PROPERTIES OF STRUCTURAL LUMBER

Physical Properties

Wood Structure

Wood is an aggregate of cells, essentially cellulose in composition, which are cemented together by a substance called lignin. Although wood cells vary in shape and size according to their function, the greater number are elongated and are positioned vertically in the standing tree. Known as fibers in hardwoods and tracheids in softwoods, wood cells vary from about 1/25 to 1/3-inch in length and 1/100 of these dimensions in width.

Hardwoods and softwoods have some horizontally positioned bands of cells called rays. These are usually evident on quarter-sawed surfaces and are more conspicuous in some species than others. They provide a pleasing pattern where visible.

Hardwoods and Softwoods

Native trees are divided into two classes–hardwoods which have broad leaves and softwoods or conifers, which have needlelike or scalelike leaves. Most hardwoods shed their leaves at the end of each growing season. Softwoods, except cypress, larch, and some exotic species are evergreen.

The terms "hardwood" and "softwood" do not apply to the hardness or softness of the wood. In fact, some species of hardwoods have softer wood than some of the species of softwoods while certain softwoods are as hard as the medium density hardwoods.

Heartwood and Sapwood

The end of a log shows three distinct zones, the bark, a light-colored zone just beneath it called the sapwood, and an inner zone, often darker in color, called heartwood. At the structural center of the heartwood is the pith or "heart center" as it is called in the lumber trade.

A tree increases in diameter by forming new layers of cells at the outer surface of the sapwood. Here a thin band of tissue called the cambium lays down new bark cells toward the outside and new wood cells toward the inner or sapwood side.

The young tree is composed primarily of sapwood which functions in sap conduction and food storage. As the tree increases in diameter, inner sapwood cells cease their conductive function and form the inactive heartwood. Deposits in these inactive cells give the heartwood of many species a darker color than the sapwood.

As all heartwood was once sapwood, there is no consistent difference between heartwood and sapwood in weight when dry or in strength. Deposits in the cells, however, make heartwood more durable when in contact with soil and under other conditions conducive to decay. Where wood is to be treated with perservative, however, deeper and more effective penetration can be attained in sapwood.

PROPERTIES OF STRUCTURAL LUMBER

Annular Growth Rings

The activity of the cambium tissue in forming new wood is influenced in temperate zones by the growing season. Through winter months the tree is dormant. In the spring the cambium begins to form thin walled cells with large cavities. Through the summer, cell walls increase in thickness and cell cavities decrease in size until growth virtually ceases in the fall. Differences in cell wall thickness between those last formed in the fall and the thin walled new cells formed the following spring results in rings of annual growth which are apparent on cross sections of all native woods.

Annual rings vary in width according to growth conditions. Narrow rings are formed during short dry seasons and wider rings occur when growing conditions are more favorable. Annual growth rings appear on the ends of timbers as concentric circles around the pith or heart center.

Springwood and Summerwood

In many woods two distinct areas are visible in each ring of annual growth: (a) an inner light colored portion, known as springwood; and (b) an outer darker portion, known as summerwood.

The springwood is composed of the large cavitied thin walled cells formed during the early part of each growing season. The thicker walled cells formed later in the year make up the summerwood portion. As the summerwood contains more solid wood substance than springwood, it usually appears darker in color. Springwood and summerwood bands are usually most noticeable in the dense softwood species. In these species the proportion of springwood and summerwood present has an important effect upon strength properties.

Density and Rate of Growth

In the softwoods commonly used for structural purposes, the rate at which trees grow has an important effect on their strength properties. An accurate measure of this is provided by the relative width and character of wood in each annual growth ring.

In such woods, pieces having medium to narrow growth rings generally have higher strength properties than those having wide rings. In addition, pieces in which a considerable portion of each annual ring is made up of dense darker summerwood are recognized as having higher strength properties than pieces with a lower percentage of summerwood. Therefore, in grading structural material of some species the rate of growth (number of rings per inch) and the density (proportion of summerwood) are considered and made a part of the specification.

PROPERTIES OF STRUCTURAL LUMBER

Grain and Texture

The terms "grain" and "texture" are used in various ways to describe the characteristics of wood. Wood from slow growing trees in which annual growth rings are narrow is sometimes described as "close-grained"; that from rapidly growing trees with wide rings as "coarse-grained." This is another way of describing the number of rings per inch in strength grading.

Straight grained and cross grained describe wood in which the direction of the fibers (not annual rings) are parallel to, or at an angle with the sides of the piece. Cross grain includes spiral grain where fibers wind around the trunk of the tree. The expression "slope of grain" is employed in the grading of structural lumber to describe the extent of cross grain permitted, as slope of grain has an important influence on strength.

Lumber sawed in such a manner that the annual rings when viewed from the end of the piece form an angle of 45° or more with the wide faces is described as edge-grain, vertical grain or rift-sawn in softwoods, and as quarter-sawn or comb-grained in hardwoods. The term "flat grain" or "plain-sawed" describes lumber in which the annual rings are at an angle of 45° or less with the wide faces of the piece.

Specific Gravity

Solid wood substance is heavier than water, its specific gravity being about 1.5 regardless of the species of wood. Despite this fact, dry wood of most species floats in water because a portion of its volume is occupied by air filled cell cavities. Variation among species in the size of cells and in the thickness of cell walls affects the amount of solid wood substance present and hence, the specific gravity. Thus, specific gravity of wood is a measure of its solid wood substance and an index of its strength properties. Specific gravity values, however, may be somewhat affected by gums, resins, and extractives which contribute little to strength. The relationship of specific gravity to wood strength is evident in the practice of assigning higher basic stress values to lumber designated as "dense."

Weights of Wood

Weights of sawed or round timbers are approximate because of moisture content, density and sapwood thickness variations within the piece. Average weights per cubic foot of various commerical wood, at 15 percent moisture content, are given in the following table. Weights of individual pieces will vary from these averages and are also different at other moisture contents.

PROPERTIES OF STRUCTURAL LUMBER

Average specific gravity and average weight in pounds per cubic foot for commercially important species or species combinations.

SPECIES	SPECIFIC[1] GRAVITY	WEIGHT PER CUBIC FOOT[2]
Aspen	0.39	26.6
Balsam Fir	0.36	24.6
Beech-Birch-Hickory	0.71	46.5
Coast Sitka Spruce	0.39	26.6
Cottonwood	0.41	27.9
Douglas Fir-Larch	0.50	33.6
Douglas Fir-Larch (North)	0.49	33.0
Douglas Fir-South	0.46	31.1
Eastern Hemlock	0.41	27.9
Eastern Hemlock-Tamarack	0.41	27.9
Eastern Hemlock-Tamarack (North)	0.47	31.7
Eastern Softwoods	0.36	24.6
Eastern Spruce	0.41	27.9
Eastern White Pine	0.36	24.6
Engelmann Spruce-Lodgepole Pine[3] (MSR 1650f and higher grades)	0.46	31.1
Engelmann Spruce-Lodgepole Pine[3] (MSR 1500f and lower grades)	0.38	25.9
Hem-Fir	0.43	29.2
Hem-Fir (North)	0.46	31.1
Mixed Maple	0.55	36.7
Mixed Oak	0.68	44.7
Mixed Southern Pine	0.51	34.2
Mountain Hemlock	0.47	31.7
Northern Pine	0.42	28.5
Northern Red Oak	0.68	44.7
Northern Species	0.35	24.0
Northern White Cedar	0.31	21.4
Ponderosa Pine	0.43	29.2
Red Maple	0.58	38.6
Red Oak	0.67	44.1
Red Pine	0.44	29.8
Redwood, close grain	0.44	29.8
Redwood, open grain	0.37	25.3
Sitka Spruce	0.43	29.2
Southern Pine	0.55	36.7
Spruce-Pine-Fir	0.42	28.5
Spruce-Pine-Fir (South)	0.36	24.6
Western Cedars	0.36	24.6
Western Cedars (North)	0.35	24.0
Western Hemlock	0.47	31.7
Western Hemlock (North)	0.46	31.1
Western White Pine	0.40	27.2
Western Woods	0.36	24.6
White Oak	0.73	47.7
Yellow Poplar	0.43	29.2

1. Specific gravity based on weight and volume when oven dry.
2. Weight per cubic foot is based on weight and volume at a moisture content of 15 percent.
3. Applies only to Engelmann Spruce-Lodgepole Pine machine stress rated (MSR) structural lumber.

PROPERTIES OF STRUCTURAL LUMBER

Moisture Content of Wood

Wood may contain moisture in two forms: As "free water" in the cell cavities and as "absorbed water" in the capillaries of the cell walls.

When green wood begins to lose moisture in the seasoning process, the cell walls remain saturated until the free water has been evaporated. The point at which evaporation of free water is complete and cell walls begin to lose their moisture is called the fiber saturation point (fsp). This point occurs between 25 and 30 percent moisture for most species.

Moisture in wood is expressed as a percentage of the oven dry weight and is determined most accurately by weighing a representative sample, drying it at slightly over 212°F. until no further loss of weight takes place, reweighing, and then dividing the difference between the original and final weights by the final (oven dry) weight. Electric moisture meters offer a simpler though less exact method of determining moisture content.

With slight seasonal variations, wood in use over a period of time attains an equilibrium moisture content (emc) corresponding to the humidity and temperature of the surrounding atmosphere. When exposed to similar atmospheric conditions, different woods will have the same moisture content regardless of their density.

Moisture content has an important effect upon susceptibility to decay. Most decay fungi require a moisture content above fiber saturation point to develop. In addition, a favorable temperature, an adequate supply of air, and a source of food are essential. Wood that is continuously water-soaked (as when submerged) or continuously dry (with a moisture content of 20 per cent or less) will not decay.

Moisture content variations above the fiber saturation point have no effect upon the volume or strength of wood. As wood dries below the fiber saturation point and begins to lose moisture from the cell walls, shrinkage begins and strength increases.

Shrinkage Due to Drying

Shrinkage of wood takes place between fiber saturation point and the oven dry condition. It is stated as a percentage of the original or green dimension. Where wood is installed at approximately the moisture content it will attain in service, only minor dimensional changes occur. These are caused by absorption or release of moisture due to atmospheric changes.

Wood shrinkage is greatest in the direction of the annual growth rings (tangentially), somewhat less across the rings (radially), and very little along the grain (longitudinally). Longitudinal shrinkage is usually too small to be of practical significance.

Shrinkage of commercial softwood boards across the grain averages about 1 per cent for each 4 per cent change in moisture content. Shrinkage of hardwoods is slightly greater.

PROPERTIES OF STRUCTURAL LUMBER

Large structural members shrink proportionately less than smaller lumber because drying does not take place simultaneously in the inner and outer portions of such pieces. In softwood structural lumber, 6" x 6" or larger in cross section, a shrinkage of approximately 1/64" per inch width of face may be expected in drying from green to average equilibrium moisture content in service.

Effect of Drying on Strength

Increase in strength begins when the cell walls begin to lose moisture; that is, as the wood is dried below the fiber saturation point. From this point most strength properties increase rapidly as drying progresses.

Drying wood from green to 5 per cent moisture content often doubles and in some cases triples end crushing strength and bending strength. However, increases in strength with seasoning may be greater in small clear specimens of wood than in larger timbers. In the latter, increase in strength may be offset to some extent if checking develops in seasoning.

Other strength properties are not equally affected by changes in moisture content. Although some properties, such as crushing strength and bending strength, increase greatly with seasoning, other, such as stiffness, change moderately. Shock resistance, an exception, shows only slight change as wood dries.

The following table presents the average variation in strength properties of small wood samples for each 1 percent change in moisture content. These changes in strength properties may not be directly applicable to structural sizes of lumber and timber. Appropriate moisture content adjustment factors for structural members are given in the National Design Specification for Wood Construction, available from the National Forest Products Association.

Average Increase (or Decrease) in Clear Wood Strength Properties for a 1-percent Decrease (or Increase) in Moisture Content Below Fiber Saturation Point.

Property	Change per 1-percent change in moisture content (percent)
Static bending	
Fiber stress at proportional limit	5
Modulus of rupture	4
Modulus of elasticity	2
Work to proportional limit	8
Work to maximum load	0.5
Impact bending, height of drop causing complete failure	0.5
Compression parallel to grain	
Fiber stress at proportional limit	5
Maximum crushing strength	6
Compression perpendicular to grain, fiber stress at proportional limit	5.5
Hardness, end grain	4
Hardness, side grain	2.5
Shear parallel to grain	3
Tension perpendicular to grain	1.5

Effect of Temperature on Strength

The usual design values for wood products are applicable to members used under ordinary ranges of temperature and occasionally heated in use to temperatures up to 150°F. Wood increases in strength when cooled below normal temperatures and decreases in strength when heated. Members heated in use to temperatures up to 150°F will return essentially to original strength when cooled. Prolonged temperatures above 150°F may result in permanent loss of strength. Some reduction in design values may be necessary in specific applications to account for the temporary decrease in strength occurring when members are heated to elevated temperatures up to 150°F for extended periods of time. Information on the approximate effect of temperature on mechanical properties is given in the National Design Specification for Wood Construction, available from the National Forest Products Association.

PROPERTIES OF STRUCTURAL LUMBER

Mechanical Properties

Wood as Structural Material

Wood is not an isotropic material in that its strength properties differ along its different axes. It is strongest when loaded to induce stress parallel to grain, either in tension or compression. However, this condition is not always possible and loading perpendicular to grain may be accomplished in a satisfactory manner.

The anisotropic nature of wood may be confusing to the designer during his first experience with its use, but as he gets to know the material he finds that engineering design with wood can be interesting as well as productive in the way of lower construction costs. The discussion which follows provides a brief description of the various mechanical properties of structural wood as they affect engineering design.

Tension Parallel to Grain

A force generating tension parallel to grain, as shown in Figure 1, creates a tendency to elongate the wood fibers and to cause them to slip by each other. Resistance to tension applied strictly parallel to grain is the highest strength property of wood. This resistance, however, is substantially reduced when the force is applied at an angle to the grain or when the cross-section of the piece is reduced by knots or holes.

Figure 1. Tension Parallel to Grain

Compression Parallel to Grain

A force generating compression parallel to grain, as shown in Figure 2, creates a tendency to compress the wood fibers in the lengthwise position. As with tension, resistance to compression parallel to grain is affected by the angle of load to grain and by the presence of knots or holes.

Figure 2. Compression Parallel to Grain

Fiber Stress in Bending

A force applied perpendicular to a beam, as shown in Figure 3, creates compression in the extreme fibers on the side to which the force is applied and it also creates tension in the extreme fibers on the opposite side. Thus, there is a tendency to compress the fibers on the compression side and to elongate the fibers on the tension side. As the stress is distributed from the extreme fibers or outside faces towards the center of neutral axis of the piece it is reduced in intensity. Thus, deviations in slope of grain and the presence of knots or holes in these outside faces tend to reduce the resistance in the extreme fibers and the bending strength of the beam.

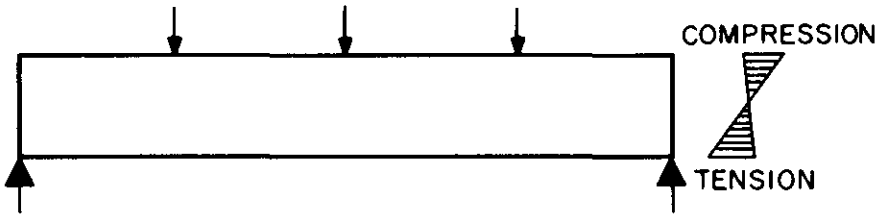


Figure 3. Fiber Stress in Bending

Shear Parallel to Grain

A force applied in the manner illustrated in Figure 4 causes one section of the piece to shear or slide along the other section in a direction parallel to grain. In a loaded beam where the induced stress on the one side is compression and on the other side is tension, as illustrated in Figure 3, there is a tendency to create shearing stress parallel to grain. The largest shear parallel to grain stress usually occurs along the neutral axis on the plane at which the induced stress changes from compression to tension. Checks and splits which may occur during the drying of lumber have the effect of reducing the area in the plane of shear resistance. Consequently, laboratory test values for shear strength parallel to grain are substantially reduced for design purposes in order to accommodate the probability of the occurrence of checks and splits after drying.

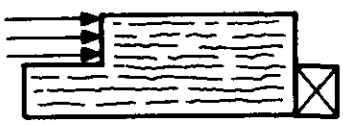


Figure 4. Shear Parallel to Grain

Compression Perpendicular to Grain

A force applied perpendicular to grain, such as the bearing under the ends of a beam as shown in Figure 5, tends to compress the wood at its surface. While the wood becomes more dense as it is compressed, this action causes slight displacement of the supported member. Thus, limits are placed on loading in bearing perpendicular to grain.

For sawn lumber, the compression perpendicular to grain values are based on a deformation limit that has been shown by experience to provide for adequate service in typical wood frame construction. Therefore, stress modifications for duration of load (see pg. 13) are not applicable to compression perpendicular to grain allowable stresses for sawn lumber.

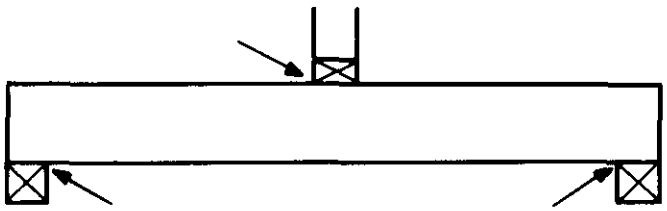


Figure 5. Compression Perpendicular to Grain

Shear Perpendicular Grain

Shear perpendicular to grain is not a design factor in solid wood because effective control is applied through limits on design stresses in shear parallel to grain and compression or bearing perpendicular to grain.

Tension Perpendicular to Grain

A force generating tension perpendicular to grain tends to separate the wood fibers along the grain. This is the direction in which wood has the least strength, and because it is not good practice to apply loading to induce tension across grain, design values are not provided for this strength property, except for special applications.

Proportional Limit, Static Bending

The proportional limit occurs at the point where the induced strain or deformation ceases to be proportional to the stress or applied load, as determined by the standard test method. Stress at proportional limit is computed by the standard method. All conventional methods of structural design for wood are within the proportional or elastic limit.

Modulus of Rupture, Static Bending

The modulus of rupture is computed from the ultimate load or the point at which the piece breaks under the standard bending test method. Loading by test beyond the proportional limit shows an increasing rate of deformation, without a specific yield point, until ultimate load is reached.

Modulus of Elasticity, Static Bending

The modulus of elasticity is a measure of stiffness and is computed on the basis of the load and deformation within the proportional limit.

PROPERTIES OF STRUCTURAL LUMBER

Design Values for Structural Lumber

General

Design values are assigned to lumber in a scientific manner to provide material of predictable strength properties to meet the requirements of engineering design. Because of the varying nature of the different species of trees there is a wide range of stress values from which the designer can make his selection. However, to avoid delay during construction, it is advisable to determine which species and grades are available locally before design values are selected.

Classification of Structural Lumber

Since the effects of knots, slope of grain, checks and shakes on the strength of lumber vary with the loading to which the piece is subjected, structural lumber is often classified according to its size and use. The three major classifications are as follows:

Dimension – Pieces of rectangular or square cross section, 2 to 4 inches thick and 2 or more inches wide (nominal dimensions) graded primarily for strength in bending edgewise or flatwise but also used where tensile or compressive strength is important. Dimension lumber may be further classified as Joists and Planks, for material 5 or more inches in nominal width, and as Light Framing or Structural Light Framing for material 2 inches to 4 inches wide.

Beams and Stringers – Pieces of rectangular cross section, 5 by 8 inches (nominal dimensions) and larger, graded for strength in bending when loaded on the narrow face.

Posts and Timbers – Pieces of square or nearly square cross section, 5 by 5 inches (nominal dimensions) and larger, graded primarily for use as posts or columns but adapted to miscellaneous uses in which bending strength is not especially important.

Characteristics Affecting Strength

Aside from the natural properties of the species, the major characteristics affecting the strength of a piece of lumber are the sizes of knots or holes and their locations, the sizes of checks or shakes and splits and their locations, the amount of wane or absence of wood, slope of grain, degree of density or rings per inch and the condition of seasoning. All of these characteristics are taken into consideration in the stress grading of a piece of lumber.

American Society for Testing and Materials

There are two ASTM standards which serve as principal references in the assignment of working stresses of lumber. One standard is ASTM Designation D-2555, "Methods for Establishing Clear Wood Strength Values" which sets forth procedures for establishing strength values for clear wood of different species in the unseasoned condition and unadjusted for end use. Such procedures may be applied to a single species or to a group of species where growth and marketing conditions justify such

grouping. The other standard is ASTM Designation D-245, "Methods for Establishing Structural Grades for Visually Graded Lumber" which sets forth reduction factors to be applied to the clear wood values and provides procedures for determining strength ratios, based on knots and other characteristics, which, when applied to the adjusted clear wood values, results in working stresses for the various commercial grades of any species. This standard also provides adjustments for degree of density and for condition of seasoning.

A third standard is ASTM D-1990, "Standard Practice for Establishing Allowable Properties for Visually Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens," which outlines criteria to properly analyze data from In-Grade tests. ASTM D-1990 applies directly to dimension lumber in sizes from 2x2 to 4x16.

Lumber Grading Rules

Lumber grading rules are, in effect, specifications of quality in that the maximum knots, slope of grain and other strength reducing characteristics are described in sufficient detail so that the procedures of ASTM Designation D-245 can be applied and working stresses assigned to the specified quality. It is common practice to give each grade a commercial designation such as No. 1, etc. This means that the purchaser orders the commercial grade which qualifies for the design values used in design.

Machine Graded Lumber

While most structural lumber has design values assigned on the basis of visual grading to meet a minimum quality specification, there is a growing trend toward the non-destructive testing of lumber by machine. In this method a piece of lumber is passed flat-wise through a series of loading rollers and the stiffness, or modulus of elasticity, is automatically recorded. Through correlation with previously established test data, bending strength and other strength properties are assigned to each piece tested. At present, machine grading is supplemented by visual grading particularly in the assignment of horizontal or longitudinal shear values.

National Design Specification

The principal reference for the working stresses for commercial grades of structural lumber is the National Design Specification® for Wood Construction (NDS®) available from the National Forest Products Association, Washington, D.C. The design value information in this specification is taken from the published rules written by the various grading rules writing agencies. When these values are used, each piece of lumber is required to be identified by the grade mark of a lumber grading or inspection agency recognized as being competent.

The NDS provides for design of single member uses of lumber and other structural timbers, and also for repetitive member uses of lumber where load sharing is known to exist between repetitive framing members, which are spaced not more than 24 inches, are not less than 3 in number and are jointed by floor, roof or other load-distributing elements adequate to support the design load. For repetitive member uses, the design values in bending are higher than those for single member uses, as provided in the NDS.

Adjustments of Design Values for Duration of Loading

Normal Duration of Loading:

The design values listed in the National Design Specification and most other wood engineering references are for normal duration of loading. Normal load duration contemplates fully stressing a member to the tabulated normal duration design value by the application of the full maximum normal design load for a duration of approximately ten years (either continuously or cumulatively) and/or the application of 90 percent of this full maximum normal load continuously throughout the remainder of the life of the structure, without encroaching on the factor of safety. See Figure 6.

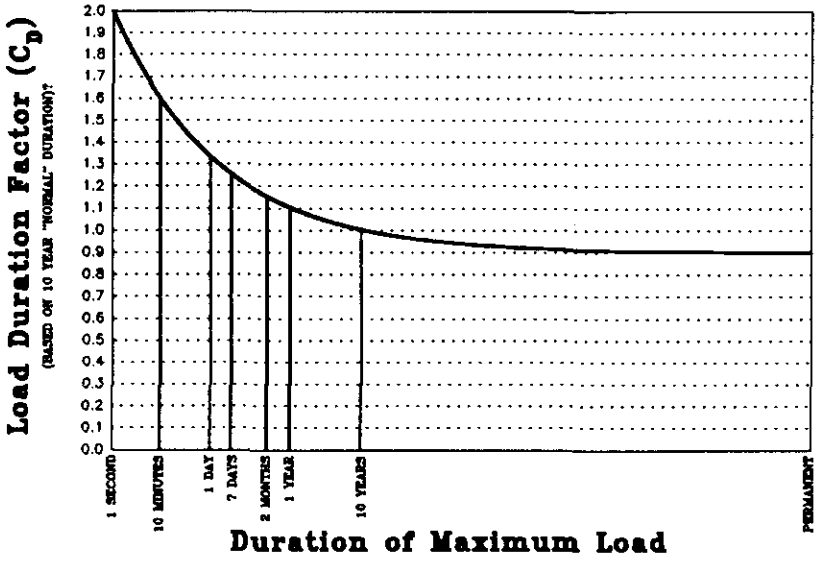


Figure 6. Adjustment of Working Stresses For Various Durations of Load.*

*Derived from the Forest Products Laboratory Report No. R1916

Adjustments for Other Durations of Loading:

Since tests have shown that wood has the property of carrying substantially greater maximum loads for short durations than for long durations of loading, the design values for normal loading, except modulus of elasticity and compression perpendicular-to-grain, are adjusted as follows for other durations of loads:

When a member is fully stressed to the design value by application of the full maximum load permanently, or for a total of more than 10 hears either continuously or for cumulative periods of full maximum load, use 90 percent of the design value given for normal loading conditions.

Likewise, when the duration of the full maximum load does not exceed the following durations, adjust the design values for normal loading durations, except modulus of elasticity and compression perpendicular-to-grain, to a new stress level by increasing them:

15 percent for two months duration, as for snow,

25 percent for seven days duration,

60 percent for 10 minutes duration, as for wind or earthquake,

100 percent for impact.

Design values for normal loading conditions may thus be used without regard for impact if the stress induced by impact does not exceed the design value for normal loading.

The impact load duration increase factor does not apply when the member has been pressure-treated with water-borne preservatives to the heavy retentions required for "marine" exposure, nor when the member has been pressure-treated with fire retardant chemicals.

Combinations of Loads of Different Durations

The preceding adjustments are not cumulative in the sense that the required size of a member cannot be determined for a load of particular duration without consideration of the total load resulting from that load together with the other loads of longer durations when applied simultaneously. In cases where combinations of loads of different durations are applied simultaneously, the size of member is usually determined for the total of all loads applied simultaneously and the adjusted design values for that load which has the shortest duration in the combination of loads. However, in some instances, this procedure may cause the member to be overstressed by loads of longer duration. To insure that the overstress will not occur the following procedure may be used:

1. Determine the magnitude of each load that will occur on a structural member and accumulate subtotals of combinations of these loads of progressively shorter durations.

2. Divide each of these subtotals by the load duration factor of the load having the shortest duration in the combination of loads under consideration.

Shortest Duration in the Combination of Loads Being Considered	Load Duration Factor
Permanent	0.90
Ten Years	1.00
Two Months	1.15
Seven Days	1.25
Ten Minutes	1.60
Impact	2.00

3. The largest value thus obtained indicates which is the critical combination and the loading to be used in determining the structural element.

Connections

The impact load duration factor shall not apply to connections. Connection design values shall be adjusted by applicable load duration factors which are less than or equal to 1.6, except when the load capacity of the connection is controlled by strength of the metal fastener.

PROPERTIES OF STRUCTURAL LUMBER

Glossary of Lumber Terms

The following list represents a limited selection of industry terms used in purchasing and describing standard grades and patterns of lumber and timber. For specific definitions and abbreviations applicable to particular wood products or species, the appropriate lumber grading rule or product standard should be consulted.

Air Dried – Seasoned by exposure to the atmosphere, in the open or under cover, without artificial heat.

All Heart – Of heartwood throughout, i.e., free of sapwood.

American Lumber Standards for Softwood Lumber (ALS) – The American Softwood Lumber Standard, Voluntary Product Standard 20-70 is developed by the American Lumber Standards Committee appointed by the Department of Commerce. It provides a basis for coordination of the grades of various species in the preparation of grading rules applicable to each species by the agencies which formulate, publish and maintain grading rules and inspection facilities.

Annual Ring – Growth put on in a single year.

Boxed Heart – The pith or soft center core of the log enclosed within the piece.

Board Feet – The number of board feet in a piece is obtained by multiplying the nominal thickness in inches by the nominal width in feet by the length in feet.

Boxed Pith – Where the pith is enclosed within the four sides of the piece.

Check – A lengthwise separation of the wood, which usually occurs through the rings of annual growth.

Compression Wood – Abnormal wood that forms on the underside of leaning and crooked trees, characterized by being hard and brittle.

Decay – Disintegration of wood substance due to action of wood-destroying fungi. Also known as dote and rot.

Density Rule – Rules for estimating the density of wood based upon the percentage of summerwood and the number of annual rings of growth.

Dry – Seasoned; not green.

Durability – A general term used to describe the resistance of a species to attack by decay when conditions for decay development are favorable. In this connection "resistance to decay" is a more specific term.

Edge – The narrow faces of rectangular-shaped lumber.

Equilibrium Moisture Content – The moisture content at which wood neither gains nor loses moisture when surrounded by air at a constant relative humidity and temperature.

Face Width – The width of the face of a piece of dressed and matched or shiplapped lumber, not including the width of the tongue or lap.

Fiber-Saturation Point – The stage in the drying or in the wetting of wood at which the cell walls are saturated and the cell cavities are free of water.

Grade – The designation of the quality of a manufactured piece of wood.

PROPERTIES OF STRUCTURAL LUMBER

Grain –

Edge Grain (vertical grain) – Annual rings which form an angle of 45 degrees or more with the surface of the piece.

Flat Grain (slash grain) – Annual rings which form an angle of less than 45 degrees with the surface of the piece.

Mixed Grain – Any combination of edge grain and flat grain.

Slope of Grain – Cross grain or deviation of the fiber from a line parallel to the sides of the piece and may consist of diagnonal grain, spiral grain or both.

Quarter Sawed – Another term for edge or vertical grain used generally in hardwoods.

Heart Face – Face side free of sapwood.

Heartwood – Inner core of the tree trunk comprising the annual rings containing nonliving elements: often darker in color than sapwood.

Kiln Dried – Seasoned in a chamber by means of artificial heat.

Knot – Branch or limb, embedded in the tree and cut through in the process of lumber manufacture; classified according to size, quality and occurrence.

Laminated Wood – A wood assembly consisting of plies or laminations joined together with an adhesive and/or mechanical fastenings.

Structural Glued Laminated Timber – Any member comprising an assembly of laminations of lumber in which the grain of all laminations is approximately parallel longitudinally; in which the laminations are bonded with adhesives; and which is designed in accordance with accepted engineering practice.

Lumber –

Yard Lumber – Lumber of those grades, sizes and patterns which is generally intended for ordinary construction and general building purposes.

Structural Lumber – Lumber that is two or more inches in thickness and width for use where working stresses are required.

Factory and Shop Lumber – Lumber that is produced or selected primarily for remanufacturing purposes.

Boards – Lumber less than two inches thick and two or more inches wide. Boards less than six inches wide may be classified as strips.

Dimension – Lumber from two inches to, but not including five inches thick, and two or more inches wide. Dimension may be classified as framing, joists, planks, rafters, studs, small timbers, etc.

Timbers – Lumber 5 or more inches in least dimension. Timber may be classified as beams, stringers, posts, caps, sills, girders, purlins, etc.

Rough Lumber – Lumber that has not been dressed (surfaced) but which has been sawed, edged, and trimmed at least to the extent of showing saw marks in the wood on the four longitudinal surfaces of each piece for its overall length.

PROPERTIES OF STRUCTURAL LUMBER

Dressed (Surfaced) Lumber – Lumber that has been surfaced by a planing machine (for purposes of attaining smoothness of surface and uniformity of size) on the one side (S1S), two sides (S2S), or a combination of sides and edges (S1S1E, S1S2E, S2S1E, or S4S).

Worked Lumber – Lumber which in addition to being dressed has been matched, shiplapped, or patterned.

Matched Lumber – Lumber that has been worked with a tongue on one edge of each piece and a groove on the opposite edge, to provide a close tongue-and-groove joint by fitting two pieces together; when end-matched the tongue and groove are worked in the ends also.

Shiplapped Lumber – Lumber that has been worked or rabbeted on both edges of each piece to provide a close lapped joint by fitting two pieces together.

Patterned Lumber – Lumber that is shaped to a pattern or to a molded form, in addition to being dressed, matched, or shiplapped, or any combination of these workings.

Moisture Content – Weight of the water in wood expressed in percentage of the weight of oven-dry wood.

Pith – Small soft core in the structural center of a log.

Rate of Growth – The rate at which a tree has increased its radius. The unit of measure in use is the number of annual growth rings per inch.

Sapwood – Outer layers of growth in a tree, exclusive of bark, which contains living elements; usually lighter in color than heartwood.

Shake – A lengthwise grain separation between or through the growth rings. Shake may be further classified as ring shake or pith shake.

Stress-Grade Lumber – Lumber to each grade of which is assigned proper design values (unit stresses).

Split – Lengthwise separation of the wood extending from one surface through the piece to the opposite surface or to an adjoining surface.

Springwood – More or less open and porous tissue marking the inner part of each annual ring formed early in the period of growth.

Summerwood – Denser, fibrous outer portion of each annual ring, usually without conspicuous pores, formed late in the growing period.

Wane – Bark, or lack of wood or bark, from any cause, on the edge or corner or a wood member.

Warp – Any variation from a true or plane surface; includes bow, crook, cup or any combination thereof.

Abbreviations of Lumber Terms

Abbreviations of lumber terms are frequently used in designing, on plans, and in specifications. The following have been selected as those most likely to be encountered in connection with structural lumber.

The form indicated is the abbreviation in common use, but variations such as the use or omission of periods, punctuation and capital letters are optional. The appropriate grading rule should be consulted for abbreviations applicable to a particular species of lumber.

AD	air dried.
ALS	American Lumber Standards.
AV. or avg.	Average.
B&B or B&Btr	B and Better.
Btr. or BTR	Better.
BD. or bd.	Board.
BD. FT. or bd. ft	Board foot.
BH	Boxed Heart.
BP	Boxed Pith.
B&S	Beams and Stringers.
BEV. or Bev.	Bevel or Beveled.
BM. or bm.	Board measure.
CLR. or clr.	clear.
CM	center matched; that is, the tongue and grooved joints are worked along the center of the edges of the piece.
com.	common.
cu. ft.	cubic foot.
DET	Double end trimmed.
D&SM	Dressed and standard matched.
DIM. or Dim.	Dimension.
DKG. or Dkg.	Decking.
D/S or D/Sdg.	Drop siding.
D2S & CM	Dressed 2 sides and center matched.
D2S&SM	Dressed 2 sides and standard matched.
EG	Edge (vertical) grain.
EM	End matched.
EV1S	Edge V one side.
EV2S	Edge V two sides.
Fac.	Factory (lumber).
FG	Flat or slash grain.
FLG or Flg	Flooring.
FOB	Free on board (named point).
FOHC	Free of heart center.
FOK	Free of knots.
FRT or Frt.	Freight.
FRM	Framing.
FT. or ft	Foot or feet (').
FT. BM or FBM	Feet board measure.
FT. SM.	Feet surface measure.
GM	Grade-marked.
G/R or G/Rfg	Grooved roofing.
HB	Hollow back.
H&M	Hit and miss.
H or M	Hit or miss.
HRT. or Hrt.	Heart.
IN. or in.	Inch or inches (").
J&P	Joists and Planks.
KD	Kiln-dried.

PROPERTIES OF STRUCTURAL LUMBER

Abbreviations of Lumber Terms

LBR. or lbr.	Lumber.
LGTH. or Lgth.	Length.
LGR. or Lgr.	Longer.
LFT or Lin. Ft.	Linear foot.
LIN.	Linear.
LNG. or Lng.	Lining.
M	thousand.
MBM	thousand (feet) board measure.
MC or m.c.	Moisture content.
MERCH. or Merch.	Merchantable.
ML	Mixed lengths.
MLDG. or Mldg.	moulding.
Mft.	thousand feet.
NO. or No.	Number.
N1E	Nosed one edge.
N2E	Nosed two edges.
PAR. or Par.	Paragraph.
PART. or Part.	Partition.
PAT. or Pat.	Pattern.
Pc.	Piece.
Pcs.	Pieces.
PE	Plain end.
P&T	Post and Timbers.
RDM. or Rdm.	Random.
REG. or Reg.	Regular.
RFG. or Rfg.	Roofing.
RGH. or Rgh.	Rough.
R/L or RL.	Random lengths.
RND.	Round.
R/W	Random widths.
R/W&L	Random widths and lengths.
S1E	Surfaced one edge.
S2E	Surfaced two edges.
S1S	Surfaced one side.
S2S	Surfaced two sides.
S1S1E	Surfaced 1 side and 1 edge.
S2S1E	Surfaced 2 sides and 1 edge.
S1S2E	Surfaced 1 side and 2 edges.
S4S	Surfaced four sides.
S2S&CM	Surfaced two sides and center matched.
S2S&SM	Surfaced two sides and standard matched.
S2S&SL	Surfaced two sides and shiplapped.
SAP.	Sapwood.
SDG. or Sdg.	Siding.
SEL. or Sel.	Select.
SE&S	Square edge and sound.
SH. D.	Shipping dry.
S/L or S/Lap	Shiplap.
SM	Surface measure.
SSND	Sap stain no defect.
SQ. or Sq.	Square.
SQ. E&H. B.	Square edged and hollow back.
STRUCT. or STR.	Structural.
T&G	Tongued and Grooved.
TBR.	Timber.
VG	Vertical grain.
WTH. or Wth.	Width.
WT. or Wt.	Weight.

PROPERTIES OF STRUCTURAL LUMBER

Tables of Board Measure

NOMINAL SIZE OF PIECE	BOARD FEET CONTENT WHEN LENGTH IN FEET EQUALS											
	2	4	6	8	10	12	14	16	18	20	22	24
1 x 2	1/3	2/3	1	1 1/3	1 2/3	2	2 1/3	2 2/3	3	3 1/3	3 2/3	4
1 x 3	1/2	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6
1 x 4	2/3	1 1/3	2	2 2/3	3 1/3	4	4 2/3	5 1/3	6	6 2/3	7 1/3	8
1 x 6	1	2	3	4	5	6	7	8	9	10	11	12
1 x 8	1 1/3	2 2/3	4	5 1/3	6 2/3	8	9 1/3	10 2/3	12	13 1/3	14 2/3	16
1 x 10	1 2/3	3 1/3	5	6 2/3	8 1/3	10	11 2/3	13 1/3	15	16 2/3	18 1/3	20
1 x 12	2	4	6	8	10	12	14	16	18	20	22	24
2 x 2	2/3	1 1/3	2	2 2/3	3 1/3	4	4 2/3	5 1/3	6	6 2/3	7 1/3	8
2 x 3	1	2	3	4	5	6	7	8	9	10	11	12
2 x 4	1 1/3	2 2/3	4	5 1/3	6 2/3	8	9 1/3	10 2/3	12	13 1/3	14 2/3	16
2 x 6	2	4	6	8	10	12	14	16	18	20	22	24
2 x 8	2 2/3	5 1/3	8	10 2/3	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
2 x 10	3 1/3	6 2/3	10	13 1/3	16 2/3	20	23 1/3	26 2/3	30	33 1/3	36 2/3	40
2 x 12	4	8	12	16	20	24	28	32	36	40	44	48
2 x 14	4 2/3	9 1/3	14	18 2/3	23 1/3	28	32 2/3	37 1/3	42	46 2/3	51 1/3	56
3 x 4	2	4	6	8	10	12	14	16	18	20	22	24
3 x 6	3	6	9	12	15	18	21	24	27	30	33	36
3 x 8	4	8	12	16	20	24	28	32	36	40	44	48
3 x 10	5	10	15	20	25	30	35	40	45	50	55	60
3 x 12	6	12	18	24	30	36	42	48	54	60	66	72
3 x 14	7	14	21	28	35	42	49	56	63	70	77	84
3 x 16	8	16	24	32	40	48	56	64	72	80	88	96
4 x 4	2 2/3	5 1/3	8	10 2/3	13 1/3	16	18 2/3	21 1/3	24	26 2/3	29 1/3	32
4 x 6	4	8	12	16	20	24	28	32	36	40	44	48
4 x 8	5 1/3	10 2/3	16	21 1/3	26 2/3	32	37 1/3	42 2/3	48	53 1/3	58 2/3	64
4 x 10	6 2/3	13 1/3	20	26 2/3	33 1/3	40	46 2/3	53 1/3	60	66 2/3	73 1/3	80
4 x 12	8	16	24	32	40	48	56	64	72	80	88	96
4 x 14	9 1/3	18 2/3	28	37 1/3	46 2/3	56	65 1/3	74 2/3	84	93 1/3	102 2/3	112
4 x 16	10 2/3	21 1/3	32	42 2/3	53 1/3	64	74 2/3	85 1/3	96	106 2/3	117 1/3	128
6 x 6	6	12	18	24	30	36	42	48	54	60	66	72
6 x 8	8	16	24	32	40	48	56	64	72	80	88	96
6 x 10	10	20	30	40	50	60	70	80	90	100	110	120
6 x 12	12	24	36	48	60	72	84	96	108	120	132	144
6 x 14	14	28	42	56	70	84	98	112	126	140	154	168
6 x 16	16	32	48	64	80	96	112	128	144	160	176	192
6 x 18	18	36	54	72	90	108	126	144	162	180	198	216
6 x 20	20	40	60	80	100	120	140	160	180	200	220	240
6 x 22	22	44	66	88	110	132	154	176	198	220	242	264
6 x 24	24	48	72	96	120	144	168	192	216	240	264	288
8 x 8	10 2/3	21 1/3	32	42 2/3	53 1/3	64	74 2/3	85 1/3	96	106 2/3	117 1/3	128
8 x 10	13 1/3	26 2/3	40	53 1/3	66 2/3	80	93 1/3	106 2/3	120	133 1/3	146 2/3	160
8 x 12	16	32	48	64	80	96	112	128	144	160	176	192
8 x 14	18 2/3	37 1/3	56	74 2/3	93 1/3	112	130 2/3	149 1/3	168	186 2/3	205 1/3	224
8 x 16	21 1/3	42 2/3	64	85 1/3	106 2/3	128	149 1/3	170 2/3	192	213 1/3	234 2/3	256
8 x 18	24	48	72	96	120	144	168	192	216	240	264	288
8 x 20	26 2/3	53 1/3	80	106 2/3	133 1/3	160	186 2/3	213 1/3	240	266 2/3	293 1/3	320
8 x 22	29 1/3	58 2/3	88	117 1/3	146 2/3	176	205 1/3	234 2/3	264	293 1/3	322 2/3	352
8 x 24	32	64	96	128	160	192	224	256	288	320	352	384
10 x 10	16 2/3	33 1/3	50	66 2/3	83 1/3	100	116 2/3	133 1/3	150	166 2/3	183 1/3	200
10 x 12	20	40	60	80	100	120	140	160	180	200	220	240
10 x 14	23 1/3	46 2/3	70	93 1/3	116 2/3	140	163 1/3	186 2/3	210	233 1/3	256 2/3	280
10 x 16	26 2/3	53 1/3	80	106 2/3	133 1/3	160	186 2/3	213 1/3	240	266 2/3	293 1/3	320
10 x 18	30	60	90	120	150	180	210	240	270	300	330	360
10 x 20	33 1/3	66 2/3	100	133 1/3	166 2/3	200	233 1/3	266 2/3	300	333 1/3	366 2/3	400
10 x 22	36 2/3	73 1/3	110	146 2/3	183 1/3	220	256 2/3	293 1/3	330	366 2/3	403 1/3	440
10 x 24	40	80	120	160	200	240	280	320	360	400	440	480

PROPERTIES OF STRUCTURAL LUMBER

Tables of Board Measure

NOMINAL SIZE OF PIECE	BOARD FEET CONTENT WHEN LENGTH IN FEET EQUALS											
	2	4	6	8	10	12	14	16	18	20	22	24
12 x 12	24	48	72	96	120	144	168	192	216	240	264	288
12 x 14	28	56	84	112	140	168	196	224	252	280	308	336
12 x 16	32	64	96	128	160	192	224	256	288	320	352	384
12 x 18	36	72	108	144	180	216	252	288	324	360	396	432
12 x 20	40	80	120	160	200	240	280	320	360	400	440	480
12 x 22	44	88	132	176	220	264	308	352	396	440	484	528
12 x 24	48	96	144	192	240	288	336	384	432	480	528	576
14 x 14	32 2/3	65 1/3	98	130 2/3	163 1/3	196	228 2/3	261 1/3	294	326 2/3	359 1/3	392
14 x 16	37 1/3	74 2/3	112	149 1/3	186 2/3	224	261 1/3	298 2/3	336	373 1/3	410 2/3	448
14 x 18	42	84	126	168	210	252	294	336	378	420	462	504
14 x 20	46 2/3	93 1/3	140	186 2/3	233 1/3	280	326 2/3	373 1/3	420	466 2/3	513 1/3	560
14 x 22	51 1/3	102 2/3	154	205 1/3	256 2/3	308	359 1/3	410 2/3	462	513 1/3	564 2/3	616
14 x 24	56	112	168	224	280	336	392	448	504	560	616	672
16 x 16	42 2/3	85 1/3	128	170 2/3	213 1/3	256	298 2/3	341 1/3	384	426 2/3	469 1/3	512
16 x 18	48	96	144	192	240	288	336	384	432	480	528	576
16 x 20	53 1/3	106 2/3	160	213 1/3	266 2/3	320	373 1/3	426 2/3	480	533 1/3	586 2/3	640
16 x 22	58 2/3	117 1/3	176	234 2/3	293 1/3	352	410 2/3	469 1/3	528	586 2/3	645 1/3	704
16 x 24	64	128	192	256	320	384	448	512	576	640	704	768
18 x 18	54	108	162	216	270	324	378	432	486	540	594	648
18 x 20	60	120	180	240	300	360	420	480	540	600	660	720
18 x 22	66	132	198	264	330	396	462	528	594	660	726	792
18 x 24	72	144	216	288	360	432	504	576	648	720	792	864
20 x 20	66 2/3	133 1/3	200	266 2/3	333 1/3	400	466 2/3	533 1/3	600	666 2/3	733 1/3	800
20 x 22	73 1/3	146 2/3	220	293 1/3	366 2/3	440	513 1/3	586 2/3	660	733 1/3	806 2/3	880
20 x 24	80	160	240	320	400	480	560	640	720	800	880	960
22 x 22	80 2/3	161 1/3	242	322 2/3	403 1/3	484	564 2/3	645 1/3	726	806 2/3	887 1/3	968
22 x 24	88	176	264	352	440	528	616	704	792	880	968	1056
24 x 24	96	192	288	384	480	576	672	768	864	960	1056	1152

PROPERTIES OF STRUCTURAL LUMBER

Standard Sizes of Yard Lumber and Timbers

Details regarding the dressed sizes of various species of lumber are provided in the grading rules of the agencies which formulate and maintain such rules. The dressed sizes in the following table conform to the sizes set forth in the American Softwood Lumber Standard, Voluntary Product Standard 20-70, and have been adopted for virtually all structural lumber. While these sizes are generally available on a commercial basis, some require special ordering and consequent extended lead time for supply. **It is good practice to consult the local lumber dealer to determine what sizes are on hand or can be readily secured.**

NOMINAL AND MINIMUM-DRESSED SIZES OF BOARDS, DIMENSION, AND TIMBERS

(The thicknesses apply to all widths and all widths to all thicknesses.)

Item	Thicknesses			Face widths		
	Nominal	Minimum dressed		Nominal	Minimum dressed	
		Dry[1]	Green[1]		Dry[1]	Green[1]
		Inches	Inches		Inches	Inches
Boards	1	3/4	25/32	2	1-1/2	1-9/16
	1-1/4	1	1-1/32	3	2-1/2	2-9/16
	1-1/2	1-1/4	1-9/32	4	3-1/2	3-9/16
				5	4-1/2	4-5/8
				6	5-1/2	5-5/8
				7	6-1/2	6-5/8
				8	7-1/4	7-1/2
				9	8-1/4	8-1/2
				10	9-1/4	9-1/2
				11	10-1/4	10-1/2
				12	11-1/4	11-1/2
				14	13-1/4	13-1/2
				16	15-1/4	15-1/2
Dimension	2	1-1/2	1-9/16	2	1-1/2	1-9/16
	2-1/2	2	2-1/16	3	2-1/2	2-9/16
	3	2-1/2	2-9/16	4	3-1/2	3-9/16
	3-1/2	3	3-1/16	5	4-1/2	4-5/8
				6	5-1/2	5-5/8
				8	7-1/4	7-1/2
				10	9-1/4	9-1/2
				12	11-1/4	11-1/2
				14	13-1/4	13-1/2
				16	15-1/4	15-1/2
Dimension	4	3-1/2	3-9/16	2	1-1/2	1-9/16
	4-1/2	4	4-1/16	3	2-1/2	2-9/16
				4	3-1/2	3-9/16
				5	4-1/2	4-5/8
				6	5-1/2	5-5/8
				8	7-1/4	7-1/2
				10	9-1/4	9-1/2
				12	11-1/4	11-1/2
				14	------	13-1/2
				16	------	15-1/2
Timbers	5 and thicker	------	1/2 off	8 and wider	------	1/2 off

1. Dry lumber is defined as lumber which has been seasoned to a moisture content of 19 per cent or less. Green lumber is defined as lumber having a moisture content in excess of 19 per cent.

PROPERTIES OF STRUCTURAL LUMBER

Properties of Standard Dressed Sizes

Certain mathematical expressions of the properties or elements of sections are used in computing the values of structural members of various shapes for the various conditions under which they are subjected to stress. The properties or elements of sections of certain standard sizes of boards, dimension, and timbers are given in the following tables.

NEUTRAL AXIS, in the cross section of a beam or column in a state of flexure, is the line on which there is neither tension or compression.

The neutral axis, X-X in the following tables of properties of rectangular and square sections of lumber has been assumed as perpendicular to the depth of the section at its center, the depth "d" being parallel to and in the direction of the application of the force or load.

MOMENT OF INERTIA, I, of the cross section of a beam is the sum of the products of each of its elementary areas by the square of their distance from the neutral axis of the section.

SECTION MODULUS, S, is the moment of inertia divided by the distance from the neutral axis to extreme fiber of the section.

CROSS SECTION is a section taken through the member perpendicular to its longitudinal axis.

The following symbols and formulas apply to rectangular and square beam sections with neutral axis perpendicular to depth at center, d/2.

A = area of section in square inches = bd

b = breadth in inches of beam face opposed to or to which the force or load is applied

d = height or depth in inches of beam face parallel with the direction of the action of the force or load.

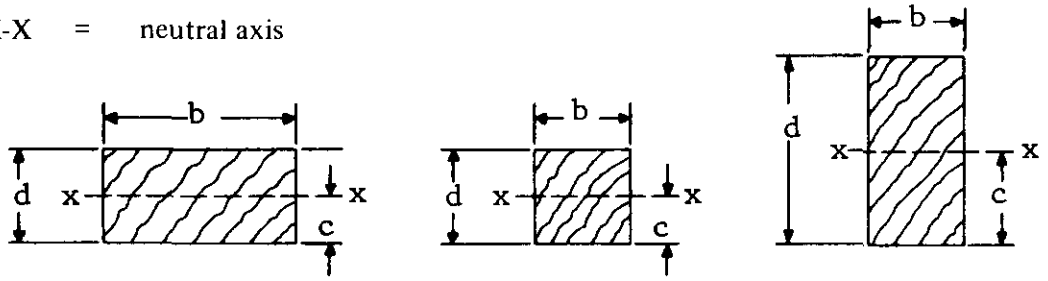
I = moment of inertia in inches^4 = $\frac{bd^3}{12}$

c = distance in inches from axis to extremities of section = $\frac{d}{2}$

r = radius of gyration in inches = $\sqrt{I/A}$

S = section modulus in inches^3 = $\frac{I}{c}$ = $\frac{bd^2}{6}$

X-X = neutral axis



PROPERTIES OF STRUCTURAL LUMBER — Sectional Properties of Standard Dressed (S4S) Lumber Sizes

NOMINAL SIZE b(inches)d	STANDARD DRESSED SIZE (S4S) b(inches)d	AREA OF SECTION A	MOMENT OF INERTIA I	SECTION MODULUS S	Weight in pounds per linear foot of piece when weight of wood per cubic foot equals:					
					25 lb.	30 lb.	35 lb.	40 lb.	45 lb.	50 lb.
1 x 3	3/4 x 2 1/2	1.875	0.977	0.781	0.326	0.391	0.456	0.521	0.586	0.651
1 x 4	3/4 x 3 1/2	2.625	2.680	1.531	0.456	0.547	0.638	0.729	0.820	0.911
1 x 6	3/4 x 5 1/2	4.125	10.398	3.781	0.716	0.859	1.003	1.146	1.289	1.432
1 x 8	3/4 x 7 1/4	5.438	23.817	6.570	0.944	1.133	1.322	1.510	1.699	1.888
1 x 10	3/4 x 9 1/4	6.938	49.466	10.695	1.204	1.445	1.686	1.927	2.168	2.409
1 x 12	3/4 x 11 1/4	8.438	88.989	15.820	1.465	1.758	2.051	2.344	2.637	2.930
2 x 3	1 1/2 x 2 1/2	3.750	1.953	1.563	0.651	0.781	0.911	1.042	1.172	1.302
2 x 4	1 1/2 x 3 1/2	5.250	5.359	3.063	0.911	1.094	1.276	1.458	1.641	1.823
2 x 6	1 1/2 x 5 1/2	8.250	20.797	7.563	1.432	1.719	2.005	2.292	2.578	2.865
2 x 8	1 1/2 x 7 1/4	10.875	47.635	13.141	1.888	2.266	2.643	3.021	3.398	3.776
2 x 10	1 1/2 x 9 1/4	13.875	98.932	21.391	2.409	2.891	3.372	3.854	4.336	4.818
2 x 12	1 1/2 x 11 1/4	16.875	177.979	31.641	2.930	3.516	4.102	4.688	5.273	5.859
2 x 14	1 1/2 x 13 1/4	19.875	290.775	43.891	3.451	4.141	4.831	5.521	6.211	6.901
3 x 1	2 1/2 x 3/4	1.875	0.088	0.234	0.326	0.391	0.456	0.521	0.586	0.651
3 x 2	2 1/2 x 1 1/2	3.750	0.703	0.938	0.651	0.781	0.911	1.042	1.172	1.302
3 x 4	2 1/2 x 3 1/2	8.750	8.932	5.104	1.519	1.823	2.127	2.431	2.734	3.038
3 x 6	2 1/2 x 5 1/2	13.750	34.661	12.604	2.387	2.865	3.342	3.819	4.297	4.774
3 x 8	2 1/2 x 7 1/4	18.125	79.391	21.901	3.147	3.776	4.405	5.035	5.664	6.293
3 x 10	2 1/2 x 9 1/4	23.125	164.886	35.651	4.015	4.818	5.621	6.424	7.227	8.030
3 x 12	2 1/2 x 11 1/4	28.125	296.631	52.734	4.883	5.859	6.836	7.813	8.789	9.766
3 x 14	2 1/2 x 13 1/4	33.125	484.625	73.151	5.751	6.901	8.051	9.201	10.352	11.502
3 x 16	2 1/2 x 15 1/4	38.125	738.870	96.901	6.619	7.943	9.266	10.590	11.914	13.238
4 x 1	3 1/2 x 3/4	2.625	0.123	0.328	0.456	0.547	0.638	0.729	0.820	0.911
4 x 2	3 1/2 x 1 1/2	5.250	0.984	1.313	0.911	1.094	1.276	1.458	1.641	1.823
4 x 3	3 1/2 x 2 1/2	8.750	4.557	3.646	1.519	1.823	2.127	2.431	2.734	3.038
4 x 4	3 1/2 x 3 1/2	12.250	12.505	7.146	2.127	2.552	2.977	3.403	3.828	4.253
4 x 6	3 1/2 x 5 1/2	19.250	48.526	17.646	3.342	4.010	4.679	5.347	6.016	6.684
4 x 8	3 1/2 x 7 1/4	25.375	111.148	30.661	4.405	5.286	6.168	7.049	7.930	8.811
4 x 10	3 1/2 x 9 1/4	32.375	230.840	49.911	5.621	6.745	7.869	8.933	10.117	11.241
4 x 12	3 1/2 x 11 1/4	39.375	415.283	73.828	6.836	8.203	9.570	10.938	12.305	13.672
4 x 14	3 1/2 x 13 1/4	46.38	678.5	102.4	8.051	9.661	11.27	12.88	14.49	16.10
4 x 16	3 1/2 x 15 1/4	53.38	1034	135.7	9.266	11.12	12.97	14.83	16.68	18.53
6 x 1	5 1/2 x 3/4	4.125	0.193	0.516	0.716	0.859	1.003	1.146	1.289	1.432
6 x 2	5 1/2 x 1 1/2	8.250	1.547	2.063	1.432	1.719	2.005	2.292	2.578	2.865
6 x 3	5 1/2 x 2 1/2	13.750	7.161	5.729	2.387	2.865	3.342	3.819	4.297	4.774
6 x 4	5 1/2 x 3 1/2	19.250	19.651	11.229	3.342	4.010	4.679	5.347	6.016	6.684
6 x 6	5 1/2 x 5 1/2	30.250	76.255	27.729	5.252	6.302	7.352	8.403	9.453	10.503
6 x 8	5 1/2 x 7 1/2	41.250	193.359	51.563	7.161	8.594	10.026	11.458	12.891	14.323
6 x 10	5 1/2 x 9 1/2	52.250	392.963	82.729	9.071	10.885	12.700	14.514	16.328	18.142
6 x 12	5 1/2 x 11 1/2	63.250	697.068	121.229	10.981	13.177	15.373	17.569	19.766	21.962
6 x 14	5 1/2 x 13 1/2	74.250	1127.672	167.063	12.891	15.469	18.047	20.625	23.203	25.781
6 x 16	5 1/2 x 15 1/2	85.250	1706.776	220.229	14.800	17.760	20.720	23.681	26.641	29.601
6 x 18	5 1/2 x 17 1/2	96.250	2456.380	280.729	16.710	20.052	23.394	26.736	30.078	33.420
6 x 20	5 1/2 x 19 1/2	107.250	3398.484	348.563	18.620	22.344	26.068	29.792	33.516	37.240
6 x 22	5 1/2 x 21 1/2	118.250	4555.086	423.729	20.530	24.635	28.741	32.847	36.953	41.059
6 x 24	5 1/2 x 23 1/2	129.250	5948.191	506.229	22.439	26.927	31.415	35.903	40.391	44.878
8 x 1	7 1/4 x 3/4	5.438	0.255	0.680	0.944	1.133	1.322	1.510	1.699	1.888
8 x 2	7 1/4 x 1 1/2	10.875	2.039	2.719	1.888	2.266	2.643	3.021	3.398	3.776
8 x 3	7 1/4 x 2 1/2	18.125	9.440	7.552	3.147	3.776	4.405	5.035	5.664	6.293
8 x 4	7 1/4 x 3 1/2	25.375	25.904	14.802	4.405	5.286	6.168	7.049	7.930	8.811
8 x 6	7 1/2 x 5 1/2	41.250	103.984	37.813	7.161	8.594	10.026	11.458	12.891	14.323
8 x 8	7 1/2 x 7 1/2	56.250	263.672	70.313	9.766	11.719	13.672	15.625	17.578	19.531
8 x 10	7 1/2 x 9 1/2	71.250	535.859	112.813	12.370	14.844	17.318	19.792	22.266	24.740
8 x 12	7 1/2 x 11 1/2	86.250	950.547	165.313	14.974	17.969	20.964	23.958	26.953	29.948
8 x 14	7 1/2 x 13 1/2	101.250	1537.734	227.813	17.578	21.094	24.609	28.125	31.641	35.156
8 x 16	7 1/2 x 15 1/2	116.250	2327.422	300.313	20.182	24.219	28.255	32.292	36.328	40.365
8 x 18	7 1/2 x 17 1/2	131.250	3349.609	382.813	22.786	27.344	31.901	36.458	41.016	45.573
8 x 20	7 1/2 x 19 1/2	146.250	4634.297	475.313	25.391	30.469	35.547	40.625	45.703	50.781
8 x 22	7 1/2 x 21 1/2	161.250	6211.484	577.813	27.995	33.594	39.193	44.792	50.391	55.990
8 x 24	7 1/2 x 23 1/2	176.250	8111.172	690.313	30.599	36.719	42.839	48.958	55.078	61.198

PROPERTIES OF STRUCTURAL LUMBER — Sectional Properties of Standard Dressed (S4S) Lumber Sizes

NOMINAL SIZE b(inches)d	STANDARD DRESSED SIZE (S4S) b(inches)d	AREA OF SECTION A	MOMENT OF INERTIA I	SECTION MODULUS S	Weight in pounds per linear foot of piece when weight of wood per cubic foot equals:					
					25 lb.	30 lb.	35 lb.	40 lb.	45 lb.	50 lb.
10 x 1	9 1/4 x 3/4	6.938	0.325	0.867	1.204	1.445	1.686	1.927	2.168	2.409
10 x 2	9 1/4 x 1 1/2	13.875	2.602	3.469	2.409	2.891	3.372	3.854	4.336	4.818
10 x 3	9 1/4 x 2 1/2	23.125	12.044	9.635	4.015	4.818	5.621	6.424	7.227	8.030
10 x 4	9 1/4 x 3 1/2	32.375	33.049	18.885	5.621	6.745	7.869	8.993	10.117	11.241
10 x 6	9 1/2 x 5 1/2	52.250	131.714	47.896	9.071	10.885	12.700	14.514	16.328	18.142
10 x 8	9 1/2 x 7 1/2	71.250	333.984	89.063	12.370	14.844	17.318	19.792	22.266	24.740
10 x 10	9 1/2 x 9 1/2	90.250	678.755	142.896	15.668	18.802	21.936	25.069	28.203	31.337
10 x 12	9 1/2 x 11 1/2	109.250	1204.026	209.396	18.967	22.760	26.554	30.347	34.141	37.934
10 x 14	9 1/2 x 13 1/2	128.250	1947.797	288.563	22.266	26.719	31.172	35.625	40.078	44.531
10 x 16	9 1/2 x 15 1/2	147.250	2948.068	380.396	25.564	30.677	35.790	40.903	46.016	51.128
10 x 18	9 1/2 x 17 1/2	166.250	4242.836	484.896	28.863	34.635	40.408	46.181	51.953	57.726
10 x 20	9 1/2 x 19 1/2	185.250	5870.109	602.063	32.161	38.594	45.026	51.458	57.891	64.323
10 x 22	9 1/2 x 21 1/2	204.250	7867.879	731.896	35.460	42.552	49.644	56.736	63.828	70.920
10 x 24	9 1/2 x 23 1/2	223.250	10274.148	874.396	38.759	46.510	54.262	62.014	69.766	77.517
12 x 1	11 1/4 x 3/4	8.438	0.396	1.055	1.465	1.758	2.051	2.344	2.637	2.930
12 x 2	11 1/4 x 1 1/2	16 875	3.164	4.219	2.930	3.516	4.102	4.688	5.273	5.859
12 x 3	11 1/4 x 2 1/2	28.125	14.648	11.719	4.883	5.859	6.836	7.813	8.789	9.766
12 x 4	11 1/4 x 3 1/2	39.375	40.195	22.969	6.836	8.203	9.570	10 938	12.305	13.672
12 x 6	11 1/2 x 5 1/2	63.250	159.443	57.979	10.981	13.177	15.373	17.569	19.766	21.962
12 x 8	11 1/2 x 7 1/2	86.250	404.297	107.813	14.974	17.969	20.964	23.958	26.953	29.948
12 x 10	11 1/2 x 9 1/2	109.250	821.651	172.979	18.967	22.760	26.554	30.347	34.141	37.934
12 x 12	11 1/2 x 11 1/2	132.250	1457.505	253.479	22.960	27.552	32.144	36.736	41.328	45.920
12 x 14	11 1/2 x 13 1/2	155.250	2357.859	349.313	26.953	32.344	37.734	43.125	48.516	53.906
12 x 16	11 1/2 x 15 1/2	178.250	3568.713	460.479	30.946	37.135	43.325	49.514	55.703	61.892
12 x 18	11 1/2 x 17 1/2	201.250	5136.066	586.979	34.939	41.927	48.915	55.903	62.891	69.878
12 x 20	11 1/2 x 19 1/2	224.250	7105.922	728.813	38.932	46.719	54.505	62.292	70.078	77.865
12 x 22	11 1/2 x 21 1/2	247.250	9524.273	885.979	42.925	51.510	60.095	68.681	77.266	85.851
12 x 24	11 1/2 x 23 1/2	270.250	12437.129	1058.479	46.918	56.302	65.686	75.069	84.453	93.837
14 x 2	13 1/4 x 1 1/2	19.875	3.727	4.969	3.451	4.141	4.831	5.521	6.211	6.901
14 x 3	13 1/4 x 2 1/2	33.125	17.253	13.802	5.751	6.901	8.051	9.201	10.352	11.502
14 x 4	13 1/2 x 3 1/2	47.250	48.234	27.563	8.203	9.844	11.484	13.125	14.766	16.406
14 x 6	13 1/2 x 5 1/2	74.250	187.172	68.063	12.891	15.469	18.047	20.625	23.203	25.781
14 x 8	13 1/2 x 7 1/2	101.250	474.609	126.563	17.578	21.094	24.609	28.125	31.641	35.156
14 x 10	13 1/2 x 9 1/2	128.250	964.547	203.063	22.266	26.719	31.172	35.625	40.078	44.531
14 x 12	13 1/2 x 11 1/2	155.250	1710.984	297.563	26.953	32.344	37.734	43.125	48.516	53.906
14 x 16	13 1/2 x 15 1/2	209.250	4189.359	540.563	36.328	43.594	50.859	58.125	65.391	72.656
14 x 18	13 1/2 x 17 1/2	236.250	6029.297	689.063	41.016	49.219	57.422	65.625	73.828	82.031
14 x 20	13 1/2 x 19 1/2	263.250	8341.734	855.563	45.703	54.844	63.984	73.125	82.266	91.406
14 x 22	13 1/2 x 21 1/2	290.250	11180.672	1040.063	50.391	60.469	70.547	80.625	90.703	100.781
14 x 24	13 1/2 x 23 1/2	317.250	14600.109	1242.563	55.078	66.094	77.109	88.125	99.141	110.156
16 x 3	15 1/2 x 2 1/2	38.750	20.182	16.146	6.727	8.073	9.418	10.764	12.109	13.455
16 x 4	15 1/2 x 3 1/2	54.250	55.380	31.646	9.418	11.302	13.186	15.069	16.953	18.837
16 x 6	15 1/2 x 5 1/2	85.250	214.901	78.146	14.800	17.760	20.720	23.681	26.641	29.601
16 x 8	15 1/2 x 7 1/2	116.250	544.922	145.313	20.182	24.219	28.255	32.292	36.328	40.365
16 x 10	15 1/2 x 9 1/2	147.250	1107.443	233.146	25.564	30.677	35.790	40.903	46.016	51.128
16 x 12	15 1/2 x 11 1/2	178.250	1964.463	341.646	30.946	37.135	43.325	49.514	55.703	61.892
16 x 14	15 1/2 x 13 1/2	209.250	3177.984	470.813	36.328	43.594	50.859	58.125	65.391	72.656
16 x 16	15 1/2 x 15 1/2	240.250	4810.004	620.646	41.710	50.052	58.394	66.736	75.078	83.420
16 x 18	15 1/2 x 17 1/2	271.250	6922.523	791.146	47.092	56.510	65.929	75.347	84.766	94.184
16 x 20	15 1/2 x 19 1/2	302.250	9577.547	982.313	52.474	62.969	73.464	83.958	94.453	104.948
16 x 22	15 1/2 x 21 1/2	333.250	12837.066	1194.146	57.856	69.427	80.998	92.569	104.141	115.712
16 x 24	15 1/2 x 23 1/2	364.250	16763.086	1426.646	63.238	75.885	88.533	101.181	113.828	126.476
18 x 6	17 1/2 x 5 1/2	96.250	242.630	88.229	16.710	20.052	23.394	26.736	30.078	33.420
18 x 8	17 1/2 x 7 1/2	131.250	615.234	164.063	22.786	27.344	31.901	36.458	41.016	45.573
18 x 10	17 1/2 x 9 1/2	166.250	1250.338	263.229	28.863	34.635	40.408	46.181	51.953	57.726
18 x 12	17 1/2 x 11 1/2	201.250	2217.943	385.729	34.939	41.927	48.915	55.903	62.891	69.878
18 x 14	17 1/2 x 13 1/2	236.250	3588.047	531.563	41.016	49.219	57.422	65.625	73.828	82.031
18 x 16	17 1/2 x 15 1/2	271.250	5430.648	700.729	47.092	56.510	65.929	75.347	84.766	94.184
18 x 18	17 1/2 x 17 1/2	306.250	7815.754	893.229	53.168	63.802	74.436	85.069	95.703	106.337
18 x 20	17 1/2 x 19 1/2	341.250	10813.359	1109.063	59.245	71.094	82.943	94.792	106.641	118.490
18 x 22	17 1/2 x 21 1/2	376.250	14493.461	1348.229	65.321	78.385	91.450	104.514	117.578	130.642
18 x 24	17 1/2 x 23 1/2	411.250	18926.066	1610.729	71.398	85.677	99.957	114.236	128.516	142.795

PROPERTIES OF STRUCTURAL LUMBER — Sectional Properties of Standard Dressed (S4S) Lumber Sizes

NOMINAL SIZE b(inches)d	STANDARD DRESSED SIZE (S4S) b(inches)d	AREA OF SECTION A	MOMENT OF INERTIA I	SECTION MODULUS S	Weight in pounds per linear foot of piece when weight of wood per cubic foot equals:					
					25 lb.	30 lb.	35 lb.	40 lb.	45 lb.	50 lb.
20 x 6	19 1/2 x 5 1/2	107.250	270.359	98.313	18.620	22.344	26.068	29.792	33.516	37.240
20 x 8	19 1/2 x 7 1/2	146.250	685.547	182.813	25.391	30.469	35.547	40.625	45.703	50.781
20 x 10	19 1/2 x 9 1/2	185.250	1393.234	293.313	32.161	38.594	45.026	51.458	57.891	64.323
20 x 12	19 1/2 x 11 1/2	224.250	2471.422	429.813	38.932	46.719	54.505	62.292	70.078	77.865
20 x 14	19 1/2 x 13 1/2	263.250	3998.109	592.313	45.703	54.844	63.984	73.125	82.266	91.406
20 x 16	19 1/2 x 15 1/2	302.250	6051.297	780.813	52.474	62.969	73.464	83.958	94.453	104.948
20 x 18	19 1/2 x 17 1/2	341.250	8708.984	995.313	59.245	71.094	82.943	94.792	106.641	118.490
20 x 20	19 1/2 x 19 1/2	380.250	12049.172	1235.813	66.016	79.219	92.422	105.625	118.828	132.031
20 x 22	19 1/2 x 21 1/2	419.250	16149.859	1502.313	72.786	87.344	101.901	116.458	131.016	145.573
20 x 24	19 1/2 x 23 1/2	458.250	21089.047	1794.813	79.557	95.469	111.380	127.292	243.203	159.115
22 x 6	21 1/2 x 5 1/2	118.250	298.088	108.396	20.530	24.635	28.741	32.847	36.953	41.059
22 x 8	21 1/2 x 7 1/2	161.250	755.859	201.563	27.995	33.594	39.193	44.792	50.391	55.990
22 x 10	21 1/2 x 9 1/2	204.250	1536.130	323.396	35.460	42.552	49.644	56.736	63.828	70.920
22 x 12	21 1/2 x 11 1/2	247.250	2724.901	473.896	42.925	51.510	60.095	68.681	77.266	85.851
22 x 14	21 1/2 x 13 1/2	290.250	4408.172	653.063	50.391	60.469	70.547	80.625	90.703	100.781
22 x 16	21 1/2 x 15 1/2	333.250	6671.941	860.896	57.856	69.427	80.998	92.569	104.141	115.712
22 x 18	21 1/2 x 17 1/2	376.250	9602.211	1097.396	65.321	78.385	91.450	104.514	117.578	130.642
22 x 20	21 1/2 x 19 1/2	419.250	13284.984	1362.563	72.786	87.344	101.901	116.458	131.016	145.573
22 x 22	21 1/2 x 21 1/2	462.250	17806.254	1656.396	80.252	96.302	112.352	128.403	144.453	160.503
22 x 24	21 1/2 x 23 1/2	505.250	23252.023	1978.896	87.717	105.260	122.804	140.347	157.891	175.434
24 x 6	23 1/2 x 5 1/2	129.250	325.818	118.479	22.439	26.927	31.415	35.903	40.391	44.878
24 x 8	23 1/2 x 7 1/2	176.250	826.172	220.313	30.599	36.719	42.839	48.958	55.078	61.198
24 x 10	23 1/2 x 9 1/2	223.250	1679.026	353.479	38.759	46.510	54.262	62.014	69.766	77.517
24 x 12	23 1/2 x 11 1/2	270.250	2978.380	517.979	46.918	56.302	65.686	75.069	84.453	93.837
24 x 14	23 1/2 x 13 1/2	317.250	4818.234	713.813	55.078	66.094	77.109	88.125	99.141	110.156
24 x 16	23 1/2 x 15 1/2	364.250	7292.586	940.979	63.238	75.885	88.533	101.181	113.828	126.476
24 x 18	23 1/2 x 17 1/2	411.250	10495.441	1199.479	71.398	85.677	99.957	114.236	128.516	142.795
24 x 20	23 1/2 x 19 1/2	458.250	14520.797	1489.313	79.557	95.469	111.380	127.292	143.203	159.115
24 x 22	23 1/2 x 21 1/2	505.250	19462.648	1810.479	87.717	105.260	122.804	140.347	157.891	175.434
24 x 24	23 1/2 x 23 1/2	552.250	25415.004	2162.979	95.877	115.052	134.227	153.403	172.578	191.753