APPENDIX

CHAPTER Ind 20

STATE OF WISCONSIN
DEPARTMENT OF INDUSTRY, LABOR AND HUMAN RELATIONS
DIVISION OF SAFETY AND BUILDINGS
201 E. WASHINGTON AVE.
BOX 7969
MADISON, WI 53707
WISCONSIN STATUTES 101.63

WISCONSIN UNIFORM BUILDING PERMIT APPLICATION

PERMIT NO. ______
PARCEL NO. ______

PERMIT REQUESTED CONST HVAC ELEC PLUMB

Owner's Name	Mailing Address	Telephone
Contractor's Name	Mailing Address	Telephone

PROJECT LOCATION ______ ¼, ______ ¼, SECTION ______ T ______ N, R ______ E or W

Building Address	Subdivision Name	Lot No.	Block No.

Zoning District	Lot Area Sq. ft.	Setbacks	Front ft.	Rear ft.	Left ft.	Right ft.

1. PROJECT
New · Addition · Alteration · Garage ☐ Attached ☐ Detached · Other · Master plan no. ______ (if applicable)

2. TYPE
Single family · Two family · Other ______

3. ELECTRICAL
Entrance Panel · Size ______ amp · Service · Underground · Overhead

4. HVAC EQUIPMENT
Forced Air Furnace · Radiant Baseboard or Panel · Heat pump · Boiler · Central Air Cond. · Other ______

5. ENERGY SOURCES
Fuel · Space Htg. · Water Htg.
LP Gas · Nat. Gas · Fuel Oil · Elec. · Wood · Solar · ... · Other ______

6. CONST. TYPE
Site const. · Manufactured

7. FOUNDATION
Concrete · Masonry · Treated Wood · Other ______

8. PLUMBING
Sewer · Municipal · Septic · Permit No. ______

9. AREA (Outside Dimension)
Basement ______ sq. ft.
Living Area ______ sq. ft.
Garage ______ sq. ft.

10. STORIES
1 Story · 2 Story · Other ______

11. USE
Seasonal · Permanent · Other ______

12. WATER
Private · Municipal

The applicant agrees to comply with the Wisconsin Uniform Dwelling Code and other Municipal ordinances and ... that the issuance of the permit creates no legal liability, express or implied, on the Department or Municipality, and certifies that ... is accurate.

SIGNATURE OF APPLICANT ______ DATE ______

CONDITIONS OF APPROVAL This permit is issued pursuant to the following conditions. Failure to comply may result in suspension or revocation of this permit or other penalty.

13. ISSUING JURISDICTION VILLAGE CITY TOWN COUNTY STATE

NAME ______ MUNIC. NO. ______

FEES		PERMIT(S) ISSUED	WIS. UNIFORM PERMIT SEAL NO.(S)	PERMIT ISSUED BY
PLAN REVIEW	$ ______	CONST	______	NAME ______
INSPECTION	______	HVAC	______	DATE ______
WIS. PERMIT SEAL(S)	______	ELEC	______	CERT. NO. ______
OTHER (______) TOTAL $	______	PLUMB	______	

DILHR-SBD-5823

WISCONSIN UNIFORM BUILDING PERMIT

☐const; ☐hvac; ☐elec; ☐plumb;

Issued to
OWNER (AGENT)
BUILDING SITE ADDRESS
CITY, VILLAGE TOWN, COUNTY

Issued by
MUNICIPALITY OR AUTHORIZED AGENCY
PERSON ISSUING · CERT. NO.
DATE ISSUED · TELEPHONE NUMBER

Site Info
SUBDIVISION
LOT NO. ______ BLOCK NO. ______
ZONING DISTRICT
¼, ¼, T ______ N, R ______ E or W
SETBACKS
FRONT YARD ______ feet
REAR YARD ______ feet
LEFT YARD ______ feet
RIGHT YARD ______ feet

Inspection

PHASE	RHG	FNL
FOUNDATION		
CONSTRUCTION		
INSULATION		
PLUMBING		
HEAT VENT/AC		
ELECTRICAL		
OCCUPANCY		

NOTICE OF NONCOMPLIANCE
This Issuing jurisdiction shall notify the applicant in writing of any violations to be corrected. All cited violations shall be corrected within 30 days after notification, unless extension of time is granted.

APPENDIX

CHAPTER Ind 21

FASTENER SCHEDULE TABLE

Description of Building Materials/Connection	Number and Type of Fastener [1 2 3 4]
Joist to sill or girder, toe nail	2-16d, 3-8d
Bridging to joist, toe nail each end	2-8d
1″ x 6″ subfloor or less to each joist, face nail	2-8d or 2 staples, 1¾″
Wider than 1″ x 6″ subfloor to each joist, face nail	3-8d or 4 staples, 1¾″
2″ subfloor to joist or girder, blind and face nail	2-16d
Sole plate to joist or blocking, face nail	16d at 16″ o.c.
Top or sole plate to stud, end nail	2-16d
Stud to sole plate, toe nail	4-8d or 3-16d
Doubled studs, face nail	16d at 24″ o.c.
Doubled top plates, face nail	16d at 16″ o.c.
Top plates, laps and intersections, face nail	2-16d
Continuous header, two pieces	16d at 16″ o.c. along each edge
Ceiling joists to plate, toe nail	2-16d, 3-8d
Continuous header to stud, toe nail	4-8d
Ceiling joist, laps over partitions, face nail	3-16d
Ceiling joist to parallel rafters, face nail	3-16d
Rafter to plate, toe nail	2-16d, 3-8d
1″ brace to each stud and plate, face nail	2-8d or 2 staples, 1¾″
1″ x 6″ sheathing to each bearing, face nail	2-8d or 2 staples, 1¾″
1″ x 8″ sheathing to each bearing, face nail	2-8d or 3 staples, 1¾″
Wider than 1″ x 8″ sheathing to each bearing, face nail	3-8d or 4 staples, 1¾″
Built-up corner studs	16d at 30″ o.c., 16d at 24″ o.c.
Built-up girder and beams	20d at 32″ o.c. at top and bottom and staggered 2-20d at ends and at each splice
2-inch planks	2-16d at each bearing
Roof rafters to ridge, valley or hip rafters, toe nail	4-16d
Roof rafters to ridge, valley or hip rafters, face nail	3-16d
Collar ties to rafters, face nail	3-8d
Plywood subfloor, roof and wall sheathing (to framing) [6]	
½-inch to 5/16-inch	6d[5] or staple
⅜-inch to ¾-inch	8d smooth or common, 6d deformed, or staple
⅞-inch to 1-inch	8d[5]
1⅛-inch to 1¼-inch	10d smooth or common, or 8d deformed
Fiberboard sheathing[7]	
½-inch	6d common or staple, 1⅛″ long or roofing nail[11]
25/32-inch	8d common or staple, 1½″ long or roofing nail[11]
Gypsum sheathing, ½″[8]	1½″ galvanized roofing nail, or 6d common, or staple
Particleboard wall sheathing (to framing) [6]	
⅜-inch to ½-inch	6d common
⅝-inch to ¾-inch	8d common or staple
Insulated sheathing	11-gauge roofing nails, 6d, 8d, or staple
Combination subfloor underlayment (to framing) [6]	
¾-inch and less	6d deformed
⅞-inch to 1-inch	8d deformed
1⅛-inch to 1¼-inch	10d smooth[9] or common or 8d deformed[9]
Panel siding (to framing) [10]	
½-inch or less	6d
⅝-inch	8d

[1]All nails are smooth-common, box or deformed shank except where otherwise stated.

[2]Nail is a general description and may be T-head, modified round head or round head.

[3]Staples are 16-gauge wire and have a minimum 7/16-inch o.d. crown width.

[4]Common or box nails may be used except where otherwise stated.

[5]Common or deformed shank.

[6]Nails spaced at 6 inches on center at edges, 12 inches at intermediate supports (10 inches at intermediate supports for floors), except 6 inches at all supports where spans are 48 inches or more.

[7]Nails spaced at 3 inches on center at edges, 6 inches at intermediate supports.

[8]Nails spaced at 4 inches on center at edges, 8 inches at intermediate supports.

[9]Nails spaced at 6 inches on center at edges and at intermediate supports.

[10]Corrosion-resistant siding and casing nails.

[11]Galvanized roofing nails with 7/16-inch diameter head and 1½-inch length for ½-inch sheathing and 1¾-inch for 25/32-inch sheathing.

SPAN TABLES FOR JOISTS AND RAFTERS
(Recommended by National Forest Products Association)

EXPLANATION OF TABLES

These span tables for joists and rafters are calculated on the basis of a series of modulus of elasticity (E) and fiber bending stress (F_b) values. The range of values in the tables provides allowable spans for all species and grades of nominal 2-inch framing lumber customarily used in construction.

Tables J-1 through J-6 list spans for floor and ceiling joists used over a single span with calculations based on E and the required F_b values shown.

Tables R-1 through R-6 list spans for rafters used over a single span with calculations based on F_b and the required E values shown.

Tables TSJ-1 and TSJ-2 list spans for floor joists continuous over two equal spans with calculations based on E and the required F_b values shown.

Appplicable design criteria for each condition of use appear at the top of each table. While these criteria are directed principally to residential construction, they are suitable for other occupancies having similar conditions of loading. Tabulated spans for rafters also apply to other types of occupancy, since the occupancy has little bearing on roof loading.

LUMBER SIZES

Tabulated spans apply to surfaced (S4S) lumber having dimensions which conform to the American Softwood Lumber Standard, PS 20-70. These sizes are as follows:

	Dressed Size (inches)	
Reference	Surfaced Dry	Surfaced Green
2 x 4	1½ x 3½	1-9/16 x 3-9/16
2 x 6	1½ x 5½	1-9/16 x 5⅝
2 x 8	1½ x 7¼	1-9/16 x 7½

2 x 10	1½ x 9¼	1-9/16 x 9½
2 x 12	1½ x 11¼	1-9/16 x 11½

MOISTURE CONTENT

The listed dry and green sizes are related at 19% maximum moisture content. Tabulated spans are calculated on the basis of the dry sizes and are also applicable to the corresponding green sizes. The spans in these tables are intended for use in covered structures or where moisture content in use does not exceed 19%.

SPAN MEASUREMENT

Tabulated spans are the clear distance between supports. For sloping rafters, the span is measured along the horizontal projection.

LUMBER DESIGN VALUES

Use of these span tables requires reference to the applicable design values for the various species and grades of lumber. "Design Values for Joists and Rafters", a supplement to these span tables, provide such values in convenient-to-use form. Modulus of elasticity (E) and fiber bending stress (F_b) values therein are based on the National Design Specification for Wood Construction (formerly National Design Specification for Stress Grade Lumber and Its Fastenings) and incorporate adjustments appropriate for repetitive-member use under various durations of load.

Repetitive-member use is that condition where framing members such as joists, rafters, studs, planks, decking or similar members are spaced not more than 24 inches, are not less than 3 in number and are joined by floor, roof or other load-distributing elements adequate to support the design load. Design values in bending (F_b) for such use are 15% greater than for single-member use.

For rafters, design values in bending (F_b) may be greater than the design values for normal duration of load, by the following amounts:

15% for 2 months' duration, as for snow.
25% for 7 days' duration, as for construction load.

The design value tables provide values for bending for repetitive-member use of joists and rafters under normal, 2-month and 7-day durations of load.

ROOF LOADS

Rafter spans are tabulated for the most common roof loads. For roof loads intermediate between those tabulated, straight line interpolation may be used.

LUMBER IDENTIFICATION

When used with the tabulated spans in these tables, lumber should be identified by the grademark of an agency recognized as being competent by the Board of Review of the American Lumber Standards Committee or the Canadian Lumber Standards Administrative Board.

USE OF THE SPAN TABLES

Spans for floor and ceiling joists are calculated on the basis of the modulus of elasticity (E) with the required fiber bending stress (F_b) listed below each span. Spans for rafters are calculated on the basis of fiber bending stress (F_b) with the required modulus of elasticity (E) listed below each span. Use of the tables is illustrated in the examples which follow.

Example 1. Floor joists. Assume a required span of 12′-9″, a live load of 40 psf and joists spaced 16 inches on centers. Table J-1 shows that a grade of 2 x 8 having an E value of 1,600,000 psi and an F_b value of 1250 psi would have a span of 12 ′-10″, which satisfies the condition.

Example 2. Rafters. Assume a horizontal projection span of 13′-0″, a live load of 30 psf, dead load of 15 psf and rafters spaced 16 inches on centers. Table R-2 shows that a 2x8 having an F_b value of 1300 psi and an E value of 1,000,000 psi would have a span of 13′-3″ of horizontal projection.

Since many combinations of size, spacing, E and F_b values are possible, it is recommended that the users examine the tables to determine which combination fits their particular case most effectively.

TABLE J-1
FLOOR JOISTS
40 Lbs. Per Sq. Ft. Live Load
(All rooms except those used for sleeping areas and attic floors.)

DESIGN CRITERIA:
Deflection: For 40 lbs. per sq. ft. live load Limited to span in inches divided by 360.
Strength: Live Load of 40 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. determines the required fiber stress value

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																		
(IN)		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x6	12.0	6 9 450	7 3 520	7 9 590	8 2 660	8 6 720	8 10 780	9 2 830	9 6 890	9 9 940	10 0 990	10 3 1040	10 6 1090	10 9 1140	10 11 1190	11 2 1230	11 4 1280	11 7 1320	11 11 1410	12 3 1490
	13.7	6 6 470	7 0 550	7 5 620	7 9 690	8 2 750	8 6 810	8 9 870	9 1 930	9 4 980	9 7 1040	9 10 1090	10 0 1140	10 3 1190	10 6 1240	10 8 1290	10 10 1340	11 1 1380	11 5 1470	11 9 1560
	16.0	6 2 500	6 7 580	7 0 650	7 5 720	7 9 790	8 0 860	8 4 920	8 7 980	8 10 1040	9 1 1090	9 4 1150	9 6 1200	9 9 1250	9 11 1310	10 2 1360	10 4 1410	10 6 1460	10 10 1550	11 2 1640
	19.2	5 9 530	6 3 610	6 7 690	7 0 770	7 3 840	7 7 910	7 10 970	8 1 1040	8 4 1100	8 7 1160	8 9 1220	9 0 1280	9 2 1330	9 4 1390	9 6 1440	9 8 1500	9 10 1550	10 2 1650	10 6 1750
	24.0	5 4 570	5 9 660	6 2 750	6 6 830	6 9 900	7 0 980	7 3 1050	7 6 1120	7 9 1190	7 11 1250	8 2 1310	8 4 1380	8 6 1440	8 8 1500	8 10 1550	9 0 1610	9 2 1670	9 6 1780	9 9 1880
	32.0					6 2 1010	6 5 1090	6 7 1150	6 10 1230	7 0 1300	7 3 1390	7 5 1450	7 7 1520	7 9 1590	7 11 1660	8 0 1690	8 2 1760	8 4 1840	8 7 1950	8 10 2060
2x8	12.0	8 11 450	9 7 520	10 2 590	10 9 660	11 3 720	11 8 780	12 1 830	12 6 890	12 10 940	13 2 990	13 6 1040	13 10 1090	14 2 1140	14 5 1190	14 8 1230	15 0 1280	15 3 1320	15 9 1410	16 2 1490
	13.7	8 6 470	9 2 550	9 9 620	10 3 690	10 9 750	11 2 810	11 7 870	11 11 930	12 3 980	12 7 1040	12 11 1090	13 3 1140	13 6 1190	13 10 1240	14 1 1290	14 4 1340	14 7 1380	15 0 1470	15 6 1560
	16.0	8 1 500	8 9 580	9 3 650	9 9 720	10 2 790	10 7 850	11 0 920	11 4 980	11 8 1040	12 0 1090	12 3 1150	12 7 1200	12 10 1250	13 1 1310	13 4 1360	13 7 1410	13 10 1460	14 3 1550	14 8 1640
	19.2	7 7 530	8 2 610	8 9 690	9 2 770	9 7 840	10 0 910	10 4 970	10 8 1040	11 0 1100	11 3 1160	11 7 1220	11 10 1280	12 1 1330	12 4 1390	12 7 1440	12 10 1500	13 0 1550	13 5 1650	13 10 1750
	24.0	7 1 570	7 7 660	8 1 750	8 6 830	8 11 900	9 3 980	9 7 1050	9 11 1120	10 2 1190	10 6 1250	10 9 1310	11 0 1380	11 3 1440	11 5 1500	11 8 1550	11 11 1610	12 1 1670	12 6 1780	12 10 1880
	32.0					8 1 990	8 5 1080	8 9 1170	9 0 1230	9 3 1300	9 6 1370	9 9 1450	10 0 1520	10 2 1570	10 5 1650	10 7 1700	10 10 1790	11 0 1840	11 4 1950	11 8 2070
2x10	12.0	11 4 450	12 3 520	13 0 590	13 8 660	14 4 720	14 11 780	15 5 830	15 11 890	16 5 940	16 10 990	17 3 1040	17 8 1090	18 0 1140	18 5 1190	18 9 1230	19 1 1280	19 5 1320	20 1 1410	20 8 1490
	13.7	10 10 470	11 8 550	12 5 620	13 1 690	13 8 750	14 3 810	14 9 870	15 3 930	15 8 980	16 1 1040	16 6 1090	16 11 1140	17 3 1190	17 7 1240	17 11 1290	18 3 1340	18 7 1380	19 2 1470	19 9 1560
	16.0	10 4 500	11 1 580	11 10 650	12 5 720	13 0 790	13 6 850	14 0 920	14 6 980	14 11 1040	15 3 1090	15 8 1150	16 0 1200	16 5 1250	16 9 1310	17 0 1360	17 4 1410	17 8 1460	18 3 1550	18 9 1640
	19.2	9 9 530	10 6 610	11 1 690	11 8 770	12 3 840	12 9 910	13 2 970	13 7 1040	14 0 1100	14 5 1160	14 9 1220	15 1 1280	15 5 1330	15 9 1390	16 0 1440	16 4 1500	16 7 1550	17 2 1650	17 8 1750
	24.0	9 0 570	9 9 660	10 4 750	10 10 830	11 4 900	11 10 980	12 3 1050	12 8 1120	13 0 1190	13 4 1250	13 8 1310	14 0 1380	14 4 1440	14 7 1500	14 11 1550	15 2 1610	15 5 1670	15 11 1780	16 5 1880
	32.0					10 4 1000	10 9 1080	11 1 1150	11 6 1240	11 10 1310	12 2 1380	12 5 1440	12 9 1520	13 0 1580	13 3 1640	13 6 1700	13 9 1770	14 0 1830	14 6 1970	14 11 2080
2x12	12.0	13 10 450	14 11 520	15 10 590	16 8 660	17 5 720	18 1 780	18 9 830	19 4 890	19 11 940	20 6 990	21 0 1040	21 6 1090	21 11 1140	22 5 1190	22 10 1230	23 3 1280	23 7 1320	24 5 1410	25 1 1490
	13.7	13 3 470	14 3 550	15 2 620	15 11 690	16 8 750	17 4 810	17 11 870	18 6 930	19 1 980	19 7 1040	20 1 1090	20 6 1140	21 0 1190	21 5 1240	21 10 1290	22 3 1340	22 7 1380	23 4 1470	24 0 1560
	16.0	12 7 500	13 6 580	14 4 650	15 2 720	15 10 790	16 5 860	17 0 920	17 7 980	18 1 1040	18 7 1090	19 1 1150	19 6 1200	19 11 1250	20 4 1310	20 9 1360	21 1 1410	21 6 1460	22 2 1550	22 10 1640
	19.2	11 10 530	12 9 610	13 6 690	14 3 770	14 11 840	15 6 910	16 0 970	16 7 1040	17 0 1100	17 6 1160	17 11 1220	18 4 1280	18 9 1330	19 2 1390	19 6 1440	19 10 1500	20 2 1550	20 10 1650	21 6 1750
	24.0	11 0 570	11 10 660	12 7 750	13 3 830	13 10 900	14 4 980	14 11 1050	15 4 1120	15 10 1190	16 3 1250	16 8 1310	17 0 1380	17 5 1440	17 9 1500	18 1 1550	18 5 1610	18 9 1670	19 4 1780	19 11 1880
	32.0					12 7 1000	13 1 1080	13 6 1150	13 11 1220	14 4 1300	14 9 1380	15 2 1450	15 6 1520	15 10 1580	16 2 1650	16 5 1700	16 9 1770	17 0 1830	17 7 1950	18 1 2070

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J-2
FLOOR JOISTS
30 lbs. Per Sq. Ft. Live Load
(All rooms used for sleeping areas and attic floors.)

DESIGN CRITERIA:
Deflection - For 30 lbs. per sq. ft. live load. Limited to span in inches divided by 360.
Strength - Live Load of 30 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. determines the required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																		
(IN)		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x6	12.0	7-5 440	8-0 510	8-6 570	8-11 640	9-4 700	9-9 750	10-1 810	10-5 860	10-9 910	11-0 960	11-3 1010	11-7 1060	11-10 1100	12-0 1150	12-3 1200	12-6 1240	12-9 1280	13-1 1370	13-6 1450
	13.7	7-1 460	7-8 530	8-2 600	8-7 670	8-11 730	9-4 790	9-8 840	10-0 900	10-3 950	10-6 1010	10-10 1060	11-1 1110	11-3 1160	11-6 1200	11-9 1250	11-11 1300	12-2 1340	12-7 1430	12-11 1510
	16.0	6-9 480	7-3 560	7-9 630	8-2 700	8-6 770	8-10 830	9-2 890	9-6 950	9-9 1000	10-0 1060	10-3 1110	10-6 1160	10-9 1220	10-11 1270	11-2 1320	11-4 1360	11-7 1410	11-11 1500	12-3 1590
	19.2	6-4 510	6-10 600	7-3 670	7-8 740	8-0 810	8-4 880	8-8 940	8-11 1010	9-2 1070	9-5 1130	9-8 1180	9-10 1240	10-1 1290	10-4 1350	10-6 1400	10-8 1450	10-10 1500	11-3 1600	11-7 1690
	24.0	5-11 550	6-4 640	6-9 720	7-1 800	7-5 880	7-9 950	8-0 1020	8-3 1080	8-6 1150	8-9 1210	8-11 1270	9-2 1330	9-4 1390	9-7 1450	9-9 1510	9-11 1560	10-1 1620	10-5 1720	10-9 1820
	32.0					6-9 960	7-0 1040	7-3 1110	7-6 1190	7-9 1270	7-11 1330	8-2 1410	8-4 1470	8-6 1530	8-8 1590	8-10 1650	9-0 1710	9-2 1780	9-6 1910	9-9 2010
2x8	12.0	9-10 440	10-7 510	11-3 570	11-10 640	12-4 700	12-10 750	13-4 810	13-9 860	14-2 910	14-6 960	14-11 1010	15-3 1060	15-7 1100	15-10 1150	16-2 1200	16-6 1240	16-9 1280	17-4 1370	17-10 1450
	13.7	9-4 460	10-1 530	10-9 600	11-4 670	11-10 730	12-3 790	12-9 840	13-2 900	13-6 950	13-11 1010	14-3 1060	14-7 1110	14-11 1160	15-2 1200	15-6 1250	15-9 1300	16-0 1340	16-7 1430	17-0 1510
	16.0	8-11 480	9-7 560	10-2 630	10-9 700	11-3 770	11-8 830	12-1 890	12-6 950	12-10 1000	13-2 1060	13-6 1110	13-10 1160	14-2 1220	14-5 1270	14-8 1320	15-0 1360	15-3 1410	15-9 1500	16-2 1590
	19.2	8-5 510	9-0 600	9-7 670	10-1 740	10-7 810	11-0 880	11-4 940	11-9 1010	12-1 1070	12-5 1130	12-9 1180	13-0 1240	13-4 1290	13-7 1350	13-10 1400	14-1 1450	14-4 1500	14-9 1600	15-3 1690
	24.0	7-9 550	8-5 640	8-11 720	9-4 800	9-10 880	10-2 950	10-7 1020	10-11 1080	11-3 1150	11-6 1210	11-10 1270	12-1 1330	12-4 1390	12-7 1450	12-10 1510	13-1 1560	13-4 1620	13-9 1720	14-2 1820
	32.0					8-11 970	9-3 1040	9-7 1120	9-11 1200	10-2 1260	10-6 1340	10-9 1410	11-0 1470	11-3 1540	11-5 1590	11-8 1660	11-11 1730	12-1 1780	12-6 1900	12-10 2010

2x10	12.0	12-6 440	13-6 510	14-4 570	15-1 640	15-9 700	16-5 750	17-0 810	17-6 860	18-0 910	18-6 960	19-0 1010	19-5 1060	19-10 1100	20-3 1150	20-8 1200	21-0 1240	21-5 1280	22-1 1370	22-9 1450
	13.7	11-11 460	12-11 530	13-8 600	14-5 670	15-1 730	15-8 790	16-3 840	16-9 900	17-3 950	17-9 1010	18-2 1060	18-7 1110	19-0 1160	19-4 1200	19-9 1250	20-1 1300	20-5 1340	21-1 1430	21-9 1510
	16.0	11-4 480	12-3 560	13-0 630	13-8 700	14-4 770	14-11 830	15-5 890	15-11 950	16-5 1000	16-10 1060	17-3 1110	17-8 1160	18-0 1220	18-5 1270	18-9 1320	19-1 1360	19-5 1410	20-1 1500	20-8 1590
	19.2	10-8 510	11-6 600	12-3 670	12-11 740	13-6 810	14-0 880	14-6 940	15-0 1010	15-5 1070	15-10 1130	16-3 1180	16-7 1240	17-0 1290	17-4 1350	17-8 1400	18-0 1450	18-3 1500	18-10 1600	19-5 1690
	24.0	9-11 550	10-8 640	11-4 720	11-11 800	12-6 880	13-0 950	13-6 1020	13-11 1080	14-4 1150	14-8 1210	15-1 1270	15-5 1330	15-9 1390	16-1 1450	16-5 1510	16-8 1560	17-0 1620	17-6 1720	18-0 1820
	32.0					11-4 960	11-10 1050	12-3 1120	12-8 1200	13-0 1260	13-4 1330	13-8 1400	14-0 1470	14-4 1540	14-7 1590	14-11 1660	15-2 1720	15-5 1780	15-11 1890	16-5 2020
2x12	12.0	15-2 440	16-5 510	17-5 570	18-4 640	19-2 700	19-11 750	20-8 810	21-4 860	21-11 910	22-6 960	23-1 1010	23-7 1060	24-2 1100	24-8 1150	25-1 1200	25-7 1240	26-0 1280	26-10 1370	27-8 1450
	13.7	14-7 460	15-8 530	16-8 600	17-6 670	18-4 730	19-1 790	19-9 840	20-5 900	21-0 950	21-7 1010	22-1 1060	22-7 1110	23-1 1160	23-7 1200	24-0 1250	24-5 1300	24-10 1340	25-8 1430	26-5 1510
	16.0	13-10 480	14-11 560	15-10 630	16-8 700	17-5 770	18-1 830	18-9 890	19-4 950	19-11 1000	20-6 1060	21-0 1110	21-6 1160	21-11 1220	22-5 1270	22-10 1320	23-3 1360	23-7 1410	24-5 1500	25-1 1590
	19.2	13-0 510	14-0 600	14-11 670	15-8 740	16-5 810	17-0 880	17-8 940	18-3 1010	18-9 1070	19-3 1130	19-9 1180	20-2 1240	20-8 1290	21-1 1350	21-6 1400	21-10 1450	22-3 1500	22-11 1600	23-7 1690
	24.0	12-1 550	13-0 640	13-10 720	14-7 800	15-2 880	15-10 950	16-5 1020	16-11 1080	17-5 1150	17-11 1210	18-4 1270	18-9 1330	19-2 1390	19-7 1450	19-11 1510	20-3 1560	20-8 1620	21-4 1720	21-11 1820
	32.0					13-10 970	14-4 1040	14-11 1130	15-4 1190	15-10 1270	16-3 1340	16-8 1400	17-0 1460	17-5 1530	17-9 1590	18-1 1650	18-5 1720	18-9 1780	19-4 1890	19-11 2010

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J-3
CEILING JOISTS
20 Lbs. Per Sq. Ft. Live Load
(Limited attic storage where development of future rooms is not possible)
(Plaster Ceiling)

DESIGN CRITERIA:
Deflection - For 20 lbs. per sq. ft. live load. Limited to span in inches divided by 360.
Strength - Live load of 20 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. determines required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																	
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	5-5 430	5-10 500	6-2 560	6-6 630	6-10 680	7-1 740	7-4 790	7-7 850	7-10 900	8-0 950	8-3 990	8-5 1040	8-7 1090	8-9 1130	8-11 1170	9-1 1220	9-3 1260	9-7 1340	9-10 1420
	13.7	5-2 450	5-7 520	5-11 590	6-3 650	6-6 720	6-9 770	7-0 830	7-3 880	7-6 940	7-8 990	7-10 1040	8-1 1090	8-3 1140	8-5 1180	8-7 1230	8-8 1270	8-10 1320	9-2 1400	9-5 1490
	16.0	4-11 470	5-4 550	5-8 620	5-11 690	6-2 750	6-5 810	6-8 870	6-11 930	7-1 990	7-3 1040	7-6 1090	7-8 1140	7-10 1200	8-0 1240	8-1 1290	8-3 1340	8-5 1390	8-8 1480	8-11 1570
	19.2	4-8 500	5-0 580	5-4 660	5-7 730	5-10 800	6-1 870	6-3 930	6-6 990	6-8 1050	6-10 1110	7-0 1160	7-2 1220	7-4 1270	7-6 1320	7-8 1370	7-9 1420	7-11 1470	8-2 1570	8-5 1660
	24.0	4-4 540	4-8 630	4-11 710	5-2 790	5-5 860	5-8 930	5-10 1000	6-0 1070	6-2 1130	6-4 1190	6-6 1250	6-8 1310	6-10 1370	7-0 1420	7-1 1480	7-3 1530	7-4 1590	7-7 1690	7-10 1790
2x6	12.0	8-6 430	9-2 500	9-9 560	10-3 630	10-9 680	11-2 740	11-7 790	11-11 850	12-3 900	12-7 950	12-11 990	13-3 1040	13-6 1090	13-9 1130	14-1 1170	14-4 1220	14-7 1260	15-0 1340	15-6 1420
	13.7	8-2 450	8-9 520	9-4 590	9-10 650	10-3 720	10-8 770	11-1 830	11-5 880	11-9 940	12-1 990	12-4 1040	12-8 1090	12-11 1140	13-2 1180	13-5 1230	13-8 1270	13-11 1320	14-4 1400	14-9 1490
	16.0	7-9 470	8-4 550	8-10 620	9-4 690	9-9 750	10-2 810	10-6 870	10-10 930	11-2 990	11-5 1040	11-9 1090	12-0 1140	12-3 1200	12-6 1240	12-9 1290	13-0 1340	13-3 1390	13-8 1480	14-1 1570
	19.2	7-3 500	7-10 580	8-4 660	8-9 730	9-2 800	9-6 870	9-10 930	10-2 990	10-6 1050	10-9 1110	11-1 1160	11-4 1220	11-7 1270	11-9 1320	12-0 1370	12-3 1420	12-5 1470	12-10 1570	13-3 1660
	24.0	6-9 540	7-3 630	7-9 710	8-2 790	8-6 860	8-10 930	9-2 1000	9-6 1070	9-9 1130	10-0 1190	10-3 1250	10-6 1310	10-9 1370	10-11 1420	11-2 1480	11-4 1530	11-7 1590	11-11 1690	12-3 1790
2x8	12.0	11-3 430	12-1 500	12-10 560	13-6 630	14-2 680	14-8 740	15-3 790	15-9 850	16-2 900	16-7 950	17-0 990	17-5 1040	17-10 1090	18-2 1130	18-6 1170	18-10 1220	19-2 1260	19-10 1340	20-5 1420
	13.7	10-9 450	11-7 520	12-3 590	12-11 650	13-6 720	14-1 770	14-7 830	15-0 880	15-6 940	15-11 990	16-3 1040	16-8 1090	17-0 1140	17-5 1180	17-9 1230	18-0 1270	18-4 1320	18-11 1400	19-6 1490
	16.0	10-2 470	11-0 550	11-8 620	12-3 690	12-10 750	13-4 810	13-10 870	14-3 930	14-8 990	15-1 1040	15-6 1090	15-10 1140	16-2 1200	16-6 1240	16-10 1290	17-2 1340	17-5 1390	18-0 1480	18-6 1570
	19.2	9-7 500	10-4 580	11-0 660	11-7 730	12-1 800	12-7 870	13-0 930	13-5 990	13-10 1050	14-2 1110	14-7 1160	14-11 1220	15-3 1270	15-6 1320	15-10 1370	16-1 1420	16-5 1470	16-11 1570	17-5 1660
	24.0	8-11 540	9-7 630	10-2 710	10-9 790	11-3 860	11-8 930	12-1 1000	12-6 1070	12-10 1130	13-2 1190	13-6 1250	13-10 1310	14-2 1370	14-5 1420	14-8 1480	15-0 1530	15-3 1590	15-9 1690	16-2 1790
2x10	12.0	14-4 430	15-5 500	16-5 560	17-3 630	18-0 680	18-9 740	19-5 790	20-1 850	20-8 900	21-2 950	21-9 990	22-3 1040	22-9 1090	23-2 1130	23-8 1170	24-1 1220	24-6 1260	25-3 1340	26-0 1420
	13.7	13-8 450	14-9 520	15-8 590	16-6 650	17-3 720	17-11 770	18-7 830	19-2 880	19-9 940	20-3 990	20-9 1040	21-3 1090	21-9 1140	22-2 1180	22-7 1230	23-0 1270	23-5 1320	24-2 1400	24-10 1490
	16.0	13-0 470	14-0 550	14-11 620	15-8 690	16-5 750	17-0 810	17-8 870	18-3 930	18-9 990	19-3 1040	19-9 1090	20-2 1140	20-8 1200	21-1 1240	21-6 1290	21-10 1340	22-3 1390	22-11 1480	23-8 1570
	19.2	12-3 500	13-2 580	14-0 660	14-9 730	15-5 800	16-0 870	16-7 930	17-2 990	17-8 1050	18-1 1110	18-7 1160	19-0 1220	19-5 1270	19-10 1320	20-2 1370	20-7 1420	20-11 1470	21-7 1570	22-3 1660
	24.0	11-4 540	12-3 630	13-0 710	13-8 790	14-4 860	14-11 930	15-5 1000	15-11 1070	16-5 1130	16-10 1190	17-3 1250	17-8 1310	18-0 1370	18-5 1420	18-9 1480	19-1 1530	19-5 1590	20-1 1690	20-8 1790

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J-4
CEILING JOISTS
20 Lbs. Per Sq. Ft. Live Load
(Limited attic storage where development of future rooms is not possible)
(Drywall Ceiling)

DESIGN CRITERIA:
Deflection - For 20 lbs. per sq. ft. live load. Limited to span in inches divided by 240.
Strength - live load of 20 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. determines required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																		
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	6-2 560	6-8 660	7-1 740	7-6 820	7-10 900	8-1 970	8-5 1040	8-8 1110	8-11 1170	9-2 1240	9-5 1300	9-8 1360	9-10 1420	10-0 1480	10-3 1540	10-5 1600	10-7 1650	10-11 1760	11-3 1860
	13.7	5-11 590	6-5 690	6-9 770	7-2 860	7-6 940	7-9 1010	8-1 1090	8-4 1160	8-7 1230	8-9 1300	9-0 1360	9-3 1420	9-5 1490	9-7 1550	9-9 1610	10-0 1670	10-2 1730	10-6 1840	10-9 1950
	16.0	5-8 620	6-1 720	6-5 810	6-9 900	7-1 990	7-5 1070	7-8 1140	7-11 1220	8-1 1290	8-4 1360	8-7 1430	8-9 1500	8-11 1570	9-1 1630	9-4 1690	9-6 1760	9-8 1820	9-11 1940	10-3 2050
	19.2	5-4 660	5-9 770	6-1 870	6-5 960	6-8 1050	6-11 1130	7-2 1220	7-5 1300	7-8 1370	7-10 1450	8-1 1520	8-3 1590	8-5 1660	8-7 1730	8-9 1800	8-11 1870	9-1 1930	9-4 2060	9-8 2180
	24.0	4-11 710	5-4 830	5-8 930	5-11 1030	6-2 1130	6-5 1220	6-8 1310	6-11 1400	7-1 1480	7-3 1560	7-6 1640	7-8 1720	7-10 1790	8-0 1870	8-1 1940	8-3 2010	8-5 2080	8-8 2220	8-11 2350
2x6	12.0	9-9 560	10-6 660	11-2 740	11-9 820	12-3 900	12-9 970	13-3 1040	13-8 1110	14-1 1170	14-5 1240	14-9 1300	15-2 1360	15-6 1420	15-9 1480	16-1 1540	16-4 1600	16-8 1650	17-2 1760	17-8 1860
	13.7	9-4 590	10-0 690	10-8 770	11-3 860	11-9 940	12-3 1010	12-8 1090	13-1 1160	13-5 1230	13-10 1300	14-2 1360	14-6 1420	14-9 1490	15-1 1550	15-5 1610	15-8 1670	15-11 1730	16-5 1840	16-11 1950
	16.0	8-10 620	9-6 720	10-2 810	10-8 900	11-2 990	11-7 1070	12-0 1140	12-5 1220	12-9 1290	13-1 1360	13-5 1430	13-9 1500	14-1 1570	14-4 1630	14-7 1690	14-11 1760	15-2 1820	15-7 1940	16-1 2050
	19.2	8-4 660	9-0 770	9-6 870	10-0 960	10-6 1050	10-11 1130	11-4 1220	11-8 1300	12-0 1370	12-4 1450	12-8 1520	12-11 1590	13-3 1660	13-6 1730	13-9 1800	14-0 1870	14-3 1930	14-8 2060	15-2 2180
	24.0	7-9 710	8-4 830	8-10 930	9-4 1030	9-9 1130	10-2 1220	10-6 1310	10-10 1400	11-2 1480	11-5 1560	11-9 1640	12-0 1720	12-3 1790	12-6 1870	12-9 1940	13-0 2010	13-3 2080	13-8 2220	14-1 2350

2x8	12.0	12-10 560	13-10 660	14-8 740	15-6 820	16-2 900	16-10 970	17-5 1040	18-0 1110	18-6 1170	19-0 1240	19-6 1300	19-11 1360	20-5 1420	20-10 1480	21-2 1540	21-7 1600	21-11 1650	22-8 1760	23-4 1860
	13.7	12-3 590	13-3 690	14-1 770	14-10 860	15-6 940	16-1 1010	16-8 1090	17-2 1160	17-9 1230	18-2 1300	18-8 1360	19-1 1420	19-6 1490	19-11 1550	20-3 1610	20-8 1670	21-0 1730	21-8 1840	22-4 1950
	16.0	11-8 620	12-7 720	13-4 810	14-1 900	14-8 990	15-3 1070	15-10 1140	16-4 1220	16-10 1290	17-3 1360	17-9 1430	18-2 1500	18-6 1570	18-11 1630	19-3 1690	19-7 1760	19-11 1820	20-7 1940	21-2 2050
	19.2	11-0 660	11-10 770	12-7 870	13-3 960	13-10 1050	14-5 1130	14-11 1220	15-5 1300	15-10 1370	16-3 1450	16-8 1520	17-1 1590	17-5 1660	17-9 1730	18-2 1800	18-5 1870	18-9 1930	19-5 2060	19-11 2180
	24.0	10-2 710	11-0 830	11-8 930	12-3 1030	12-10 1130	13-4 1220	13-10 1310	14-3 1400	14-8 1480	15-1 1560	15-6 1640	15-10 1720	16-2 1790	16-6 1870	16-10 1940	17-2 2010	17-5 2080	18-0 2220	18-6 2350
2x10	12.0	16-5 560	17-8 660	18-9 740	19-9 820	20-8 900	21-6 970	22-3 1040	22-11 1110	23-8 1170	24-3 1240	24-10 1300	25-5 1360	26-0 1420	26-6 1480	27-1 1540	27-6 1600	28-0 1650	28-11 1760	29-9 1860
	13.7	15-8 590	16-11 690	17-11 770	18-11 860	19-9 940	20-6 1010	21-3 1090	21-11 1160	22-7 1230	23-3 1300	23-9 1360	24-4 1420	24-10 1490	25-5 1550	25-10 1610	26-4 1670	26-10 1730	27-8 1840	28-6 1950
	16.0	14-11 620	16-0 720	17-0 810	17-11 900	18-9 990	19-6 1070	20-2 1140	20-10 1220	21-6 1290	22-1 1360	22-7 1430	23-2 1500	23-8 1570	24-1 1630	24-7 1690	25-0 1760	25-5 1820	26-3 1940	27-1 2050
	19.2	14-0 660	15-1 770	16-0 870	16-11 960	17-8 1050	18-4 1130	19-0 1220	19-7 1300	20-2 1370	20-9 1450	21-3 1520	21-9 1590	22-3 1660	22-8 1730	23-2 1800	23-7 1870	23-11 1930	24-9 2060	25-5 2180
	24.0	13-0 710	14-0 830	14-11 930	15-8 1030	16-5 1130	17-0 1220	17-8 1310	18-3 1400	18-9 1480	19-3 1560	19-9 1640	20-2 1720	20-8 1790	21-1 1870	21-6 1940	21-10 2010	22-3 2080	22-11 2220	23-8 2350

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE J-5
CEILING JOISTS
10 Lbs. Per Sq. Ft. Live Load
(No attic storage and roof slope not steeper than 3 in 12)
(Plaster Ceiling)

DESIGN CRITERIA:
Deflection - For 10 lbs. per sq. ft. live load. Limited to span in inches divided by 360.
Strength - live load of 10 lbs. per sq. ft. plus dead load of 5 lbs. per sq. ft. determines required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																		
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	6-10 340	7-4 400	7-10 450	8-3 500	8-7 540	8-11 590	9-3 630	9-7 670	9-10 710	10-1 750	10-4 790	10-7 830	10-10 860	11-1 900	11-3 930	11-6 970	11-8 1000	12-1 1070	12-5 1130
	13.7	6-6 360	7-0 410	7-6 470	7-10 520	8-3 570	8-7 610	8-10 660	9-2 700	9-5 740	9-8 780	9-11 820	10-2 860	10-4 900	10-7 940	10-9 970	11-0 1010	11-2 1050	11-6 1110	11-10 1180
	16.0	6-2 380	6-8 440	7-1 490	7-6 550	7-10 600	8-1 650	8-5 690	8-8 740	8-11 780	9-2 830	9-5 870	9-8 910	9-10 950	10-0 990	10-3 1030	10-5 1060	10-7 1100	10-11 1170	11-3 1240
	19.2	5-10 400	6-3 460	6-8 520	7-0 580	7-4 630	7-8 690	7-11 740	8-2 790	8-5 830	8-8 880	8-10 920	9-1 970	9-3 1010	9-5 1050	9-8 1090	9-10 1130	10-0 1170	10-4 1250	10-7 1320
	24.0	5-5 430	5-10 500	6-2 560	6-6 630	6-10 680	7-1 740	7-4 790	7-7 850	7-10 900	8-0 950	8-3 990	8-5 1040	8-7 1090	8-9 1130	8-11 1170	9-1 1220	9-3 1260	9-7 1340	9-10 1420
2x6	12.0	10-9 340	11-7 400	12-3 450	12-11 500	13-6 540	14-1 590	14-7 630	15-0 670	15-6 710	15-11 750	16-3 790	16-8 830	17-0 860	17-4 900	17-8 930	18-0 970	18-4 1000	18-11 1070	19-6 1130
	13.7	10-3 360	11-1 410	11-9 470	12-4 520	12-11 570	13-5 610	13-11 660	14-4 700	14-9 740	15-2 780	15-7 820	15-11 860	16-3 900	16-7 940	16-11 970	17-3 1010	17-6 1050	18-1 1110	18-8 1180
	16.0	9-9 380	10-6 440	11-2 490	11-9 550	12-3 600	12-9 650	13-3 690	13-8 740	14-1 780	14-5 830	14-9 870	15-2 910	15-6 950	15-9 990	16-1 1030	16-4 1060	16-8 1100	17-2 1170	17-8 1240
	19.2	9-2 400	9-10 460	10-6 520	11-1 580	11-7 630	12-0 690	12-5 740	12-10 790	13-3 830	13-7 880	13-11 920	14-3 970	14-7 1010	14-10 1050	15-2 1090	15-5 1130	15-8 1170	16-2 1250	16-8 1320
	24.0	8-6 430	9-2 500	9-9 560	10-3 630	10-9 680	11-2 740	11-7 790	11-11 850	12-3 900	12-7 950	12-11 990	13-3 1040	13-6 1090	13-9 1130	14-1 1170	14-4 1220	14-7 1260	15-0 1340	15-6 1420

2x8	12.0	14-2 340	15-3 400	16-2 450	17-0 500	17-10 540	18-6 590	19-2 630	19-10 670	20-5 710	20-11 750	21-5 790	21-11 830	22-5 860	22-11 900	23-4 930	23-9 970	24-2 1000	24-11 1070	25-8 1130
	13.7	13-6 360	14-7 410	15-6 470	16-3 520	17-0 570	17-9 610	18-4 660	18-11 700	19-6 740	20-0 780	20-6 820	21-0 860	21-5 900	21-11 940	22-4 970	22-9 1010	23-1 1050	23-10 1110	24-7 1180
	16.0	12-10 380	13-10 440	14-8 490	15-6 550	16-2 600	16-10 650	17-5 690	18-0 740	18-6 780	19-0 830	19-6 870	19-11 910	20-5 950	20-10 990	21-2 1030	21-7 1060	21-11 1100	22-8 1170	23-4 1240
	19.2	12-1 400	13-0 460	13-10 520	14-7 580	15-3 630	15-10 690	16-5 740	16-11 790	17-5 830	17-11 880	18-4 920	18-9 970	19-2 1010	19-7 1050	19-11 1090	20-4 1130	20-8 1170	21-4 1250	21-11 1320
	24.0	11-3 430	12-1 500	12-10 560	13-6 630	14-2 680	14-8 740	15-3 790	15-9 850	16-2 900	16-7 950	17-0 990	17-5 1040	17-10 1090	18-2 1130	18-6 1170	18-10 1220	19-2 1260	19-10 1340	20-5 1420
2x10	12.0	18-0 340	19-5 400	20-8 450	21-9 500	22-9 540	23-8 590	24-6 630	25-3 670	26-0 710	26-9 750	27-5 790	28-0 830	28-7 860	29-2 900	29-9 930	30-4 970	30-10 1000	31-10 1070	32-9 1130
	13.7	17-3 360	18-7 410	19-9 470	20-9 520	21-9 570	22-7 610	23-5 660	24-2 700	24-10 740	25-7 780	26-2 820	26-10 860	27-5 900	27-11 940	28-6 970	29-0 1010	29-6 1050	30-5 1110	31-4 1180
	16.0	16-5 380	17-8 440	18-9 490	19-9 550	20-8 600	21-6 650	22-3 690	22-11 740	23-8 780	24-3 830	24-10 870	25-5 910	26-0 950	26-6 990	27-1 1030	27-6 1060	28-0 1100	28-11 1170	29-9 1240
	19.2	15-5 400	16-7 460	17-8 520	18-7 580	19-5 630	20-2 690	20-11 740	21-7 790	22-3 830	22-10 880	23-5 920	23-11 970	24-6 1010	25-0 1050	25-5 1090	25-11 1130	26-4 1170	27-3 1250	28-0 1320
	24.0	14-4 430	15-5 500	16-5 560	17-3 630	18-0 680	18-9 740	19-5 790	20-1 850	20-8 900	21-2 950	21-9 990	22-3 1040	22-9 1090	23-2 1130	23-8 1170	24-1 1220	24-6 1260	25-3 1340	26-0 1420

Note: The required extreme fiber stress in bending, "F_b" in pounds per square inch is shown below each span.

TABLE J-6
CEILING JOISTS
10 Lbs. Per Sq. Ft. Live Load
(No attic storage and roof slope not steeper than 3 in 12)
(Drywall Ceiling)

DESIGN CRITERIA:
Deflection - For 10 lbs. per sq. ft. live load. Limited to span in inches divided by 240.
Strength - live load of 10 lbs. per sq. ft. plus dead load of 5 lbs. per sq. ft. determines required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi																	
		0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4
2x4	12.0	7-10 450	8-5 520	8-11 590	9-5 650	9-10 710	10-3 770	10-7 830	10-11 880	11-3 930	11-7 980	11-10 1030	12-2 1080	12-5 1130	12-8 1180	12-11 1220	13-2 1270	13-4 1310	13-9 1400	14-2 1480
	13.7	7-6 470	8-1 540	8-7 610	9-0 680	9-5 740	9-9 800	10-2 860	10-6 920	10-9 970	11-1 1030	11-4 1080	11-7 1130	11-10 1180	12-1 1230	12-4 1280	12-7 1320	12-9 1370	13-2 1460	13-7 1550
	16.0	7-1 490	7-8 570	8-1 650	8-7 720	8-11 780	9-4 850	9-8 910	9-11 970	10-3 1030	10-6 1080	10-9 1140	11-0 1190	11-3 1240	11-6 1290	11-9 1340	11-11 1390	12-2 1440	12-6 1540	12-11 1630
	19.2	6-8 520	7-2 610	7-8 690	8-1 760	8-5 830	8-9 900	9-1 970	9-4 1030	9-8 1090	9-11 1150	10-2 1210	10-4 1270	10-7 1320	10-10 1380	11-0 1430	11-3 1480	11-5 1530	11-9 1630	12-2 1730
	24.0	6-2 560	6-8 660	7-1 740	7-6 820	7-10 900	8-1 970	8-5 1040	8-8 1110	8-11 1170	9-2 1240	9-5 1300	9-8 1360	9-10 1420	10-0 1480	10-3 1540	10-5 1600	10-7 1650	10-11 1760	11-3 1860
2x6	12.0	12-3 450	13-3 520	14-1 590	14-9 650	15-6 710	16-1 770	16-8 830	17-2 880	17-8 930	18-2 980	18-8 1030	19-1 1080	19-6 1130	19-11 1180	20-3 1220	20-8 1270	21-0 1310	21-8 1400	22-4 1480
	13.7	11-9 470	12-8 540	13-5 610	14-2 680	14-9 740	15-5 800	15-11 860	16-5 920	16-11 970	17-5 1030	17-10 1080	18-3 1130	18-8 1180	19-0 1230	19-5 1280	19-9 1320	20-1 1370	20-9 1460	21-4 1550
	16.0	11-2 490	12-0 570	12-9 650	13-5 720	14-1 780	14-7 850	15-2 910	15-7 970	16-1 1030	16-6 1080	16-11 1140	17-4 1190	17-8 1240	18-1 1290	18-5 1340	18-9 1390	19-1 1440	19-8 1540	20-3 1630
	19.2	10-6 520	11-4 610	12-0 690	12-8 760	13-3 830	13-9 900	14-3 970	14-8 1030	15-2 1090	15-7 1150	15-11 1210	16-4 1270	16-8 1320	17-0 1380	17-4 1430	17-8 1480	17-11 1530	18-6 1630	19-1 1730
	24.0	9-9 560	10-6 660	11-2 740	11-9 820	12-3 900	12-9 970	13-3 1040	13-8 1110	14-1 1170	14-5 1240	14-9 1300	15-2 1360	15-6 1420	15-9 1480	16-1 1540	16-4 1600	16-8 1650	17-2 1760	17-8 1860

2x8	12.0	16-2 450	17-5 520	18-6 590	19-6 650	20-5 710	21-2 770	21-11 830	22-8 880	23-4 930	24-0 980	24-7 1030	25-2 1080	25-8 1130	26-2 1180	26-9 1220	27-2 1270	27-8 1310	28-7 1400	29-5 1480
	13.7	15-6 470	16-8 540	17-9 610	18-8 680	19-6 740	20-3 800	21-0 860	21-8 920	22-4 970	22-11 1030	23-6 1080	24-0 1130	24-7 1180	25-1 1230	25-7 1280	26-0 1320	26-6 1370	27-4 1460	28-1 1550
	16.0	14-8 490	15-10 570	16-10 650	17-9 720	18-6 780	19-3 850	19-11 910	20-7 970	21-2 1030	21-9 1080	22-4 1140	22-10 1190	23-4 1240	23-10 1290	24-3 1340	24-8 1390	25-2 1440	25-11 1540	26-9 1630
	19.2	13-10 520	14-11 610	15-10 690	16-8 760	17-5 830	18-2 900	18-9 970	19-5 1030	19-11 1090	20-6 1150	21-0 1210	21-6 1270	21-11 1320	22-5 1380	22-10 1430	23-3 1480	23-8 1530	24-5 1630	25-2 1730
	24.0	12-10 560	13-10 660	14-8 740	15-6 820	16-2 900	16-10 970	17-5 1040	18-0 1110	18-6 1170	19-0 1240	19-6 1300	19-11 1360	20-5 1420	20-10 1480	21-2 1540	21-7 1600	21-11 1650	22-8 1760	23-4 1860
2x10	12.0	20-8 450	22-3 520	23-8 590	24-10 650	26-0 710	27-1 770	28-0 830	28-11 880	29-9 930	30-7 980	31-4 1030	32-1 1080	32-9 1130	33-5 1180	34-1 1220	34-8 1270	35-4 1310	36-5 1400	37-6 1480
	13.7	19-9 470	21-3 540	22-7 610	23-9 680	24-10 740	25-10 800	26-10 860	27-8 920	28-6 970	29-3 1030	30-0 1080	30-8 1130	31-4 1180	32-0 1230	32-7 1280	33-2 1320	33-9 1370	34-10 1460	35-10 1550
	16.0	18-9 490	20-2 570	21-6 650	22-7 720	23-8 780	24-7 850	25-5 910	26-3 970	27-1 1030	27-9 1080	28-6 1140	29-2 1190	29-9 1240	30-5 1290	31-0 1340	31-6 1390	32-1 1440	33-1 1540	34-1 1630
	19.2	17-8 520	19-0 610	20-2 690	21-3 760	22-3 830	23-2 900	23-11 970	24-9 1030	25-5 1090	26-2 1150	26-10 1210	27-5 1270	28-0 1320	28-7 1380	29-2 1430	29-8 1480	30-2 1530	31-2 1630	32-1 1730
	24.0	16-5 560	17-8 660	18-9 740	19-9 820	20-8 900	21-6 970	22-3 1040	22-11 1110	23-8 1170	24-3 1240	24-10 1300	25-5 1360	26-0 1420	26-6 1480	27-1 1540	27-6 1600	28-0 1650	28-11 1760	29-9 1860

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE R-1
FLAT OR SLOPED RAFTERS
Supporting Drywall Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 20 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 20 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 20 lbs. per sq. ft. live load. Limited to span in inches divided by 240.

RAFTER SIZE	SPACING (IN)	Extreme Fiber Stress in Bending, "F_b" (psi).										
		300	400	500	600	700	800	900	1000	1100	1200	1300
2x6	12.0	6-7 0.12	7-7 0.19	8-6 0.26	9-4 0.35	10-0 0.44	10-9 0.54	11-5 0.64	12-0 0.75	12-7 0.86	13-2 0.98	13-8 1.11
	13.7	6-2 0.12	7-1 0.18	7-11 0.25	8-8 0.33	9-5 0.41	10-0 0.50	10-8 0.60	11-3 0.70	11-9 0.81	12-4 0.92	12-10 1.04
	16.0	5-8 0.11	6-7 0.16	7-4 0.23	8-1 0.30	8-8 0.38	9-4 0.46	9-10 0.55	10-5 0.65	10-11 0.75	11-5 0.85	11-10 0.96
	19.2	5-2 0.10	6-0 0.15	6-9 0.21	7-4 0.27	7-11 0.35	8-6 0.42	9-0 0.51	9-6 0.59	9-11 0.68	10-5 0.78	10-10 0.88
	24.0	4-8 0.09	5-4 0.13	6-0 0.19	6-7 0.25	7-1 0.31	7-7 0.38	8-1 0.45	8-6 0.53	8-11 0.61	9-4 0.70	9-8 0.78
2x8	12.0	8-8 0.12	10-0 0.19	11-2 0.26	12-3 0.35	13-3 0.44	14-2 0.54	15-0 0.64	15-10 0.75	16-7 0.86	17-4 0.98	18-0 1.11
	13.7	8-1 0.12	9-4 0.18	10-6 0.25	11-6 0.33	12-5 0.41	13-3 0.50	14-0 0.60	14-10 0.70	15-6 0.81	16-3 0.92	16-10 1.04
	16.0	7-6 0.11	8-8 0.16	9-8 0.23	10-7 0.30	11-6 0.38	12-3 0.46	13-0 0.55	13-8 0.65	14-4 0.75	15-0 0.85	15-7 0.96
	19.2	6-10 0.10	7-11 0.15	8-10 0.21	9-8 0.27	10-6 0.35	11-2 0.42	11-10 0.51	12-6 0.59	13-1 0.68	13-8 0.78	14-3 0.88
	24.0	6-2 0.09	7-1 0.13	7-11 0.19	8-8 0.25	9-4 0.31	10-0 0.38	10-7 0.45	11-2 0.53	11-9 0.61	12-3 0.70	12-9 0.78
2x10	12.0	11-1 0.12	12-9 0.19	14-3 0.26	15-8 0.35	16-11 0.44	18-1 0.54	19-2 0.64	20-2 0.75	21-2 0.86	22-1 0.98	23-0 1.11
	13.7	10-4 0.12	11-11 0.18	13-4 0.25	14-8 0.33	15-10 0.41	16-11 0.50	17-11 0.60	18-11 0.70	19-10 0.81	20-8 0.92	21-6 1.04
	16.0	9-7 0.11	11-1 0.16	12-4 0.23	13-6 0.30	14-8 0.38	15-8 0.46	16-7 0.55	17-6 0.65	18-4 0.75	19-2 0.85	19-11 0.96
	19.2	8-9 0.10	10-1 0.15	11-3 0.21	12-4 0.27	13-4 0.35	14-3 0.42	15-2 0.51	15-11 0.59	16-9 0.68	17-6 0.78	18-2 0.88
	24.0	7-10 0.09	9-0 0.13	10-1 0.19	11-1 0.25	11-11 0.31	12-9 0.38	13-6 0.45	14-3 0.53	15-0 0.61	15-8 0.70	16-3 0.78
2x12	12.0	13-5 0.12	15-6 0.19	17-4 0.26	19-0 0.35	20-6 0.44	21-11 0.54	23-3 0.64	24-7 0.75	25-9 0.86	26-11 0.98	28-0 1.11
	13.7	12-7 0.12	14-6 0.18	16-3 0.25	17-9 0.33	19-3 0.41	20-6 0.50	21-9 0.60	23-0 0.70	24-1 0.81	25-2 0.92	26-2 1.04
	16.0	11-8 0.11	13-5 0.16	15-0 0.23	16-6 0.30	17-9 0.38	19-0 0.46	20-2 0.55	21-3 0.65	22-4 0.75	23-3 0.85	24-3 0.96
	19.2	10-8 0.10	12-3 0.15	13-9 0.21	15-0 0.27	16-3 0.35	17-4 0.42	18-5 0.51	19-5 0.59	20-4 0.68	21-3 0.78	22-2 0.88
	24.0	9-6 0.09	11-0 0.13	12-3 0.19	13-5 0.25	14-6 0.31	15-6 0.38	16-6 0.45	17-4 0.53	18-2 0.61	19-0 0.70	19-10 0.78

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-1 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F_b" (psi)											RAFTER SPACING (IN)	SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
14-2 1.24	14-8 1.37	15-2 1.51	15-8 1.66	16-1 1.81	16-7 1.96	17-0 2.12	17-5 2.28	17-10 2.44			12.0	
13-3 1.16	13-9 1.29	14-2 1.42	14-8 1.55	15-1 1.69	15-6 1.83	15-11 1.98	16-3 2.13	16-8 2.28	17-5 2.60		13.7	
12-4 1.07	12-9 1.19	13-2 1.31	13-7 1.44	13-11 1.56	14-4 1.70	14-8 1.83	15-1 1.97	15-5 2.11	16-1 2.41		16.0	2x6
11-3 0.98	11-7 1.09	12-0 1.20	12-4 1.31	12-9 1.43	13-1 1.55	13-5 1.67	13-9 1.80	14-1 1.93	14-8 2.20		19.2	
10-0 0.88	10-5 0.97	10-9 1.07	11-1 1.17	11-5 1.28	11-8 1.39	12-0 1.50	12-4 1.61	12-7 1.73	13-2 1.97	13-11 2.35	24.0	
18-9 1.24	19-5 1.37	20-0 1.51	20-8 1.66	21-3 1.81	21-10 1.96	22-4 2.12	22-11 2.28	23-6 2.44			12.0	
17-6 1.16	18-2 1.29	18-9 1.42	19-4 1.55	19-10 1.69	20-5 1.83	20-11 1.98	21-5 2.13	21-11 2.28	22-11 2.60		13.7	
16-3 1.07	16-9 1.19	17-4 1.31	17-10 1.44	18-5 1.56	18-11 1.70	19-5 1.83	19-10 1.97	20-4 2.11	21-3 2.41		16.0	2x8
14-10 0.98	15-4 1.09	15-10 1.20	16-4 1.31	16-9 1.43	17-3 1.55	17-8 1.67	18-2 1.80	18-7 1.93	19-5 2.20		19.2	
13-3 0.88	13-8 0.97	14-2 1.07	14-7 1.17	15-0 1.28	15-5 1.39	15-10 1.50	16-3 1.61	16-7 1.73	17-4 1.97	18-5 2.35	24.0	
23-11 1.24	24-9 1.37	25-6 1.51	26-4 1.66	27-1 1.81	27-10 1.96	28-7 2.12	29-3 2.28	29-11 2.44			12.0	
22-4 1.16	23-2 1.29	23-11 1.42	24-7 1.55	25-4 1.69	26-0 1.83	26-8 1.98	27-4 2.13	28-0 2.28	29-3 2.60		13.7	
20-8 1.07	21-5 1.19	22-1 1.31	22-10 1.44	23-5 1.56	24-1 1.70	24-9 1.83	25-4 1.97	25-11 2.11	27-1 2.41		16.0	2x10
18-11 0.98	19-7 1.09	20-2 1.20	20-10 1.31	21-5 1.43	22-0 1.55	22-7 1.67	23-2 1.80	23-8 1.93	24-9 2.20		19.2	
16-11 0.88	17-6 0.97	18-1 1.07	18-7 1.17	19-2 1.28	19-8 1.39	20-2 1.50	20-8 1.61	21-2 1.73	22-1 1.97	23-5 2.35	24.0	
29-1 1.24	30-1 1.37	31-1 1.51	32-0 1.66	32-11 1.81	33-10 1.96	34-9 2.12	35-7 2.28	36-5 2.44			12.0	
27-2 1.16	28-2 1.29	29-1 1.42	29-11 1.55	30-10 1.69	31-8 1.83	32-6 1.98	33-3 2.13	34-1 2.28	35-7 2.60		13.7	
25-2 1.07	26-0 1.19	26-11 1.31	27-9 1.44	28-6 1.56	29-4 1.70	30-1 1.83	30-10 1.97	31-6 2.11	32-11 2.41		16.0	2x12
23-0 0.98	23-9 1.09	24-7 1.20	25-4 1.31	26-0 1.43	26-9 1.55	27-5 1.67	28-2 1.80	28-9 1.93	30-1 2.20		19.2	
20-6 0.88	21-3 0.97	21-11 1.07	22-8 1.17	23-3 1.28	23-11 1.39	24-7 1.50	25-2 1.61	25-9 1.73	26-11 1.97	28-6 2.35	24.0	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-2
FLAT OR SLOPED RAFTERS
Supporting Drywall Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 30 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 30 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 30 lbs. per sq. ft. live load. Limited to span in inches divided by 240.

RAFTER SIZE	SPACING (IN)	Extreme Fiber Stress in Bending, "F_b" (psi).										
		300	400	500	600	700	800	900	1000	1100	1200	1300
2x6	12.0	5-10 0.13	6-8 0.19	7-6 0.27	8-2 0.36	8-10 0.45	9-6 0.55	10-0 0.66	10-7 0.77	11-1 0.89	11-7 1.01	12-1 1.14
	13.7	5-5 0.12	6-3 0.18	7-0 0.25	7-8 0.33	8-3 0.42	8-10 0.52	9-5 0.61	9-11 0.72	10-5 0.83	10-10 0.95	11-3 1.07
	16.0	5-0 0.11	5-10 0.17	6-6 0.24	7-1 0.31	7-8 0.39	8-2 0.48	8-8 0.57	9-2 0.67	9-7 0.77	10-0 0.88	10-5 0.99
	19.2	4-7 0.10	5-4 0.15	5-11 0.22	6-6 0.28	7-0 0.36	7-6 0.44	7-11 0.52	8-4 0.61	8-9 0.70	9-2 0.80	9-6 0.90
	24.0	4-1 0.09	4-9 0.14	5-4 0.19	5-10 0.25	6-3 0.32	6-8 0.39	7-1 0.46	7-6 0.54	7-10 0.63	8-2 0.72	8-6 0.81
2x8	12.0	7-8 0.13	8-10 0.19	9-10 0.27	10-10 0.36	11-8 0.45	12-6 0.55	13-3 0.66	13-11 0.77	14-8 0.89	15-3 1.01	15-11 1.14
	13.7	7-2 0.12	8-3 0.18	9-3 0.25	10-1 0.33	10-11 0.42	11-8 0.52	12-5 0.61	13-1 0.72	13-8 0.83	14-4 0.95	14-11 1.07
	16.0	6-7 0.11	7-8 0.17	8-7 0.24	9-4 0.31	10-1 0.39	10-10 0.48	11-6 0.57	12-1 0.67	12-8 0.77	13-3 0.88	13-9 0.99
	19.2	6-1 0.10	7-0 0.15	7-10 0.22	8-7 0.28	9-3 0.36	9-10 0.44	10-6 0.52	11-0 0.61	11-7 0.70	12-1 0.80	12-7 0.90
	24.0	5-5 0.09	6-3 0.14	7-0 0.19	7-8 0.25	8-3 0.32	8-10 0.39	9-4 0.46	9-10 0.54	10-4 0.63	10-10 0.72	11-3 0.81

2x10	12.0	9-9 0.13	11-3 0.19	12-7 0.27	13-9 0.36	14-11 0.45	15-11 0.55	16-11 0.66	17-10 0.77	18-8 0.89	19-6 1.01	20-4 1.14
	13.7	9-1 0.12	10-6 0.18	11-9 0.25	12-11 0.33	13-11 0.42	14-11 0.52	15-10 0.61	16-8 0.72	17-6 0.83	18-3 0.95	19-0 1.07
	16.0	8-5 0.11	9-9 0.17	10-11 0.24	11-11 0.31	12-11 0.39	13-9 0.48	14-8 0.57	15-5 0.67	16-2 0.77	16-11 0.88	17-7 0.99
	19.2	7-8 0.10	8-11 0.15	9-11 0.22	10-11 0.28	11-9 0.36	12-7 0.44	13-4 0.52	14-1 0.61	14-9 0.70	15-5 0.80	16-1 0.90
	24.0	6-11 0.09	8-0 0.14	8-11 0.19	9-9 0.25	10-6 0.32	11-3 0.39	11-11 0.46	12-7 0.54	13-2 0.63	13-9 0.72	14-4 0.81
2x12	12.0	11-10 0.13	13-8 0.19	15-4 0.27	16-9 0.36	18-1 0.45	19-4 0.55	20-6 0.66	21-8 0.77	22-8 0.89	23-9 1.01	24-8 1.14
	13.7	11-1 0.12	12-10 0.18	14-4 0.25	15-8 0.33	16-11 0.42	18-1 0.52	19-3 0.61	20-3 0.72	21-3 0.83	22-2 0.95	23-1 1.07
	16.0	10-3 0.11	11-10 0.17	13-3 0.24	14-6 0.31	15-8 0.39	16-9 0.48	17-9 0.57	18-9 0.67	19-8 0.77	20-6 0.88	21-5 0.99
	19.2	9-5 0.10	10-10 0.15	12-1 0.22	13-3 0.28	14-4 0.36	15-4 0.44	16-3 0.52	17-1 0.61	17-11 0.70	18-9 0.80	19-6 0.90
	24.0	8-5 0.09	9-8 0.14	10-10 0.19	11-10 0.25	12-10 0.32	13-8 0.39	14-6 0.46	15-4 0.54	16-1 0.63	16-9 0.72	17-5 0.81

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-2 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F_b" (psi).											RAFTER SPACING (IN)	SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
12-6 1.28	13-0 1.41	13-5 1.56	13-10 1.71	14-2 1.86	14-7 2.02	15-0 2.18	15-4 2.34	15-8 2.51			12.0	
11-9 1.19	12-2 1.32	12-6 1.46	12-11 1.60	13-3 1.74	13-8 1.89	14-0 2.04	14-4 2.19	14-8 2.35			13.7	
10-10 1.10	11-3 1.22	11-7 1.35	11-11 1.48	12-4 1.61	12-8 1,75	13-0 1.89	13-3 2.03	13-7 2.18	14-2 2.48		16.0	2x6
9-11 1.01	10-3 1.12	10-7 1.23	10-11 1.35	11-3 1.47	11-6 1.59	11-10 1.72	12-2 1.85	12-5 1.99	13-0 2.26		19.2	
8-10 0.90	9-2 1.00	9-6 1.10	9-9 1.21	10-0 1.31	10-4 1.43	10-7 1.54	10-10 1.66	11-1 1.78	11-7 2.02	12-4 2.41	24.0	
16-6 1.28	17-1 1.41	17-8 1.56	18-2 1.71	18-9 1.86	19-3 2.02	19-9 2.18	20-3 2.34	20-8 2.51			12.0	
15-5 1.19	16-0 1.32	16-6 1.46	17-0 1.60	17-6 1.74	18-0 1.89	18-5 2.04	18-11 2.19	19-4 2.35			13.7	
14-4 1.10	14-10 1.22	15-3 1.35	15-9 1.48	16-3 1.61	16-8 1.75	17-1 1.89	17-6 2.03	17-11 2.18	18-9 2.48		16.0	2x8
13-1 1.01	13-6 1.12	13-11 1.23	14-5 1.35	14-10 1.47	15-2 1.59	15-7 1.72	16-0 1.85	16-4 1.99	17-1 2.26		19.2	
11-8 0.90	12-1 1.00	12-6 1.10	12-10 1.21	13-3 1.31	13-7 1.43	13-11 1.54	14-4 1.66	14-8 1.78	15-3 2.02	16-3 2.41	24.0	

21-1 1.28	21-10 1.41	22-6 1.56	23-3 1.71	23-11 1.86	24-6 2.02	25-2 2.18	25-10 2.34	26-5 2.51			12.0	
19-8 1.19	20-5 1.32	21-1 1.46	21-9 1.60	22-4 1.74	22-11 1.89	23-7 2.04	24-2 2.19	24-8 2.35			13.7	
18-3 1.10	18-11 1.22	19-6 1.35	20-1 1.48	20-8 1.61	21-3 1.75	21-10 1.89	22-4 2.03	22-10 2.18	23-11 2.48		16.0	2x10
16-8 1.01	17-3 1.12	17-10 1.23	18-4 1.35	18-11 1.47	19-5 1.59	19-11 1.72	20-5 1.85	20-10 1.99	21-10 2.26		19.2	
14-11 0.90	15-5 1.00	15-11 1.10	16-5 1.21	16-11 1.31	17-4 1.43	17-10 1.54	18-3 1.66	18-8 1.78	19-6 2.02	20-8 2.41	24.0	
25-7 1.28	26-6 1.41	27-5 1.56	28-3 1.71	29-1 1.86	29-10 2.02	30-7 2.18	31-4 2.34	32-1 2.51			12.0	
24-0 1.19	24-10 1.32	25-7 1.46	26-5 1.60	27-2 1.74	27-11 1.89	28-8 2.04	29-4 2.19	30-0 2.35			13.7	
22-2 1.10	23-0 1.22	23-9 1.35	24-5 1.48	25-2 1.61	25-10 1.75	26-6 1.89	27-2 2.03	27-10 2.18	29-1 2.48		16.0	2x12
20-3 1.01	21-0 1.12	21-8 1.23	22-4 1.35	23-0 1.47	23-7 1.59	24-2 1.72	24-10 1.85	25-5 1.99	26-6 2.26		19.2	
18-1 0.90	18-9 1.00	19-4 1.10	20-0 1.21	20-6 1.31	21-1 1.43	21-8 1.54	22-2 1.66	22-8 1.78	23-9 2.02	25-2 2.41	24.0	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-3
FLAT OR SLOPED RAFTERS
Supporting Drywall Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 40 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 40 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 40 lbs. per sq. ft. live load. Limited to span in inches divided by 240.

RAFTER SIZE	SPACING (IN)	Extreme Fiber Stress in Bending, "F_b" (psi).										
		300	400	500	600	700	800	900	1000	1100	1200	1300
2x6	12.0	5-3 0.12	6-1 0.19	6-9 0.27	7-5 0.35	8-0 0.44	8-7 0.54	9-1 0.65	9-7 0.76	10-0 0.88	10-6 1.00	10-11 1.13
	13.7	4-11 0.12	5-8 0.18	6-4 0.25	6-11 0.33	7-6 0.42	8-0 0.51	8-6 0.61	8-11 0.71	9-5 0.82	9-10 0.93	10-3 1.05
	16.0	4-6 0.11	5-3 0.17	5-10 0.23	6-5 0.31	6-11 0.39	7-5 0.47	7-10 0.56	8-3 0.66	8-8 0.76	9-1 0.86	9-5 0.98
	19.2	4-2 0.10	4-9 0.15	5-4 0.21	5-10 0.28	6-4 0.35	6-9 0.43	7-2 0.51	7-7 0.60	7-11 0.69	8-3 0.79	8-8 0.89
	24.0	3-8 0.09	4-3 0.14	4-9 0.19	5-3 0.25	5-8 0.31	6-1 0.38	6-5 0.46	6-9 0.54	7-1 0.62	7-5 0.71	7-9 0.80
2x8	12.0	6-11 0.12	8-0 0.19	8-11 0.27	9-9 0.35	10-7 0.44	11-3 0.54	12-0 0.65	12-7 0.76	13-3 0.88	13-10 1.00	14-5 1.13
	13.7	6-6 0.12	7-6 0.18	8-4 0.25	9-2 0.33	9-11 0.42	10-7 0.51	11-2 0.61	11-10 0.71	12-5 0.82	12-11 0.93	13-6 1.05
	16.0	6-0 0.11	6-11 0.17	7-9 0.23	8-6 0.31	9-2 0.39	9-9 0.47	10-4 0.56	10-11 0.66	11-6 0.76	12-0 0.86	12-6 0.98
	19.2	5-6 0.10	6-4 0.15	7-1 0.21	7-9 0.28	8-4 0.35	8-11 0.43	9-6 0.51	10-0 0.60	10-6 0.69	10-11 0.79	11-5 0.89
	24.0	4-11 0.09	5-8 0.14	6-4 0.19	6-11 0.25	7-6 0.31	8-0 0.38	8-6 0.46	8-11 0.54	9-4 0.62	9-9 0.71	10-2 0.80

2x10	12.0	8-10 0.12	10-2 0.19	11-5 0.27	12-6 0.35	13-6 0.44	14-5 0.54	15-3 0.65	16-1 0.76	16-11 0.88	17-8 1.00	18-4 1.13
	13.7	8-3 0.12	9-6 0.18	10-8 0.25	11-8 0.33	12-7 0.42	13-6 0.51	14-3 0.61	15-1 0.71	15-10 0.82	16-6 0.93	17-2 1.05
	16.0	7-8 0.11	8-10 0.17	9-10 0.23	10-10 0.31	11-8 0.39	12-6 0.47	13-3 0.56	13-11 0.66	14-8 0.76	15-3 0.86	15-11 0.98
	19.2	7-0 0.10	8-1 0.15	9-0 0.21	9-10 0.28	10-8 0.35	11-5 0.43	12-1 0.51	12-9 0.60	13-4 0.69	13-11 0.79	14-6 0.89
	24.0	6-3 0.09	7-2 0.14	8-1 0.19	8-10 0.25	9-6 0.31	10-2 0.38	10-10 0.46	11-5 0.54	11-11 0.62	12-6 0.71	13-0 0.80
2x12	12.0	10-9 0.12	12-5 0.19	13-10 0.27	15-2 0.35	16-5 0.44	17-6 0.54	18-7 0.65	19-7 0.76	20-6 0.88	21-5 1.00	22-4 1.13
	13.7	10-0 0.12	11-7 0.18	12-11 0.25	14-2 0.33	15-4 0.42	16-5 0.51	17-5 0.61	18-4 0.71	19-3 0.82	20-1 0.93	20-11 1.05
	16.0	9-3 0.11	10-9 0.17	12-0 0.23	13-2 0.31	14-2 0.39	15-2 0.47	16-1 0.56	17-0 0.66	17-9 0.76	18-7 0.86	19-4 0.98
	19.2	8-6 0.10	9-10 0.15	10-11 0.21	12-0 0.28	12-11 0.35	13-10 0.43	14-8 0.51	15-6 0.60	16-3 0.69	17-0 0.79	17-8 0.89
	24.0	7-7 0.09	8-9 0.14	9-10 0.19	10-9 0.25	11-7 0.31	12-5 0.38	13-2 0.46	13-10 0.54	14-6 0.62	15-2 0.71	15-9 0.80

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

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TABLE R-3 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F_b" (psi).											RAFTER SPACING (IN)	SIZE (IN)
1400	1500	1600	1700	1800	1900	2000	2100	2200	2400	2700		
11-4 1.26	11-9 1.40	12-1 1.54	12-6 1.68	12-10 1.83	13-2 1.99	13-6 2.15	13-10 2.31	14-2 2.48			12.0	
10-7 1.18	11-0 1.31	11-4 1.44	11-8 1.57	12-0 1.72	12-4 1.86	12-8 2.01	13-0 2.16	13-3 2.32			13.7	
9-10 1.09	10-2 1.21	10-6 1.33	10-10 1.46	11-1 1.59	11-5 1.72	11-9 1.86	12-0 2.00	12-4 2.15	12-10 2.45		16.0	2x6
8-11 0.99	9-3 1.10	9-7 1.22	9-10 1.33	10-2 1.45	10-5 1.57	10-8 1.70	11-0 1.83	11-3 1.96	11-9 2.23		19.2	
8-0 0.89	8-3 0.99	8-7 1.09	8-10 1.19	9-1 1.30	9-4 1.41	9-7 1.52	9-10 1.63	10-0 1.75	10-6 2.00	11-1 2.38	24.0	
14-11 1.26	15-5 1.40	16-0 1.54	16-5 1.68	16-11 1.83	17-5 1.99	17-10 2.15	18-3 2.31	18-9 2.48			12.0	
14-0 1.18	14-6 1.31	14-11 1.44	15-5 1.57	15-10 1.72	16-3 1.86	16-8 2.01	17-1 2.16	17-6 2.32			13.7	
12-11 1.09	13-5 1.21	13-10 1.33	14-3 1.46	14-8 1.59	15-1 1.72	15-5 1.86	15-10 2.00	16-3 2.15	16-11 2.45		16.0	2x8
11-10 0.99	12-3 1.10	12-7 1.22	13-0 1.33	13-5 1.45	13-9 1.57	14-1 1.70	14-6 1.83	14-10 1.96	15-5 2.23		19.2	
10-7 0.89	10-11 0.99	11-3 1.09	11-8 1.19	12-0 1.30	12-4 1.41	12-7 1.52	12-11 1.63	13-3 1.75	13-10 2.00	14-8 2.38	24.0	

19-1 1.26	19-9 1.40	20-4 1.54	21-0 1.68	21-7 1.83	22-2 1.99	22-9 2.15	23-4 2.31	23-11 2.48			12.0	
17-10 1.18	18-5 1.31	19-1 1.44	19-8 1.57	20-2 1.72	20-9 1.86	21-4 2.01	21-10 2.16	22-4 2.32			13.7	
16-6 1.09	17-1 1.21	17-8 1.33	18-2 1.46	18-9 1.59	19-3 1.72	19-9 1.86	20-2 2.00	20-8 2.15	21-7 2.45		16.0	2x10
15-1 0.99	15-7 1.10	16-1 1.22	16-7 1.33	17-1 1.45	17-7 1.57	18-0 1.70	18-5 1.83	18-11 1.96	19-9 2.23		19.2	
13-6 0.89	13-11 0.99	14-5 1.09	14-10 1.19	15-3 1.30	15-8 1.41	16-1 1.52	16-6 1.63	16-11 1.75	17-8 2.00	18-9 2.38	24.0	
23-2 1.26	24-0 1.40	24-9 1.54	25-6 1.68	26-3 1.83	27-0 1.99	27-8 2.15	28-5 2.31	29-1 2.48			12.0	
21-8 1.18	22-5 1.31	23-2 1.44	23-11 1.57	24-7 1.72	25-3 1.86	25-11 2.01	26-7 2.16	27-2 2.32			13.7	
20-1 1.09	20-9 1.21	21-5 1.33	22-1 1.46	22-9 1.59	23-5 1.72	24-0 1.86	24-7 2.00	25-2 2.15	26-3 2.45		16.0	2x12
18-4 0.99	19-0 1.10	19-7 1.22	20-2 1.33	20-9 1.45	21-4 1.57	21-11 1.70	22-5 1.83	23-0 1.96	24-0 2.23		19.2	
16-5 0.89	17-0 0.99	17-6 1.09	18-1 1.19	18-7 1.30	19-1 1.41	19-7 1.52	20-1 1.63	20-6 1.75	21-5 2.00	22-9 2.38	24.0	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-4
FLAT OR SLOPED RAFTERS
Supporting Plaster Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 20 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 20 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 20 lbs. per sq. ft. live load. Limited to span in inches divided by 360.

RAFTER SIZE	SPACING (IN)	Extreme Fiber Stress in Bending, "F_b" (psi).									
		300	400	500	600	700	800	900	1000	1100	1200
2x6	12.0	6-7 0.18	7-7 0.28	8-6 0.40	9-4 0.52	10-0 0.66	10-9 0.80	11-5 0.96	12-0 1.12	12-7 1.29	13-2 1.48
	13.7	6-2 0.17	7-1 0.27	7-11 0.37	8-8 0.49	9-5 0.61	10-0 0.75	10-8 0.90	11-3 1.05	11-9 1.21	12-4 1.38
	16.0	5-8 0.16	6-7 0.25	7-4 0.34	8-1 0.45	8-8 0.57	9-4 0.70	9-10 0.83	10-5 0.97	10-11 1.12	11-5 1.28
	19.2	5-2 0.15	6-0 0.22	6-9 0.31	7-4 0.41	7-11 0.52	8-6 0.63	9-0 0.76	9-6 0.89	9-11 1.02	10-5 1.17
	24.0	4-8 0.13	5-4 0.20	6-0 0.28	6-7 0.37	7-1 0.46	7-7 0.57	8-1 0.68	8-6 0.79	8-11 0.92	9-4 1.04
2x8	12.0	8-8 0.18	10-0 0.28	11-2 0.40	12-3 0.52	13-3 0.66	14-2 0.80	15-0 0.96	15-10 1.12	16-7 1.29	17-4 1.48
	13.7	8-1 0.17	9-4 0.27	10-6 0.37	11-6 0.49	12-5 0.61	13-3 0.75	14-0 0.90	14-10 1.05	15-6 1.21	16-3 1.38
	16.0	7-6 0.16	8-8 0.25	9-8 0.34	10-7 0.45	11-6 0.57	12-3 0.70	13-0 0.83	13-8 0.97	14-4 1.12	15-0 1.28
	19.2	6-10 0.15	7-11 0.22	8-10 0.31	9-8 0.41	10-6 0.52	11-2 0.63	11-10 0.76	12-6 0.89	13-1 1.02	13-8 1.17
	24.0	6-2 0.13	7-1 0.20	7-11 0.28	8-8 0.37	9-4 0.46	10-0 0.57	10-7 0.68	11-2 0.79	11-9 0.92	12-3 1.04
2x10	12.0	11-1 0.18	12-9 0.28	14-3 0.40	15-8 0.52	16-11 0.66	18-1 0.80	19-2 0.96	20-2 1.12	21-2 1.29	22-1 1.48
	13.7	10-4 0.17	11-11 0.27	13-4 0.37	14-8 0.49	15-10 0.61	16-11 0.75	17-11 0.90	18-11 1.05	19-10 1.21	20-8 1.38
	16.0	9-7 0.16	11-1 0.25	12-4 0.34	13-6 0.45	14-8 0.57	15-8 0.70	16-7 0.83	17-6 0.97	18-4 1.12	19-2 1.28
	19.2	8-9 0.15	10-1 0.22	11-3 0.31	12-4 0.41	13-4 0.52	14-3 0.63	15-2 0.76	15-11 0.89	16-9 1.02	17-6 1.17
	24.0	7-10 0.13	9-0 0.20	10-1 0.28	11-1 0.37	11-11 0.46	12-9 0.57	13-6 0.68	14-3 0.79	15-0 0.92	15-8 1.04
2x12	12.0	13-5 0.18	15-6 0.28	17-4 0.40	19-0 0.52	20-6 0.66	21-11 0.80	23-3 0.96	24-7 1.12	25-9 1.29	26-11 1.48
	13.7	12-7 0.17	14-6 0.27	16-3 0.37	17-9 0.49	19-3 0.61	20-6 0.75	21-9 0.90	23-0 1.05	24-1 1.21	25-2 1.38
	16.0	11-8 0.16	13-5 0.25	15-0 0.34	16-6 0.45	17-9 0.57	19-0 0.70	20-2 0.83	21-3 0.97	22-4 1.12	23-3 1.28
	19.2	10-8 0.15	12-3 0.22	13-9 0.31	15-0 0.41	16-3 0.52	17-4 0.63	18-5 0.76	19-5 0.89	20-4 1.02	21-3 1.17
	24.0	9-6 0.13	11-0 0.20	12-3 0.28	13-5 0.37	14-6 0.46	15-6 0.57	16-6 0.68	17-4 0.79	18-2 0.92	19-0 1.04

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-4 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F_b" (psi).									RAFTER SPACING (IN)	SIZE (IN)
1300	1400	1500	1600	1700	1800	1900	2000	2100		
13-8 1.66	14 2 1.86	14 8 2.06	15 2 2.27	15 8 2.49					12.0	
12 10 1.56	13 3 1.74	13 9 1.93	14-2 2.12	14 8 2 33	15 1 2.54				13.7	
11 10 1.44	12-4 1.61	12-9 1.79	13-2 1.97	13 7 2.15	13 11 2.35	14 4 2 55			16.0	2×6
10-10 1.32	11 3 1.47	11 7 1.63	12 0 1.80	12 4 1 97	12 9 2.14	13 1 2.32	13 5 2.51		19.2	
9-8 1.18	10 0 1.31	10 5 1.46	10 9 1.61	11 1 1 76	11 5 1.92	11 8 2 08	12 0 2.24	12 4 2 41	24.0	
18 0 1 66	18-9 1.86	19 5 2.06	20 0 2.27	20 8 2.49					12 0	
16 10 1.56	17 6 1.74	18 2 1.93	18 9 2.12	19 4 2 33	19 10 2 54				13.7	
15 7 1.44	16 3 1.61	16 9 1.79	17 4 1.97	17 10 2.15	18 5 2 35	18 11 2 55			16.0	2×8
14 3 1.32	14 10 1.47	15 4 1.63	15 10 1.80	16 4 1.97	16 9 2 14	17 3 2 32	17 8 2 51		19.2	
12 9 1 18	13 3 1.31	13 8 1 46	14 2 1 61	14 7 1.76	15 0 1 92	15 5 2 08	15 10 2.24	16 3 2 41	24 0	

23 0 1 66	23 11 1 86	24 9 2 06	25 6 2 27	26 4 2 49					12 0	
21 6 1 56	22 4 1 74	23 2 1 93	23 11 2 12	24 7 2 33	25 4 2 54				13 7	
19 11 1 44	20 8 1 61	21 5 1 79	22 1 1 97	22 10 2 15	23 5 2 35	24 1 2 55			16 0	2×10
18 2 1 32	18 11 1 47	19 7 1 63	20 2 1 80	20 10 1 97	21 5 2 14	22 0 2 32	22 7 2 51		19.2	
16 3 1 18	16 11 1 31	17 6 1 46	18 1 1 61	18 7 1 76	19 2 1 92	19 8 2 08	20 2 2 24	20 8 2 41	24 0	
28 0 1 66	29 1 1 86	30 1 2 06	31 1 2 27	32 0 2 49					12 0	
26 2 1 56	27 2 1 74	28 2 1 93	29 1 2 12	29 11 2 33	30 10 2 54				13 7	
24 3 1 44	25 2 1 61	26 0 1 79	26 11 1 97	27 9 2 15	28 6 2 35	29 4 2 55			16 0	2×12
22 2 1 32	23 0 1 47	23 9 1 63	24 7 1 80	25 4 1 97	26 0 2 14	26 9 2 32	27 5 2 51		19 2	
19 10 1 18	20 6 1 31	21 3 1 46	21 11 1 61	22 8 1 76	23 3 1 92	23 11 2 08	24 7 2 24	25 2 2 41	24 0	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

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TABLE R-5
FLAT OR SLOPED RAFTERS
Supporting Plaster Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 30 lb. per sq. ft.

DESIGN CRITERIA:
Strength - 15 lbs. per sq. ft. dead load plus 30 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 30 lbs. per sq. ft. live load. Limited to Span in inches divided by 360.

RAFTER SIZE	SPACING (IN)	Extreme Fiber Stress in Bending, "F_b" (psi).									
		300	400	500	600	700	890	900	1000	1100	1200
2x6	12.0	5-10 0.19	6-8 0.29	7-6 0.41	8-2 0.54	8-10 0.68	9-6 0.83	10-0 0.99	10-7 1.15	11-1 1.33	11-7 1.52
	13.7	5-5 0.18	6-3 0.27	7-0 0.38	7-8 0.50	8-3 0.63	8-10 0.77	9-5 0.92	9-11 1.08	10 5 1.25	10 10 1.42
	16.0	5-0 0.16	5-10 0.25	6-6 0.35	7-1 0.46	7-8 0.59	8-2 0.72	8-8 0.85	9-2 1.00	9-7 1.15	10 0 1.31
	19.2	4-7 0.15	5-4 0.23	5-11 0.32	6-6 0.42	7-0 0.53	7-6 0.65	7-11 0.78	8-4 0.91	8-9 1.05	9 2 1.20
	24.0	4-1 0.13	4-9 0.21	5-4 0.29	5-10 0.38	6-3 0.48	6-8 0.58	7-1 0.70	7-6 0.82	7-10 0.94	8 2 1.07
2x8	12.0	7-8 0.19	8-10 0.29	9-10 0.41	10-10 0.54	11 8 0.68	12-6 0.83	13-3 0.99	13 11 1.15	14-8 1.33	15 3 1.52
	13.7	7-2 0.18	8-3 0.27	9-3 0.38	10-1 0.50	10 11 0.63	11-8 0.77	12-5 0.92	13-1 1.08	13-8 1.25	14-4 1.42
	16.0	6-7 0.16	7-8 0.25	8 7 0.35	9-4 0.46	10-1 0.59	10-10 0.72	11-6 0.85	12 1 1.00	12 8 1.15	13 3 1.31
	19.2	6-1 0.15	7-0 0.23	7-10 0.32	8 7 0.42	9-3 0.53	9-10 0.65	10-6 0.78	11 0 0.91	11 7 1.05	12 1 1.20
	24.0	5-5 0.13	6-3 0.21	7-0 0.29	7-8 0.38	8 3 0.48	8-10 0.58	9-4 0.70	9 10 0.82	10-4 0.94	10 10 1.07
2x10	12.0	9-9 0.19	11-3 0.29	12-7 0.41	13-9 0.54	14 11 0.68	15 11 0.83	16-11 0.99	17 10 1.15	18-8 1.33	19-6 1.52
	13.7	9-1 0.18	10-6 0.27	11 9 0.38	12-11 0.50	13 11 0.63	14-11 0.77	15-10 0.92	16 8 1.08	17 6 1.25	18 3 1.42
	16.0	8-5 0.16	9-9 0.25	10-11 0.35	11 11 0.46	12 11 0.59	13 9 0.72	14 8 0.85	15 5 1.00	16 2 1.15	16-11 1.31
	19.2	7-8 0.15	8 11 0.23	9-11 0.32	10 11 0.42	11 9 0.53	12 7 0.65	13 4 0.78	14 1 0.91	14 9 1.05	15 5 1.20
	24.0	6-11 0.13	8 0 0.21	8-11 0.29	9-9 0.38	10 6 0.48	11 3 0.58	11 11 0.70	12 7 0.82	13 2 0.94	13 9 1.07
2x12	12.0	11-10 0.19	13 8 0.29	15-4 0.41	16-9 0.54	18-1 0.68	19 4 0.83	20 6 0.99	21 8 1.15	22-8 1.33	23 9 1.52
	13.7	11-1 0.18	12-10 0.27	14 4 0.38	15 8 0.50	16 11 0.63	18 1 0.77	19 3 0.92	20 3 1.08	21 3 1.25	22 2 1.42
	16.0	10-3 0.16	11-10 0.25	13 3 0.35	14 6 0.46	15 8 0.59	16 9 0.72	17 9 0.85	18 9 1.00	19 8 1.15	20 6 1.31
	19.2	9-5 0.15	10-10 0.23	12-1 0.32	13-3 0.42	14 4 0.53	15 4 0.65	16 3 0.78	17 1 0.91	17 11 1.05	18 9 1.20
	24.0	8-5 0.13	9 8 0.21	10-10 0.29	11-10 0.38	12 10 0.48	13 8 0.58	14 6 0.70	15 4 0.82	16 1 0.94	16 9 1.07

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-5 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F_b" (psi).									RAFTER SPACING (IN)	SIZE (IN)
1300	1400	1500	1600	1700	1800	1900	2000	2100		
12 1 1.71	12 6 1 91	13 0 2 12	13 5 2.34	13 10 2.56					12.0	
11 3 1.60	11 9 1.79	12 2 1.98	12 6 2.19	12 11 2.39					13.7	
10 5 1.48	10 10 1.66	11 3 1.84	11 7 2.02	11 11 2.22	12 4 2.41				16.0	2x6
9 6 1 35	9 11 1 51	10 3 1 68	10 7 1.85	10 11 2 02	11 3 2.20	11 6 2 39	11 10 2.58		19.2	
8 6 1 21	8 10 1 35	9 2 1.50	9 6 1.65	9 9 1 81	10 0 1.97	10 4 2 14	10 7 2.31	10 10 2.48	24.0	
15 11 1.71	16 6 1 91	17 1 2 12	17 8 2 34	18 2 2.56					12.0	
14 11 1 60	15 5 1 79	16 0 1 98	16 6 2 19	17 0 2.39					13.7	
13 9 1 48	14 4 1 66	14 10 1 84	15 3 2.02	15 9 2 22	16 3 2 41				16.0	2x8
12 7 1.35	13 1 1 51	13 6 1 68	13 11 1 85	14 5 2 02	14 10 2.20	15 2 2 39	15 7 2 58		19.2	
11 3 1.21	11 8 1 35	12 1 1 50	12 6 1 65	12 10 1 81	13 3 1.97	13 7 2 14	13 11 2 31	14 4 2 48	24.0	

20 4 1 71	21 1 1 91	21 10 2 12	22 6 2 34	23 3 2 56					12.0	
19 0 1 60	19 8 1 79	20 5 1 98	21 1 2 19	21 9 2 39					13.7	
17 7 1 48	18 3 1 66	18 11 1 84	19 6 2 02	20 1 2 22	20 8 2 41				16.0	2x10
16 1 1 35	16 8 1 51	17 3 1 68	17 10 1 85	18 4 2 02	18 11 2 20	19 5 2 39	19 11 2 58		19.2	
14 4 1.21	14 11 1 35	15 5 1 50	15 11 1 65	16 5 1 81	16 11 1 97	17 4 2 14	17 10 2 31	18 3 2 48	24.0	
24 8 1 71	25 7 1 91	26 6 2 12	27 5 2 34	28 3 2 56					12 0	
23 1 1.60	24 0 1 79	24 10 1 98	25 7 2 19	26 5 2 39					13.7	
21 5 1 48	22 2 1 66	23 0 1 84	23 9 2 02	24 5 2 22	25 2 2 41				16 0	2x12
19 6 1 35	20 3 1 51	21 0 1 68	21 8 1 85	22 4 2 02	23 0 2 20	23 7 2 39	24 2 2 58		19.2	
17 5 1 21	18 1 1 35	18 9 1 50	19 4 1 65	20 0 1 81	20 6 1 97	21 1 2 14	21 8 2 31	22 2 2 48	24.0	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-6
FLAT OR SLOPED RAFTERS
Supporting Plaster Ceiling
(Flat roof or cathedral ceiling with no attic space)
Live Load - 40 lb. per sq. ft.

DESIGN CRITERIA::
Strength - 15 lbs. per sq. ft. dead load plus 40 lbs. per sq. ft. live load determines required fiber stress.
Deflection - For 40 lbs. per sq. ft. live load. Limited to span in inches divided by 360.

RAFTER SIZE (IN)	SPACING (IN)	Extreme Fiber Stress in Bending, "F_b" (psi). 300	400	500	600	700	800	900	1000	1100	1200
2x6	12.0	5-3 0.19	6-1 0.29	6-9 0.40	7-5 0.53	8-0 0.67	8-7 0.82	9-1 0.97	9-7 1.14	10-0 1.31	10-6 1.50
	13.7	4-11 0.18	5-8 0.27	6-4 0.38	6-11 0.50	7-6 0.62	8-0 0.76	8-6 0.91	8-11 1.07	9-5 1.23	9-10 1.40
	16.0	4-6 0.16	5-3 0.25	5-10 0.35	6-5 0.46	6-11 0.58	7-5 0.71	7-10 0.84	8-3 0.99	8-8 1.14	9-1 1.30
	19.2	4-2 0.15	4-9 0.23	5-4 0.32	5-10 0.42	6-4 0.53	6-9 0.64	7-2 0.77	7-7 0.90	7-11 1.04	8-3 1.18
	24.0	3-8 0.13	4-3 0.20	4-9 0.28	5-3 0.37	5-8 0.47	6-1 0.58	6-5 0.69	6-9 0.81	7-1 0.93	7-5 1.06
2x8	12.0	6-11 0.19	8-0 0.29	8-11 0.40	9-9 0.53	10-7 0.67	11-3 0.82	12-0 0.97	12-7 1.14	13-3 1.31	13-10 1.50
	13.7	6-6 0.18	7-6 0.27	8-4 0.38	9-2 0.50	9-11 0.62	10-7 0.76	11-2 0.91	11-10 1.07	12-5 1.23	12-11 1.40
	16.0	6-0 0.16	6-11 0.25	7-9 0.35	8-6 0.46	9-2 0.58	9-9 0.71	10-4 0.84	10-11 0.99	11-6 1.14	12-0 1.30
	19.2	5-6 0.15	6-4 0.23	7-1 0.32	7-9 0.42	8-4 0.53	8-11 0.64	9-6 0.77	10-0 0.90	10-6 1.04	10-11 1.18
	24.0	4-11 0.13	5-8 0.20	6-4 0.28	6-11 0.37	7-6 0.47	8-0 0.58	8-6 0.69	8-11 0.81	9-4 0.93	9-9 1.06

2x10	12.0	8-10 0.19	10-2 0.29	11-5 0.40	12-6 0.53	13-6 0.67	14-5 0.82	15-3 0.97	16-1 1.14	16-11 1.31	17-8 1.50
	13.7	8-3 0.18	9-6 0.27	10-8 0.38	11-8 0.50	12-7 0.62	13-6 0.76	14-3 0.91	15-1 1.07	15-10 1.23	16-6 1.40
	16.0	7-8 0.16	8-10 0.25	9-10 0.35	10-10 0.46	11-8 0.58	12-6 0.71	13-3 0.84	13-11 0.99	14-8 1.14	15-3 1.30
	19.2	7-0 0.15	8-1 0.23	9-0 0.32	9-10 0.42	10-8 0.53	11-5 0.64	12-1 0.77	12-9 0.90	13-4 1.04	13-11 1.18
	24.0	6-3 0.13	7-2 0.20	8-1 0.28	8-10 0.37	9-6 0.47	10-2 0.58	10-10 0.69	11-5 0.81	11-11 0.93	12-6 1.06
2x12	12.0	10-9 0.19	12-5 0.29	13-10 0.40	15-2 0.53	16-5 0.67	17-6 0.82	18-7 0.97	19-7 1.14	20-6 1.31	21-5 1.50
	13.7	10-0 0.18	11-7 0.27	12-11 0.38	14-2 0.50	15-4 0.62	16-5 0.76	17-5 0.91	18-4 1.07	19-3 1.23	20-1 1.40
	16.0	9-3 0.16	10-9 0.25	12-0 0.35	13-2 0.46	14-2 0.58	15-2 0.71	16-1 0.84	17-0 0.99	17-9 1.14	18-7 1.30
	19.2	8-6 0.15	9-10 0.23	10-11 0.32	12-0 0.42	12-11 0.53	13-10 0.64	14-8 0.77	15-6 0.90	16-3 1.04	17-0 1.18
	24.0	7-7 0.13	8-9 0.20	9-10 0.28	10-9 0.37	11-7 0.47	12-5 0.58	13-2 0.69	13-10 0.81	14-6 0.93	15-2 1.06

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE R-6 (cont.)

RAFTERS: Spans are measured along the horizontal projection and loads are considered as applied on the horizontal projection.

Extreme Fiber Stress in Bending, "F_b" (psi).									RAFTER SPACING (IN)	SIZE (IN)
1300	1400	1500	1600	1700	1800	1900	2000	2100		
10-11 1.69	11-4 1.89	11-9 2.09	12-1 2.31	12-6 2.53					12.0	2x6
10-3 1.58	10-7 1.77	11-0 1.96	11-4 2.16	11-8 2.36	12-0 2.57				13.7	
9-5 1.46	9-10 1.63	10-2 1.81	10-6 2.00	10-10 2.19	11-1 2.38	11-5 2.58			16.0	
8-8 1.34	8-11 1.49	9-3 1.65	9-7 1.82	9-10 2.00	10-2 2.18	10-5 2.36	10-8 2.55		19.2	
7-9 1.19	8-0 1.33	8-3 1.48	8-7 1.63	8-10 1.79	9-1 1.95	9-4 2.11	9-7 2.28	9-10 2.45	24.0	
14-5 1.69	14-11 1.89	15-5 2.09	16-0 2.31	16-5 2.53					12.0	2x8
13-6 1.58	14-0 1.77	14-6 1.96	14-11 2.16	15-5 2.36	15-10 2.57				13.7	
12-6 1.46	12-11 1.63	13-5 1.81	13-10 2.00	14-3 2.19	14-8 2.38	15-1 2.58			16.0	
11-5 1.34	11-10 1.49	12-3 1.65	12-7 1.82	13-0 2.00	13-5 2.18	13-9 2.36	14-1 2.55		19.2	
10-2 1.19	10-7 1.33	10-11 1.48	11-3 1.63	11-8 1.79	12-0 1.95	12-4 2.11	12-7 2.28	12-11 2.45	24.0	

18-4 1.69	19-1 1.89	19-9 2.09	20-4 2.31	21-0 2.53					12.0	2x10
17-2 1.58	17-10 1.77	18-5 1.96	19-1 2.16	19-8 2.36	20-2 2.57				13.7	
15-11 1.46	16-6 1.63	17-1 1.81	17-8 2.00	18-2 2.19	18-9 2.38	19-3 2.58			16.0	
14-6 1.34	15-1 1.49	15-7 1.65	16-1 1.82	16-7 2.00	17-1 2.18	17-7 2.36	18-0 2.55		19.2	
13-0 1.19	13-6 1.33	13-11 1.48	14-5 1.63	14-10 1.79	15-3 1.95	15-8 2.11	16-1 2.28	16-6 2.45	24.0	
22-4 1.69	23-2 1.89	24-0 2.09	24-9 2.31	25-6 2.53					12.0	2x12
20-11 1.58	21-8 1.77	22-5 1.96	23-2 2.16	23-11 2.36	24-7 2.57				13.7	
19-4 1.46	20-1 1.63	20-9 1.81	21-5 2.00	22-1 2.19	22-9 2.38	23-5 2.58			16.0	
17-8 1.34	18-4 1.49	19-0 1.65	19-7 1.82	20-2 2.00	20-9 2.18	21-4 2.36	21-11 2.55		19.2	
15-9 1.19	16-5 1.33	17-0 1.48	17-6 1.63	18-1 1.79	18-7 1.95	19-1 2.11	19-7 2.28	20-1 2.45	24.0	

Note: The required modulus of elasticity, "E", in 1,000,000 pounds per square inch is shown below each span.

TABLE TSJ-1
TWO-SPAN FLOOR JOISTS
40 Lbs. Per Sq. Ft. Live Load
(All rooms except those used for sleeping areas and attic floors)

DESIGN CRITERIA:
Deflection - For 40 lbs. per sq. ft. live load on one span and 20 lbs. per sq. ft. on other. Limited to span in inches divided by 360.
Strength - Live load of 40 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. on both spans determines the required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi															
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4	2.6
2x6	12.0	10-3 1060	10-8 1150	11-1 1230	11-5 1310	11-9 1390	12-1 1460	12-5 1540	12-8 1610	13-0 1680	13-3 1750	13-6 1820	13-9 1880	14-0 1950	14-2 2010	14-5 2080	14-8 2140
	13.7	9-10 1110	10-3 1200	10-7 1280	10-11 1370	11-3 1450	11-7 1530	11-10 1610	12-2 1680	12-5 1760	12-8 1830	12-11 1900	13-1 1970	13-4 2040	13-7 2100	13-9 2170	14-0 2240
	16.0	9-4 1170	9-9 1260	10-1 1350	10-5 1440	10-8 1530	11-0 1610	11-3 1690	11-6 1770	11-9 1850	12-0 1920	12-3 2000	12-6 2070	12-8 2140	12-11 2210	13-2 2280	13-4 2350
	19.2	8-9 1240	9-2 1340	9-6 1440	9-9 1530	10-1 1620	10-4 1710	10-7 1800	10-10 1880	11-1 1960	11-4 2040	11-6 2120	11-9 2200	11-11 2280	12-2 2350	12-4 2430	12-6 2500
	24.0	8-2 1330	8-6 1440	8-9 1550	9-1 1650	9-4 1750	9-7 1840	9-10 1940	10-1 2030	10-3 2120	10-6 2200	10-8 2290	10-11 2370	11-1 2450	11-3 2530	11-5 2610	11-7 2690
2x8	12.0	13-7 1060	14-1 1150	14-7 1230	15-1 1310	15-6 1390	15-11 1460	16-4 1540	16-9 1610	17-1 1680	17-5 1750	17-9 1820	18-1 1880	18-5 1950	18-9 2010	19-0 2080	19-4 2140
	13.7	13-0 1110	13-6 1200	14-0 1290	14-5 1370	14-10 1450	15-3 1530	15-8 1610	16-0 1680	16-4 1760	16-8 1830	17-0 1900	17-4 1970	17-7 2040	17-11 2110	18-2 2180	18-6 2240
	16.0	12-4 1170	12-10 1260	13-3 1350	13-8 1440	14-1 1530	14-6 1610	14-10 1690	15-2 1770	15-6 1850	15-10 1930	16-2 2000	16-5 2070	16-9 2150	17-0 2220	17-3 2290	17-6 2360
	19.2	11-7 1240	12-1 1340	12-6 1440	12-11 1530	13-3 1620	13-8 1710	14-0 1800	14-4 1880	14-7 1970	14-11 2050	15-2 2130	15-6 2200	15-9 2280	16-0 2360	16-3 2430	16-6 2500
	24.0	10-9 1340	11-2 1440	11-7 1550	12-0 1650	12-4 1750	12-8 1840	13-0 1940	13-3 2030	13-7 2320	13-10 2200	14-1 2290	14-4 2370	14-7 2460	14-10 2540	15-1 2620	15-4 2700

2x10	12.0	17-4 1060	18-0 1150	18-8 1230	19-3 1310	19-10 1390	20-4 1460	20-10 1540	21-4 1610	21-10 1680	22-3 1750	22-8 1820	23-1 1880	23-6 1950	23-11 2010	24-3 2080	24-8 2140
	13.7	16-7 1110	17-3 1200	17-10 1290	18-5 1370	19-0 1450	19-6 1530	20-0 1610	20-5 1680	20-10 1760	21-4 1830	21-9 1900	22-1 1970	22-6 2040	22-10 2110	23-3 2170	23-7 2240
	16.0	15-9 1170	16-4 1260	16-11 1350	17-6 1440	18-0 1530	18-6 1610	19-0 1690	19-5 1770	19-10 1850	20-3 1930	20-7 2000	21-0 2070	21-4 2150	21-9 2220	22-1 2290	22-5 2360
	19.2	14-10 1240	15-5 1340	15-11 1440	16-6 1530	16-11 1620	17-5 1710	17-10 1800	18-3 1880	18-8 1970	19-0 2050	19-5 2130	19-9 2200	20-1 2280	20-5 2360	20-9 2430	21-1 2500
	24.0	13-9 1340	14-3 1440	14-9 1550	15-3 1650	15-9 1750	16-2 1840	16-7 1940	16-11 2030	17-4 2120	17-8 2200	18-0 2290	18-4 2370	18-8 2460	19-0 2540	19-3 2620	19-7 2700
2x12	12.0	21-1 1060	21-11 1150	22-8 1230	23-5 1310	24-1 1390	24-9 1460	25-5 1540	26-0 1610	26-7 1680	27-1 1750	27-7 1820	28-1 1880	28-7 1950	29-1 2010	29-6 2080	30-0 2140
	13.7	20-2 1110	20-11 1200	21-8 1290	22-5 1370	23-1 1450	23-8 1530	24-2 1610	24-10 1680	25-5 1760	25-11 1830	26-5 1900	26-11 1970	27-4 2040	27-9 2110	28-3 2170	28-8 2240
	16.0	19-2 1170	19-11 1260	20-7 1350	21-3 1440	21-11 1530	22-6 1610	23-1 1690	23-7 1770	24-1 1850	24-7 1930	25-1 2000	25-7 2070	26-0 2150	26-5 2220	26-10 2290	27-3 2360
	19.2	18-0 1240	18-9 1340	19-5 1440	20-0 1530	20-7 1620	21-2 1710	21-8 1800	22-3 1880	22-8 1970	23-2 2050	23-7 2130	24-0 2200	24-5 2280	24-10 2360	25-3 2430	25-7 2500
	24.0	16-9 1340	17-5 1440	18-0 1550	18-7 1650	19-2 1750	19-8 1840	20-2 1940	20-8 2030	21-1 2120	21-6 2200	21-11 2290	22-4 2370	22-8 2460	23-1 2540	23-5 2620	23-9 2700

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

TABLE TSJ-2
TWO-SPAN FLOOR JOISTS
30 Lbs. Per Sq. Ft. Live Load
(All rooms used for sleeping and attic floors)

DESIGN CRITERIA:
Deflection - For 30 lbs. per sq. ft. live load on one span and 15 lbs. per sq. ft. on other
Limited to span in inches divided by 360.
Strength - Live load of 30 lbs. per sq. ft. plus dead load of 10 lbs. per sq. ft. on both spans determines the required fiber stress value.

JOIST SIZE	SPACING (IN)	Modulus of Elasticity, "E", in 1,000,000 psi															
		0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.2	2.4	2.6
2x6	12.0	11-4 1030	11-9 1110	12-2 1190	12-7 1270	13-0 1340	13-4 1420	13-8 1490	14-0 1560	14-3 1630	14-7 1700	14-10 1760	15-1 1830	15-5 1890	15-8 1950	15-10 2010	16-1 2070
	13.7	10-10 1070	11-3 1160	11-8 1250	12-0 1330	12-5 1410	12-9 1480	13-1 1560	13-4 1630	13-8 1700	13-11 1770	14-2 1840	14-5 1910	14-8 1970	14-11 2040	15-2 2100	15-5 2170
	16.0	10-3 1130	10-8 1220	11-1 1310	11-5 1400	11-9 1480	12-1 1560	12-5 1640	12-8 1720	13-0 1790	13-3 1870	13-6 1940	13-9 2010	14-0 2080	14-2 2150	14-5 2210	14-8 2280
	19.2	9-8 1200	10-1 1300	10-5 1390	10-9 1480	11-1 1570	11-5 1660	11-8 1740	11-11 1820	12-2 1900	12-5 1980	12-8 2060	12-11 2130	13-2 2210	13-4 2280	13-7 2350	13-9 2420
	24.0	9-0 1290	9-4 1400	9-8 1500	10-0 1600	10-3 1690	10-7 1790	10-10 1880	11-1 1960	11-4 2050	11-7 2130	11-9 2220	12-0 2300	12-2 2380	12-5 2460	12-7 2530	12-9 2610
2x8	12.0	14-11 1030	15-6 1110	16-1 1190	16-7 1270	17-1 1350	17-7 1420	18-0 1490	18-5 1560	18-10 1630	19-2 1700	19-7 1760	19-11 1830	20-3 1890	20-7 1950	20-11 2010	21-3 2070
	13.7	14-3 1080	14-10 1160	15-5 1250	15-11 1330	16-4 1410	16-10 1480	17-3 1560	17-7 1630	18-0 1700	18-4 1770	18-9 1840	19-1 1910	19-5 1980	19-9 2040	20-0 2110	20-4 2170
	16.0	13-7 1130	14-1 1220	14-7 1310	15-1 1400	15-6 1480	15-11 1560	16-4 1640	16-9 1720	17-1 1790	17-5 1870	17-9 1940	18-1 2010	18-5 2080	18-9 2150	19-0 2220	19-4 2280
	19.2	21-9 1200	13-3 1300	13-9 1390	14-2 1490	14-7 1570	15-0 1660	15-5 1740	15-9 1830	16-1 1910	16-5 1980	16-9 2060	17-0 2140	17-4 2210	17-7 2280	17-11 2350	18-2 2430
	24.0	11-10 1290	12-4 1400	12-9 1500	13-2 1600	13-7 1690	13-11 1790	14-3 1880	14-7 1970	14-11 2050	15-3 2140	15-6 2220	15-10 2300	16-1 2380	16-4 2460	16-7 2540	16-10 2610

2x10	12.0	19-1 1030	19-10 1110	20-6 1190	21-2 1270	21-10 1350	22-5 1420	23-0 1490	23-6 1560	24-0 1630	24-6 1700	25-0 1760	25-5 1830	25-11 1890	26-4 1950	26-9 2010	27-1 2070
	13.7	18-3 1080	19-0 1160	19-8 1250	20-3 1330	20-11 1410	21-5 1480	22-0 1560	22-6 1630	23-0 1700	23-5 1770	23-11 1840	24-4 1910	24-9 1980	25-2 2040	25-7 2110	25-11 2170
	16.0	17-4 1120	18-0 1220	18-8 1310	19-3 1400	19-10 1480	20-4 1560	20-11 1640	21-4 1720	21-10 1790	22-3 1870	22-8 1940	23-1 2010	23-6 2080	23-11 2150	24-3 2220	24-8 2280
	19.2	16-4 1200	16-11 1300	17-7 1390	18-1 1490	18-8 1570	19-2 1660	19-8 1740	20-1 1830	20-6 1910	20-11 1980	21-4 2060	21-9 2140	22-1 2210	22-6 2280	22-10 2350	23-2 2430
	24.0	15-1 1290	15-9 1400	16-4 1500	16-10 1600	17-4 1690	17-9 1790	18-3 1880	18-8 1970	19-1 2050	19-5 2140	19-10 2220	20-2 2300	20-6 2380	20-11 2460	21-2 2540	21-6 2610
2x12	12.0	23-2 1030	24-1 1110	25-0 1190	25-10 1270	26-7 1350	27-3 1420	27-11 1490	28-7 1560	29-3 1630	29-10 1700	30-5 1760	30-11 1830	31-6 1890	32-0 1950	32-6 2010	33-0 2070
	13.7	22-2 1080	23-1 1160	23-11 1250	24-8 1330	25-5 1410	26-1 1480	26-9 1560	27-4 1630	27-11 1700	28-6 1770	29-1 1840	29-7 1910	30-1 1980	30-7 2040	31-1 2110	31-7 2170
	16.0	21-1 1130	21-11 1220	22-8 1310	23-5 1400	24-1 1480	24-9 1560	25-5 1640	26-0 1720	26-7 1790	27-1 1870	27-7 1940	28-1 2010	28-7 2080	29-1 2150	29-6 2220	30-0 2280
	19.2	19-10 1200	20-7 1300	21-4 1390	22-1 1490	22-8 1570	23-4 1660	23-11 1740	24-5 1830	25-0 1910	25-6 1980	26-0 2060	26-6 2140	26-11 2210	27-4 2280	27-9 2350	28-2 2430
	24.0	18-5 1290	19-2 1400	19-10 1500	20-6 1600	21-1 1690	21-8 1790	22-2 1880	22-8 1970	23-2 2050	23-8 2140	24-2 2220	24-7 2300	25-0 2380	25-5 2460	25-10 2540	26-2 2610

Note: The required extreme fiber stress in bending, "F_b", in pounds per square inch is shown below each span.

DESIGN VALUES FOR JOISTS AND RAFTERS--VISUAL GRADING

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13%.

Values for surfaced dry or surfaced green lumber apply at 19% maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F_b"			Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading	7-Day Loading		
BALSAM FIR (Surfaced dry or surfaced green)						
Select Structural	2x4	1550	1780	1940	1,200,000	
No. 1		1300	1500	1620	1,200,000	Northeastern
No. 2		1100	1260	1380	1,100,000	Lumber
No. 3		600	690	750	900,000	Manufacturers
Appearance		1150	1320	1440	1,200,000	Association
Stud		600	690	750	900,000	
Construction	2x4	800	920	1000	900,000	Northern
Standard		450	520	560	900,000	Hardwood
Utility		200	230	250	900,000	& Pine
Select Structural	2x5	1350	1550	1690	1,200,000	Manufacturers
No. 1 & Appearance	and	1150	1320	1440	1,200,000	Association
No. 2	wider	950	1090	1190	1,100,000	(See notes 1
No. 3		550	630	690	900,000	and 3)
Stud		550	630	690	900,000	

DOUGLAS FIR-LARCH (Surfaced dry or surfaced green)						
Dense Select Structural	2x4	2800	3220	3500	1,900,000	
Select Structural		2400	2760	3000	1,800,000	
Dense No. 1		2400	2760	3000	1,900,000	
No. 1 & Appearance		2050	2360	2560	1,800,000	
Dense No. 2		1950	2240	2440	1,700,000	
No. 2		1650	1900	2060	1,700,000	Western Wood
No. 3		925	1060	1160	1,500,000	Products
Stud		925	1060	1160	1,500,000	Association
Construction	2x4	1200	1380	1500	1,500,000	(See notes 1
Standard		675	780	840	1,500,000	and 3)
Utility		325	370	410	1,500,000	
Dense Select Structural	2x5	2400	2760	3000	1,900,000	West Coast
Select Structural	and	2050	2360	2560	1,800,000	Lumber
Dense No. 1	wider	2050	2360	2560	1,900,000	Inspection
No. 1 & Appearance		1750	2010	2190	1,800,000	Bureau
Dense No. 2		1700	1960	2120	1,700,000	
No. 2		1450	1670	1810	1,700,000	
No. 3		850	980	1060	1,500,000	
Stud		850	980	1060	1,500,000	

DESIGN VALUES FOR JOISTS AND RAFTERS--VISUAL GRADING (CONT)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13%.

Values for surfaced dry or surfaced green lumber apply at 19% maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F_b" Normal Duration	Snow Loading	7-Day Loading	Modulus of Elasticity "E"	Grading Rules Agency
EASTERN SPRUCE (Surfaced dry or surfaced green)						
Select Structural	2x4	1750	2010	2190	1,400,000	
No. 1		1500	1720	1880	1,400,000	Northeastern
No. 2		1200	1380	1500	1,200,000	Lumber
No. 3		675	780	840	1,100,000	Manufacturers
Appearance		1250	1440	1560	1,400,000	Association
Stud		675	780	840	1,100,000	
Construction	2x4	875	1010	1090	1,100,000	Northern
Standard		500	580	620	1,100,000	Hardwood
Utility		225	260	280	1,100,000	& Pine
Select Structural	2x5	1500	1720	1880	1,400,000	Manufacturers
No. 1 & Appearance	and	1250	1440	1560	1,400,000	Association
No. 2	wider	1000	1150	1250	1,200,000	(See notes 1
No. 3		600	690	750	1,100,000	and 3)
Stud		600	690	750	1,100,000	

EASTERN WHITE PINE (Surfaced dry or surfaced green)						Northeastern
Select Structural	2x4	1550	1780	1940	1,200,000	Lumber
No. 1 & Appearance		1350	1550	1690	1,200,000	Manufacturers
No. 2		1100	1260	1380	1,100,000	Association
No. 3		600	690	750	1,000,000	(See note 1)
Construction	2x4	800	920	1000	1,000,000	NeLMA and
Standard		450	520	560	1,000,000	NHPMA
Utility		200	230	250	1,000,000	
Stud		600	690	750	1,000,000	(See note 1)
Select Structural	2x5	1350	1550	1690	1,200,000	Northeastern
No. 1 & Appearance	and	1150	1320	1440	1,200,000	Lumber
No. 2	wider	950	1090	1190	1,100,000	Manufacturers
No. 3		550	630	690	1,000,000	Association
Stud		550	630	690	1,000,000	(See notes 1 and 3)

DESIGN VALUES FOR JOISTS AND RAFTERS--VISUAL GRADING (CONT)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13%.

Values for surfaced dry or surfaced green lumber apply at 19% maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F_b" Normal Duration	Snow Loading	7-Day Loading	Modulus of Elasticity "E"	Grading Rules Agency
EASTERN WHITE PINE (NORTH) (Surfaced dry or surfaced green)						
Select Structural	2x4	1550	1780	1940	1,200,000	
No. 1 & Appearance		1350	1550	1690	1,200,000	
No. 2		1100	1260	1380	1,100,000	
No. 3		600	690	750	1,000,000	National
Stud		600	690	750	1,000,000	Lumber
Construction	2x4	800	920	1000	1,000,000	Grades
Standard		450	520	560	1,000,000	Authority
Utility		200	230	250	1,000,000	(A Canadian
Select Structural	2x5	1350	1550	1690	1,200,000	Agency--
No. 1 & Appearance	and	1150	1320	1440	1,200,000	
No. 2	wider	950	1090	1190	1,100,000	See notes 1,
No. 3		550	630	690	1,000,000	2 and 3)
Stud		550	630	690	1,000,000	

HEM-FIR (Surfaced dry or surfaced green)						
Select Structural	2x4	1900	2180	2380	1,500,000	
No. 1 & Appearance		1600	1840	2000	1,500,000	
No. 2		1350	1550	1690	1,400,000	Western Wood
No. 3		725	830	910	1,200,000	Products
Stud		725	830	910	1,200,000	Association
Construction	2x4	975	1120	1220	1,200,000	(See notes 1
Standard		550	630	690	1,200,000	and 3)
Utility		250	290	310	1,200,000	
Select Structural	2x5	1650	1900	2060	1,500,000	West Coast
No. 1 & Appearance	and	1400	1610	1750	1,500,000	Lumber
No. 2	wider	1150	1320	1440	1,400,000	Inspection
No. 3		675	780	840	1,200,000	Bureau
Stud		675	780	840	1,200,000	
NORTHERN PINE (Surfaced dry or surfaced green)						
Select Structural	2x4	1850	2130	2310	1,400,000	Northeastern
No. 1		1600	1840	2000	1,400,000	Lumber
No. 2		1300	1500	1620	1,300,000	Manufacturers
No. 3		725	830	910	1,100,000	Association
Appearance		1400	1610	1750	1,400,000	
Stud		725	830	910	1,100,000	Northern
Construction	2x4	950	1090	1190	1,100,000	Hardwood
Standard		525	600	660	1,100,000	& Pine
Utility		250	290	310	1,100,000	Manufacturers
Select Structural	2x5	1600	1840	2000	1,400,000	Association
No. 1 & Appearance	and	1400	1610	1750	1,400,000	
No. 2	wider	1100	1260	1380	1,300,000	(See notes 1
No. 3		650	750	810	1,100,000	and 3)
Stud		650	750	810	1,100,000	

DESIGN VALUES FOR JOISTS AND RAFTERS--VISUAL GRADING (CONT)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13%.

Values for surfaced dry or surfaced green lumber apply at 19% maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F_b" Normal Duration	Snow Loading	7-Day Loading	Modulus of Elasticity "E"	Grading Rules Agency
SOUTHERN PINE (Surfaced dry)						
Select Structural	2x4	2300	2640	2880	1,700,000	
Dense Select Structural		2700	3100	3380	1,800,000	
No. 1		1950	2240	2440	1,700,000	
No. 1 Dense		2300	2640	2880	1,800,000	
No. 2		1650	1900	2060	1,600,000	
No. 2 Dense		1900	2180	2380	1,600,000	
No. 3		900	1040	1120	1,400,000	
No. 3 Dense		1050	1210	1310	1,500,000	Southern
Stud		900	1040	1120	1,400,000	Pine
Construction	2x4	1150	1320	1440	1,400,000	Inspection
Standard		675	780	840	1,400,000	Bureau
Utility		300	340	380	1,400,000	
Select Structural	2x5	2000	2300	2500	1,700,000	(See note 3)
Dense Select Structural	and	2350	2700	2940	1,800,000	
No. 1	wider	1700	1960	2120	1,700,000	
No. 1 Dense		2000	2300	2500	1,800,000	
No. 2		1400	1610	1750	1,600,000	
No. 2 Dense		1650	1900	2060	1,600,000	
No. 3		800	920	1000	1,400,000	
No. 3 Dense		925	1060	1160	1,500,000	
Stud		850	980	1060	1,400,000	

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SOUTHERN PINE (Surfaced at 15% moisture content-KD)						
Select Structural	2x4	2500	2880	3120	1,800,000	
Dense Select Structural		2900	3340	3620	1,900,000	
No. 1		2100	2420	2620	1,800,000	
No. 1 Dense		2450	2820	3060	1,900,000	
No. 2		1750	2010	2190	1,600,000	
No. 2 Dense		2050	2360	2560	1,700,000	
No. 3		975	1120	1220	1,500,000	Southern
No. 3 Dense		1150	1320	1440	1,500,000	Pine
Stud		975	1120	1220	1,500,000	Inspection
Construction	2x4	1250	1440	1560	1,500,000	Bureau
Standard		725	830	910	1,500,000	
Utility		300	340	380	1,500,000	(See note 3)
Select Structural	2x5	2150	2470	2690	1,800,000	
Dense Select Structural	and	2500	2880	3120	1,900,000	
No. 1	wider	1850	2130	2310	1,800,000	
No. 1 Dense		2150	2470	2690	1,900,000	
No. 2		1500	1720	1880	1,600,000	
No. 2 Dense		1750	2010	2190	1,700,000	
No. 3		875	1010	1090	1,500,000	
No. 3 Dense		1000	1150	1250	1,500,000	
Stud		900	1040	1120	1,500,000	

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DESIGN VALUES FOR JOISTS AND RAFTERS--VISUAL GRADING (CONT)

These "F_b" values are for use where repetitive members are spaced not more than 24 inches. For wider spacing, the "F_b" values should be reduced 13%.

Values for surfaced dry or surfaced green lumber apply at 19% maximum moisture content in use.

Species and Grade	Size	Design Value in Bending "F_b"			Modulus of Elasticity "E"	Grading Rules Agency
		Normal Duration	Snow Loading	7-Day Loading		
SPRUCE-PINE-FIR (Surfaced dry or surfaced green)						
Select Structural	2x4	1650	1900	2060	1,500,000	
No. 1 & Appearance		1400	1610	1750	1,500,000	
No. 2		1150	1320	1440	1,300,000	
No. 3		650	750	810	1,200,000	National Lumber Grades Authority (A Canadian Agency--See notes 1, 2 and 3)
Stud		650	750	810	1,200,000	
Construction	2x4	850	980	1060	1,200,000	
Standard		475	550	590	1,200,000	
Utility		225	260	280	1,200,000	
Select Structural	2x5 and wider	1450	1670	1810	1,500,000	
No. 1 & Appearance		1200	1380	1500	1,500,000	
No. 2		1000	1150	1250	1,300,000	
No. 3		575	660	720	1,200,000	
Stud		575	660	720	1,200,000	

WHITE WOODS (WESTERN WOODS) (Surfaced dry or surfaced green)						
Select Structural	2x4	1550	1780	1940	1,100,000	
No. 1 & Appearance		1300	1500	1620	1,100,000	
No. 2		1050	1210	1310	1,000,000	
No. 3		600	690	750	900,000	Western Wood Products Association (See notes 1 and 3)
Stud		600	690	750	900,000	
Construction	2x4	775	890	970	900,000	
Standard		425	490	530	900,000	
Utility		200	230	250	900,000	
Select Structural	2x5 and wider	1300	1500	1620	1,100,000	
No. 1 & Appearance		1100	1260	1380	1,100,000	
No. 2		925	1060	1160	1,000,000	
No. 3		550	630	690	900,000	
Stud		550	630	690	900,000	

1. When 2-inch lumber is manufactured at a maximum moisture content of 15% (grade-marked MC-15) and used in a condition where the moisture content does not exceed 15% the design values shown for "surfaced dry or surfaced green" lumber may be increased 8% for design value in bending "F_b", and 5% for modulus of elasticity "E".

2. National Lumber Grades Authority is the Canadian rules writing agency responsible for preparation, maintenance and dissemination of a uniform softwood lumber grading rule for all Canadian species.

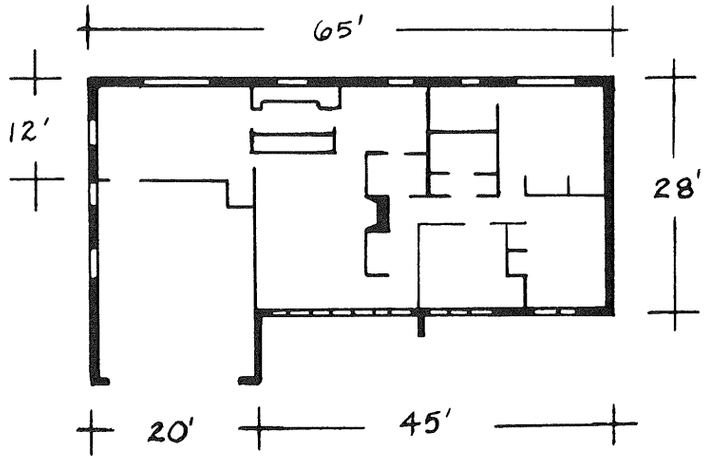
3. Design values for stud grade in 2x5 and wider size classifications apply to 5-inch and 6-inch widths only.

APPENDIX A

CHAPTER Ind 22

DETERMINING THE LEVEL OF INSULATION

Two methods are outlined for determining the level of insulation required by section Ind 22.06 using the following sample dwelling:



Sample dwelling: 1,500 square feet (186 lineal feet)

Gross wall area = 8.13′ x 186 lineal feet =1,512.18 square feet
Opaque wall area = 1,301.69 square feet (20% framing, 80% cavity)
Box sill area = .81′ x 186 lineal feet = 150.66 square feet
Exposed foundation wall area = 108.97 square feet
Basement window area = 15.65 square feet
Insulated window area = 172.67 square feet
Insulated door area = 37.82 square feet
Ceiling area = 1,500 square feet (10% framing, 90% cavity)

METHOD I - ACCEPTABLE PRACTICE METHOD

The acceptable practice method outlined below can be used with minimum calculations for determining the acceptable level of insulation.

Problem: Using the acceptable practice method determine the level of insulation required for the 1,500 square foot dwelling in Phase I.

Step 1: Determine the percentage window and door area.

$$\text{Percent opening area} = \frac{\text{Window area + Door area}}{\text{Gross wall area + Box sill area}} \times 100\%$$

$$= \frac{172.67 \text{ sq. ft.} + 37.82 \text{ sq. ft.}}{1512.18 \text{ sq. ft.} + 150.66 \text{ sq. ft.}} \times 100\%$$

$$= \frac{210.49 \text{ sq. ft.}}{1{,}662.84 \text{ sq. ft.}} \times 100\% = 12.66\%$$

Step 2: Determine level of insulation required for the box sill and sidewalls for the given window and door area from Table A-1. (Phase 1)

Using ⅝ inch plywood siding the table shows that an R-11 batt with R-1.22 fiberboard will allow up to 12.8% window and door area.

Step 3: Determine the percentage window area for the exposed foundation wall.

$$\text{Percent opening area} = \frac{\text{Window area}}{\text{Total exposed foundation area}} \times 100\%$$

$$= \frac{15.65 \text{ sq. ft.}}{108.97 \text{ sq. ft.} + 15.65 \text{ sq. ft.}} \times 100\%$$

$$= 12.6\%$$

Step 4: Determine the amount of exposed foundation wall: If there is 8″ of wall exposed and the wall height is 8′,

$$\text{Percent exposed wall} = \frac{8''/(12'' \text{ per foot})}{8'} \times 100\% = 8.3\%$$

Step 5: Refer to Table A-2 to determine the level of insulation required for the foundation.

Using the requirements for less than 25% exposed foundation wall the table shows that an R-5.27 insulation can be used for up to 24.8% double glazed windows.

Step 6: Select the level of insulation required for the ceiling from Table A-3.

TABLE A-1

WALL INSULATION GUIDE

(Based on U_o requirements above the foundation wall)

Insulation Type	Percent Window and Door Area					
	Phase I		Phase II (4/1/79)		Phase III (4/1/80)	
	U_o = .14		U_o = .13		U_o = .12	
	⅝ inch Plywood Siding	Backed Aluminum Siding	⅝ inch Plywood Siding	Backed Aluminum Siding	⅝ inch Plywood Siding	Backed Aluminum Siding
R-11 Batt	11.0	12.6	8.9	10.5	6.8	8.4
R-11 Batt, R-1.22 Fiberboard	12.8	14.0	10.8	12.0	8.7	9.9
R-11 Batt, R-5.27 Extruded Polystyrene	16.4	17.0	14.4	15.0	12.4	13.0
R-11 Batt, R-10.54 Extruded Polystyrene	18.8	19.1	16.8	17.2	14.9	15.3
R-13 Batt	12.5	13.9	10.4	11.8	8.3	9.8
R-13 Batt, R-1.22 Fiberboard	14.1	15.4	12.2	13.3	10.3	11.2
R-13 Batt, R-5.27 Extruded Polystyrene	17.0	17.5	15.0	15.6	13.1	13.6
R-13 Batt, R-10.54 Extruded Polystyrene	19.2	19.5	17.3	17.6	15.3	15.6
R-19 Batt	15.3	16.2	13.2	14.2	11.2	12.2
R-19 Batt, R-1.22 Fiberboard	16.4	17.1	14.4	15.1	12.3	13.1
R-19 Batt, R-5.27 Extruded Polystyrene	18.6	19.0	16.7	17.0	14.7	15.1
R-19 Batt, R-10.54 Extruded Polystyrene	20.1	20.4	18.2	18.5	16.3	16.6

Note: The following assumptions were used to derive this table:
1. Door area = 2% of wall and box sill area.
2. Insulated doors are used with a U-value of .47.
3. Insulated windows are used with a U-value of .56.
4. The insulation type is carried down through the box sill.

TABLE A-2

EXPOSED FOUNDATION INSULATION

Foundation exposure	Requirement	Insulation type	Percent window area: Single glazed	Percent window area: Double glazed
Less than 25% of foundation exposed	U_o = .25	R-5.27	10.4	24.8
		R-11 batt	15.5	34.2
		Multi-cell insul. block (R-12.06)	16.0	35.0
More than 25% of foundation exposed	U_o = .14	R-11 batt	4.9	10.8
		R-13 batt	5.8	12.7
		Multi-cell insul. block (R-12.06)	5.5	12.0
	U_o = .13	R-11 batt	3.9	8.7
		R-13 batt	4.8	10.6
		Multi-cell insul. block (R-12.06)	4.5	9.9
	U_o = .12	R-11 batt	3.0	6.7
		R-13 batt	3.9	8.5
		Multi-cell insul. block (R-12.06)	3.5	7.8

TABLE A-3

INSULATION LEVELS REQUIRED TO MEET CEILING U VALUES

U_o Value	Insulation	R-Value Required: In Cavity	R-Value Required: Over Framing
.033	Fiber glass batt	R-19 and R-13	R-13
	Fiber glass blown	12 in. (R-30)	6.4 in. (R-16)
	Rock wool	9.7 in. (R-29)	4.2 in. (R-13)
	Cellulose	8.4 in. (R-31)	2.9 in. (R-11)
.029	Fiber glass batt	R-38	R-19
	Fiber glass blown	13.6 in. (R-34)	8.1 in. (R-20)
	Rock wool	10.9 in (R-33)	5.4 in. (R-16)
	Cellulose	9.5 in. (R-35)	4.0 in. (R-15)

Note: The following assumptions are used:
1. Fiber glass blown = R-2.5 per inch
2. Rock wool = R-3.0 per inch
3. Cellulose = R-3.7 per inch

METHOD II — SYSTEM DESIGN METHOD

The system design method is the more complex method of determining the level of insulation required by the code. This procedure may be used when it becomes necessary to combine various materials to comply with the code. If the window area is increased and the same wall insula-

tion is used, the wall section will not meet the requirements of section Ind 22.06 (6), but the system design method can be used by adding extra insulation elsewhere.

Problem: Using the system design method, increase the opening area to 15% and determine compliance by adding extra insulation to the walls and ceiling.

Step 1: Determine the inside and outside design temperatures from Tables 22.04-A and B.

Inside temperature = 70° F
Outside temperature = -20° F
$\Delta T = T_{inside} - T_{outside} = 70 - (-20) = 90°$ F.

Note: Degree days may be used for system design instead of design temperatures:

Zone 1, 9,000 degree days
Zone 2, 8,000 degree days
Zone 3, 7,500 degree days
Zone 4, 7,000 degree days

Step 2: Using section Ind 22.06, determine the insulation values for the exterior walls above grade and the roof/ceiling for Phase I.

Exposed exterior walls above grade; $U_o = .15$
Roof/ceiling; $U_o = .033$

Step 3: Fill in the worksheet to determine requirements for building enclosure heat loss.

Step 4: Select the levels of insulation to be used and determine the U values for the ceiling, wall, box sill and foundation (shown in Figure A-1). Fill in the building enclosure worksheet.

Step 5: If the total heat loss determined through the system design method is within one percent or is less than the heat loss determined through the code requirements, the code has been satisfied.

R-VALUE DETERMINATION BY COMPONENT

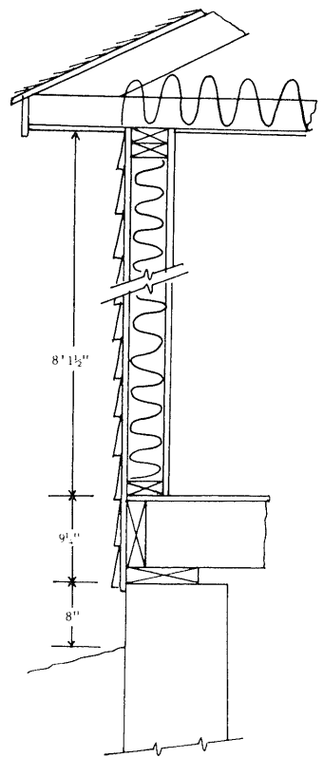


Figure A-1

Ceiling	Cavity R	Joist R
Top surface	.17	.17
Insulation	38.0	19.0
Wood	—	6.88
½" gyp. wall board	.45	.45
Bottom surface	.61	.61
	39.23	27.11
	(U=.025)	(U=.037)

Wall	Cavity R	Stud R
Outside surface	.17	.17
⅝" ext. siding	.77	.77
Rigid insulation	—	—
Insulation	11.00	—
Wood stud	—	4.38
½" gyp. wall board	.45	.45
Inside surface	.68	.68
	13.07	6.45
	(U=.070)	(U=.13)

Box sill	R
Outside surface	.17
⅝" ext. siding	.77
Rigid insulation	—
Insulation	11.00
1½" wood	1.88
Inside surface	.68
	14.50
	(U=.064)

Foundation	R
Outside surface	.17
8" concrete	.64
Inside surface	.68
Rigid insulation	5.27
	6.76
	(U=.15)

WORKSHEET FOR SYSTEM DESIGN ANALYSIS

CODE REQUIREMENTS				
Component	U_o Reqd.	Area	ΔT	Heat Loss
Walls				
Above grade	.15	1512.18	90	20,414.4
Box sill	.15	150.66	70	1,581.9
Foundation	.15	124.62	70	1,308.5
Roof/Ceiling	.033	1500.00	90	4,455.0
Floor				
Over unheated spaces				
Slab-on-grade				
			TOTAL	27,759.9

SYSTEM DESIGN ALTERNATIVE				
Component	U	Area	ΔT	Heat Loss
Walls				
Cavity	.070	1010.20	90	6,364.3
Solid	.13	252.60	90	2,955.4
Box sill	.064	150.66	70	675.0
Foundation	.15	108.97	70	1,114.2
Roof/Ceiling				
Cavity	.025	1350.00	90	3,037.5
Solid	.037	150.00	90	499.5
Floor				
Over unheated spaces				
Slab-on-grade				
Windows	.56	211.61	90	10,665.1
Doors	.31	37.82	90	1,055.2
Basement windows	1.13	15.65	70	1,237.9
			TOTAL	27,634.1

WORKSHEET FOR SYSTEM DESIGN ANALYSIS

CODE REQUIREMENTS				
Component	U_o Reqd.	Area	ΔT	Heat Loss
Walls				
Above grade				
Box sill				
Foundation				
Roof/Ceiling				
Floor				
Over unheated spaces				
Slab-on-grade				
			TOTAL	

SYSTEM DESIGN ALTERNATIVE				
Component	U	Area	ΔT	Heat Loss
Walls				
Cavity				
Solid				
Box sill				
Foundation				
Roof/Ceiling				
Cavity				
Solid				
Floor				
Over unheated spaces				
Slab-on-grade				
Windows				
Doors				
Basement windows				
			TOTAL	

TABLE A-4
COMMON CONSTRUCTION MATERIAL R-VALUES*

Material	Description		Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
BUILDING BOARD Boards, panels, subflooring, sheathing, woodbased panel products	Asbestos-cement board		120	0.25	—
	Asbestos-cement board	⅛ in.	120	—	0.03
	Asbestos-cement board	¼ in.	120	—	0.06
	Gypsum or plaster board	⅜ in.	50	—	0.32
	Gypsum or plaster board	½ in.	50	—	0.45
	Plywood		34	1.25	—
	Plywood	¼ in.	34	—	0.31
	Plywood	⅜ in.	34	—	0.47
	Plywood	½ in.	34	—	0.62
	Plywood or wood panels	¾ in.	34	—	0.93
	Insulating board Sheathing, reg. density	½ in.	18	—	1.32
		25/32 in.	18	—	2.06
	Sheathing, intermediate density	½ in.	22	—	1.22
	Nail-base sheathing	½ in.	25	—	1.14
	Shingle backer	⅜ in.	18	—	0.94
	Shingle backer	5/16 in.	18	—	0.78
	Sound deadening board	½ in.	15	—	1.35
	Tile and lay-in panels, plain or acoustic		18	2.50	—
		½ in.	18	—	1.25
		¾ in.	18	—	1.89
	Laminated paperboard		30	2.00	—
	Homogeneous board from repulped paper		30	2.00	—
	Hardboard Medium density siding	7/16 in.	40	—	0.67
	Other medium density		50	1.37	—
	High density, underlay		55	1.22	—
	High density std. tempered		63	1.00	—
	Particleboard Low density		37	1.85	—

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	Medium density	50	1.06	—
	High density	62.5	0.85	—
	Underlayment ⅜ in.	40	—	0.82
	Wood subfloor ¾ in.	—	—	0.94
BUILDING PAPER	Vapor-permeable felt	—	—	0.06
	Vapor-seal, 2 layers of mopped 15 lb. felt	—	—	0.12
	Vapor-seal, plastic film	—	—	Negl.
ROOF INSULATION	Preformed, for use above deck			
	Approximately ½ in.	—	—	1.39
	Approximately 1 in.	—	—	2.78
	Appproximately 1½ in	—	—	4.17
	Appproximately 2 in.	—	—	5.56
	Approximately 2½ in.	—	—	6.67
	Approximately 3 in.	—	—	8.33
	Cellular glass	9	2.50	—
MASONRY MATERIALS Concrete	Cement mortar	116	0.20	—
	Gypsum-fiber concrete 87½% gypsum, 12½% wood chips	51	0.60	—
	Lightweight aggregates	120	0.19	—
	including expanded shale,	100	0.28	—
	clay or slate, expanded	80	0.40	—
	slags; cinders; pumice;	60	0.59	—
	vermiculite; also cellular	40	0.86	—
	concretes	30	1.11	—
		20	1.43	—
	Perlite	40	1.08	—
		30	1.41	—
		20	2.00	—
	Sand and gravel or stone aggregate (oven dried)	140	0.11	—
	Sand and gravel or stone aggregate (not dried)	140	0.08	—
	Stucco	116	0.20	—
MASONRY UNITS	Brick, common	120	0.20	—
	Brick, face	130	0.11	—
	Clay tile, hollow:			
	1 cell deep 3 in.	—	—	0.80
	1 cell deep 4 in.	—	—	1.11
	2 cells deep 6 in.	—	—	1.52
	2 cells deep 8 in.	—	—	1.85
	2 cells deep 10 in.	—	—	2.22
	3 cells deep 12 in.	—	—	2.50
	Concrete blocks, 3 oval core:			
	Sand & gravel aggregate 4 in.	—	—	0.71
	8 in.	—	—	1.11
	12 in.	—	—	1.28
	Cinder aggregate 3 in.	—	—	0.86
	..... 4 in.	—	—	1.11
	..... 8 in.	—	—	1.72
	..... 12 in.	—	—	1.89
	Lightweight 3 in.	—	—	1.27
	aggregate (expanded 4 in.	—	—	1.50
	shale, clay, slate 8 in.	—	—	2.00
	or slag; pumice) 12 in.	—	—	2.27
	Concrete blocks, rectangular core			
	Sand & gravel aggregate			
	2 core, 8″ 36 lb	—	—	1.04

Material	Description	Density lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	Same with filled cores	—	—	1.93
	Lightweight aggregate (expanded shale, clay, slate or slag, pumice):			
	3 core, 6″ 19 lb	—	—	1.65
	Same with filled cores	—	—	2.99
	2 core, 8″ 24 lb	—	—	2.18
	Same with filled cores	—	—	5.03
	3 core, 12″ 38 lb	—	—	2.48
	Same with filled cores	—	—	5.82
	Stone, lime or sand	—	0.08	—
	Gypsum partition tile:			
	3 x 12 x 30 in. solid	—	—	1.26
	3 x 12 x 30 in. 4-cell	—	—	1.35
	4 x 12 x 30 in. 3-cell	—	—	1.67
PLASTERING MATERIALS	Cement plaster, sand aggregate	116	0.20	—
	Sand aggregate ¾ in.	—	—	0.08
	Sand aggregate ¾ in.	—	—	0.15
	Gypsum plaster:			
	Lightweight aggregate ½ in.	45	—	0.32
	Lightweight aggregate ⅝ in.	45	—	0.39
	Lightweight aggregate on metal lath ¾ in.	—	—	0.47
	Perlite aggregate	45	0.67	—
	Sand aggregate	105	0.18	—
	Sand aggregate ½ in.	105	—	0.09
	Sand aggregate ⅝ in.	105	—	0.11
	Sand aggregate on metal lath ¾ in	—	—	0.1
	Vermiculite aggregate	45	0.59	—
ROOFING	Asbestos-cement shingles	120	—	0.21
	Asphalt roll roofing	70	—	0.15
	Asphalt shingles	70	—	0.44
	Built-up roofing ⅜ in	70	—	0.33
	Slate ½ in.	—	—	0.05
	Wood shingles, plain plastic film faced	—	0.94	
SIDING MATERIALS (On flat surface)	Shingles:			
	Asbestos-cement	120	—	0.21
	Wood, 16″, 7½″ exposure	—	—	0.87
	Wood, double, 16″, 12″ exposure	—	—	1.19
	Wood, plus insulating backer board 5/16 in.	—	—	1.40
	Siding:			
	Asbestos-cement, ¼″ lapped	—	—	0.21
	Asphalt roll siding	—	—	0.15
	Asphalt insulating siding (½″ bd.)	—	—	1.46
	Wood drop 1 x 8″	—	—	0.79
	Wood bevel, ½″ x 8″ lapped	—	—	0.81

Material	Description	Density (lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	Wood bevel, ¼ x 10″ lapped	—	—	1.05
	Wood plywood ⅜″ lapped	—	—	0.59
	Aluminum or steel, over sheathing, hollow-backed	—	—	0.61
	Insulating-board backed nominal ⅜″	—	—	1.82
	Insulating-board backed nominal ⅜″ foil backed	—	—	2.96
	Architectural glass	—	—	0.10
FINISH FLOORING MATERIALS	Carpet and fibrous pad	—	—	2.08
	Carpet and rubber pad	—	—	1.23
	Cork tile ⅛ in.	—	—	0.28
	Terrazzo 1 in.	—	—	0.08
	Tile-asphalt, linoleum, vinyl, rubber	—	—	0.05
	Wood, hardwood finish ¾ in.	—	—	0.08
INSULATING MATERIALS Blanket and batt	Mineral fiber, fibrous form processed from rock, slag or glass			
	Approx. 2 to 2¾″ Note 1	—	—	7
	Approx. 3 to 3½″ Note 1	—	—	11
	Approx. 5¼ to 6½″ Note 1	—	—	19
Board and Slabs	Cellular glass	9	2.50	—
	Glass fiber, organic bonded	4-9	4.00	—
	Expanded rubber (rigid)	4.5	4.55	—
	Expanded polystyrene extruded, plain	1.8	4.00	—
	Expanded polystyrene extruded (R-12 exp.)	2.2	5.00	—
	Expanded polystyrene extruded (R-12 exp.) (Thickness 1″ and greater)	3.5	5.26	—
	Expanded polystyrene, molded beads	1.0	3.57	—
	Expanded polyurethane (R-11 exp.)	1.5	6.25	—
	Mineral fiber with resin binder.	15	3.45	—
	Mineral fiberboard wet felted			
	Core or roof insulation	16-17	2.94	—
	Acoustical tile	18	2.86	—
	Acoustical tile	21	2.70	—
	Mineral fiberboard wet molded			
	Acoustical tile	23	2.38	—
	Wood or cane fiberboard			
	Acoustical tile ½ in.	—	—	1.25
	Acoustical tile ¾ in.	—	—	1.89
	Interior finish (plank, tile)	15	2.86	—
	Insulating roof deck			
	Approximately 1½ in.	—	—	4.17
	Approximately 2 in.	—	—	5.56
	Approximately 3 in.	—	—	8.33
	Wood shredded (cemented in preformed slabs)	22	1.67	—
Loose Fill	Cellulose insulation (milled paper or wood pulp)	2.5-3	3.70	—
	Sawdust or shavings	0.8-1.5	2.22	—
	Wood fiber, softwoods	2.0-3.5	3.33	—

Material	Description	Density lb per cu ft)	Per inch thickness R-Value	For thickness listed R-Value
	Perlite, expanded	5.0-8.0	2.70	—
	Mineral fiber (rock, slag or glass):			
	Approximately 3″ Note 1	8-15	—	9
	Approximately 4½″ Note 1	8-15	—	13
	Approximately 6¼″ Note 1	8-15	—	19
	Approximately 7¼″ Note 1	8-15	—	24
	Silica aerogel	7.6	5.88	—
	Vermiculite (expanded)	7.0-8.2	2.13	—
		4.0-6.0	2.27	—
WOODS	Maples, oak and similar hardwoods	45	0.91	—
	Fir, pine, and similar softwoods	32	1.25	—
	Fir, pine, and similar softwoods ¾ in.	32	—	0.94
	..... 1½ in.	32	—	1.89
	..... 2½ in.	32	—	3.12
	..... 3½ in.	32	—	4.35

Note 1: R-value varies with fiber diameter. Insulation is produced by different densities; therefore, there is a wide variation in thickness for the same R-value between various manufacturers. (See Batt and Loose Fill Insulation.)

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TABLE A-5
COEFFICIENTS OF TRANSMISSION (U) OF WINDOWS, SKYLIGHTS, AND LIGHT TRANSMITTING PARTITIONS*
(These values are for heat transfer from air to air.)
Btu per (hr) (sq ft) (F Deg)

PART A
VERTICAL PANELS (EXTERIOR WINDOWS, SLIDING PATIO DOORS AND PARTITIONS)—FLAT GLASS, GLASS BLOCK AND PLASTIC SHEET

Description	Exterior[1] Winter	Summer	Interior
Flat Glass			
single glass	1.13	1.06	0.73
insulating glass—double[2]			
3/16 in. air space	0.69	0.64	0.51
¼ in. air space	0.65	0.61	0.49
½ in. air space	0.58	0.56	0.46
½ in. air space, low emissivity coating[3]			
emissivity = 0.20	0.38	0.36	0.32
emissivity = 0.40	0.45	0.44	0.38
emissivity = 0.60	0.52	0.50	0.42
insulating glass—triple[2]			
¼ in. air spaces	0.47	0.45	0.38
½ in. air spaces	0.36	0.35	0.30
storm windows			
1 in.-4 in. air space	0.56	0.54	0.44
Glass Block[4]			
6 x 6 x 4 in. thick	0.60	0.57	0.46
8 x 8 x 4 in. thick	0.56	0.54	0.44
—with cavity divider	0.48	0.46	0.38
12 x 12 x 4 in. thick	0.52	0.50	0.41
—with cavity divider	0.44	0.42	0.36
12 x 12 x 2 in. thick	0.60	0.57	0.46
Single Plastic Sheet	1.09	1.00	0.70

[1]See Part C for adjustment for various window and sliding patio door types.
[2]Double and triple refer to the number of lights of glass.
[3]Coating on either glass surface facing air space; all other glass surfaces uncoated.
[4]Dimensions are nominal.

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PART B
HORIZONTAL PANELS (SKYLIGHTS)
FLAT GLASS, GLASS BLOCK AND PLASTIC BUBBLES

Description	Exterior[1] Winter[5]	Summer[6]	Interior[5]
Flat Glass			
single glass	1.22	0.83	0.96
insulating glass—double[2]			
3/16 in. air space	0.75	0.49	0.62
¼ in. air space	0.70	0.46	0.59
½ in. air space	0.66	0.44	0.56
½ in. air space, low emissivity coating[3]			
emissivity = 0.20	0.46	0.31	0.39
emissivity = 0.40	0.53	0.36	0.45
emissivity = 0.60	0.60	0.40	0.50
Glass Block[4]			
11 x 11 x 3 in. thick with cavity divider	0.53	0.35	0.44
12 x 12 x 4 in. thick with cavity divider	0.51	0.34	0.42
Plastic Bubbles[7]			
single walled	1.15	0.80	—
double walled	0.70	0.46	—

[5]For heat flow up.
[6]For heat flow down.
[7]Based on area of opening, not total surface area.

(See following page for Part C of this table.)

PART C
ADJUSTMENT FACTORS FOR VARIOUS WINDOW AND SLIDING PATIO DOOR TYPES
(Multiply U values in Parts A and B by these factors)

Description	Single Glass	Double or Triple Glass	Storm Windows
Windows			
All Glass[8]	1.00	1.00	1.00
Wood Sash—80% Glass	0.90	0.95	0.90
Wood Sash—60% Glass	0.80	0.85	0.80
Metal Sash—80% Glass	1.00	1.20	1.20[9]
Sliding Patio Doors			
Wood Frame	0.95	1.00	—
Metal Frame	1.00	1.10	—

[8]Refers to windows with negligible opaque area.
[9]Value becomes 1.00 when storm sash is separated from prime window by a thermal break.

TABLE A-6
COEFFICIENTS OF TRANSMISSION (U) FOR SLAB DOORS*
Btu per (hr) (sq ft) (F Deg)

Thickness[1]	Winter: Solid Wood, No Storm Door	Winter: Storm Door[2] Wood	Winter: Storm Door[2] Metal	Summer, No Storm Door
1 in.	0.64	0.30	0.39	0.61
1¼ in.	0.55	0.28	0.34	0.53
1½ in.	0.49	0.27	0.33	0.47
2 in.	0.43	0.24	0.29	0.42
Steel Door				
1¾ in.				
A[3]	0.59	—	—	0.58
B[4]	0.40	—	—	0.39
C[5]	0.47	—	—	0.46

[1]Nominal thickness.
[2]Values for wood storm doors are for approximately 50% glass; for metal storm doors values apply for any percent of glass.
[3]A = Mineral fiber core (2 lb/cu ft).
[4]B = Solid urethane foam core.
[5]C = Solid polystyrene core.

Note: Hollow core doors 1⅜ in. thick - R = 2.17; U = 0.46
1¾ in. thick - R = 2.22; U = 0.45

*Reprinted with permission from ASHRAE Handbook of Fundamentals.

APPENDIX B

FORMULA FOR DETERMINING THE OVERALL U_o OF THE WALL

$$U_O = \frac{U_{cav}\,A_{cav} + U_{sol}\,A_{sol} + U_{win}\,A_{win} + U_{door}\,A_{door} + U_{box}\,A_{box} + U_{found}\,A_{found}}{A_O}$$

Where:

U_O = Average thermal transmittance of gross wall area
A_O = Gross area of exterior walls.
U_{cav} = Thermal transmittance of cavity area (usually assume 80%)
A_{cav} = Area between wall framing where insulation may be placed.
U_{sol} = Thermal transmittance of wood framing area.
A_{sol} = Area of wood framing (usually assume 20%)
U_{box} = Thermal transmittance of box sill area.
A_{box} = Area of box sill
U_{found} = Thermal transmittance of foundation area.
A_{found} = Area of above grade exposed concrete.
U_{win} = Thermal transmittance of window.
A_{win} = Total glass area.
U_{door} = Thermal transmittance of door.
A_{door} = Total door area.

FORMULA FOR DETERMINING THE OVERALL U_o OF THE CEILING

$$U_O = \frac{U_{cav}\,A_{cav} + U_{sol}\,A_{sol} + U_{skylight}\,A_{skylight}}{A_O}$$

Where:

U_O = Average thermal transmittance of gross roof/ceiling.
A_O = Gross area of roof/ceiling assembly.
U_{cav} = Thermal transmittance of cavity area.
A_{cav} = Area between wood framing.
U_{sol} = Thermal transmittance of framing.
A_{sol} = Area of wood framing (usually assume 10%)
$U_{skylight}$ = Thermal transmittance of skylight elements.
$A_{skylight}$ = Area of skylight (including frame).

APPENDIX C

INSULATION, EQUIPMENT AND CONDENSATION CONTROL

This appendix is a guide for the proper installation of insulation. The preceding appendices indicated the required amounts and types of insulation necessary to provide the various thermal resistance values for the building envelope. In order to attain the resistance values specified, it is important that the insulation be properly installed. This appendix includes types of materials currently available and common application practices.

Condensation control should be provided in the form of vapor barriers and thermal breaks. Vapor barriers should be installed on the warm side (area heated in winter) of all walls, ceilings, and insulated floors. All metal window, skylight, and door frames should contain a thermal break.

Insulation is manufactured in many forms and types. The most commonly used materials in residential construction are batts and blankets, rigid insulation, reflective insulation, loose fill, and sprayed insulation. The following is a list of types of materials and the federal specifications governing their characteristics.

Cork board	FS HH-I-561
Cellular glass	FS HH-I-551
Duct insulation	FS HH-I-558b
Expanded polystyrene insulation board	FS HH-I-524
Fiberboard	FS LLL-I-535 or ASTM C-208 Class C
Insulation board (urethane)	FS HH-I-530
Insulation, thermal (perlite)	FS HH-I-574
Mineral fiber, pneumatic or poured	FS HH-I-1030A
Mineral fiber, insulation blanket	FS HH-I-521E
Perlite	FS HH-I-526a
Perimeter insulation	FS HH-I-524a Type II FS HH-I-558b Form A, Class 1 or 2
Reflective, thermal	FS HH-I-1552
Structural fiberboard insulation roof deck	AIMA IB Spec. No. 1
Cellulose; vegetable or wood fiber	FS HH-I-515b-25
Vermiculite	FS HH-I-585
Vermiculite, water repellent loose fill	FHA UM-30
Mineral fiber, roof insulation	HH-I-526c

BATTS AND BLANKETS

These materials are usually identified on the package and on the vapor barrier facing with their "R" values. Under the federal specifications, there are 3 standard products identified as R-7, R-11, and R-19. These values are based on the insulation value of the mass. Some manufacturers offer other products such as R-8, R-13 and R-22. The specific thickness of insulation required for a specific "R" value may vary from one manufacturer to another due to differences in base materials and manufacturing processes.

General Guidelines

1. Install insulation so the vapor barrier faces the interior of the dwelling.
2. Vapor barriers should not be left exposed.
3. Insulate all voids of the building envelope including small spaces, gaps, around receptacles, pipes, etc.

4. Place insulation on the cold side of pipes and ducts (see Fig. 4). Insulation is not required for supply and return air ducts in heated basements and cellars.

Ceilings

There is a variety of methods for installing blanket insulation in ceilings.

1. Fastening from below (Fig. 1b).
2. Installing unfaced (without a vapor barrier), friction-fit blankets (Fig. 2).
3. Laying the insulation in from above when the ceiling finish material is in place (Fig. 1a).

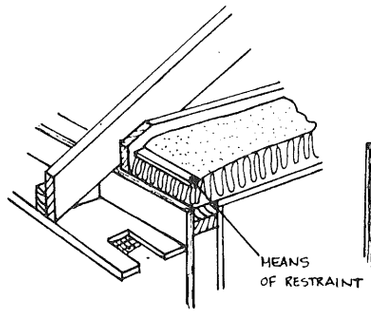


Fig. 1a

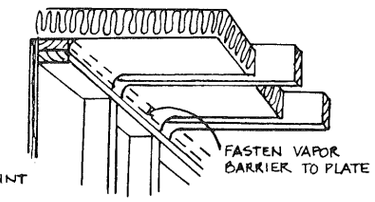


Fig. 1b

Fasten flanges to the inside of ceiling joists as shown in Fig. 1b. Extend the insulation entirely across the top plate, keeping the blanket as close to the plate as possible. Fasten vapor barrier to plate. When eave vents are used, the insulation should not block air movement from eave to space above insulation (Fig. 1a).

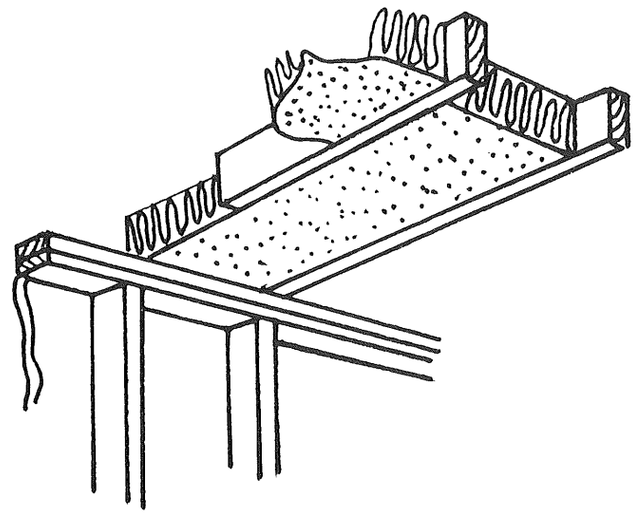


Fig. 2

Insert friction-fit blankets between ceiling joists (Fig. 2). Allow insulation to overlap the top plate of the exterior wall, but not enough to block eave ventilation. The insulation should be in contact with the top of the plate to avoid heat loss and air infiltration beneath the insulation. The required vapor barrier is not shown.

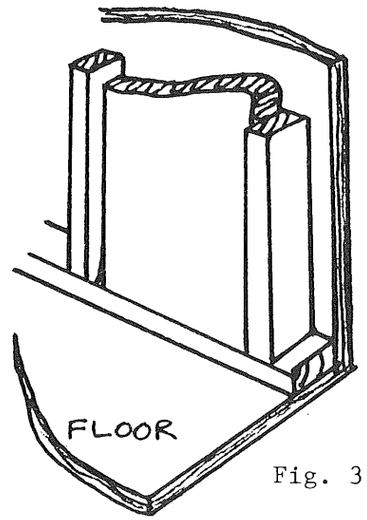


Fig. 3

Insert blankets into stud spaces. Working from the top down, space fasteners per manufacturers recommendations, fitting flanges tightly

against face of stud (Fig. 3). Cut blankets slightly over length and fasten the vapor barrier to the top and bottom plates.

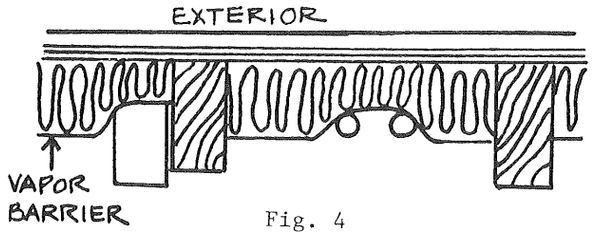


Fig. 4

Insert insulation behind (cold side in winter) pipes, ducts, and electrical boxes (Fig. 4).

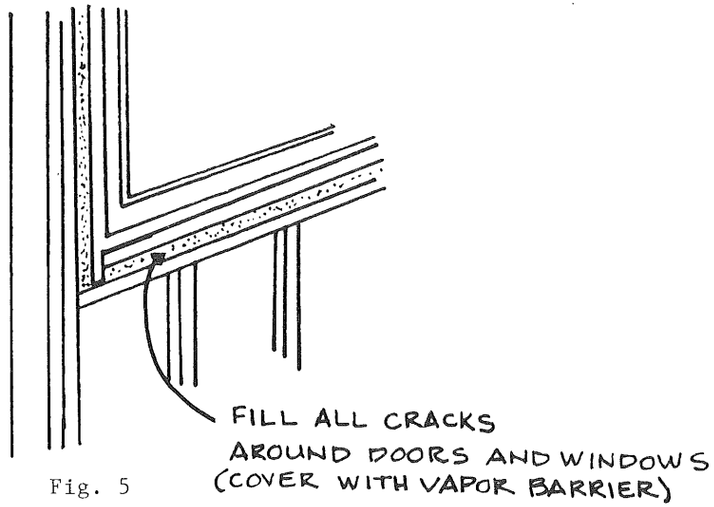


Fig. 5

Fill small spaces between rough framing and door and window heads, jambs and sills with pieces of insulation (Fig. 5).

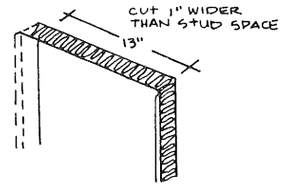


Fig. 6a

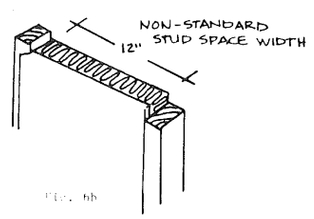


Fig. 6b

Insulate nonstandard-width stud or joist spaces by cutting the insulation and vapor barrier an inch or so wider than the space to be filled (Fig. 6a). Pull the vapor barrier on the cut side to the other stud, compressing the insulation behind it, and fasten through vapor barrier to stud face (Fig. 6b). Unfaced blankets are cut slightly oversize and fitted into place.

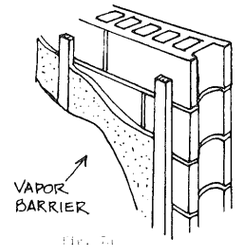


Fig. 7a

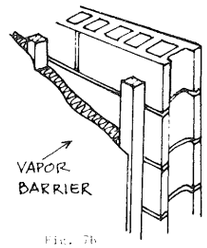


Fig. 7b

Masonry walls may be insulated by inserting insulation between furring strips spaced at 16 or 24 inches o.c. (Fig. 7a and 7b). It is recommended to apply the vapor barrier to the inside surface.

Floor and Crawl Spaces

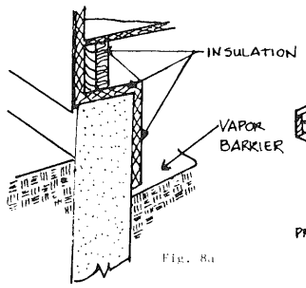


Fig. 8a

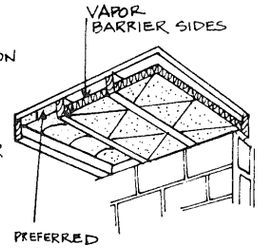


Fig. 8b

Floors over crawl spaces (Fig. 8a) should be insulated either by insulating the foundation walls or by placing insulation on or between the joists. Insulation should be securely fastened. In all cases, the vapor barrier side of the insulation should face the floor above; that is, be adjacent to the warm side in winter. A vapor barrier should be used to cover the ground.

Dropped Soffits

Insulation of dropped soffits over kitchen cabinets, bathtubs, showers, or similar areas, need special attention when they are exposed to the attic. If the dropped soffit is framed before ceiling finish material is applied, a "board" (plywood, hardboard, gypsumboard, etc.) should be installed over the cavity to support insulation.

In multiple dwellings with back-to-back kitchens or baths, it is necessary to extend ceiling finish material over dropped soffits to the party wall to avoid loss of acoustical control and to provide adequate fire stops.

Rigid Insulation

Rigid insulation is available in various sizes and thicknesses made of polystyrene, polyurethane, cork, cellular glass, mineral fiber (glass or rock wool), perlite, wood fiberboard, etc. They are used as insulation for masonry construction, as perimeter insulations around concrete slabs, as exterior sheathing under the weather barrier, as rigid insulations on top of roof decks, and other applications. Rigid insulations, such as polystyrene and polyurethane, are vapor barriers and, in most applications, will not require the installation of a separate barrier.

Installation Procedures

Masonry walls: Rigid insulations are applied to either face of a masonry wall (Fig. 9a and 9c) or are used as a cavity insulation between two wythes of masonry (Fig. 9b). When applied to the face of masonry walls, they are generally installed with adhesive and/or mechanical fasteners. The manufacturer's recommendation should be followed.

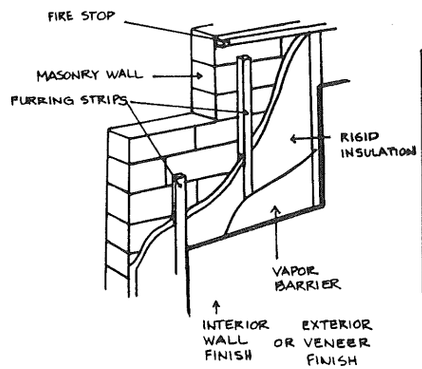


Fig. 9a

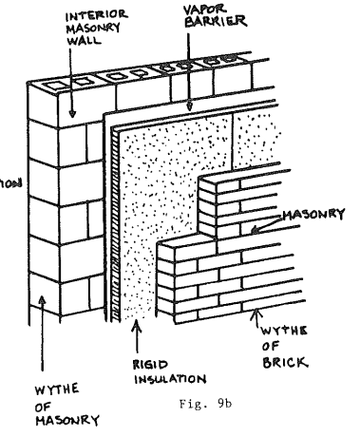


Fig. 9b

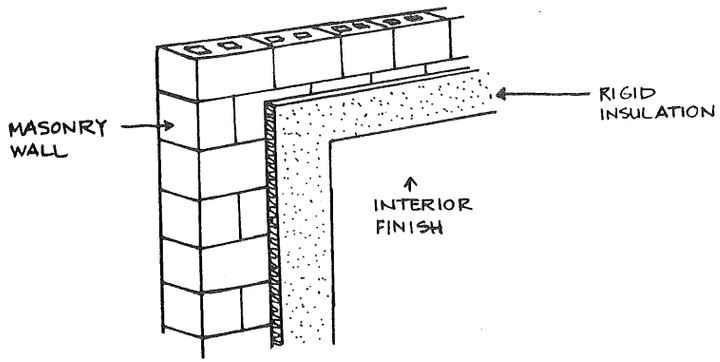


Fig. 9c

Frame Construction: When rigid insulation is used with frame construction (Fig. 10), it is usually applied as sheathing to the outside of the framing, and mechanically attached with nails to wood studs or to metal studs with screws or clips or other approved methods.

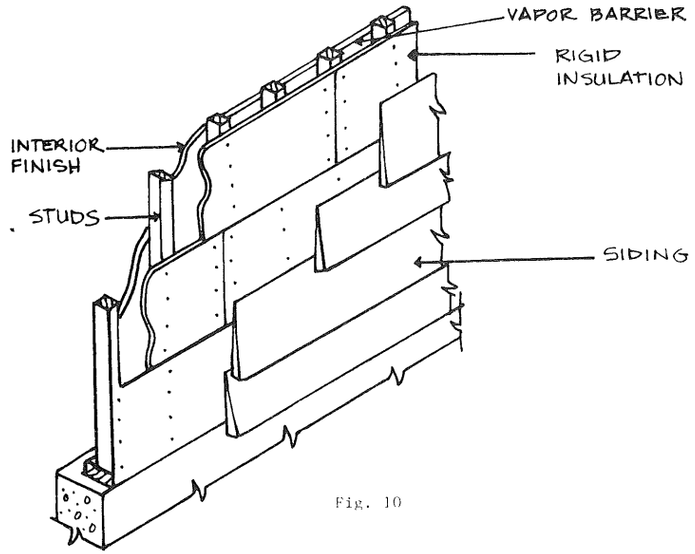


Fig. 10

Roof Insulation: Roof insulation boards are usually installed with an approved adhesive, hot asphalt, or may be nailed to the roof sheathing. The manufacturer's instructions should be followed.

Slab-on-Grade: Rigid insulation is frequently used as insulation around the perimeter of concrete slabs-on-grade (Fig. 11b, c, d) and also may be used on the inside of foundation walls adjacent to heated crawl spaces, basements or cellars (Fig. 11a). Installation is usually accomplished with adhesive and/or mechanical fasteners. Perimeter insulation should be installed against the foundation wall or extended into the interior of the building to a distance equal to the design frost line (Fig. 11b, c and d). Where the slab bears on the foundation ledge, the insulation should be a load-bearing type.

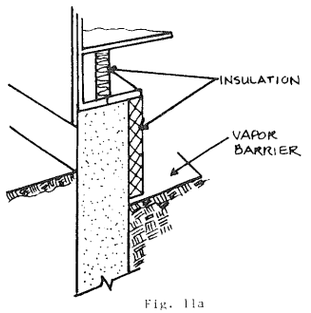


Fig. 11a

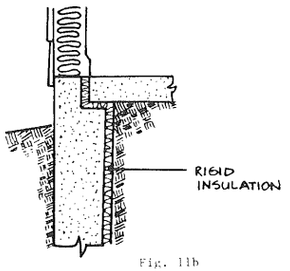


Fig. 11b

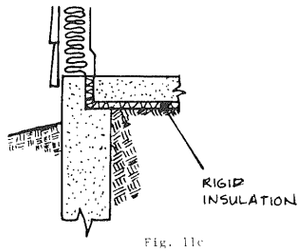


Fig. 11c

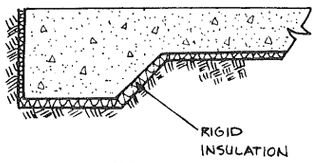
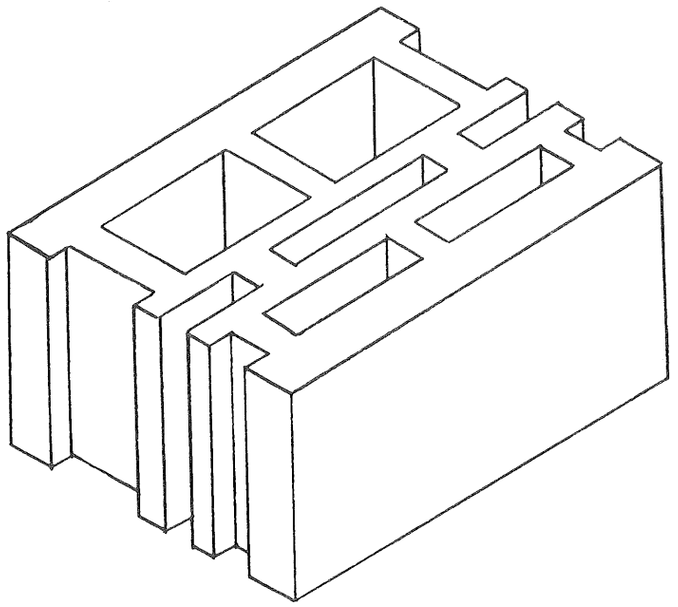


Fig. 11d

Concrete block manufacturers are currently producing several types of multi-celled block with improved insulating values. The thermal resistance of the block will vary depending upon the types of insulation used and the configuration of the cells. An example of a typical multi-celled block is shown below.



LOOSE FILL INSULATION

Materials of this type are those made from mineral fibers (rock or glass), cellulose materials (wood fibers or shredded paper), or other manufactured products that can easily be poured.

BLOWN ATTIC INSULATION

There are several factors pertaining to blown attic insulation that can cause differences in its installed thermal resistance value (R). For a given manufacturer's insulation, the installed thermal resistance (R) value depends on thickness and weight of insulating material applied per square foot. Federal specification HH-I-1030A for insulation requires that each bag of insulation be labeled to show the minimum

thickness, the maximum net coverage, and the minimum weight of (that particular) insulation material required per square foot to produce resistance values of R-30, 22, 19, and 11. A bag label example for blown insulation is shown in Fig. 12.

The number of bags of blown insulation required to provide a given R-value to insulate an attic of a given size may be calculated from data provided by the manufacturer. If only the thickness of blown attic insulation is specified, and the density or number of bags is not, the desired or assumed thermal resistance (R) value may not be achieved. The important characteristic is weight per square foot. Thickness is the minimum thickness, not the average thickness experienced in the field.

Adequate baffling of the vent opening or insulation blocking should be provided so as to deflect the incoming air above the surface of the installed blown or poured insulation. Baffles should be made of durable material securely fastened. Baffles should be in place at the time of framing inspection.

Three blown insulations that provide R-19 are:

Material	Minimum Thickness	Maximum Net Coverage/Bag	Bags/1000 Sq. Ft.
Cellulose	5⅛″	59 sq. ft. (40 lb. bag)	17
Glass fiber	8¾″	51 sq. ft. (24 lb. bag)	20
Rock wool	6½″	26 sq. ft. (27 lb. bag)	38

Bag Label Example: The manufacturer recommends these maximum coverages at these minimum thicknesses to provide the levels of installed insulation resistance (R) values shown:

(Based on 25-pound nominal weight bag)

R-Value	Minimum Thickness	Minimum Weight per Sq. Ft.	Bags per 1000 Sq. Ft.	Maximum Net Coverage per Bag
To obtain an insulation resistance R of:	Installed insulation should not be less than:	The weight per sq. ft. of installed insulation should be not less than:	Number of bags per 1000 sq. ft. of net area should not be less than:	Contents of this bag should not cover more than:
R-30	13¾ in. thick	0.768 lbs. per sq. ft.	30	33 sq. ft.
R-22	10 in. thick	0.558 lbs. per sq. ft.	22	45 sq. ft.
R-19	8¾ in. thick	0.489 lbs. per sq. ft.	20	51 sq. ft.
R-11	5 in. thick	0.279 lbs. per sq. ft.	11	90 sq. ft.

Weight contents: not less than 24 lbs.

R-values are determined in accordance with ASTM C-687 and C-236

Fig. 12

REFLECTIVE INSULATION

Reflective insulation is composed of aluminum foil in one or more layers either plain or laminated to one or both sides of kraft paper for structural strength. The insulation value for reflective air spaces, which this type of insulation provides, varies widely depending on the direction of heat flow. They are much more efficient when the heat flow is *down*. Reflective insulations which comply with the requirements when used in a floor, may not be satisfactory in ceilings or walls, where the heat flow is

upward and horizontal, respectively. Reflective insulations are effective in controlling radiant heat energy when installed so that they face an air space. Insulation should be installed in such a manner that it is continuous, without holes or tears.

SPRAYED INSULATION

There are several types of insulation which are sprayed against the surface of the building materials or in cavities. Some of these are cellulose with binder, mineral wool with binder, and cellular foams. They may be sprayed directly on concrete, masonry, wood, plastic, or metal panels or may be sprayed between the framing members. Manufacturer's recommended instructions should be followed. To determine that the proper thickness is installed, either refer to the plans and specifications, or request a certification from the supplier that the insulation installed provides the required "R" value.

TYPICAL INSULATION THICKNESSES AND VALUES

Insulation	Approximate R-Value	Thickness
Fiber glass	11	3½″
Fiber glass	13	3⅝″
Fiber glass	19	6″
Fiber glass	30	8″
Fiber glass	38	12″
Extruded Polystyrene Foam	5.4	1″
Extruded Polystyrene Foam	10.8	2″

VAPOR BARRIERS

Vapor barriers are used in conjunction with insulation to decrease the chance of moisture condensation inside the building insulation. Vapor barriers are placed on the side of the wall, ceiling or floor that is warm in winter. For equal vapor pressures, moisture vapor penetration through holes or tears in the insulation vapor barrier is proportional to the size of the opening. Holes or tears should be repaired. A snug fit of blanket flanges against the framing is necessary to prevent moisture from bypassing the vapor barrier.

EQUIPMENT

The installation of the heating system can contribute to inefficiencies. A furnace which is oversized by a factor of 2 will require 8 to 10% more fuel than a furnace of correct size. An installation that has uninsulated ducts passing through an unheated crawl or attic space will lose about 1.5 Btu per hour per square foot of duct per degree of temperature differential between duct air and outside air. This can amount to 40% of a furnace output under mild conditions. Undersized ducting will reduce the amount of circulating air and will affect the capacity of the furnace, but will normally have little effect upon its efficiency. Atmospheric combustion equipment that draws its combustion and stack-dilution air from the heated space will require up to 8% more fuel in a season to heat the required makeup air than sealed combustion equipment. Stack heat recovery devices can recover from about 4% at 450° F to 8% at 800° F.

The appliance manufacturer should be consulted when retrofitting the appliance with combustion air to assure that the appliance warranty is not affected.

Effect of Sizing Limitation on Equipment

Using the example on system design illustrated in Appendix A, an analysis was made to see what impact or problem the proposal for limiting the size of equipment to 15% above the design losses would have.

Example:

Total construction loss 27,760 Btu/hour

One air change per hour:

Inside volume = 12,188 cu. ft.
Q = (12,188) (90) (.018) = 19,744 Btu/hour

Total infiltration loss 19,744 Btu/hour

47,504 Btu/hour

Maximum furnace size:

47,504 Btu/hour + 47,504 (.15) Btu/hour = 54,630 Btu/hour

COMBUSTION AIR FOR FIREPLACES

It is recommended that combustion air from the exterior be provided for all fireplaces. Masonry fireplaces can be made more energy efficient with combustion air terminating in the fireplace. The opening of the fireplace should be equipped with a door and the combustion air duct with a damper and a louver to minimize air leakage during periods of nonuse.

CONDENSATION CONTROL

Air Infiltration

The department will accept infiltration losses determined by the air crack method or an overall value of ½ air change per hour.

The department will accept the use of engineered top-side moisture vent systems.

Relative Humidity

Winter: During the winter it is desirable to have humidity in the air in order to prevent the nostrils from becoming dry, furniture from cracking, etc. However, from an energy standpoint, it is desirable to keep the relative humidity low; the trade-off is at about 30%.

Summer: During the summer it is desirable to reduce the level of relative humidity in the building in relationship to the outside relative humidity. The relative humidity should be kept as high as possible in order to conserve energy, but low enough for comfort. The relative humidity should be kept above 55%, but less than 60%.

INDEX

See also first page of each chapter for listing of section headings.

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