Structural Lumber Grading 101

Introduction to the Basics

The “Why” and “How” relating to nominal thicknesses of 2” lumber

June 2021 by Lon Sibert, President of RRA
“When you change the way you look at things, the things you look at change.”

Author: Dr. Wayne Dyer
How do we go from conifer trees in a forest
..... to structural lumber suitable for wood-frame construction?
The limited time available today only allows for a “teaser” orientation on the subject of structural lumber features. We do **NOT** have the time to review:

1. Details about the ALSC system of accredited grading agencies (American Lumber Standard Committee) & how it all ties to the Voluntary Product Standard Standard PS-20.
2. How **RRA** fits into the ALSC framework;
3. Details about lumber design values, how lumber properties are determined and what the properties mean.
4. **Non-structural features**, such as knot quality, wane, skip, warp, pitch pockets, stains, checks, etc.
5. Appearance grades of 1” thick boards, “Factory” or “Shop” Lumber, Decking grades (5/4 x 6 RED), & Timber grades (≥ 5” thickness).
Although the grading rules differ on the grading of “Boards” (1” thickness) & “Timber” (5” + thickness), all six sets of grading rules carry, word-for-word, the “National Grading Rule for Dimension Lumber” developed by the National Grading Rule Committee, of which all such agencies are members along with other representatives of the industry.
DISTINCT from the grading of “Boards” of 1” nominal thickness, which are graded for APPEARANCE from a “Face” & a “Reverse”:
The **Basic and Key Concept** in the grading of Structural Lumber is the **DISPLACEMENT** of wood fiber by knots in any **CROSS-SECTION**.

- The “Cross Section” is any three-dimensional section.
- We have to contemplate the analogy of a “chain is as strong as its weakest link” (or cross-section).
- One can imagine a Cross Section as a potential weak link in an otherwise strong chain of wood fibers.
Engineering Design Values are assigned to the different grades of lumber:

- To permit the safe and efficient use of lumber.
- Therefore, different grades & species of lumber can resist different loads.

A important precedent is the following table of relative “bending strength ratios” for structural lumber, in comparison to a piece of lumber free of characteristics.

### Grades of Structural Lumber

<table>
<thead>
<tr>
<th>Grade</th>
<th>Relative Bending Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select Structural:</td>
<td>65%</td>
</tr>
<tr>
<td>No. 1:</td>
<td>55%</td>
</tr>
<tr>
<td>No. 2:</td>
<td>45% ✓</td>
</tr>
<tr>
<td>No. 3:</td>
<td>26% ✓</td>
</tr>
<tr>
<td>Stud:</td>
<td>26%</td>
</tr>
</tbody>
</table>
OK, which knot is “larger”?
Knot “A” appears larger by its superficial extension on the piece of lumber, but Knot “B” actually DISPLACES more wood fiber. Therefore, Knot “B” is larger.

To make the determination, you have to know where the PITH of the tree is in relation to the Cross-Section of lumber being judged.

The “Pith” is the tree-center.
Photo Credit: Geoffrey Cottenceau
What are we seeing here, in terms of the “Annual Rings” and “Wood Fiber”?

Consider the “Displacement” of a 1” knot coming from the pith.
Cross-section of a pine log
Figure 3–14. Quartersawn (A) and plainsawn (B) boards cut from a log.
Note the importance of being able to “read” a piece of lumber by its grain pattern or figure.

Examples of “Round Knots” or “Oval Knots” in pieces of lumber sawn from the outside section of a log, with a “Tangential Cut” sawing pattern.
Examples of “Spike Knots” in lumber showing a “Vertical” or “Radial” Grain pattern.

Note the evolution of the knot, from a “live-red” knot to a “dead knot” & later to a “decayed knot”.

FULL 14 (b) - Structural Lumber Grading Basics
An example of a “shallow knot” in a Cross Section of wood with a “Radial” or ”Vertical” grain” pattern.
OK, which knot is “larger” in this “real” example?
From this perspective, which knot is larger?
OK. You now have an appreciation for the subject of **knot displacement** and the projection of knots to (or from) the pith.

The obvious next question is: How do we determine the **location of the pith** in the multitude of cross sections along the length of a piece of lumber???

As human beings, we lumber graders do not have **X-RAY VISION**!
A lumber grader “reads” the grain or “figure” of a piece of lumber to determine the actual or relative position of the pith:

From Left to Right: Flat Grain (tangential) – Vertical Grain (radial) – Flat Grain

Note the “arrow” patterns on the Flat Grain cuts.
Let’s apply that concept, of being able to “read” the grain pattern of a piece of lumber. Let’s open a piece of wood that shows a “narrow face knot” going to (coming from) the pith about 3/4 of the way across the width & at the midpoint of the thickness. Note the “vertical grain” section. Note the section with the “arrow pattern”. We are looking at a #3 grade of structural lumber.
Consider this example of “Knot Displacement”:
The knot laps a wide face and narrow face & goes to a pith on the opposite corner of the piece. It displaces a lot of wood fiber.
Examples of two cross sections of two pieces of 2 x 10, showing two ugly knots in the superior piece and one not-so-ugly-knot occupying part of the face and edge in the lower piece.

Before cutting through the knots
The same two pieces of 2 x 10 after having cut through the knots in the respective cross sections:
Important Subject: How to measure a knot that shows on opposite wide faces in pieces of lumber without the pith.

Example: Knot on Face “A” of an example “2x4” (with net dimensions of 1 1/2” x 3 1/2”) measures 1 1/2” between lines parallel with the edges, and 1/2” on Face “B”. The **knot size** – averaging both wide faces – is 1” or about 28% of the cross-sectional displacement of the displayed 2x4.
Important Subject: How to measure “Spike Knots”? 

Spike knots are measured on the basis of “Equivalent Displacement” to the stated maximum allowable “Edge-of-Wide-Face Knots”, which translates roughly to about 1/4, 1/3 and 1/2 of the cross section, for the respective grades of #1, #2 and #3.

As an example, the displacement of Knot A and Knot B, below, are both 25% of the subject cross-section, qualifying both pieces for the grade of No. 1.
The National Grading Rule for Dimension Lumber ("NGR"): Theory – Examples of Knots in the Grade #2: “Edge of Wide Face Knots”, or Knots that occupy the majority of the Narrow Face.

Compare to #1 & #3 grades, using 2x4 as an example. Similar concepts apply to other widths.
The National Grading Rule for Dimension Lumber (“NGR”):
Theory – Examples of Knots in the Grade #2:
Knots located in the Center of the Wide Face and/or
Combinations of Knots in the same Cross Section.

In the case of #2 grade, individual knots located in the center of the wide face, or any combination of knots in the same cross-section, are limited to between about 42% & 57% of the Cross-Section, depending on the net width of the surfaced lumber.

The grade rule takes into consideration Tension versus Compression forces relative to “Edge Knots” and “Centerline Knots”.

Compare to #1 & #3 grades, using 2x4 as an example.
Similar concepts apply to other widths.
The National Grading Rule for Dimension Lumber (“NGR”):

**Theory** – Examples of Knots in the **Grade #3**:
“Edge of Wide Face Knots”, or Knots that occupy the majority of the Narrow Face.

Compare to #1 & #2 grades, using 2x4 as an example.
Similar concepts apply to other widths.
The National Grading Rule for Dimension Lumber ("NGR"): Theory – Examples of Knots in the Grade #3: Knots located in the Center of the Wide Face and/or Combinations of Knots in the same Cross Section.

In the case of #3 grade, individual knots located in the center of the wide face, or any combination of knots in the same cross-section, are limited to between about 57% & 71% of the Cross-Section, depending on the net width of the surfaced lumber.

The grade rule takes into consideration Tension versus Compression forces relative to "Edge Knots" and "Centerline Knots".

Compare to #1 & #2 grades, using 2x4 as an example. Similar concepts apply to other widths.
How to measure round and oval knots:
The art of lumber grading: How to measure spike knots and knots going to a pith located within the cross section, including combinations of both in the same cross section:
Other natural characteristics that affect the strength of lumber. Consider the family known as “Slope of Grain” - with characteristics that occur without and with knots.

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En su presentacion al MSFLPC Workshop, en abril 2014

“Spiral Grain”

“Spiral Grain”

“Diagonal Grain”

Cross Grain

Abnormal Grain Around Knots
“DENSITY”

“Natural Breaks” & “Processing Breaks”
Examples of “Compression Wood”
Examples of Compression Wood
Other natural characteristics that affect the resistance of lumber: Examples of “Decayed Wood” - Heart-Center Decay
Examples of “Decayed Wood” in Canadian Spruce

Bug-Killed Timber
Example “Decayed Wood” in Canadian Spruce
Examples of “Decayed Wood” Known as “Honeycomb” in Canadian SPF
Other examples of “Decayed Wood” developing from “green lumber” and package or pile rot:
PLEASE,
Do not assume that you can simply read the grade rules & attempt to apply them!

The training of graders takes time and a rigorous process.

The graders have to take into account many characteristics and imperfections to be able to assure that the buyer would receive the desired grade &/or the grade marked by a stamp recognized by the ALSC.

The task of grading requires training, supervision, experience and systems of control & auditing.
Examples of ALSC-recognized USA Gradestamps:

- RR® No 2 KD 048 SYP HT
- SPIB® No. 2 KD19 HT 7
- TP® NO. 1 KD-19 000 HT SYP
- SPIB® CONST S-GRN W-10 HEM-FIR WCLB RULES KD-HT STUD 001 NELMA® SPFs
- 12 S-DRY
- W® 2 D. FIR
- MILL 10 NO. 2
- WCLB® DOUG FIR S-DRY
Consider the value and merit of the ALSC system of continuous audits!!

- Approximately 910 sawmills and/or lumber manufacturing plants in the USA & Canada.
- Approximately 98% of the coniferous wood used in the USA.

Organizational Structure of ALSC Untreated Lumber Program

American Lumber Standard Committee (ALSC) → National Grading Rule (NGR) Committee → ALSC Board of Review

Rules Writing Agencies
- NELMA
- RIS
- SPIB
- PUB
- WAPA
- NLGA

Inspection Agencies
- TP
- RRA
- CLS
- AFPA
- CLA
- CLMA
- CFIBC
- ILMAB
- MLB
- QLMA

The Mills

American Lumber Standard Committee, Incorporated
I trust that you will now look at lumber differently!

When you change the way you look at things, the things you look at change.

Author: Dr. Wayne Dyer