Timber Cribbing Use

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Cribbing is an essential tool during rescue operations. In fact, cribbing is one of the most frequently used tools during rescue operations, and considered to be among the strongest means of support. Gravity is inescapable, thus cribbing is used to transfer the weight of a load into a 'footprint'. Cribbing provides a simple *temporary* support during rescue operations. In order to correctly and effectively transfer weight from top to bottom, full and direct contact must be made with both the load and lower surface. Rescuers should begin with a solid base of support, especially in soft surfaces such as mud, sand, snow, etc. This substantial base of support will assist in effective weight transfer, and should be level or nearly so if at all possible. Make an attempt to keep all cribbing plumb and level to provide greater stability. Remember, stabilization is a dynamic process frequently needing inspection to ascertain its effectiveness. **Three smart cribbing considerations are: 1. Avoid the area of danger, i.e. remain clear of the load's footprint, 2. Mitigate the hazard if possible, i.e. uprighting a heavy vehicle off a smaller vehicle, and 3. Crib or shore from a safe into an unsafe area.** Always place cribbing/shoring in a manner that provides both responder and patient egress! Prior to cribbing/shoring, rescuers should ask three questions, 1. Are the needed materials readily available, 2. Are the tools needed readily available, and 3. Are the rescuers trained and possess the expertise to perform the needed operations?

Wooden cribbing pieces seem to be the most commonly used, with softwood a popular choice. However, hardwood and softwood generally refer to the type of tree producing the wood and not the strength of the wood itself. Hardwood trees shed their leaves in the fall, while softwood trees retain their leaves/needles consistently. Softwoods most frequently used are Southern Yellow Pine and Douglas Fir, although other species are also used. Always attempt to obtain and use #1 Grade timber for cribbing/shoring. Advantages of softwood cribbing pieces include being lighter in weight compared to hardwood, and most importantly providing warnings of failure. These warnings include visible cracking or splitting of the wood, and sounds produced by such cracking. Generally the signs of failure begin near the ends of the timber piece as 'checks' and 'splits'. Checks are separations in wood transecting the annular growth rings, while splits occur when wood cells tear apart, parallel to the grain of the wood. The properties of wood allowing the noticeable signs of failure result from the two primary growing season's, spring and summer. Spring growth produces softer fibers while summer growth produces harder fibers. The softer fibers of spring growth produce the noise of cracking and the evident physical cracks during crossgrain loading. When building stack cribbing the load is perpendicular to the wood grain producing slow, noisy, and visible warnings of failure. This compression stress actually crushes a timber piece. Timber pieces with greater strength values in perpendicular compression (stated in psi) are better suited for wedges and bearing timbers (cribbing). Axial loading such as in shoring operations relies upon buckling failure. Greater strength in compression parallel to the grain is better suited for columns such as used in shoring.

In some instances fifty pieces or more may be needed to stabilize an upright school bus. If your primary response vehicle doesn't carry this amount, is it easily obtainable? Preplanning for the need of cribbing is fundamental for heavy rescue. How can your agency obtain the needed timber 24/7/365? If not readily available, consider establishing a quantity to be stored at your agency. Pack this cribbing according to dimension or primary purpose into open mesh crates. These crates can be easily handled. Consider storing a hand truck with the cribbing to transport a large quantity quickly using minimal personnel.

Wooden cribbing should be left unfinished and unpainted. Cribbing pieces rely on gravity and friction between bearing points for stability. Painted surfaces become slippery when wet and may hide damage or defects of the pieces. Cribbing pieces may be 'toe-nailed' together to maintain integrity. A cordless or pneumatic nailer should be used to drive 16d framing nails into place. Optimally nails being used should be driven so that 2/3 of their length extends into the second piece of wood. Colored handles of rope or webbing may be attached near the ends of cribbing to separate the types and sizes. The ends of cribbing may be painted or labeled to identify various types and sizes as well.

Cribbing should be inspected frequently for physical and chemical damage, or other deterioration. Cracks are obviously indicative of physical damage. Moisture is a bitter enemy of cribbing. Store it in a clean, dry and ventilated area with room for air movement among pieces if possible. If cribbing is found to be damaged it should be removed from service, and not used for training.

Varied lengths of cribbing may be used, however an accepted value is that the height of a stack crib shouldn't exceed three times its width (footprint), provided all contact points are covered. For example, if the footprint of a stack crib is 18" (calculated using 26" timber pieces, and allowing 8" of overlap measurement), the height shouldn't exceed 54" (3:1). Therefore rescuers may gain insight into cribbing length based upon this value, especially if considerable height is anticipated. Although shorter lengths are most commonly used, longer cribbing pieces such as 4', 6', and 8' should be in a timber cribbing inventory.

Stack crib height shouldn't exceed three times its 'footprint' <u>if all contact points are covered</u>

2 x 2 construction method

The 2 x 2-construction method of building a stack crib uses two pieces of cribbing per layer, each layer at right angles.

3 x 3 construction method

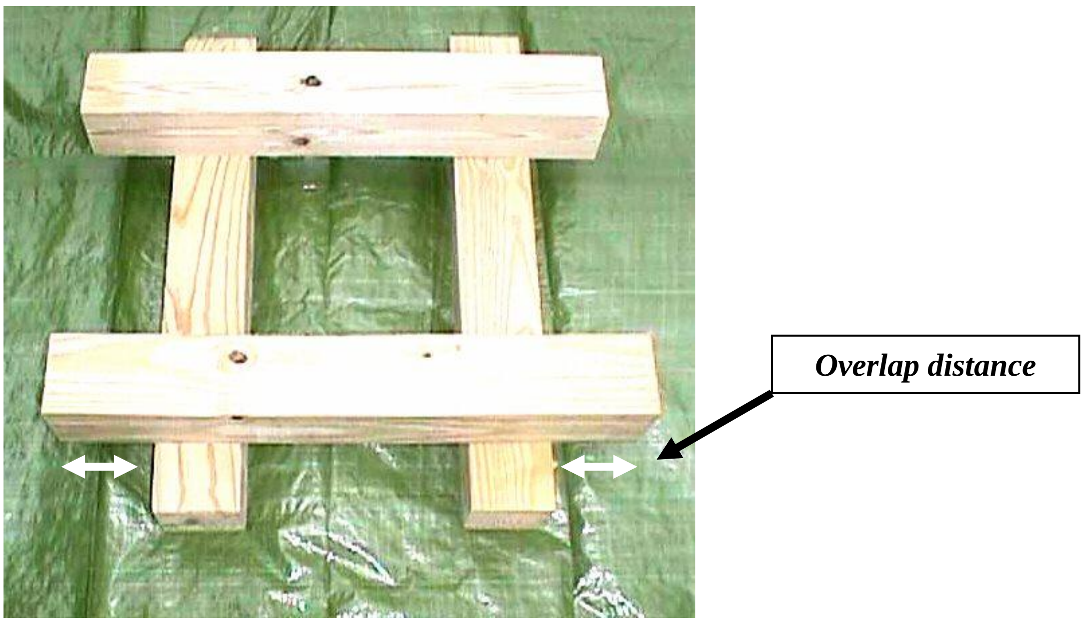
The 3 x 3 construction method uses three pieces per layer, each layer at right angles.

Using the 2 x 2 construction method with 4" x 4" timbers the weight bearing capacity of the stack crib is 24,000 pounds, 6,000 pounds per column (12 tons total), <u>if all four contact points are covered</u>. The weight bearing capacity would increase to 55,000 pounds, 6,111.1 pounds per column (27.5 tons total) if the 3 x 3-construction method was used and <u>all nine</u> <u>contact points were covered</u>. The 3 x 3 construction method increases the weight bearing capacity, however only uses 50% more cribbing pieces. The weight bearing capacity of a stack crib is calculated by the maximum perpendicular load to the grain (stated in psi) as accepted by structural engineers on the sum of all bearing points. It is important that stack cribbing be centered under the load if possible, maintaining majority of the load in the center 1/3 of the stack crib. Do not use the 2x2 construction method when using stack cribbing as a platform for air bag lifting systems, <u>*unless*</u> the top tier of cribbing is completely solid and capable of supporting the force imposed by the air bag as it lifts the load. Ideally the solid top tier of cribbing pieces is connected together by some means to prevent unwanted movement, i.e. 'scabs'. High pressure air bag lifting systems tend to inflate from the center outward and may dislodge a stack crib resulting in catastrophic failure during a lifting operation.

Using 6" x 6" timbers and the 2 x 2 construction method the weight bearing capacity is 60,000 pounds, 15,000 pounds per column (30 tons total). The weight bearing capacity would increase to 136,000 pounds, 15,111 pounds per column (68 tons total) if the 3 x 3-construction method were used. These capacities are valid if the load covers <u>all contact points</u>. The formula to calculate weight sustaining capacity *per column* is: Total surface (in square inches) of cribbing piece multiplied by the compression strength perpendicular to the grain (stated as psi).

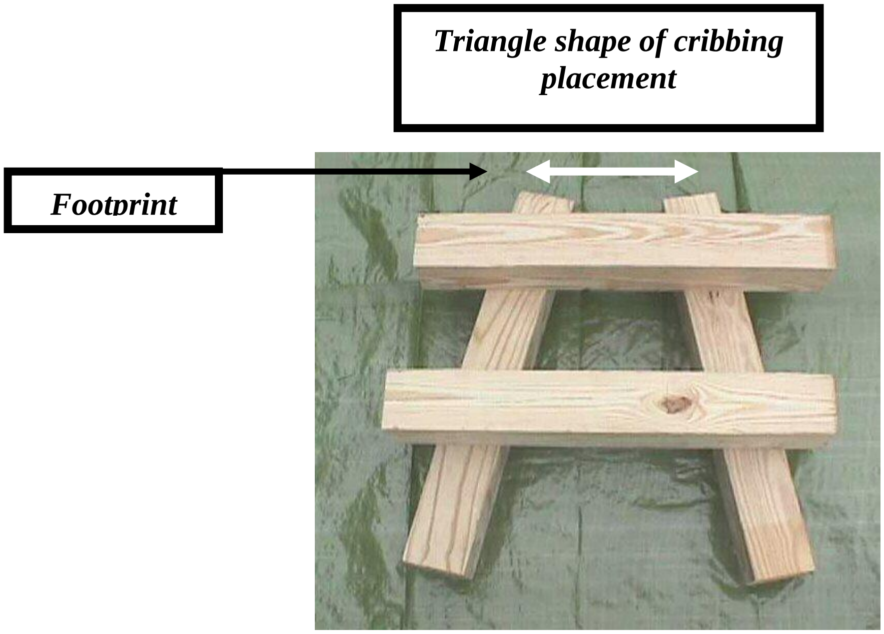
The weight bearing capacity values expressed within this document are based on the use of undamaged #1 Grade Southern Yellow Pine or Douglas Fir, and accepted by FEMA for USAR response. It is vitally important for responders to determine specifically what the strength of their respective cribbing pieces are using accepted engineering values. There is no strength loss for treated vs. untreated wood provided the moisture content is less than 19%. Cribbing pieces should be of #1 Grade, which provides greater strength and better cosmetic appearance.

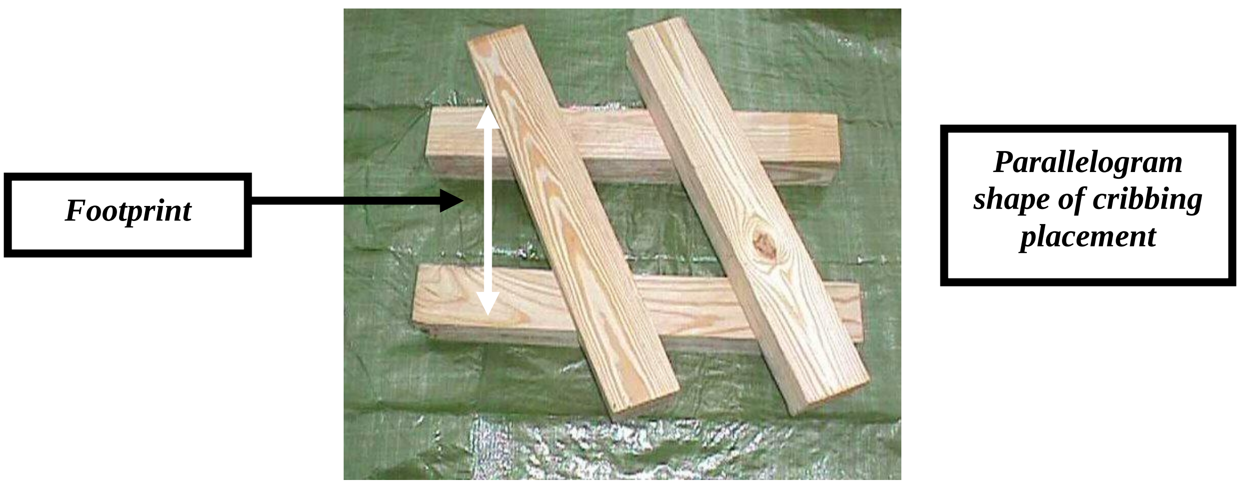
Manufacturers are now producing varied cribbing pieces using plastic. These pieces are formed into such tools as stepchocks, wedges, buttresses, "lock blocks" and others. The surfaces of plastic cribbing are resistant to soiling and staining. The durability of these pieces is reported to be longer than wood, and the weight bearing capacity greater.



The ends of cribbing pieces should overlap the preceding layer by the width of that particular piece for two primary reasons, 1. Should the cribbing pieces slip minimally, some degree of integrity is maintained, and 2. Failure will begin at the ends of the cribbing pieces, showing warning signs of deteriorating integrity. For example, when using 4" timber the ends of each layer should overlap a minimum of 4".

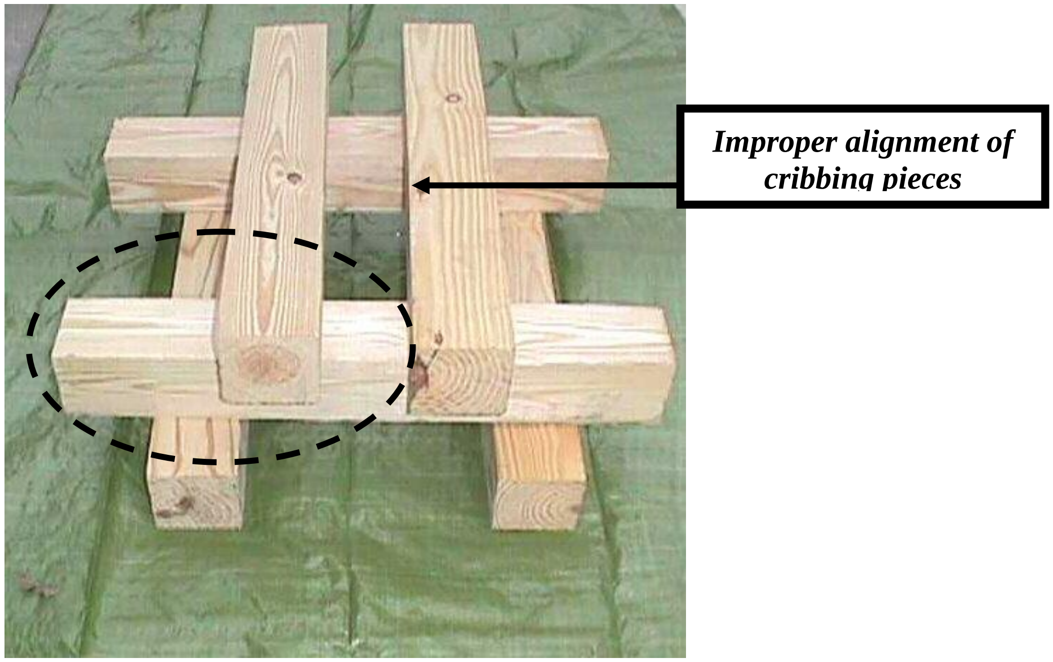
Rescue situations may dictate that cribbing pieces be placed in shapes other than a square. When other than a square shape is used the footprint will vary. Thus, the safe column height will vary.





If the square shape of a cribbing stack is modified, the safe height of the stack is limited to one times the footprint (1:1). For example, if the footprint of modified stack cribbing is 12”, the safe height of the column is limited to 12”.

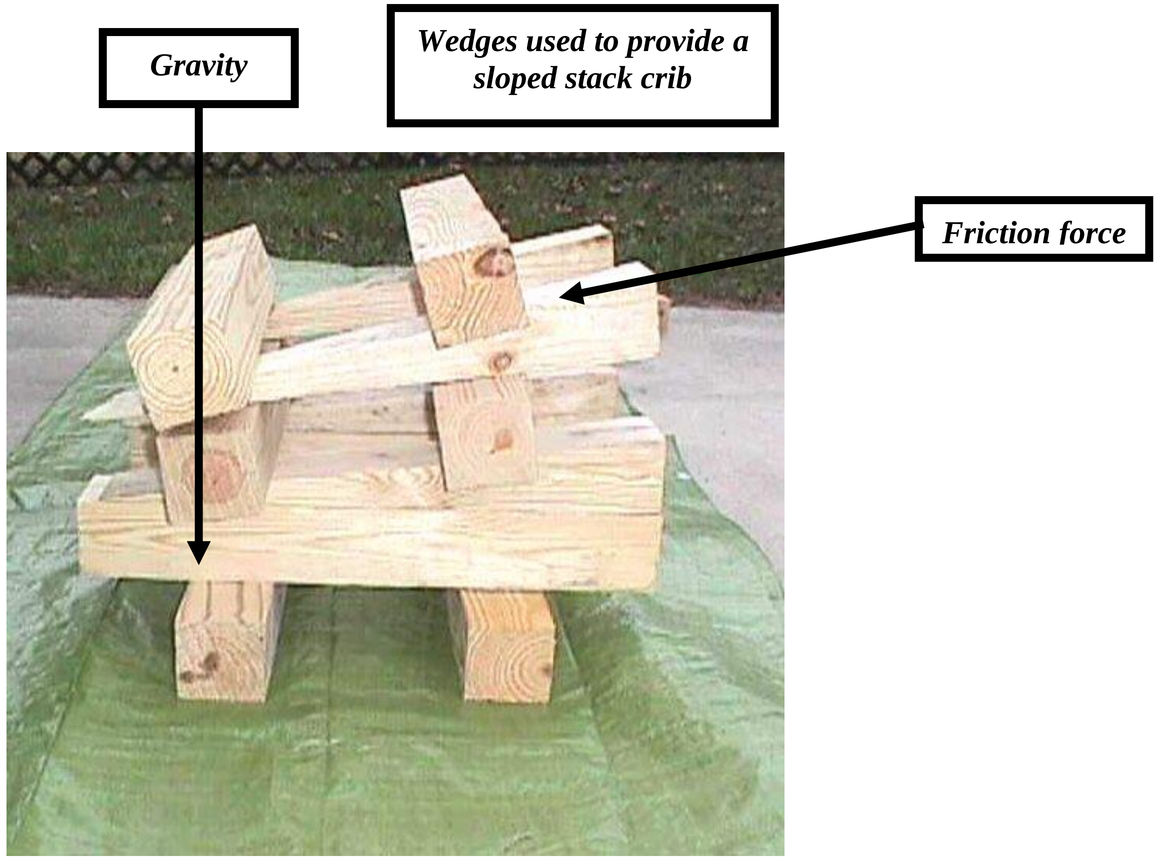
Stack cribbing should form columns, which support the load. The pieces should be aligned vertically to form such a column and provide the required strength.



If all contact points of a stack crib aren't covered, the safe and stable height of the stack will be affected. Using 2 x 2 construction, if three of the contact points are covered, the safe and stable height for the stack crib is 2 times the footprint (2:1). If two of the contact points are covered, the safe and stable height of the stack crib is 1.5 times the footprint (1.5:1). If only one contact point is covered the safe and stable height for the stack crib is 1 times the footprint (1:1).

The weight bearing capacity of the stack crib will vary also if all contact points aren't covered. Rescuers can estimate 6,000 pounds of weight bearing capacity per contact point when using 4" x 4" timber. If 6" x 6" timber is used the weight bearing capacity per contact point is 15,000 pounds.

Wedges are be used to fill voids between the load and cribbing pieces, and should be the same width, preferably the same length as the cribbing pieces themselves. If 4" timber cribbing pieces are being used, the wedge should be 4" in width. The length of a wedge shouldn't exceed six times its width, i.e. 4" timber cribbing pieces are being used, thus a 24" wedge is the maximum size that should be used (6 x 4= 24). Proper placement of wedges serves to transmit the load into a column, with no more than two wedges stacked upon one another. Stacking more than two wedges upon one another will likely produce instability with the middle wedge becoming dislodged. Wedges can also be used to change the vertical direction of the stack crib allowing rescuers to support a sloped load. Sloped loads have two primary forces acting upon them, gravity and friction. Gravity produces a vertical load force while friction produces a load acting downslope. Friction is the resistance encountered when two solid surfaces slide or tend to slip. The degree of surface roughness has an influence on the Coefficient of Friction (the measurement of friction). When a surface is soft and coarse, greater frictional resistance is produced. The Coefficient of Friction is expressed as an angle, or its decimal equivalent, i.e. 15 degrees=.27. Stack cribbing generally may be used to a height of less than 3' against a sloped surface with an angle less the 15 degrees (30%). Small protractors are useful in determining angles. When building a stack crib into a sloping surface the height of the cribbing shouldn't exceed 1.5 times the footprint, or instability may result. Optimally the stack crib should be constructed plumb and level with wedges used upon the top tier, or underneath the bottom tier to produce stability. Sloped surfaces may alter the direction of downward force upon the stack crib, necessitating frequent monitoring of stability.



When placing cribbing pieces, **<u>never</u>** put a part of your body between the load and the cribbing. Use a tool or another piece of cribbing to maneuver it into place. During cribbing operations the use of personal protective equipment is necessary to ensure safety.

Cribbing is an essential rescue tool, often supporting tremendous weight while rescuers operate underneath. It is necessary that all rescuers understand the safe and proper use of this vital tool.

TIMBER CRIBBING OPERATIONS REFERENCE INFORMATION

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Weight Bearing Capacity/Stack Cribbing Height (All contact points covered)

Timber Size	Construction Method	Weight Bearing Capacity	Stack Cribbing Height
4” x 4”	2 x 2	24,000#	3x footprint
4” x 4”	3 x 3	55,000#	3x footprint
6” x 6”	2 x 2	60,000#	3x footprint
6” x 6”	3 x 3	136,000#	3x footprint

Weight Bearing Capacity/Stack Cribbing Height (Less than 4 contact points)

Timber Size	Contact Points	Weight Bearing Capacity	Stack Cribbing Height
4” x 4”	3	18,000#	2x footprint
4” x 4”	2	12,000#	1.5x footprint
4” x 4”	1	6,000#	1x footprint
6” x 6”	3	45,000#	2x footprint
6” x 6”	2	30,000#	1.5x footprint
6” x 6”	1	15,000#	1x footprint

Configurations other than square stack crib are 1x footprint

Cribbing of sloped surfaces are 1.5x footprint

Listed in the following table are representative wood species and their strength in compression perpendicular to the grain. By no means are these the only wood species used for cribbing pieces. Rescuer should investigate the wood actually used by their agency and determine its strength characteristics.

TREE SPECIES	COMPRESSION PERPENDICULAR TO GRAIN, MAXIMUM FIBER STRESS AT PROPORTIONAL LIMIT
U. S. HARDWOODS	
Red Maple	1,000 psi
White Oak	1,070 psi
Pin Oak	1,020 psi
Southern Red Oak	870 psi
Yellow Poplar	500 psi
U. S. SOFTWOODS	
Douglas Fir, Southern	740 psi
Douglas Fir, Northern	770 psi
Pine, Eastern White	440 psi
Pine, Loblolly	790 psi
Pine, Longleaf	960 psi
Pine, Slash	1,020 psi
Pine, Virginia	910 psi

BIG RIG RESCUE
Timber Cribbing
LEARNING MEASUREMENT EXERCISE

1. Cribbing is one of the most frequently used tools during vehicle rescue operations.
   TRUE FALSE

2. Wooden cribbing pieces should be unfinished and unpainted. TRUE FALSE

3. Given a ***footprint*** of 24 inches, what height may the stack crib be built, if all contact points are covered? ______ inches

4. When using 4" timber, the ends of each layer in a stack crib should overlap a minimum of _____ inches.

5. If the footprint of a modified stack crib is 12 inches, the safe height of this stack crib is limited to ______inches.

6. If timber cribbing pieces may sustain a load of 500 psi perpendicular to the grain, and *full dimensional 4x4" timber* is used, what is the capacity of a stack crib in a 2x2 configuration if all contact points are covered? __________ pounds or ____ tons
   If the footprint of this stack crib is 18 inches and all contact points are covered, what height can the stack crib be built? _________inches or ____feet

TIMBER CRIBBING STATISTICS

FEMA published capacity **of timber cribbing using 4"x4"** ***Southern Yellow Pine*** **pieces (inclusive of 2:1 safety factor) in 2x2 configuration.**

16 sq. in. of contact area per contact point=64 sq. in. sum of all contact points.

CAPACITY (Pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*
24,000	12	6,000# or 3T

Estimated Capacity using 500psi perpendicular crossgrain-bearing forces.

CAPACITY (Pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*
32,000	16	8,000# or 4T

Estimated Capacity exclusive of 2:1 safety factor.

CAPACITY (Pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*
48,000	24	12,000# or 6T

TESTED Capacity of ***Southern Yellow Pine*** **using 3.5"x3.5" timber pieces in 2x2 configuration. Testing performed under authority from Frank Maltese of Branch Corp.**

12.25 sq. in. per contact point=49 sq. in. sum of all contact points.

CAPACITY (Pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*	*Other*
40,000	20	10,000 or 5T	15 sq. in. or 23.4% ***less*** contact area than full dimension 4"x4" pieces 16,000# (8T) or 40% ***greater*** than FEMA published capacity

ESTIMATED Capacity (inclusive of 2:1 safety factor) calculated using tested capacity of *Southern Yellow Pine*. ☜☜☜

CAPACITY (Pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*	*Other*
20,000	10T	5,000# or 2.5T	4,000# (2T) or 16.7% ***less*** than FEMA published capacity inclusive of 2:1 safety factor

TESTED Capacity using 4"x4" *Red Maple* timber pieces in 2x2 configuration.
16 sq. in. of contact area per contact point=64 sq. in. sum of all contact points.

CAPACITY (Pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*	*Other*
126,000	63T	31,500# or 15.8T	86,000# (43T) or 68.3% ***greater*** than estimated capacity of So. Yellow Pine using test results (exclusive of 2:1 safety factor)

ESTIMATED Capacity (inclusive of 2:1 safety factor) calculated using tested capacity of *Red Maple* timber pieces. ☜☜☜

CAPACITY (pounds)	*CAPACITY (Tons)*	*CAPACITY per Contact Point*	*Other*
63,000	31.5T	15,750# or 7.9T	43,000# (21.5T) or 68.3% ***greater*** than estimated capacity of So. Yellow Pine calculated using test results (inclusive of 2:1 safety factor)

B. Leach 08Dec03

Strength Properties of Commercially Important Woods

The table below provides laboratory-derived values for several mechanical properties of wood that are associated with wood strength. Note that due to sampling inadequacies, these values may not necessarily represent average species characteristics.

Source: U.S. Forest Products Laboratory

Tree Species	**Average Specific Gravity, Oven Dry Sample**	**Static Bending Modulus of Elasticity (E)**	**Impact Bending, Height of Drop Causing Failure**	**Compress. Parallel to Grain, Max Crushing Strength**	***Compress. Perpen. to Grain, Fiber Stress at Prop. Limit***	**Shear Parallel to Grain, Max Shear Strength**
	(0-1.0)	**10^6 psi**	**inches**	**psi**	***psi***	**psi**
U. S. Hardwoods						
Alder, Red	0.41	1.38	20	5,820	***440***	1,080
Ash, Black	0.49	1.60	35	5,970	***760***	1,570
Ash, Blue	0.58	1.40	-	6,980	***1,420***	2,030
Ash, Green	0.56	1.66	32	7,080	***1,310***	1,910
Ash, Oregon	0.55	1.36	33	6,040	***1,250***	1,790
Ash, White	0.60	1.74	43	7,410	***1,160***	1,910
Aspen, Bigtooth	0.39	1.43	-	5,300	***450***	1,080
Aspen, Quaking	0.38	1.18	21	4,250	***370***	850
Basswood	0.37	1.46	16	4,730	***370***	990
Beech, American	0.64	1.72	41	7,300	***1,010***	2,010
Birch, Paper	0.55	1.59	34	5,690	***600***	1,210
Birch, Sweet	0.65	2.17	47	8,540	***1,080***	2,240
Birch, Yellow	0.62	2.01	55	8,170	***970***	1,880
Butternut	0.38	1.18	24	5,110	***460***	1,170
Cherry, Black	0.50	1.49	29	7,110	***690***	1,700
Chestnut, American	0.43	1.23	19	5,320	***620***	1,080
Cottonwood, Balsam Poplar	0.34	1.1	-	4,020	***300***	790
Cottonwood, Black	0.35	1.27	22	4,500	***300***	1,040
Elm, Eastern	0.40	1.37	20	4,910	***380***	930
Elm, American	0.50	1.34	39	5,520	***690***	1,510
Elm, Rock	0.63	1.54	56	7,050	***1,230***	1,920

Elm, Slippery	0.53	1.49	45	6,360	***820***	1,630
Hackberry	0.53	1.19	43	5,440	***890***	1,590
Hickory, Bitternut	0.66	1.79	66	9,040	***1,680***	–
Hickory, Nutmeg	0.6	1.70	–	6,910	***1,570***	–
Hickory, Pecan	0.66	1.73	44	7,850	***1,720***	2,080
Hickory, Water	0.62	2.02	53	8,600	***1,550***	–
Hickory, Mockernut	0.72	2.22	77	8,940	***1,730***	1,740
Hickory, Pignut	0.75	2.26	74	9,190	***1,980***	2,150
Hickory, Shagbark	0.72	2.16	67	9,210	***1,760***	2,430
Hickory, Shellbark	0.69	1.89	88	8,000	***1,800***	2,110
Honeylocust	–	1.63	47	7,500	***1,840***	2,250
Locust, Black	0.69	2.05	57	10,180	***1,830***	2,480
Magnolia,Cucumbertree	0.48	1.82	35	6,310	***570***	1,340
Magnolia, Southern	0.50	1.40	29	5,460	***860***	1,530
Maple, Bigleaf	0.48	1.45	28	5,950	***750***	1,730
Maple, Black	0.57	1.62	40	6,680	***1,020***	1,820
Maple, Red	0.54	1.64	32	6,540	***1,000***	1,850
Maple, Silver	0.47	1.14	25	5,220	***740***	1,480
Maple, Sugar	0.63	1.83	39	7,830	***1,470***	2,330
Oak, Black	0.61	1.64	41	6,520	***930***	1,910
Oak, Cherrybark	0.68	2.28	49	8,740	***1,250***	2,000
Oak, Laurel	0.63	1.69	39	6,980	***1,060***	1,830
Oak, Northern Red	0.63	1.82	43	6,760	***1,010***	1,780
Oak, Pin	0.63	1.73	45	6,820	***1,020***	2,080
Oak, Scarlet	0.67	1.91	53	8,330	***1,120***	1,890
Oak, Southern Red	0.59	1.49	26	6,090	***870***	1,390
Oak, Water	0.63	2.02	44	6,770	***1,020***	2,020
Oak, Willow	0.69	1.90	42	7,040	***1,130***	1,650
Oak, Bur	0.64	1.03	29	6,060	***1,200***	1,820
Oak, Chestnut	0.66	1.59	40	6,830	***840***	1,490
Oak, Live	0.88	1.98	–	8,900	***2,840***	2,660
Oak, Overcup	0.63	1.42	38	6,200	***810***	2,000
Oak, Post	0.67	1.51	46	6,600	***1,430***	1,840
Oak, Swamp Chestnut	0.67	1.77	41	7,270	***1,110***	1,990
Oak, Swamp White	0.72	2.05	49	8,600	***1,190***	2,000
Oak, White	0.68	1.78	37	7,440	***1,070***	2,000
Sassafras	0.46	1.12	–	4,760	***850***	1,240
Sweetgum	0.52	1.64	32	6,320	***620***	1,600
Sycamore, American	0.49	1.42	26	5,380	***700***	1,470
Tupelo, Black	0.50	1.20	22	5,520	***930***	1,340
Tupelo, Water	0.50	1.26	23	5,920	***870***	1,590

Walnut, Black	0.55	1.68	34	7,580	***1,010***	1,370
Willow, Black	0.39	1.01	-	4,100	***430***	1,250
Yellow-poplar	0.42	1.58	24	5,540	***500***	1,190
U. S. Softwoods						
Baldcypress	0.46	1.44	24	6,360	***730***	1,000
Cedar, Alaska	0.44	1.42	29	6,310	***620***	1,130
Cedar, Atlantic White	0.32	0.93	13	4,700	***410***	800
Cedar, Eastern Redcedar	0.47	0.88	22	6,020	***920***	-
Cedar, Incense	0.37	1.04	17	5,200	***590***	880
Cedar, Northern White	0.31	0.80	12	3,960	***310***	850
Cedar, Port-Orford	0.43	1.70	28	6,250	***720***	1,370
Cedar, Western Redcedar	0.32	1.11	17	4,560	***460***	990
Douglas-fir, Coast	0.48	1.95	31	7,230	***800***	1,130
Douglas-fir, Interior West	0.50	1.83	32	7,430	***760***	1,290
Douglas-fir, Interior North	0.48	1.79	26	6,900	***770***	1,400
Douglas-fir, Interior South	0.46	1.49	20	6,230	***740***	1,510
Fir, Balsam	0.35	1.45	20	5,280	***404***	944
Fir, California Red	0.38	1.50	24	5,460	***610***	1,040
Fir, Grand	0.37	1.57	28	5,290	***500***	900
Fir, Noble	0.39	1.72	23	6,100	***520***	1,050
Fir, Pacific silver	0.43	1.76	24	6,410	***450***	1,220
Fir, Subalpine	0.32	1.29	-	4,860	***390***	1,070
Fir, White	0.39	1.50	20	5,800	***530***	1,100
Hemlock, Eastern	0.40	1.20	21	5,410	***650***	1,060
Hemlock, Mountain	0.45	1.33	32	6,440	***860***	1,540
Hemlock, Western	0.45	1.63	23	7,200	***550***	1,290
Larch, western	0.52	1.87	35	7,620	***930***	1,360
Pine, Eastern white	0.35	1.24	18	4,800	***440***	900
Pine, Jack	0.43	1.35	27	5,660	***580***	1,170
Pine, Loblolly	0.51	1.79	30	7,130	***790***	1,390
Pine, Lodgepole	0.41	1.34	20	5,370	***610***	880
Pine, Longleaf	0.59	1.98	34	8,470	***960***	1,510
Pine, Pitch	0.52	1.43	-	5,940	***820***	1,360
Pine, Pond	0.56	1.75	-	7,540	***910***	1,380
Pine, Ponderosa	0.40	1.29	19	5,320	***580***	1,130
Pine, Red	0.46	1.63	26	6,070	***600***	1,210
Pine, Sand	0.48	1.41	-	6,920	***836***	-

Pine, Shortleaf	0.51	1.75	33	7,270	***820***	1,390
Pine, Slash	0.59	1.98	-	8,140	***1,020***	1,680
Pine, Spruce	0.44	1.23	-	5,650	***730***	1,490
Pine, Sugar	0.36	1.19	18	4,460	***500***	1,130
Pine, Virginia	0.48	1.52	32	6,710	***910***	1,350
Pine, Western white	0.38	1.46	23	5,040	***470***	1,040
Redwood, Old-growth	0.40	1.34	19	6,150	***700***	940
Redwood, Young-growth	0.35	1.10	15	5,220	***520***	1,110
Spruce, Black	0.42	1.61	23	5,960	***550***	1,230
Spruce, Engelmann	0.35	1.30	18	4,480	***410***	1,200
Spruce, Red	0.40	1.61	25	5,540	***550***	1,290
Spruce, Sitka	0.40	1.57	25	5,610	***580***	1,150
Spruce, White	0.36	1.43	20	5,180	***430***	970
Tamarack	0.53	1.64	23	7,160	***800***	1,280