each member is stressed by running it through rollers which measure the deflection and stiffness. The E modulus in bending can be calculated from the deflection.

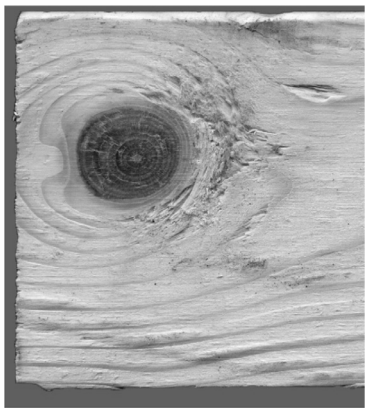


GROWTH CHARACTERISTICS

Annual Rings

- Latewood is denser and stronger than earlywood.
- Sapwood is the actively living part of the tree. It is younger and transports water more readily than heartwood. The strength of the two is about the same.
- Density can be gauged visually by noting the % of latewood to earlywood



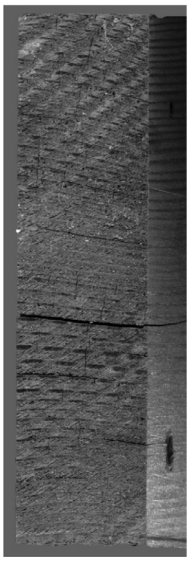


Knots

- Knots result from tree branches
- Knots weaken the member and effect the grading

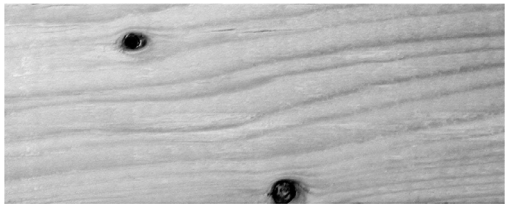
Checks, Shakes and Splits

- All three are defects which weaken the wood
- **Checks and splits** are seasoning defects
- **Shakes** result from stress in the growing tree



Slope of Grain

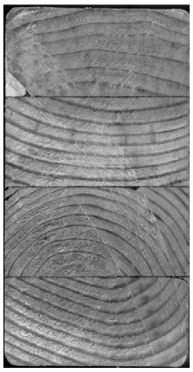
- The slope of the grain is taken in relation to the long edge of the member
- It is measured as a ratio e.g. 1” in 8”
- Increase in slope lowers the strength of the member



Engineered Wood Products

Glulam

- Glue laminated lumber
- Stress rated and graded
- Parallel grain
- Different finish grades
- Standard widths and lams
- Straight or curved
- Size limit by transportation
- Stock or custom dimensions



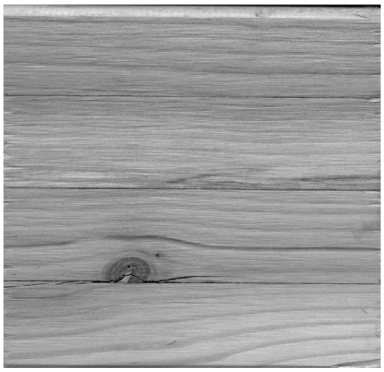
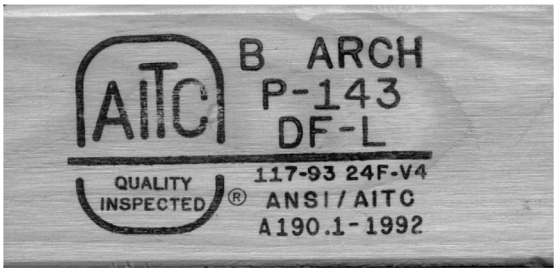


Table 5.1.3 Net Finished Widths of Structural Glued Laminated Timbers

Nominal Width (in.)	3	4	6	8	10	12	14	16
Minimum Net Finished Width (in.)	**Western Species**							
	2-½	3-⅛	5-⅛	6-¾	8-¾	10-¾	12-¼	14-¼
	Southern Pine							
	-	3	5	6-¾	8-½	10-½	-	-

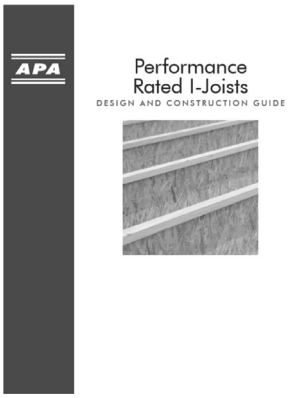
2005 NDS



Engineered Wood Products

Prefabricated Wood I-Joists

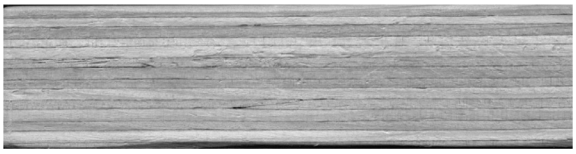
- ASTM D 5055
- Standard dimensions
- Specifications per manufacturer

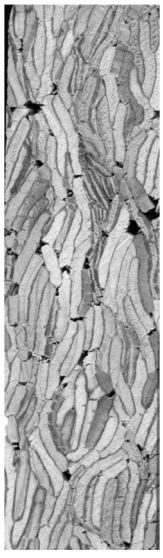


Engineered Wood Products

Structural Composite Lumber

- **Laminated Veneer Lumber** (LVL)
  - Veneer ≤ ¼”
- **Parallel Strand Lumber** (PSL)
  - Strand thickness ≤ ¼”
- **Laminated Strand Lumber** (LSL)
  - Strand thickness ≤ .10”

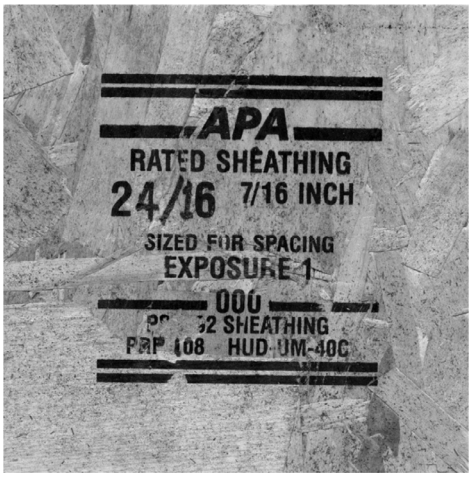




Engineered Wood Products

Wood Structural Panels

- **Plywood** – cross laminated wood veneer panels pressed and glued.
- **Oriented Strand Board** (OSB) – cross laminated layers of wood strands or wafers, compressed and glued
- **Composite Panel** – wood veneer and reconstituted wood based material



Engineered Wood Products

Wood Structural Panels

- **Cross Laminated Timber (CLT)** – cross laminated wood panels using at least three layers of boards or dimensioned lumber pressed and glued together. Thickness of layers varies from 5/8 inch to 2.0 inches. The width to pieces may vary from 2.4 to 9.5 inches. Panels are produced in different widths – commonly: 2 ft., 4 ft., 8 ft., 10 ft. and up to 60 ft. length.

Engineered Wood Products

Wood Structural Panels
CLT

Brock Commons
Tallwood House

The University of
British Columbia

18-storey, 53 m
2017

Engineered Wood Products

Wood Structural Panels - CLT

Brock Commons Tallwood House, 2017

Engineered Wood Products

Wood Structural Panels - CLT

Ascent in Milwaukee – 25 stories, under construction