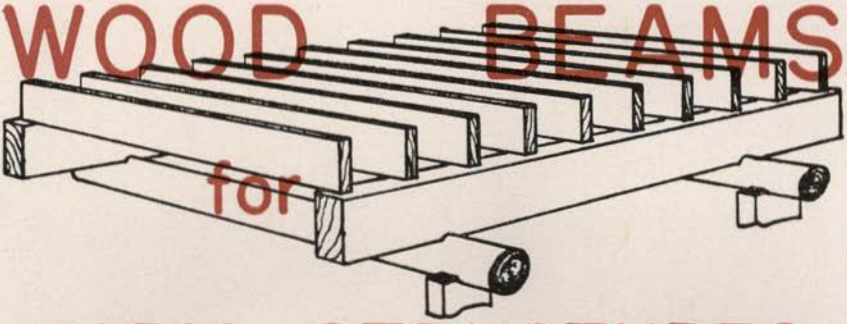
UNIVERSITY OF IDAHO
College of Agriculture

WOOD BEAMS for FARM STRUCTURES



J. E. Dixon
Everett H. Davis

IDAHO Agricultural Extension Service

Bulletin No. 324
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Use This Bulletin

TO { Find the size of beams
Find the carrying weight of beams

FOR { Pole beams
Rectangular beams

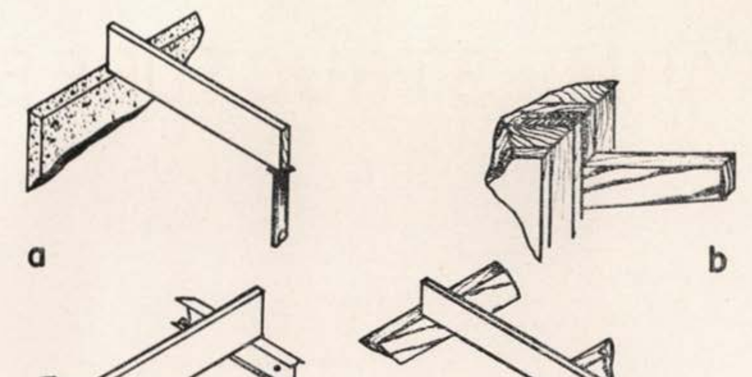

Figure 1—Classes of beams: (a) simple beam, (b) cantilever beam, (c) overhanging beam, (d) continuous beam.

Wood Beams For Farm Structures

J. E. Dixon and Everett H. Davis*

This bulletin was prepared for farmers and ranchers who find it necessary to replace outmoded buildings or remodel existing structures to make them more serviceable. Many different kinds of crops and products are stored on Idaho farms. Buildings must be constructed with proper size beams to handle the weight of these stored products. Table 1 lists their weights, volumes, and densities.

Species

For the purpose of this bulletin, lumber has been divided into two species groups.

Group A: This group produces lumber that is basically the strongest: Douglas Fir, Larch (Tamarack).

Group B: This group produces lumber that has about 60 percent of the strength of Group A: Western Red Cedar, Lodgepole Pine, Spruce, Ponderosa Pine, White Pine.

Lumber Grades

Softwood lumber is graded for **yard lumber, structural lumber,** and **shop lumber.** The lumber used for beams selected on the basis of this bulletin should be graded as **structural lumber** or **yard lumber.** Yard lumber provides the largest portion of lumber for farm building construction and includes beam material 2 inches and under 5 inches thick. For larger sizes, structural grades of lumber are used.

The actual grade for a piece of lumber is determined by lumber-grading association rules. Most of the lumber manufactured in Idaho is graded by the Western Pine Association. **Yard lumber** grade designations of **No. 1, No. 2** and **No. 3 dimension** are generally used for beams and joists.

Beams selected on the basis of this bulletin should be graded No. 2 or better. For best results the wood should be dry when installed.

Class of Beams

Beams are generally classed as **simple beams, cantilever beams, overhanging beams,** and **continuous beams (see Figure 1).** All of these classes of beams are found in farm buildings but beams supported on each end (simple beams) are the most common.

Beams selected on the basis of this bulletin should be simple beams. Continuous beams selected from information in this bulletin will be stronger than indicated but can be used. This bulletin should not be used for the selection of cantilever or overhanging beams.

How to Select a Beam

To select a beam, the load on it must be determined. To find the load, the span and spacing of the beam must be known or selected. (Common floor joist spacings are 12, 16 and 24 inches. The span is determined by the design.) From this information the load on the beam can be found by the follow-

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Table 1—Weights, volumes, and densities of farm products

PRODUCT	Weight (Lbs. per bushel)	Volume (Cu. ft. per ton)	Density (Lbs. per cu. ft.)
*Alfalfa Seed	60	41.7	48.0
Apples	48	52.1	38.4
Barley	48	52.1	38.4
*Beans, navy	60	41.7	48.0
Beets	56	44.7	44.8
Beet Pulp, dried	19	131.7	15.2
Bermuda grass seed	14	177.5	11.2
Bluegrass seed	14	177.5	11.2
Bran	20	125.0	16.0
*Buckwheat	50	50.0	40.0
Carrots, topped	50	50.0	40.0
*Castor beans	46	54.4	36.8
Cherries	56	44.7	44.8
*Clover seed	60	41.7	48.0
Corn: husked ear	70**	71.5	28.0
shelled	56	44.7	44.8
cob meal	45	55.6	36.0
Eggs	45 lb. per 30 doz. case	....	....
Flaxseed	56	44.7	44.8
Ground mixed feed	40	62.5	32.0
Hay: Baled tight	....	142.9 to 166.7	12 to 14
Baled loose	....	210.0	9.5
Chopped short	....	200.0 to 250.0	8 to 10
Loose	....	500.0	4.0
Linseed or soybean meal	....	50 to 66.7	30to 40
Malt	34	73.5	27.2
*Millet seed	50	50.0	40.0
Onions, dry	50 to 57	43.5 to 50.0	40 to 46
*Oats	32	78.2	25.6
Peaches, green	48	53.5	38.4
*Pellets	56	44.7	44.8
Potatoes	60	43.5	48.0
*Rye	56	44.7	44.8
Sawdust	....	133.3 to 166.7	12 to 15
Shavings, loose	....	227.4	8.8
Silage	....	50 to 60.6	33 to 40
Straw: baled	....	200.0	10.0
loose	....	571.4 to 1000	2 to 3.5
Tomatoes	50	50.0	40.0
*Wheat	60	41.7	48.0
Wool: Compressed bales	....	41.7	48.0
Loose bales	....	154.0	13.0

*This item exerts high pressure on the storage structure walls as well as the floor. If more than 2 or 3 feet of depth is to be piled against a wall, allowance for high pressures should be provided in the building design.

**Equivalent to 1 bushel when shelled.

Table 2—Floor loads for various densities and heights of stored products

Floor Load – Pounds per square foot

Density Lbs. per cu. ft.	Height (feet) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	22.0	24.0	26.0	28.0	30.0
3.5	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0	38.5	42.0	45.5	49.0	52.5
4.0	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0
8.0	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0	88.0	96.0	104.0	112.0	120.0
8.8	8.8	17.6	26.4	35.2	44.0	52.8	61.6	70.4	79.2	88.0	96.8	105.6	114.4	123.2	132.0
9.5	9.5	19.0	28.5	38.0	47.5	57.0	66.5	76.0	85.5	95.0	104.5	114.0	123.5	133.0	142.5
10.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0	110.0	120.0	130.0	140.0	150.0
11.2	11.2	22.4	33.6	44.8	56.0	67.2	78.4	89.6	100.8	112.0	123.2	134.4	145.6	156.8	168.0
12.0	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0	132.0	144.0	156.0	168.0	180.0
13.0	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0	117.0	130.0	143.0	156.0	169.0	182.0	195.0
14.0	14.0	28.0	42.0	56.0	70.0	84.0	98.0	112.0	126.0	140.0	154.0	168.0	182.0	196.0	210.0
15.0	15.0	30.0	45.0	60.0	75.0	90.0	105.0	120.0	135.0	150.0	165.0	180.0	195.0	210.0	225.0
15.2	15.2	30.4	45.6	60.8	76.0	91.2	106.4	121.6	136.8	152.0	167.2	182.4	197.6	212.8	228.0
16.0	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0	176.0	192.0	208.0	224.0	240.0
25.6	25.6	51.2	76.8	102.4	128.0	153.6	179.2	204.8	230.4	256.0	281.6	307.2	332.8	358.4	384.0
27.2	27.2	54.4	81.6	108.8	136.0	163.2	190.4	217.6	244.8	272.2	299.2	326.4	353.6	380.8	408.0
28.0	28.0	56.0	84.0	112.0	140.0	168.0	196.0	224.0	252.0	280.0	308.0	336.0	364.0	392.0	420.0
30.0	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0	330.0	360.0	390.0	420.0	450.0
32.0	32.0	64.0	96.0	128.0	160.0	192.0	224.0	256.0	288.0	320.0	352.0	384.0	316.0	448.0	480.0
33.0	33.0	66.0	99.0	132.0	165.0	198.0	231.0	264.0	297.0	330.0	363.0	396.0	429.0	462.0	495.0
36.0	36.0	72.0	108.0	144.0	180.0	216.0	252.0	288.0	324.0	360.0	396.0	432.0	468.0	504.0	540.0
36.8	36.8	73.6	110.4	147.2	184.0	220.8	257.6	294.4	331.2	368.0	404.8	441.6	478.4	515.2	552.0
38.4	38.4	76.8	115.2	153.6	192.0	230.4	268.8	307.2	345.6	384.0	422.4	460.8	499.2	537.6	576.0
40.0	40.0	80.0	120.0	160.0	200.0	240.0	280.0	320.0	360.0	400.0	440.0	480.0	520.0	560.0	600.0
44.8	44.8	89.6	134.4	179.2	224.0	268.8	313.6	358.4	403.2	448.0	492.8	537.6	582.4	627.2	672.0
46.0	46.0	92.0	138.0	184.0	230.0	276.0	322.0	368.0	414.0	460.0	506.0	552.0	598.0	644.0	690.0
48.0	48.0	96.0	144.0	192.0	240.0	288.0	336.0	384.0	432.0	480.0	528.0	576.0	624.0	672.0	720.0

Table 3—Allowable beam load—uniformly distributed
(A and B refer to species groups. See page 4).

8-Foot Span

Lumber size dressed	Total load* (lbs.) A	B	Floor loads (pounds per square foot) 12" spacing A	B	16" spacing A	B	24" spacing A	B
	f=1300	f=800						
2 x 4	386	237	48.2	29.6	36.3	22.2	24.1	14.8
2 x 6	928	571	116	71.4	87.1	53.6	58	35.7
2 x 8	1650	1015	203.1	127	155	95.6	101.5	63.5
2 x 10	2055	1629	257	203.5	193	153	128	101.7
2 x 12	2485	1990	310.5	248.1	235.5	186.5	155.5	124.0
4 x 4	860	529	107.5	62.8	NOT GENERALLY USED			
4 x 6	2070	1274	258.7	159.0				
4 x 8	3681	2265	460.1	283.1				
6 x 6	3004	1849	375.5	331.1				
6 x 8	5586	3437	698.5	429.6				

10-Foot Span

Lumber size dressed	Total load* (lbs.) A	B	Floor loads (pounds per square foot) 12" spacing A	B	16" spacing A	B	24" spacing A	B
	f=1300	f=800						
2 x 4	306	190	30.6	19.0	23	14.3	15.3	9.5
2 x 6	743	457	74.3	45.7	56.9	34.4	37.1	22.8
2 x 8	1320	812	132.0	81.2	99.3	61.1	66.0	40.6
2 x 10	2118	1303	211.8	130.3	159.2	98.0	105.9	65.1
2 x 12	2482	1910	248.2	191.0	186.9	143.5	124.2	95.5
4 x 4	688	423	68.8	43.3	NOT GENERALLY USED			
4 x 6	1656	1019	165.6	101.9				
4 x 8	2945	1812	294.5	181.2				
6 x 6	2403	1479	240.3	147.9				
6 x 8	4468	2750	446.8	275.0				

12-Foot Span

Lumber size dressed	Total load* (lbs.) A	B	Floor loads (pounds per square foot) 12" spacing A	B	16" spacing A	B	24" spacing A	B
	f=1300	f=800						
2 x 4	257	158	21.4	13.2	16.1	9.9	10.7	6.6
2 x 6	619	381	51.6	31.7	38.8	23.8	25.8	15.8
2 x 8	1100	677	92.5	55.8	69.6	42.0	46.2	27.9
2 x 10	1765	1086	147.0	90.4	111.0	68.0	73.5	45.2
2 x 12	2587	1592	215.6	132.6	162.0	99.6	107.8	66.3
4 x 4	573	353	47.8	29.4	NOT GENERALLY USED			
4 x 6	1380	849	115.0	70.8				
4 x 8	2454	1510	204.5	125.8				
6 x 6	2003	1232	166.9	102.7				
6 x 8	3724	2292	310.3	191.0				

14-Foot Span

Lumber size dressed	Total load* (lbs.) A	B	Floor loads (pounds per square foot) 12" spacing A	B	16" spacing A	B	24" spacing A	B
	f=1300	f=800						
2 x 4	220	136	15.7	9.7	11.8	7.3	7.8	4.8
2 x 6	531	326	37.9	23.3	28.5	17.5	18.9	11.6
2 x 8	943	580	67.4	41.4	50.7	31.1	33.7	20.7
2 x 10	1513	931	108.1	66.5	81.2	50.0	54.0	33.2
2 x 12	2217	1365	158.3	97.5	119.0	73.4	79.1	48.7
4 x 4	491	302	29.9	21.6	NOT GENERALLY USED			
4 x 6	1183	728	84.5	52.0				
4 x 8	2103	1294	150.2	92.4				
6 x 6	1717	1056	122.6	75.4				
6 x 8	3192	1964	288.0	140.3				

16-Foot Span

Lumber size dressed	Total load* (lbs.) A	Total load* (lbs.) B	Floor loads (pounds per square foot) 12" spacing A	12" spacing B	16" spacing A	16" spacing B	24" spacing A	24" spacing B
	f=1300	f=800	A	B	A	B	A	B
2 x 4	193	119	12.1	7.5	9.1	5.6	6.0	3.7
2 x 6	464	286	29.0	17.9	21.8	16.4	14.5	8.9
2 x 8	825	508	51.6	31.7	38.8	29.2	25.8	15.8
2 x 10	1324	815	82.8	51.0	62.3	46.8	41.4	25.5
2 x 12	1940	1194	120.0	74.7	90.2	56.2	60.0	37.3
4 x 4	430	265	26.9	16.6	NOT GENERALLY USED			
4 x 6	1035	637	64.7	39.8				
4 x 8	1841	1133	115.1	70.8				
6 x 6	1502	924	93.9	57.7				
6 x 8	2793	1719	174.6	107.4				
6 x 10	4481	2758	280.1	172.3				

18-Foot Span

Lumber size dressed	Total load* (lbs.) A	Total load* (lbs.) B	Floor loads (pounds per square foot) 12" spacing A	12" spacing B	16" spacing A	16" spacing B	24" spacing A	24" spacing B
	f=1300	f=800	A	B	A	B	A	B
2 x 8	733	451	40.7	25.0	30.6	18.8	20.3	12.5
2 x 10	1177	724	65.4	40.2	49.2	30.2	32.7	20.1
2 x 12	1725	1061	95.7	59.0	72.0	44.4	47.8	29.5
3 x 6	666	410	37.0	22.7	27.8	17.1	18.5	11.3
3 x 8	1184	729	65.8	40.5	49.5	30.4	32.9	20.3
3 x 10	1901	1170	105.6	65.0	79.4	48.9	52.6	32.5
4 x 8	1636	1007	90.8	55.9	NOT GENERALLY USED			
4 x 10	2625	1615	145.8	89.7				
6 x 6	1335	822	74.2	45.7				
6 x 8	2482	1528	137.9	84.9				
6 x 10	3983	2451	221.3	153.0				

20-Foot Span

Lumber size dressed	Total load* (lbs.) A	Total load* (lbs.) B	Floor loads (pounds per square foot) 12" spacing A	12" spacing B	16" spacing A	16" spacing B	24" spacing A	24" spacing B
	f=1300	f=800	A	B	A	B	A	B
2 x 8	660	406	33.0	20.3	24.8	15.1	16.5	10.1
2 x 10	1059	652	52.9	32.6	39.8	24.6	26.4	16.3
2 x 12	1552	955	77.6	47.8	58.4	35.9	38.8	23.9
2 x 16	2820	1735	141.0	86.7	106.0	65.2	70.5	43.3
3 x 8	1066	656	53.3	32.8	40.1	24.7	26.6	16.4
3 x 10	1711	1053	85.5	51.1	64.3	38.4	42.7	26.3
4 x 8	1472	906	73.6	45.3	NOT GENERALLY USED			
4 x 10	2362	1454	118.1	72.7				
4 x 12	3462	2131	173.1	106.6				
6 x 8	2234	1375	111.7	68.8				
6 x 10	3585	2206	179.3	110.3				
8 x 8	3047	1875	152.4	93.8				

* Total uniformly distributed load—a concentrated load at the center of the beam can be only one-half this value.

Table 4—Solid round beam to sawn beam equivalents

Sawn size (Inches)	Round diameter (Inches*)	Sawn size (Inches)	Round diameter (Inches*)
2 x 4	3 1/8	2 x 12	7 1/4
4 x 4	4 1/4	3 x 10	7 1/2
2 x 6	4 3/8	6 x 8	8 1/8
2 x 8	5 1/2	4 x 10	8 1/4
4 x 6	5 7/8	8 x 8	8 7/8
2 x 10	6 1/2	4 x 12	9 1/4
3 x 8	6 1/2	6 x 10	9 1/2
4 x 8	7 1/8		

* For tapered-pole beams the diameter should be taken at a point 1/3 of the span length from the small end.

ing rule: **The load on any one beam is equal to the weight of the material directly above the beam and half-way both directions to the next beam or support.** The sum of the two half-way distances is usually equal to the beam spacing. Figure 2 shows how this applies to a floor joist while Figure 3 shows the application of this principle to a floor girder.

Tables 1 and 2 will assist you in determining the load on any one beam. The tables are used as follows: From Table 1 determine the density (last column) of the material you want to store. Next find this density in the left column of Table 2 and move to the right until you come to the column for the height you are going to store the material. This is the load that will be on each square foot of the floor. You now can refer directly to Table 3 and select the beam. Pick out the section of the table for the span in your design, then refer to the spacing (12", 16", 24") and move down the species A or species B column until you come to the load that must be carried. If your exact load is not listed pick the next largest and move to the left column for the size of lumber you need. (A discussion of species and grades is given on page 3).

EXAMPLE I:

You have a milking parlor over which you want to store ground feed. Posts on each side of the milking pit provide a span of 10 feet for the overhead floor joists. You plan to store the grain 3 feet deep. Referring to Table 1 you find that ground-mixed-feed weighs 32 pounds per cubic foot. With this you refer to Table 2 and find for a density of 32 pounds per cubic foot and a height of 3 feet the floor load is 96 pounds per square foot*. Now, by looking at the 10-foot span section of Table 3, you can select the size joist needed. Looking over the table you will note for this case there are three choices:

(1) A 2" x 8" of species A will carry 99.3 pounds per square foot at 16" spacing.

(2) A 2" x 10" of species B will carry 98.0 pounds per square foot at 16" spacing.

(3) A 2" x 10" of species A will carry 105.9 pounds per square foot at 24" spacing.

Any one of these three choices will be satisfactory from a load-carrying standpoint. Other factors such as cost of the lumber for the different choices and availability can be used to make the final selection.

Choice 3 will use the least amount of material, 100 board feet for a 10 x 12 foot area. For the same area, choices 1 and 2 will use 120 and 150 board feet respectively.

How to Find the Safe Load for a Beam

To find the safe load that a beam will carry you need to know the span, the beam size and species. **The beam must be physically sound for the tables in this bulletin to apply.**

First, refer to Table 3 and find the beam-span for your problem. In the "Lumber size dressed" col-

* This includes weight of feed only; the weight of flooring, beams or other items need to be added if excessive. For applications such as this, the weight of wooden beams and flooring is usually small and thus ignored.

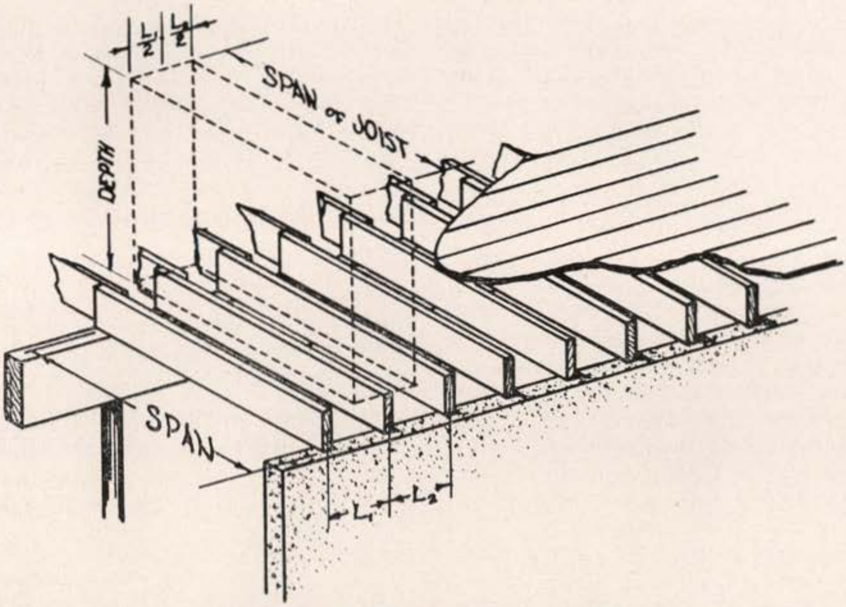

Figure 2—Typical floor joist loading.

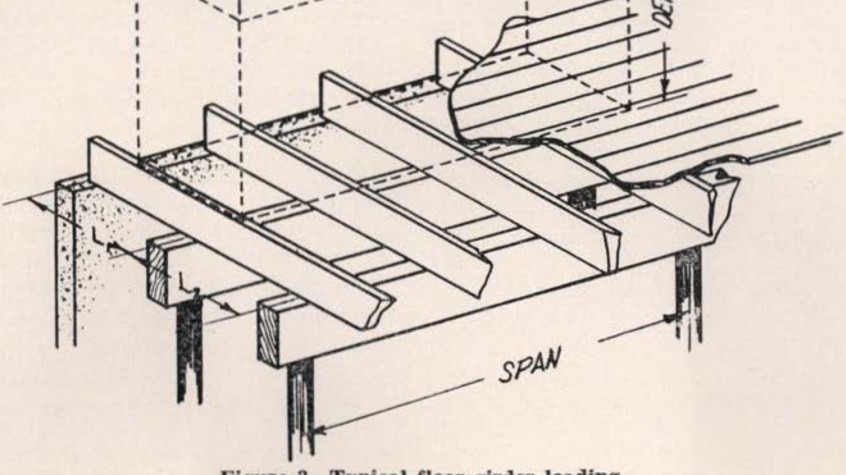

Figure 3—Typical floor girder loading.

umn find the size of the beam in your problem, now move to the right into the species column that applies and pick the total load. This is the total number of pounds that the beam can safely carry, evenly distributed over its length.

If the beam has a spacing of 12, 16, or 24 inches the safe floor load can be found in the appropriate spacing and species column. If the spacing is other than that listed in the table, divide the value listed in the 12-inch spacing column by the spacing, in feet, of the beams in your problem. This will give you the safe floor load in pounds per square foot, if your beams are evenly spaced.

EXAMPLE II:

You would like to store loosely-baled hay in an existing barn loft. The floor is made of 2"x8" Douglas Fir joists 16 inches on center. The floor girders, which support the floor joists, are 6" x 8" Douglas Fir spaced 14 feet apart with a span of 8 feet.

Referring to Table 3 for a 14-foot span, you see that the floor joists can carry a load of 50.7 pounds per square foot. The girder on an 8-foot span can carry 5,586 pounds or 698.5 pounds per square foot if on 12-inch centers. Dividing 698.5 by the 14-foot spacing shows that a safe load of 49.8 pounds per square foot can be carried by the girder. This is less than the safe floor-joist load and is therefore the limiting load. Referring to Table 1 you see that loosely baled hay weighs 9.5 pounds per cubic foot. With this 9.5 pounds per cubic foot and the floor load figure of 49.8 pounds per square foot in mind, you can now refer to Table 2. Find 9.5 pounds per cubic foot in the density column and move to the right until you come to 47.5 pounds per square foot floor load for a depth of 5 feet. Since the beam can carry 49.8 pounds per square foot the hay can be stacked about 5¼ feet high.

Solid, Built-Up and Round Beams

Wooden beams are found in three forms: **solid sawn material**, **built-up sawn material** and **solid round material.**

The tables in this bulletin were prepared as if the beams were solid sawn material. Beams of the two other forms can be selected from the same tables if the modifications discussed below are made.

Built-up beams will carry the load of the individual piece times the number of pieces. For example, a built-up beam made of four 2 x 10's will carry four times the load of one 2 x 10. To do this, however, the pieces must be loaded on their edge. Fastening built-up beams together can be done with nails or spikes. For best results the nails should penetrate at least three members (or most of the beam width if only two members thick). Nails should be spaced about six times the plank thickness along the beam's length.

Glued, built-up beams are also available. The carrying capacity of these beams can best be obtained from their manufacturer.

Poles and logs can be used as **round beams. A round beam** has about the same strength as a square beam of the same cross sectional area and species. Table 4 shows the round-beam equivalent for all sizes of timber beams discussed in this bulletin. To select a round beam size, first find the size of sawn lumber needed to carry your load, then convert this to the round beam size using Table 4. See Examples I and III.

EXAMPLE III:

Referring to Example I, round beams can be selected for the floor joists instead of the 2" x 10" Douglas Fir joists on 24" centers. Table 4 shows that a 2 x 10 is equivalent to a round beam 6½" in diameter. Therefore Douglas Fir poles 6½" in diameter can be used for the floor joists.

The load that a round beam will carry can also be found from these tables. First use Table 4 to find the equivalent sawn size for the round beam. With this sawn size in mind, refer to the load table (Table 3) with the span for your problem and read the appropriate load. See Example IV.

EXAMPLE IV:

As a storage place for sawdust you want to use an existing building which has 9½" diameter pine logs on a 16-foot span. The logs are 5 feet apart.

From Table 4 you find a 9½" round beam is equivalent to a 6" x 10" beam. Referring to Table 3 for a 16-foot span and species B, you find a 6 x 10 will carry 2,758 pounds or 172.3 pounds per square foot on a 12" spacing. Since the spacing of the logs are 5 feet, divide 172.3 by 5. This will allow you to put 34.4 pounds per square foot on the floor. Since, from Table 1 you find sawdust weighs 15.0 pounds per cubic foot, you now can turn to Table 2. With a density of 15 move to the right until you come to the load of 34.4 pounds per square foot. This is in between 30 and 45 on the table. Thus you can safely put a little more than 2 feet of sawdust in this building. (If a support is placed in the middle of the 16-foot span, twice as much sawdust could be safely stored.)

Farm Building Plan Service

The University of Idaho maintains a farm building plan service and can furnish blueprints of many types of structures for storage of farm products. Over 400 plans of all types of farm buildings and livestock equipment are on hand. County extension agricultural agents have plan service books which show many of these structures. Plans are purchased through the Agricultural Engineering Department at the University of Idaho, Moscow, at nominal cost.

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