General and Technical Information

DAYTON SUPERIOR

Definitions

Safe Working Load — The maximum working load that should be applied to any forming product.

Ultimate Load — The load at which a product fails or will no longer support or carry a load.

Safety Factor — The theoretical reserve capability defined by dividing the ultimate load of the product by its safe working load. This is expressed as a ratio, such as 2:1 or 2 to 1 (ultimate to safe working load).

Concrete Form Pressure — The lateral pressure applied per square foot of form contact.

Slab Formwork Dead Load — The weight of fresh concrete and reinforcement bars plus the weight of the formwork.

Slab Formwork Live Load — Any additional loads imposed during the construction process, such as materials, workmen, equipment, including lateral forces.

Slab Formwork Design Load — Dead load plus live load per square foot of contact.

Formwork Impact Load — Loads caused by dumping concrete or the starting/stopping of construction related equipment.

Safety Notes and Product Application

Dayton Superior ensures that all products meet or exceed appropriate safety requirements. However, the performance of a product can be greatly affected by the manner in which it is used. It is imperative that the user properly installs and uses the products displayed in this publication.

Production runs are constantly tested to assure a high standard of quality. Safe working loads listed in this publication were determined from independent testing and results of the Company quality assurance/quality control program.

Safety factors may be dependent on the application of a particular product. Job site conditions can often affect the safety factor of a product. Concentrated loads, such as, unsymmetrical loading, uplift, impact and lateral forces are examples of job site conditions that may affect the safety factor. The user must adjust safety factors accordingly to accommodate these various conditions.

Dayton Superior publishes the minimum safe working loads and the associated safety factors of its products and strongly advises that the minimum safety factors displayed in the table below not be compromised. When there are unusual job conditions such as mentioned above, the minimum safety factors must be increased by the user. Refer to the provisions of the American National Standards Institute (ANSI A 10.9), the Occupational Safety and Health Administration (OSHA) Act, Part 1910 and the American Concrete Institute (ACI) *Recommended Practice for Concrete Formwork* (ACI 347-94) when considering product safety factors.

Minimum Safety Factors of Formwork Accessories		
Accessory	**Safety Factor**	**Type of Construction**
Form Tie	2.0 to 1	All applications.
Form Anchor	2.0 to 1	Formwork supporting form weight and concrete pressures only.
Form Anchor	3.0 to 1	Formwork supporting form weight, concrete, construction live loads and impact.
Form Hangers	2.0 to 1	All applications.
Anchoring Inserts (Used as Form Ties)	2.0 to 1	Precast concrete panels when used as formwork.

Dayton Superior Technical Services

Dayton Superior maintains three strategically located technical departments that are well staffed with trained personnel to service inquiries concerning Dayton Superior products and/or methods.

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Usage Affecting a Product's Safe Working Load

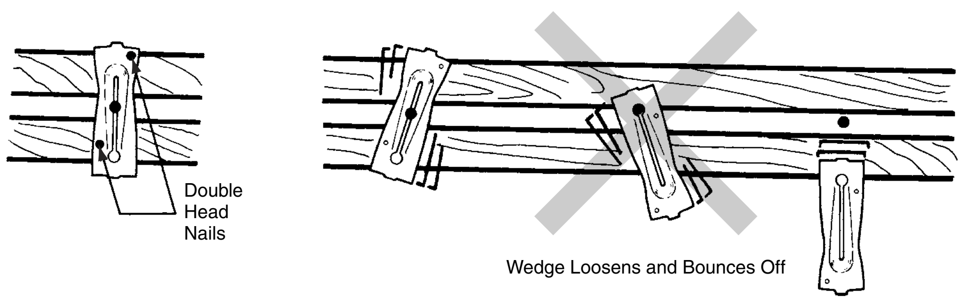
Forming accessories may be subjected to excessive wear, field modification/bending and straightening. Any product so noted must be discarded. Do not try to straighten bent forming accessories, discard and replace them. Also discard any reusable device that has experienced excessive loading, 70% or more, of ultimate load. Such items may have become brittle.

Every user must establish a control program that replaces reusable forming products after a predetermined time period or number of uses, regardless of product appearance. All reusable forming accessories shown in this publication are subject to wear, misuse, overloading, corrosion, deformation, intentional alteration and other factors which may affect the product's safe working load. Therefore, it is mandatory that the user inspect all reusable accessories to determine their condition. The frequency of inspection is dependent on factors such as frequency of use, period of use, environment, etc., and is best determined by the user consistent with good construction practices.

When in doubt about the proper use or installation of Dayton Superior forming accessories, contact Dayton Superior for clarification. Failure to do so may result in exposure of workers to safety hazards, resulting in possible injury and/or death.

ALL SAFE WORKING LOADS SHOWN IN THIS PUBLICATION CONTAIN AN APPROXIMATE MINIMUM SAFETY FACTOR. THE SAFE WORKING LOADS WERE ESTABLISHED WITH THE FOLLOWING FACTORS IN MIND:

1. All safe working loads are based on the accessory being in new or in "as new" condition. The safe working load is considered to be the maximum load that should be applied to a product.
2. The safe working load of Dayton Superior Snap Ties and related products can only be developed when used in conjunction with A-16 Omni Wedges, A-81 Jahn A Brackets or A-82 Jahn C Brackets.



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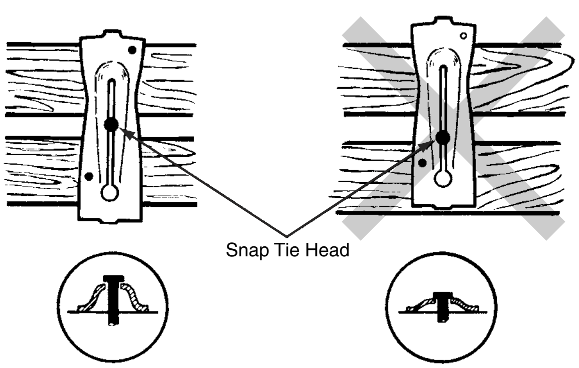
3. Care is taken to ensure that internal vibration has not caused snap tie wedges to loosen, bounce around or fall off.
4. It is important that the snap tie head and wedge be positioned properly.



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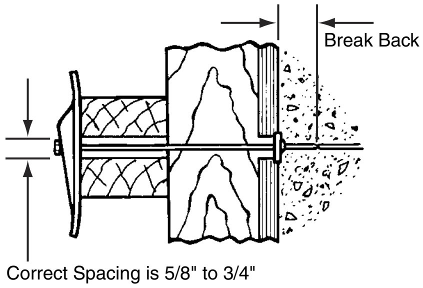
The proper tie head position is at the midpoint, or higher, of the wedge slot. The tie head must not be positioned lower than the midpoint of the wedge.

5. Correct spacing between double wales, when using snap ties is 5/8" to 3/4".



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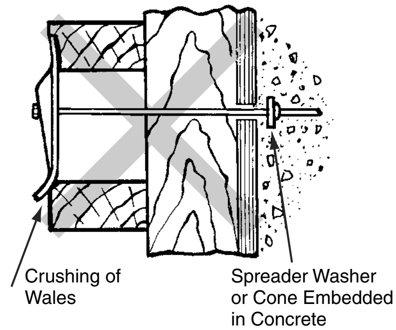

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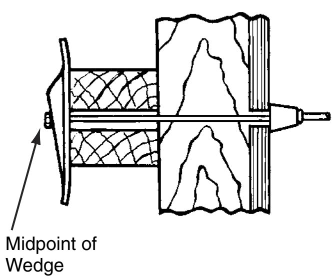
Too much space allowed between the wales may cause crushing of the wales and/or the bending of the wedge allowing the form to bulge outward. This results in incorrect wall thickness and causes the tie spreader washers or cones to become embedded and trapped in the concrete. Trapped tie washers or cones will cause difficulties during the tie breakback operation.

6. The plastic tie cones and metal washers are designed to act as form spreaders only.



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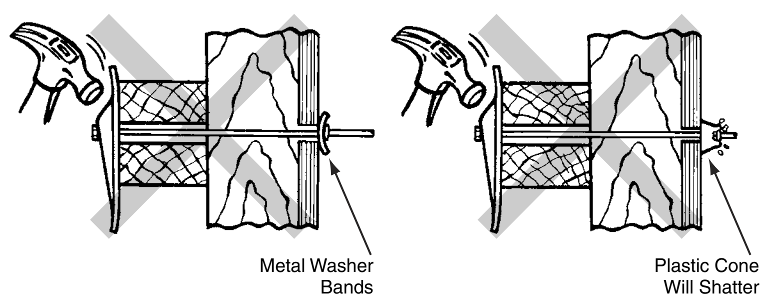

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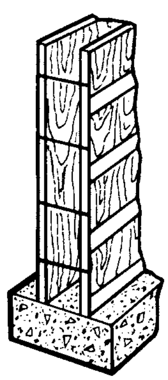
Do not attempt to draw-up warped wales with the wedge. Do not over tighten the wedge in any manner. Over tightening will cause metal spreader washers to bend out of shape or will break plastic cones resulting in incorrect wall thickness.

7. Care must be taken to be sure that all form ties are installed and used properly.



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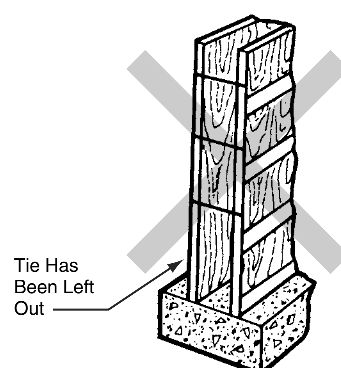

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Failure to install all of the required ties or their required mating hardware will cause excessive loads to be transferred to adjacent ties and may result in form failure.

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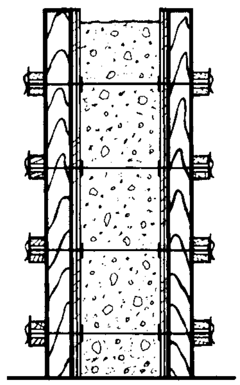
Care must be taken to ensure that form ties are properly aligned. Misalignment may result in form failure due to increased loads placed on the form ties. Misalignment may also cause damage to the form tie during installation that may result in reduced load capacities.



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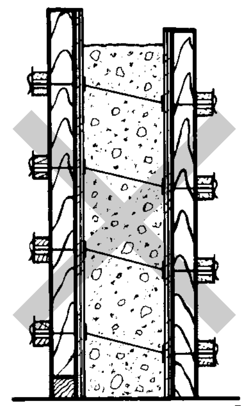

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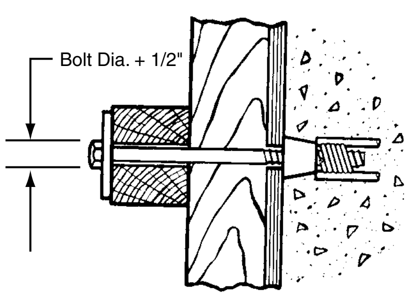
8. When using coil bolts, coil ties, coil hanger saddles, he-bolts, taper-ties, she-bolts and other coil thread items, maximum spacing between the double wales should be 1/2" more than the nominal diameter of the bolting device being used.



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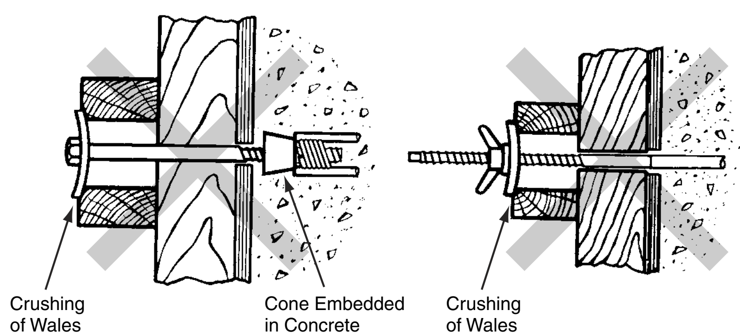

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When too much space is allowed between the wales, the wales may crush or the washers may bend. This causes the form to move outward to cause incorrect wall thickness and allowing the spreader cones to become trapped in the concrete. The higher than anticipated lateral form pressure can also deflect the washers resulting in incorrect wall thickness.

9. Coil bolts, coil rod and other coil thread products must have proper coil penetration. A bolting device with proper coil penetration will extend past the coil a minimum of one diameter of the bolting device. For example a properly penetrating 1/2" diameter coil bolt will extend past the coil a minimum of 1/2". Incorrect penetration of threaded items may result in form failure.

Bolt Diameter	Minimum Coil Penetration
1/2"	2"
3/4"	2-1/4"
1"	2-1/2"
1-1/4"	2-1/2"
1-1/2"	3"

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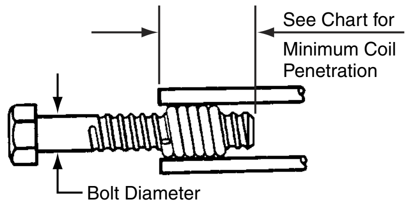

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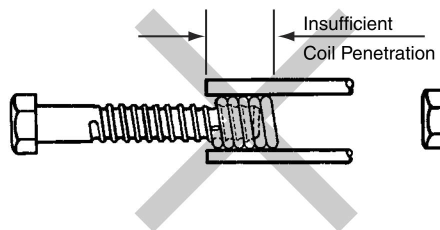

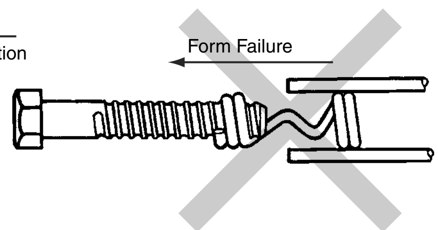

Failure to obtain proper penetration will cause excessive wear on the first few threads of the bolt, but more importantly it places the entire bolt load on a smaller portion of the coil welds. The increased loading can cause the coil welds to fail and result in form failure.

10. Do not beat on the end of loop ties to force them into position. This may damage the tie and result in form failure.

11. Use only correct length form ties. Incorrect length ties, when mixed with correct ones, will cause a transfer of lateral pressure to adjacent ties and may result in form failure.

12. Do not climb on form ties.

13. Do not use impact wrenches to tighten form-tying devices.

14. Do not over-vibrate the concrete. Excessive vibration will cause concrete at the bottom of the form to remain in a liquid state longer than expected. This will result in higher than anticipated lateral form pressure and may result in a form failure. Depth of vibration should be limited to within four (4) feet of the top of the fresh concrete.

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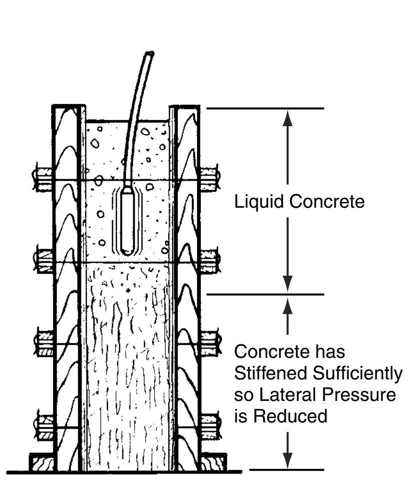

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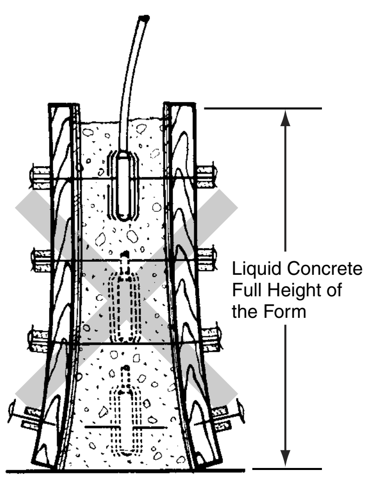

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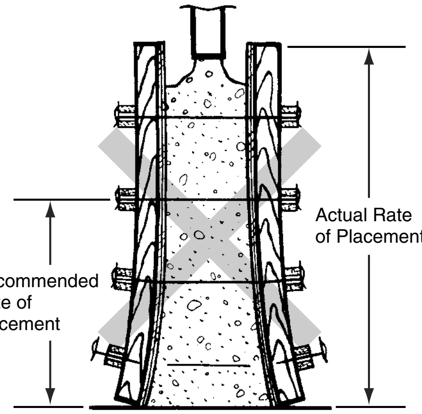
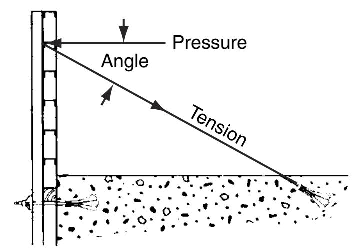
15. Do not exceed the recommended rate of placement and do not continue to place concrete while the concrete in the bottom of the form is still in a liquid state. A form failure may result.
16. Do not use forming accessories with underrated working parts.
17. All forming accessories and related hardware must be of proper length, diameter and capacity. If a greater safety factor is necessary for any reason, the user must reduce the safe working load accordingly.
18. Extreme caution must be used when welding any forming system item. Welding may affect material properties resulting in lower product performance. It is necessary to have a good working knowledge of materials, heat treating and welding procedures before welding any forming accessory. Since Dayton Superior cannot control field conditions or workmanship, Dayton Superior **does not guarantee** any product altered in any way after leaving the factory.



Induced Tension Loads

It is important to remember that tying at an angle causes an increase in the tension that is applied to the angled tie. The table lists various angles and the corresponding multiplication factor to use in calculating the tension load in an angled tie.



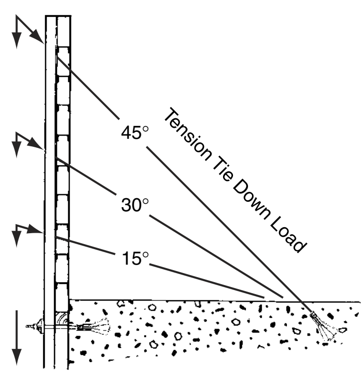
Angle	Multiplication Factor
15°	1.04
30°	1.16
45°	1.42
60°	2.00

Note: Tension = Pressure x Multiplication Factor

Induced Shear Loads

It is important to remember that tie downs placed at an angle will produce shear loads as shown. The total shear load may be several times greater than the shear load produced by the weight of the form alone.

Both tension and shear loads must be taken into consideration when deciding which form tie system to be used for a particular forming application.



Combined Shear and Tension Loads

Form accessories and inserts that are subjected to combined shear and tension loading should satisfy the following equation:

$$\left(\frac{f_t}{F_t}\right)^2 + \left(\frac{f_v}{F_v}\right)^2 \leq 1.0$$

Where
f_t = induced tension load,
F_t = insert tension safe working load or bolt tension safe working load whichever is less,
f_v = induced shear load,
F_v = insert shear safe working load or bolt shear safe working whichever is less.

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Forming Accessories Selection

Dayton Superior Concrete Accessories manufactures and supplies a large variety of form tying devices for concrete formwork. Form tying devices can generally be classified in two ways, by load carrying capacity and by method of use.

Load Carrying Capacity Classifications:

Light Forming — Light forming form ties have safe working load values of 3,750 pounds or less. Typical light duty ties include Snap Ties, Loop Ties and Pencil Rod.

Medium/Heavy Forming — Medium/heavy form ties have safe working load values over 3,750 pounds. Typical medium/heavy form ties include Coil Ties, She-Bolts, Taper Ties, etc.

Method of Use Classifications:

Through Ties — This type of tie extends through the wall thickness and through both sides of the formwork. Dayton Superior manufactures four types of through ties to satisfy most forming application requirements. Snap Ties, Loop Ties, Taper Ties and Pencil Rod are all quality through tie systems.

Coil Ties — The Coil Tie System consists of two Coil Bolts, two Flat Washers, optional Tie Cones and a Coil Tie. The optional Tie Cones act as an internal spreader and assures proper set-back of the tie. Continuous Threaded Coil Rod can be used in place of the Coil Bolts in emergency conditions or in applications requiring varying bolt lengths.

She-Bolts — A She-Bolt has external threads on the large end and internal threads on the tapered end. The external threads provide adjustment for varying form thickness. The internal threads provide attachment for the Inside Rod that ties the two She-Bolt sections together. Various working parts and form anchorages, are available for use with the She-Bolt System.

Lumber and Form Tie Analysis

Assume a project contains100,000 square feet of form contact area. 12" thick walls X 14'-0" high and that 10,000 square feet of form will be constructed. Schedule will be six months with form reuse based on three uses per month.

Assume that the working parts are purchased. Experience has shown that Example A working parts have a life of 10 uses and Example B working parts have a life of 50 uses. Form lumber in Example A has a salvage value of 25% while Example B has a salvage value of 60%.

For this analysis the cost of nails, band iron, connecting bolts, lifting devices, etc., have been omitted. Both examples were calculated in the same manner with the exception of the number of uses of the working parts and the difference in salvage value as noted.

Example A	Example B
3/4" Plywood	3/4" Plywood
2"x4" Studs @ 12" o.c.	2"x4" Studs @ 6" o.c.
2–2"x4" Wales @ 24" o.c.	2–3"x6" Wales @ 24" o.c.
A-3, A-4 or A-44 Standard	B-1 Heavy Coil Ties @ 32" o.c.
Snap Ties @ 24" o.c.	D-1 or D-18 Inside Rod with She-Bolts @ 32" o.c.
Rate of Placement: 50° F. = 2-1/4 ft./hr. 70° F. = 3-1/4 ft./hr.	**Rate of Placement:** 50° F. = 10 ft./hr. 70° F. = 10 ft./hr.

Note: Refer to “Typical Formwork Designs for Wall Forms” footnotes for data regarding allowable stresses for plywood and lumber, concrete temperature and short term loading conditions.

The two examples present average costs for lumber and form ties. The examples are only displayed to give the reader an outline to prepare similar cost analyses for specific formwork designs. Note that labor costs must be added to the material costs. Example A has 12,500 ties that must be installed and removed and 25,000 tie holes to be patched. Example B has 9,375 ties to install and remove and 18,750 tie holes to patch.

These comparative figures illustrate the advantage of “balanced” formwork designs; proper capacity form ties matched with appropriate lumber size and strength results in an efficient, economical form design. Also evident is the small material cost difference in building a heavy form compared to a light duty form. Users must account for the significant labor cost difference of installing, removing and patching the additional form ties.

Note also that the placement rate for Example B is 4-1/2 times greater than Example A. The placing crew cost savings must be considered to arrive at the total in-place cost per unit of measure.

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Calculations for Formwork Costs

Description	Example A	Example B
a) Form Contact Area Per Tie = $\frac{\text{Wale Center (in.)}}{12} \times \frac{\text{Tie Centers (in.)}}{12} \times 2$	8 sq. ft.	10.67 sq. ft.
b) Unit Cost of Tie	$0.93	$3.02
c) Tie Cost per sq. ft. of Form Contact Area = (b ÷ a)	$0.12	$0.28
d) Working Part Cost/Tie	$3.38	$29.96
e) Working Part Cost/Tie per sq. ft. of Form Contact Area per Use	$0.042	$0.056
f) Total Tie Cost per sq. ft. of Form Contact Area per Use = (c + e)	$0.162	$0.336
g) Board Feet of Lumber per sq. ft. of Form, Excluding Plywood. See note below.	1.43	2.76
h) Material Cost of Lumber per sq. ft. of Form. See note below.	$1.99	$2.91
i) Lumber cost per sq. ft. of Form Contact Area = $\frac{(10{,}000 \text{ sq. ft.})(\ h\ )}{100{,}000 \text{ sq. ft. of Form Contact Area}}$	$0.20	$0.29
j) Salvage Value per sq. ft. of Form Contact Area = (i x .25) or (i x .60)	= $0.05	$0.17
k) Net Lumber Cost per sq. ft. of Form Contact Area = (i -– j)	= $0.15	$0.12
l) Total Form Tie and Lumber Cost per sq. ft. of Form Contact Area = (f + k)	= $0.31	$0.456
m) Total Number of Ties Required	12,500 pcs.	9,375 pcs.

Check (Example A):

Total Tie Cost	= (0.162)(100,000)	= $ 16,200
Total Lumber Cost	= (1.99)(10,000)(.75)	= 14,925
	TOTAL COST	= $ 31,125

Cost per sq. ft. of Form Contact Area = $\frac{\$31{,}125}{100{,}000}$ = $0.31

Note: Depending upon local prices, the plywood and structural lumber costs in Example A may be separated as follows:

3/4" Plyform Class 1, Grade B-B	= $ 1.00/sq. ft.
1.43 bd. ft. @ $630/M	= 0.90
Bracing Lumber @ 10%	= 0.09
Total Lumber Cost/sq. ft.	$ 1.99/sq. ft.

Chart for Determining Required Quantities of Form Ties

Form Tie Calculator Based on 10,000 sq. ft. of Wall Area or 20,000 sq. ft. of Form Contact Area	
Form Tie Spacing	**Form Ties Required**
16" x 16" = 1.77 sq. ft.	5,650
24" x 24" = 4.0 sq. ft.	2,500
24" X 32" = 5.33 sq. ft.	1,877
32" x 32" = 7.11 sq. ft.	1,407
32" x 48" = 10.67 sq. ft.	938
48" x 48" = 16 sq. ft.	625
60" X 60" = 25 sq. ft.	400

Typical Formwork Designs for Wall Forms

The table below list several of the most common form lumber sizes and spacings that are being used in the industry today. For each formwork design the appropriate form tie is shown.

Typical Formwork Designs									
Recommended Form Ties	Form Tie Safe Working Load (lbs.)	Maximum Rate of Placement Vertical Feet per Hour		Maximum Form Tie Spacings		Form Design			
						Single Vertical Studs		Double Horizontal Wales	
		50°F	70°F	Vertical	Horizontal	Size	Centers	Size	Centers
A-3, A-4 or A-44 Snap Ties, Standard	2,250	2-1/4	3-1/4	24"	24"	2"x4"	12"	2"x4"	24"
		5-3/4	10	16"	16"	2"x4"	8"	2"x4"	16"
A-3 Snap Tie, Heavy	3,350	2-2/3	3-2/3	24"	32"	2"x4"	12"	2"x6"	24"
		3-3/4	5-1/3	24"	24"	2"x4"	8"	2"x4"	24"
B-1 Coil Tie, Standard D-19 Taper Tie	4,500	2-2/3	3-3/4	32"	32"	2"X6"	12"	2"x6"	32"
		5-1/3	8-3/4	24"	24"	2"x4"	8"	2"x6"	24"
D-19 Taper Tie	6,000	3-3/4	5-1/3	32"	32"	2"x6"	8"	2"x6"	32"
		5-1/3	8-3/4	24"	32"	2"x4"	8"	2"x6"	24"
		5-2/3	10	24"	24"	2"x4"	8"	2"x6"	24"
B-1 Coil Tie, Heavy	6,750	2-2/3	3-3/4	32"	48"	2"x6"	12"	2"x8"	32"
		4-1/3	6-1/4	32"	32"	2"x4"	8"	2"x6"	32"
		6	10	24"	32"	2"x4"	8"	2"x6"	24"
B-1 Coil Tie, Heavy D-1 or D-18 Inside Rod with She-Bolts	9,000	3-1/3	4-2/3	32"	48"	2"x4"	8"	2"x8"	32"
		6	10	32"	32"	2"x6"	8"	2"x6"	32"
		10	10	24"	32"	2"x4"	6"	3"x6"	24"
D-9 Taper Tie	18,000	5-1/3	8-3/4	48"	48"	Aluminum or steel studs and wales are normally used for these conditions.			
B-2 Coil Tie, Standard	18,000	5-1/3	8-3/4	48"	48"				
D-1 or D-18 Inside Rod with She-Bolts	18,000	5-1/3	8-3/4	48"	48"				
B-2 Coil Tie, Standard	27,000	5	7-3/4	60"	60"				
D-9 Taper TIe	34,000	6-2/3	10	60"	60"				
D-1 or D-18 inside Rod with She-Bolts	37,500	5	7	72"	72"				
D-9 Taper Tie	40,500	5-1/3	8-3/4	72"	72"				

Note: the above table is based on the following conditions:

- **Concrete** – Made with type 1 cement weighing 150 pcf. contains no admixtures, slump of 4" or less and normal internal vibration to a depth of 4 ft. or less. If conditions vary contact Dayton Superior for additional recommendations.
- **Concrete Temperature** – For practical purposes, 50°F. is used by many form designers as the temperature of fresh concrete during winter, with 70°F. being used as the summer temperature. This “rule of thumb” appears to work satisfactory unless the concrete has been heated or cooled to a controlled temperature.
- **Plywood Sheathing** – 3/4" plyform class 1 or structural 1 used the strong direction. Experience has shown that 3/4" plywood is more economical in form usage than other thickness even though initial cost may be slightly more. Deflection has been limited to ℓ/360 or 1/16" whichever is less and plyform is supported by four or more studs.
- **Studs** – Fiber Stress in bending = varies psi, modulus of elasticity = 1,400,000 psi horizontal shear = 225 psi, deflection limited to ℓ/270 or 1/8" whichever is less with studs continuous over four or more wales.
- **Double Wales** – Fiber Stress in bending = varies psi, modulus of elasticity = 1,400,000 psi horizontal shear = 225 psi, deflection limited to ℓ/270 or 1/8" whichever is less with wales continuous over four or more ties.
- **Short Term Loading Conditions** – Allowable stresses, except for modulus of elasticity include a 25% increase for short term loading.
- **Form Ties** – Safe working loads are based on a factor of safety of approximately 2 to 1 (ultimate to SWL).

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Vertical Formwork Design Loads

The selection of the proper sheathing, studs and/or wales for concrete formwork requires a knowledge of the maximum lateral pressure which will be exerted by the concrete. Dayton Superior is in agreement with the **Lateral Pressure Design Formulas** contained in the American Concrete Institute's "Guide to Formwork for Concrete", (ACI 347 latest revision). Designers of formwork for concrete walls or columns will find the following information useful:

- For general purpose conditions and unless the special conditions listed below are met, all formwork should be designed for the lateral pressure of the newly placed concrete using the formula of:

  $$P = W \times H$$

  Where P = lateral pressure, pounds per square foot;

  W = unit weight of fresh concrete, pounds per cubic foot or 150 pcf for normal weight concrete;

  H = depth of fluid or plastic concrete in feet. (Normally height of wall or column form.)

  Please note that the maximum and minimum values given for the formulas under the special conditions do not apply to the above lateral pressure formula.

- **Special Condition No. 1** — For concrete made with type 1 cement, weighing 150 pounds per cubic foot, containing no pozzolans or admixtures, having a slump of 4" or less and normal internal vibration to a depth of 4 ft. or less. Then the formwork may be designed for a lateral pressure as follows:

  For columns:

  $$P = 150 + \frac{9{,}000 \times R}{T}$$

  with a maximum of 3,000 pounds per square foot, a minimum of 600 pounds per square foot, but in no case greater than W x H.

  For walls with a rate of placement less than 7 ft. per hour:

  $$P = 150 + \frac{9{,}000 \times R}{T}$$

  with a maximum of 2,000 pounds per square foot, a minimum of 600 pounds per square foot, but in no case greater than W x H.

  For walls with a rate of placement of over 7 ft. per hour but less than 10 ft. per hour:

  $$P = 150 + \frac{43{,}400}{T} + \frac{2800 \times R}{T}$$

  with a maximum of 2,000 pounds per square foot, a minimum of 600 pounds per square foot, but in no case greater that W x H.

  Where P = lateral pressure, pounds per square foot;

  R = rate of placement, feet per hour, and

  T = temperature of concrete in the form, degree fahrenheit. For practical purposes, 50°F. is used by many form designers as the temperature of fresh concrete during the winter, with 70°F. being used as the summer temperature. This "rule of thumb" appears to work satisfactorily unless the concrete has been heated or cooled to a controlled temperature.

- **Special Condition No. 2** — If concrete is to be pumped from the base of the form, the form should be designed for a full hydrostatic head of concrete (W x H) plus a minimum allowance of 25% for pump surge pressure. In certain instances pressures may be as high as the face pressure of the pump piston.

- **Special Condition No. 3** — Caution must be taken when using external vibration or concrete made with shrinkage compensating or expansive cements. Pressure in excess of equivalent hydrostatic may occur.

Wall forms should be designed to meet wind load requirements of American National Standards Institute A-58.1 (Reference to section 2-6) or of the local building code, whichever is more stringent. The minimum wind design load should be 15 pounds per square foot. Bracing for wall forms should also be designed for a horizontal load of at least 100 pounds per lineal foot of wall applied at the top of the form.

Lateral Pressure of Concrete for General Purpose Conditions

Depth of Fluid or Plastic Concrete in feet	Pounds Per Square Foot
4	600
5	750
6	900
7	1,050
8	1,200
9	1,350
10	1,500
12	1,800
14	2,100
16	2,400
18	2,700
20	3,000

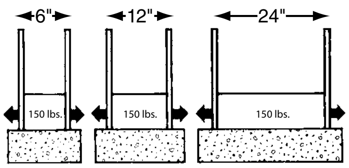
Lateral Pressure of Concrete for Special Condition No. 1 – Walls

Rate of Placement Feet Per Hour	Pounds per Square Foot for Indicated Temperature	
	50°F.	70°F.
2	600	600
3	690	600
4	870	664
5	1,050	793
6	1,230	921
7	1,410	1,050
8	1,466	1,090
9	1,522	1,130
10	1,578	1,170

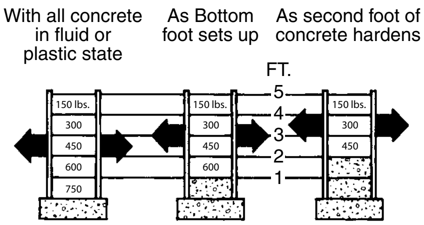
Note: Do not use lateral pressures in excess of 150 x height of fluid or plastic concrete in forms.

General and Technical Information

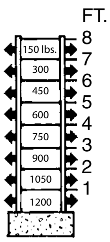
Points to Remember



Fluid or plastic concrete exerts the same side pressure on forms regardless of their width.

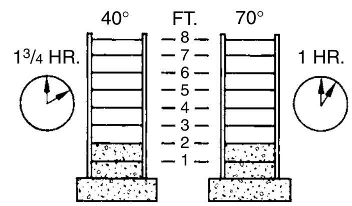


As concrete hardens, lateral pressure on forms decreases.



As you add more fluid or plastic concrete to forms, the pressure will build up toward the bottom at about the rate of 150 pounds per foot of depth. This will be true as long as all concrete remains in a plastic state.

Example: Eight feet of fluid or plastic concrete bears on the bottom foot of forms with a pressure of 8 x 150 pounds or 1200 pounds per square foot.



Concrete sets up or hardens faster with an increase in temperature.

Example: At 70°F. concrete sets in approximately 1 hour. At 40°F concrete will set up in about 1-3/4 hours.

Slab Formwork Design Loads

The loadings used in the designs of slab formwork consists of a dead load and a live load. The weight of the formwork plus the concrete is considered dead load while the live load is made up of the weight of workers, equipment, material storage and other like items which is supported by the formwork. The tables below tabulate design loads based on the concrete weight for the thicknesses indicated, and includes 10 pounds per square foot for the weight of forms and a live load of 50 or 75 pounds per square foot as indicated. A live load of 75 pounds per square foot is generally used when motorized carts are used to transport concrete during the placing operation.

Slab Formwork Design Load for Uniform Slab Thickness									
(Includes 50 psf Live Load) Pounds per Square Foot for Indicated Thickness									
2"	**4"**	**6"**	**8"**	**10"**	**12"**	**14"**	**16"**	**18"**	**20"**
100	110	135	160	185	210	235	260	285	310
(Includes 75 psf Live Load) Pounds per Square Foot for Indicated Thickness									
2"	**4"**	**6"**	**8"**	**10"**	**12"**	**14"**	**16"**	**18"**	**20"**
125*	135	160	185	210	235	260	285	310	335

Note: Chart is based on a concrete weight of 150 pounds per cubic foot.
* ACI 347 recommends a minimum 100 psf for form design or 125 psf if motorized carts are used.

For a complete explanation of general objectives in formwork design, planning, materials and accessories, loads and pressures, design tables and much more, it's recommended that a copy of ACI publication SP-4 "Formwork for Concrete" be obtained. The current edition is available from American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333.

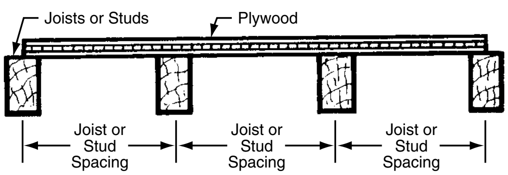
General and Technical Information

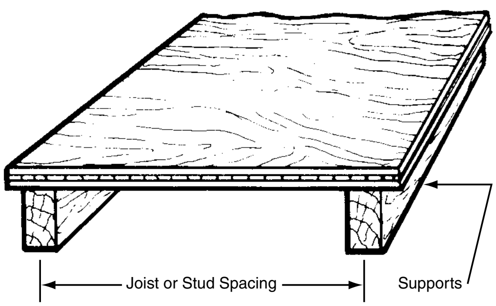
Technical Data–Plywood

Data is based on information supplied by the American Plywood Association (APA). The recommended spacings listed in the following table are for Plyform Class 1 or STRUCTURAL 1 Plyform. Plyform is a special exterior type of plywood designed by APA for use in formwork for concrete construction.

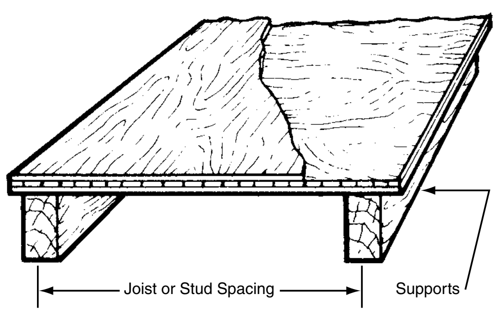
Though not manufactured specifically for concrete forming, grades other than Plyform have been used in formwork. The spacings shown in the table give a good estimate of performance for sanded grades such as APA A-C Exterior, APA B-C Exterior and unsanded grades such as APA RATED SHEATHING Exterior and Exposure 1 (CDX) (marked PSI), provided the plywood is used in the same direction only.

For additional information on APA Plyform, please contact the American Plywood Association, P.O. Box 11700, Tacoma, WA 98411.





Plywood Used Strong Way
Face Grain Across Supports



Plywood Used Weak Way
Face Grain Along Supports

Safe Spacing in inches of Support for Plyform Sheathing Continuous Over Four or More Supports

Design Load of Concrete Pounds Per Sq. Ft.	F_b = 1,930 psi; Rolling Shear = 72 psi E = 1,500,000 psi — Plyform Used Weak Way 19/32"	5/8"	23/32"	3/4"	Plyform Used Strong Way 19/32"	5/8"	23/32"	3/4"
100	13"	14"	17"	19"	20"	21"	23"	24"
125	12"	13"	16"	17"	19"	19"	22"	22"
150	11"	12"	15"	16"	17"	18"	20"	21"
175	10"	11"	14"	15"	17"	17"	19"	20"
200	10"	11"	14"	15"	16"	17"	18"	19"
225	10"	10"	13"	14"	15"	16"	18"	18"
250	9"	10"	13"	14"	15"	15"	17"	18"
275	9"	10"	12"	13"	14"	15"	17"	17"
300	9"	9"	12"	13"	14"	14"	16"	17"
350	8"	9"	11"	12"	13"	14"	15"	16"
400	8"	9"	11"	12"	13"	13"	15"	15"
500	7"	8"	10"	11"	12"	12"	14"	14"
600	7"	7"	9"	10"	11"	11"	13"	13"
700	6"	7"	9"	10"	10"	11"	12"	12"
800	6"	7"	8"	9"	10"	10"	11"	11"
900	6"	6"	7"	8"	9"	9"	10"	11"
1,000	5"	6"	7"	7"	9"	9"	10"	10"
1,200	5"	5"	6"	6"	8"	8"	9"	9"
1,400	4"	4"	5"	5"	7"	7"	8"	8"
1,600	4"	4"	5"	5"	6"	6"	8"	8"
1,800	4"	4"	4"	5"	6"	6"	7"	7"
2,000	3"	3"	4"	4"	5"	5"	6"	6"

Support spacings are governed by bending, shear or deflection. Maximum deflection ℓ/360 of spacing, but not more than 1/16". Contact Dayton Superior for safe spacing of supports when plyform is used over two or three supports.

Curved Forms: Plyform can be used for building curved forms. However, the following radii have been found to be appropriate minimums for mill run panels of the thicknesses shown, when bent dry. An occasional panel may develop localized failure at these radii.

Plywood Data

Plywood Thickness	Approximate Weight, lbs. 4 x 8 Sheet	Approximate Weight, lbs. Sq. Ft.	Minimum Bending Radii, Ft. Across Grain	Minimum Bending Radii, Ft. Parallel to Grain
1/4"	26	.8	2	5
5/16"	32	1.0	2	6
11/32" or 3/8"	35	1.1	3	8
15/32" or 1/2"	48	1.5	6	12
19/32" or 5/8"	58	1.8	8	16
23/32" or 3/4"	70	2.2	12	20

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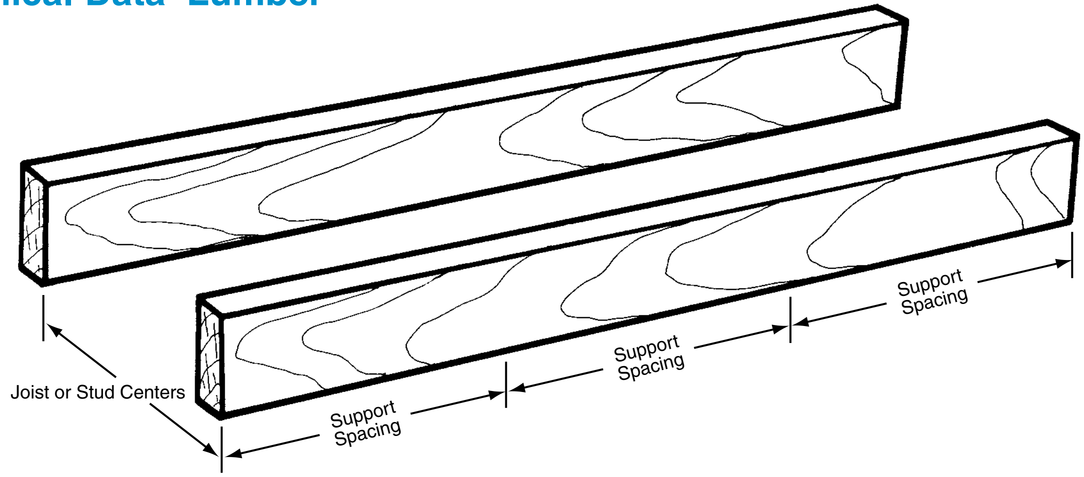
Technical Data–Lumber



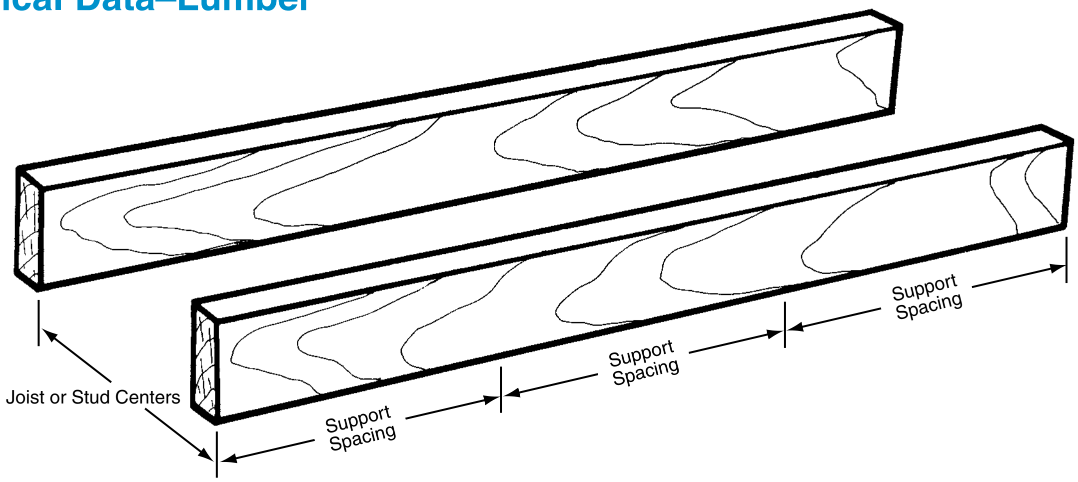
Safe Spacing of Supports for Joists or Studs Continuous Over Four or More Supports Based on use of No. 2 Grade Southern Pine or Douglas Fir-Larch						
Uniform Load, Pounds per Linear Foot (Equals Design Load, Pounds per Sq. Ft. Times Joist or Stud Centers in Feet.)	F_b = varies psi E = 1,400,000 psi F_v = 225 psi					
	Nominal Size Lumber, bxh (S4S) at 19% Maximum Moisture					
	2 x 4	2 x 6	2 x 8	3 x 6	4 x 2	4 x 4
	F_b psi					
	1625	1438	1313	1438	1438	1625
100	64"	89"	110"	101"	42"	79"
200	53"	75"	92"	85"	34"	66"
300	45"	66"	83"	77"	27"	60"
400	39"	57"	72"	72"	24"	56"
500	35"	51"	64"	66"	21"	53"
600	32"	47"	59"	60"	19"	48"
700	29"	43"	54"	56"	18"	45"
800	27"	40"	51"	52"	17"	42"
900	25"	38"	48"	49"	16"	39"
1,000	23"	36"	45"	47"	15"	37"
1,100	21"	34"	43"	44"	14"	36"
1,200	20"	32"	42"	43"	14"	34"
1,300	19"	30"	40"	41"	13"	33"
1,400	18"	29"	38"	39"	13"	32"
1,500	18"	28"	36"	38"	12"	30"
1,600	17"	26"	35"	37"	12"	29"
1,700	16"	26"	34"	35"	12"	29"
1,800	16"	25"	33"	34"	11"	27"
1,900	15"	24"	32"	33"	11"	26"
2,000	15"	23"	31"	32"	11"	25"
2,200	14"	22"	29"	30"	10"	24"
2,400	14"	21"	28"	28"	10"	22"
2,600	13"	21"	27"	27"	9"	21"
2,800	13"	20"	26"	26"	9"	20"
3,000	12"	19"	25"	25"	8"	19"

Note: F_b and F_v shown above includes a 25% increase because of short term loading conditions.
Horizontal shear stress adjustment assumes members have no splits, checks or shakes.

Support spacings are governed by bending, shear or deflection. Maximum deflection ℓ/270 of spacing, but not more than 1/8". Contact Dayton Superior for safe spacings of supports for joists or studs used over two or three supports.

General and Technical Information

Technical Data–Lumber

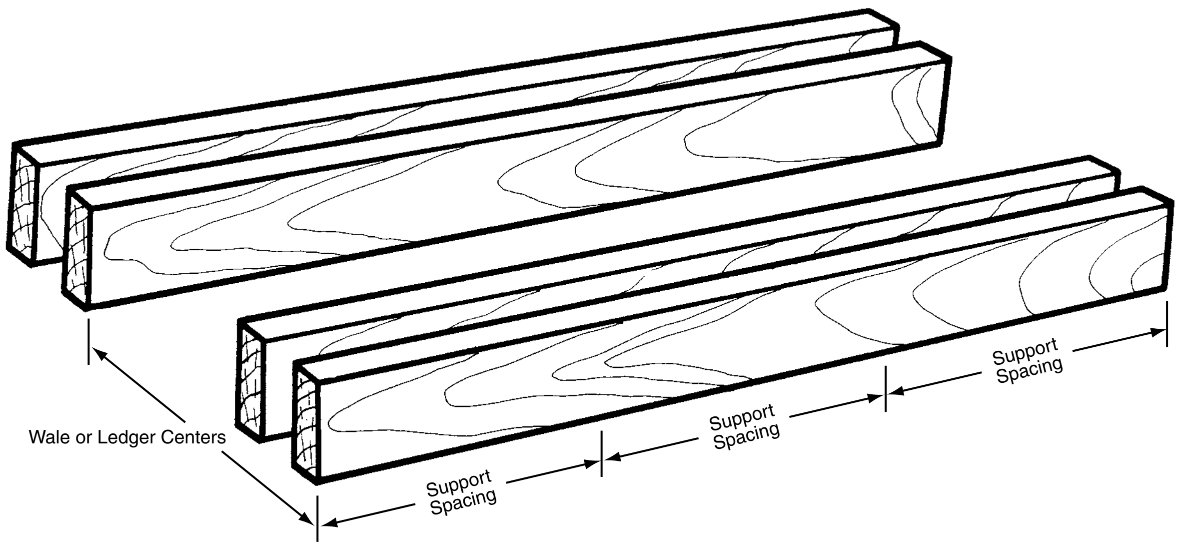


Safe Spacing of Supports for Joists or Studs Continuous Over Four or More Supports Based on use of No. 2 Grade Spruce-Pine-Fir or Hem-Fir						
Uniform Load, Pounds per Linear Foot (Equals Design Load, Pounds per Sq. Ft. Times Joist or Stud Centers in Feet.)	F_b = varies psi E = 1,300,000 psi F_v = 175 psi					
	Nominal Size Lumber, bxh (S4S) at 19% Maximum Moisture					
	2 x 4	2 x 6	2 x 8	3 x 6	4 x 2	4 x 4
	F_b psi					
	1594	1381	1275	1381	1275	1594
100	62"	88"	108"	99"	41"	77"
200	52"	74"	91"	84"	32"	65"
300	44"	65"	82"	76"	26"	59"
400	38"	56"	71"	70"	22"	55"
500	32"	50"	63"	65"	20"	52"
600	27"	43"	57"	59"	18"	48"
700	25"	39"	51"	55"	17"	44"
800	22"	35"	46"	51"	16"	41"
900	21"	32"	43"	47"	15"	39"
1,000	19"	30"	40"	43"	14"	36"
1,100	18"	29"	38"	40"	14"	33"
1,200	17"	27"	36"	38"	13"	31"
1,300	16"	26"	34"	36"	12"	29"
1,400	16"	25"	33"	34"	12"	27"
1,500	15"	24"	31"	32"	11"	26"
1,600	15"	23"	30"	31"	11"	25"
1,700	14"	22"	29"	30"	10"	24"
1,800	14"	22"	29"	29"	10"	23"
1,900	13"	21"	28"	28"	9"	22"
2,000	13"	21"	27"	27"	9"	21"
2,200	13"	20"	26"	26"	9"	20"
2,400	12"	19"	25"	24"	8"	19"
2,600	12"	18"	24"	23"	8"	18"
2,800	11"	18"	24"	22"	7"	17"
3,000	11"	17"	23"	22"	7"	17"

Note: F_b and F_v shown above includes a 25% increase because of short term loading conditions.
Horizontal shear stress adjustment assumes members have no splits, checks or shakes.

Support spacings are governed by bending, shear or deflection. Maximum deflection ℓ/270 of spacing, but not more than 1/8". Contact Dayton Superior for safe spacings of supports for joists or studs used over two or three supports.

Technical Data–Lumber



Safe Spacing of Supports for Double Ledgers or Wales Continuous Over Four or More Supports Based on use of No. 2 Grade Southern Pine or Douglas Fir-Larch					
Uniform Load, Pounds per Linear Foot (Equals Design Load, Pounds per Sq. Ft. Times Ledger or Wale Centers in Feet.)	F_b = varies psi E = 1,400,000 psi F_v = 225 psi				
	Nominal Size Lumber, bxh (S4S) at 19% Maximum Moisture				
	Double 2 x 4	Double 2 x 6	Double 2 x 8	Double 3 x 6	Double 3 x 8
	F_b psi				
	1625	1438	1313	1438	1313
1,000	35"	51"	64"	66"	83"
1,100	33"	49"	61"	63"	79"
1,200	32"	47"	59"	60"	76"
1,300	30"	45"	56"	58"	73"
1,400	29"	43"	54"	56"	70"
1,500	28"	42"	53"	54"	68"
1,600	27"	40"	51"	52"	66"
1,700	26"	39"	49"	51"	64"
1,800	25"	38"	48"	49"	62"
1,900	24"	37"	47"	48"	60"
2,000	23"	36"	45"	47"	59"
2,200	21"	34"	43"	44"	56"
2,400	20"	32"	42"	43"	54"
2,600	19"	30"	40"	41"	51"
2,800	18"	29"	38"	39"	50"
3,000	18"	28"	36"	38"	48"
3,200	17"	26"	35"	37"	46"
3,400	16"	26"	34"	35"	45"
3,600	16"	25"	33"	34"	44"
3,800	15"	24"	32"	33"	43"
4,000	15"	23"	31"	32"	42"

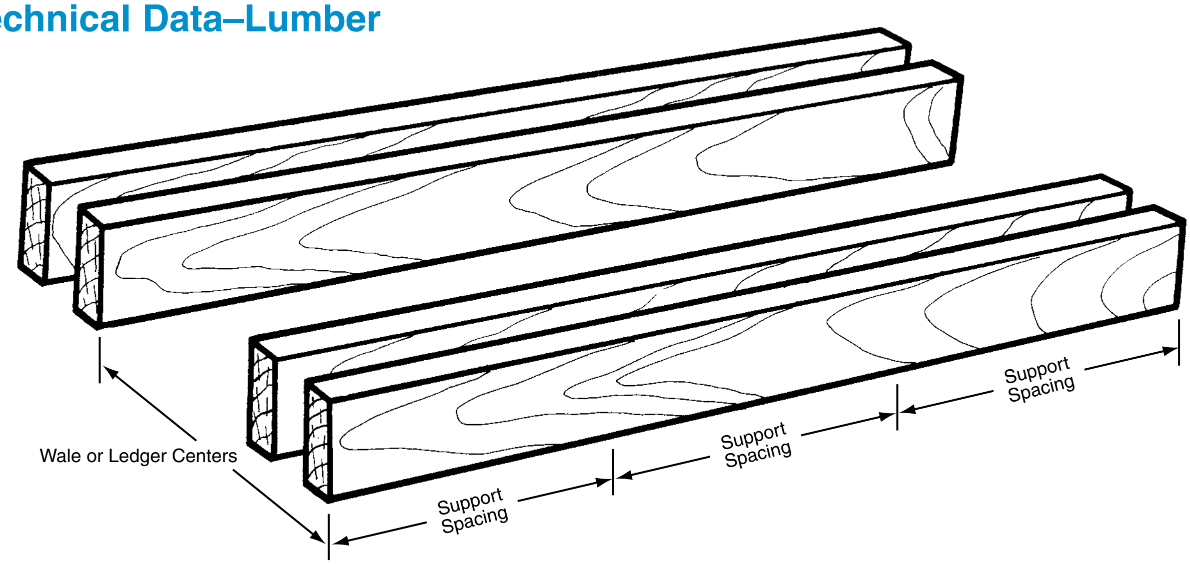
Note: F_b and F_v shown above includes a 25% increase because of short term loading conditions.
Horizontal shear stress adjustment assumes members have no splits, checks or shakes.

Support spacings are governed by bending, shear or deflection. Maximum deflection ℓ/270 of spacing, but not more than 1/8". Contact Dayton Superior for safe spacings of supports for joists or studs used over two or three supports.

General and Technical Information

DAYTON SUPERIOR

Technical Data–Lumber



Safe Spacing of Supports for Double Ledgers or Wales Continuous Over Four or More Supports Based on use of No. 2 Grade Spruce-Pine-Fir or Hem-Fir					
Uniform Load, Pounds per Linear Foot (Equals Design Load, Pounds per Sq. Ft. Times Ledger or Wale Centers in Feet.)	F_b = varies psi E = 1,300,000 psi F_v = 175 psi				
	Nominal Size Lumber, bxh (S4S) at 19% Maximum Moisture				
	Double 2 x 4	Double 2 x 6	Double 2 x 8	Double 3 x 6	Double 3 x 8
	F_b psi				
	1594	1381	1275	1381	1275
1,000	32"	50"	63"	65"	82"
1,100	29"	46"	60"	62"	78"
1,200	27"	43"	57"	59"	75"
1,300	26"	41"	54"	57"	72"
1,400	25"	39"	51"	55"	69"
1,500	23"	37"	48"	53"	67"
1,600	22"	35"	46"	51"	65"
1,700	21"	34"	44"	49"	63"
1,800	21"	32"	43"	47"	61"
1,900	20"	31"	41"	45"	59"
2,000	19"	30"	40"	43"	57"
2,200	18"	29"	38"	40"	53"
2,400	17"	27"	36"	38"	50"
2,600	16"	26"	34"	36"	47"
2,800	16"	25"	33"	34"	45"
3,000	15"	24"	31"	32"	43"
3,200	15"	23"	30"	31"	41"
3,400	14"	22"	29"	30"	39"
3,600	14"	22"	29"	29"	38"
3,800	13"	21"	28"	28"	37"
4,000	13"	21"	27"	27"	36"

Note: F_b and F_v shown above includes a 25% increase because of short term loading conditions.
Horizontal shear stress adjustment assumes members have no splits, checks or shakes.

Support spacings are governed by bending, shear or deflection. Maximum deflection $\ell/270$ of spacing, but not more than 1/8". Contact Dayton Superior for safe spacings of supports for joists or studs used over two or three supports.

Technical Data–Lumber

Formulas for Calculating Safe Support Spacings of Lumber Formwork Members			
To Check	**for Single Span Beam**	**for Two-Span Beam**	**for Three of More Span Beam**
$\Delta_{max} = \ell/360$	$\ell = 1.37 \sqrt[3]{\frac{EI}{w}}$	$\ell = 1.83 \sqrt[3]{\frac{EI}{w}}$	$\ell = 1.69 \sqrt[3]{\frac{EI}{w}}$
$\Delta_{max} = \ell/270$	$\ell = 1.51 \sqrt[3]{\frac{EI}{w}}$	$\ell = 2.02 \sqrt[3]{\frac{EI}{w}}$	$\ell = 1.86 \sqrt[3]{\frac{EI}{w}}$
$\Delta_{max} = 1/16$ in.	$\ell = 2.75 \sqrt[4]{\frac{EI}{w}}$	$\ell = 3.43 \sqrt[4]{\frac{EI}{w}}$	$\ell = 3.23 \sqrt[4]{\frac{EI}{w}}$
$\Delta_{max} = 1/8$ in.	$\ell = 3.27 \sqrt[4]{\frac{EI}{w}}$	$\ell = 4.08 \sqrt[4]{\frac{EI}{w}}$	$\ell = 3.84 \sqrt[4]{\frac{EI}{w}}$
$\Delta_{max} = 1/4$ in.	$\ell = 3.90 \sqrt[4]{\frac{EI}{w}}$	$\ell = 4.85 \sqrt[4]{\frac{EI}{w}}$	$\ell = 4.57 \sqrt[4]{\frac{EI}{w}}$
Bending	$\ell = 9.80 \sqrt[2]{\frac{F_bS}{w}}$	$\ell = 9.80 \sqrt[2]{\frac{F_bS}{w}}$	$\ell = 10.95 \sqrt[2]{\frac{F_bS}{w}}$
Horizontal Shear	$\ell = \frac{16F_vbh}{w} + 2h$	$\ell = \frac{192F_vbh}{15w} + 2h$	$\ell = \frac{40F_vbh}{3w} + 2h$

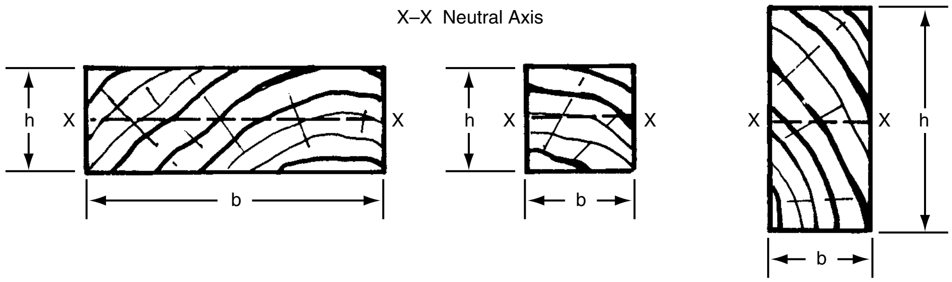
Notation:

A = area of cross section, sq. in.
b = width of section, in.
E = modulus of elasticity, psi
F_b = design value for extreme fiber in bending, psi
F_v = design value in horizontal shear, psi
F_c = design value in compression parallel to grain, psi
$F_{c\perp}$ = design value in compression perpendicular to grain, psi
h = depth of section, in.
I = moment of inertia, $in.^4$
ℓ = safe spacing of supports, in.
S = section modulus, $in.^3$
w = load, lbs. per lineal ft.
Δ = deflection, in.

General and Technical Information

DAYTON SUPERIOR

Technical Data–Lumber



Properties of Structural Lumber									
Nominal Size in Inches, *bxh*	American Standard Sizes in Inches, *bxh S4S** 19% Maximum Moisture	Area of section $A = bh$, sq. in.		Moment of Inertia, in.[4] $I = \frac{bh^3}{12}$		Section Modulus, in.[3] $S = \frac{bh^2}{6}$		Board Feet per Lineal Foot of Piece	Approx. Weight per Lineal Foot (lbs.) of S4S Lumber
		Rough	S4S	Rough	S4S	Rough	S4S		
4x1	3-1/2 x 3/4	3.17	2.62	0.20	0.12	0.46	0.33	1/3	.7
6x1	5-1/2 x 3/4	4.92	4.12	0.31	0.19	0.72	0.52	1/2	1.0
8x1	7-1/4 x 3/4	6.45	5.44	0.41	0.25	0.94	0.68	2/3	1.4
10x1	9-1/4 x 3/4	8.20	6.94	0.52	0.32	1.20	0.87	5/6	1.7
12x1	11-1/4 x 3/4	9.95	8.44	0.63	0.39	1.45	1.05	1	2.1
4x2	3-1/2 x 1-1/2	5.89	5.25	1.30	0.98	1.60	1.31	2/3	1.3
6x2	5-1/2 x 1-1/2	9.14	8.25	2.01	1.55	2.48	2.06	1	2.0
8x2	7-1/4 x 1-1/2	11.98	10.87	2.64	2.04	3.25	2.72	1-1/3	2.7
10x2	9-1/4 x 1-1/2	15.23	13.87	3.35	2.60	4.13	3.47	1-2/3	3.4
12x2	11-1/4 x 1-1/2	18.48	16.87	4.07	3.16	5.01	4.21	2	4.1
2x4	1-1/2 x 3-1/2	5.89	5.25	6.45	5.36	3.56	3.06	2/3	1.3
2x6	1-1/2 x 5-1/2	9.14	8.25	24.10	20.80	8.57	7.56	1	2.0
2x8	1-1/2 x 7-1/4	11.98	10.87	54.32	47.63	14.73	13.14	1-1/3	2.7
2x10	1-1/2 x 9-1/4	15.23	13.87	111.58	98.93	23.80	21.39	1-2/3	3.4
2x12	1-1/2 x 11-1/4	18.48	16.87	199.31	177.97	35.04	31.64	2	4.1
3x4	2-1/2 x 3-1/2	9.52	8.75	10.42	8.93	5.75	5.10	1	2.2
3x6	2-1/2 x 5-1/2	14.77	13.75	38.93	34.66	13.84	12.60	1-1/2	3.4
3x8	2-1/2 x 7-1/4	19.36	18.12	87.74	79.39	23.80	21.90	2	4.4
3x10	2-1/2 x 9-1/4	24.61	23.12	180.24	164.89	38.45	35.65	2-1/2	5.7
3x12	2-1/2 x 11-1/4	29.86	28.12	321.96	296.63	56.61	52.73	3	6.9
4x4	3-1/2 x 3-1/2	13.14	12.25	14.39	12.50	7.94	7.15	1-1/3	3.0
4x6	3-1/2 x 5-1/2	20.39	19.26	53.76	48.53	19.12	17.65	2	4.7
4x8	3-1/2 x 7-1/4	26.73	25.38	121.17	111.15	32.86	30.66	2-2/3	6.2
4x10	3-1/2 x 9-1/4	33.98	32.38	248.91	230.84	53.10	49.91	3-1/3	7.9
6x3	5-1/2 x 2-1/2	14.77	13.75	8.48	7.16	6.46	5.73	1-1/2	3.4
6x4	5-1/2 x 3-1/2	20.39	19.25	22.33	19.65	12.32	11.23	2	4.7
6x6	5-1/2 x 5-1/2	31.64	30.25	83.43	76.26	29.66	27.73	3	7.4
6x8	5-1/2 x 7-1/2	42.89	41.25	207.81	193.36	54.51	51.56	4	10.0
8x8	7-1/2 x 7-1/2	58.14	56.25	281.69	263.67	73.89	70.31	5-1/3	13.7

*Rough dry sizes are 1/8 in. larger, both dimensions.

Properties and weights of American Standard Board, Dimension and Timber sizes commonly used for formwork construction are based on data supplied by the National Forest Products Association.

Approximate weights listed are based on lumber weighing 35 lbs. per cubic foot.

Notes and Sketches