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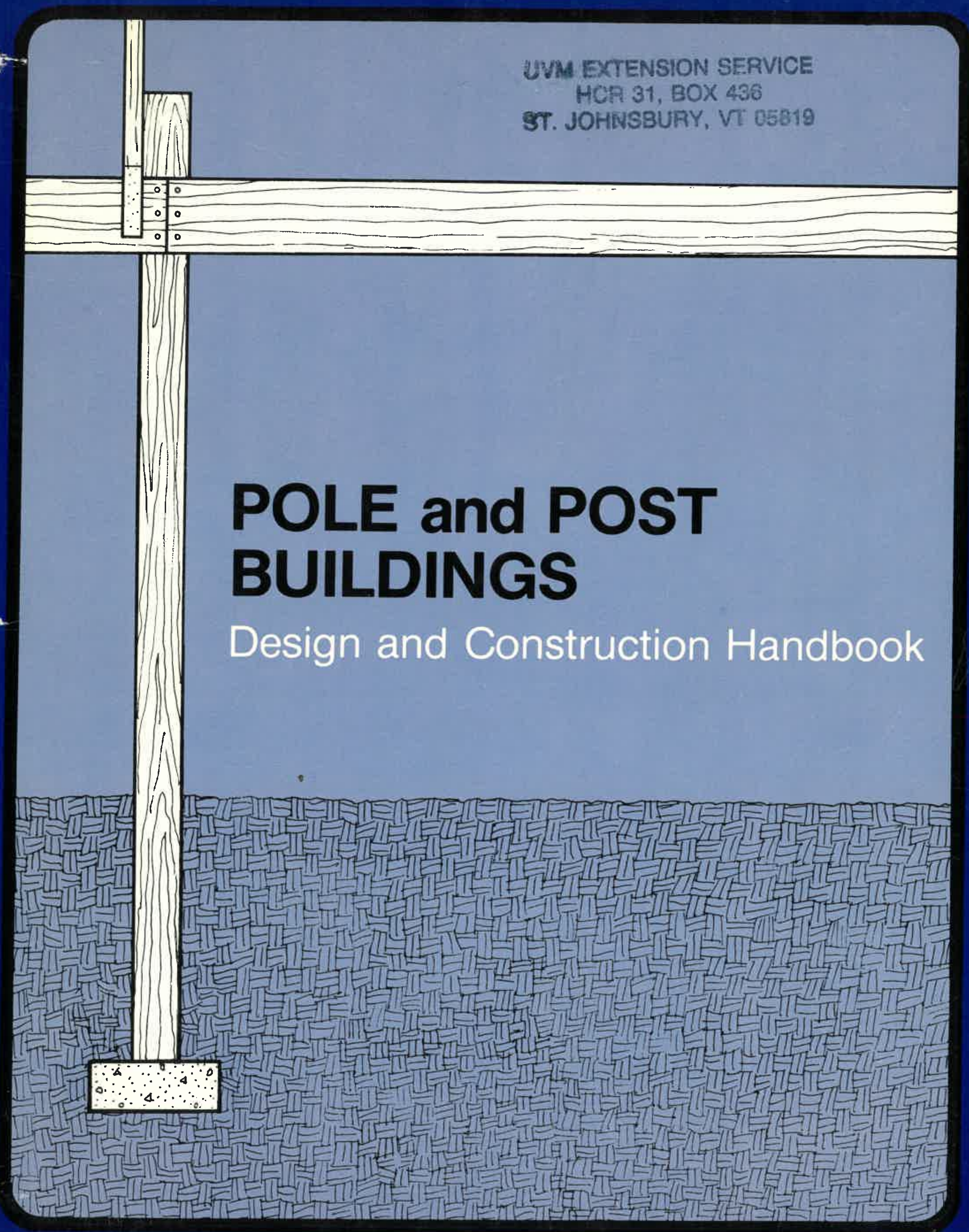

POLE and POST BUILDINGS

Design and Construction Handbook

COOPERATIVE EXTENSION
Northeast Regional Agricultural Engineering Service

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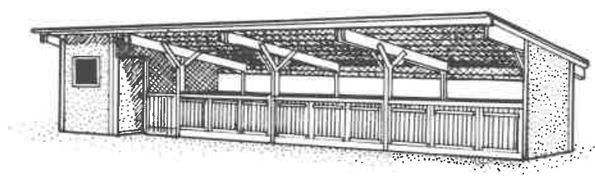
CONTENTS

Pole and Post Buildings

A pole or post utility building is a versatile and economical structure that can be used to store machinery or shelter animals. Other uses include boat sheds, fair exhibit buildings, corn cribs, horizontal silos, hay barns, shops, utility sheds, covered feed bunks, lumber sheds, warehouses, roadside stands, cabins and airplane hangers. One or more sides may be left open for a simple low-cost shelter. Pole-type buildings range in size from simple 10' x 12' shelters to large clear span buildings 100' wide and several hundred feet long with 24' high sidewalls.

Pole buildings are most often built as low cost uninsulated shelters for multiple use. The pressure preservative treated rectangular posts or round timber poles that are set in the ground transfer the snow, wind and other loads on the building into the ground. (Figures 1 and 2)

This handbook will help you design and construct a pole-type building. The information is particularly useful where professional engineering design help is not available. However, a consulting agricultural engineer can plan for your specific needs and often reduce construction costs. The information is based on engineering data and experience with agricultural buildings; it does not meet **all** requirements of some building codes. Check with local officials about specific building ordinances.



CALF BARN

Figure 1. Post Building with Trusses

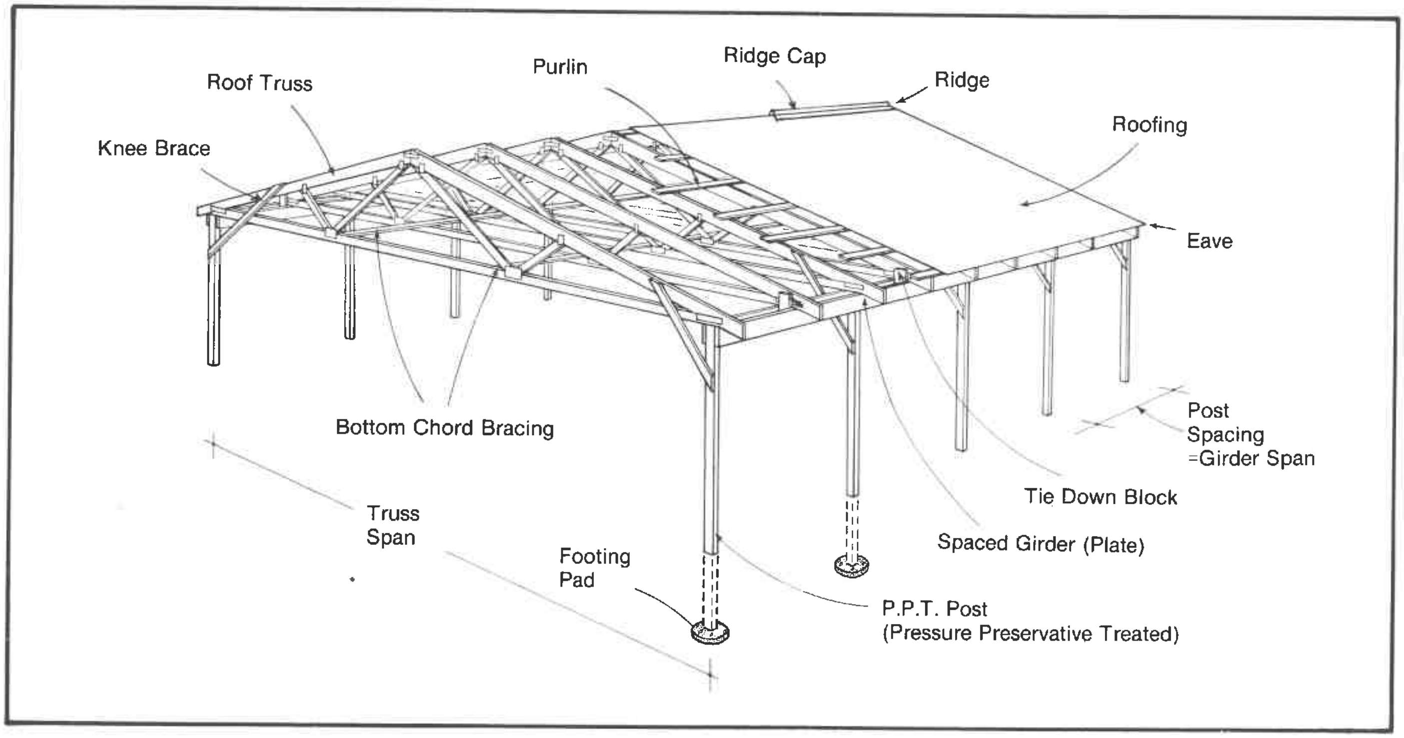
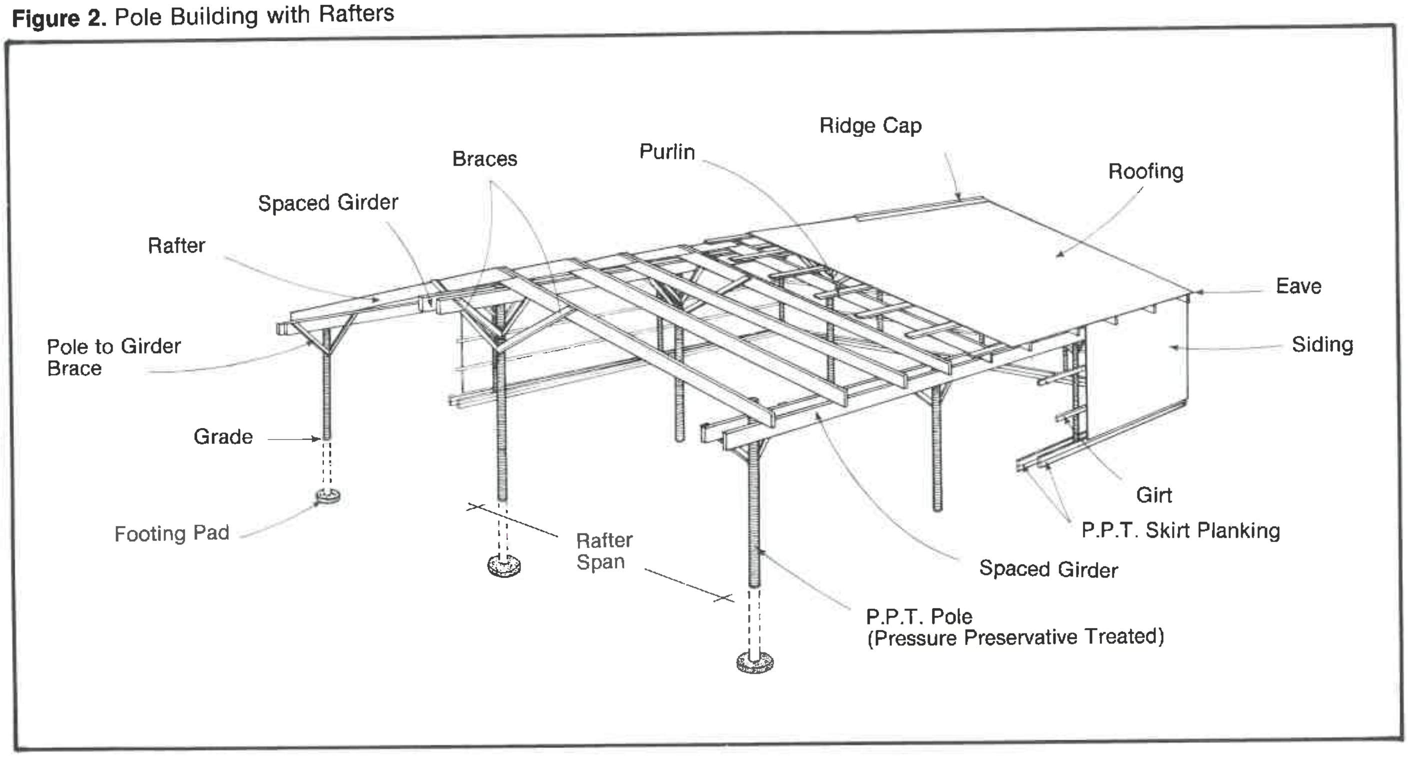


Figure 2. Pole Building with Rafters

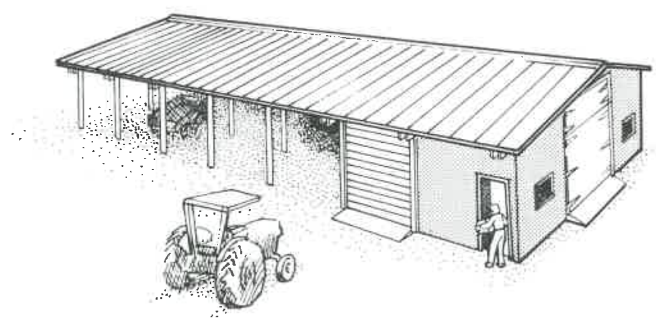


• Advantages

- Pole-type construction is generally simpler, easier, faster and less expensive to build than other types of construction.
- No massive or continuous foundation is needed.
- Site preparation is minimal. Pole buildings can be built with less disturbance to sloping ground.
- Pole buildings are built in units (bays or bents) that can be lengthened when more space is needed.
- Poles or posts support the roof, so sides can be left open for easy access.

• Limitations

- Rocks and ledge may limit the depth of poles and make other foundations desirable or required.
- Pole utility buildings are rarely more than one story high.
- Generally the cost and availability of poles and wood roof trusses limit sidewall heights to 20′ and clear spans to 60′. Greater heights and spans require more exact design and experienced builders, so construction costs per square foot may increase.
- Insulated pole buildings with interior linings can be as expensive as conventional construction with stud walls and concrete foundations.



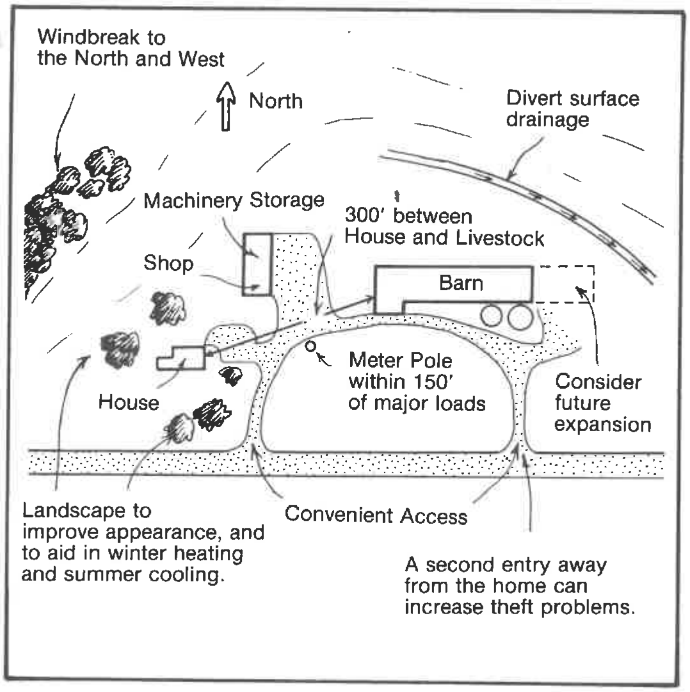
MACHINERY SHED

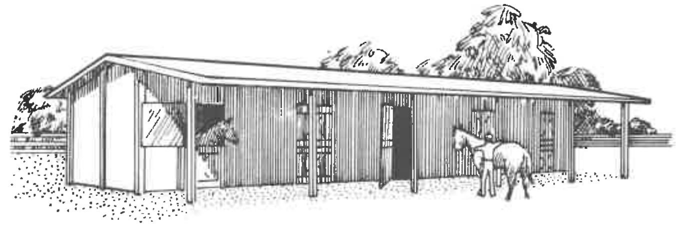
Site Selection and Drainage

Ideally any building should be located on a well drained, nearly level site that is convenient to other buildings. Ease of access may be more important than the ideal site, however. The building can be located to give wind protection, to capture winter sun or summer breezes, and to screen animal exercise and feed lots from view. (Figure 3)

Consider drifting snow as well as wind protection when locating the building. In many areas buildings are oriented to protect against winter storms that come from the northwest. Check conditions locally as severe storms may come from other directions. A building open to the

Figure 3. Farmstead Plan





SADDLE HORSE BARN

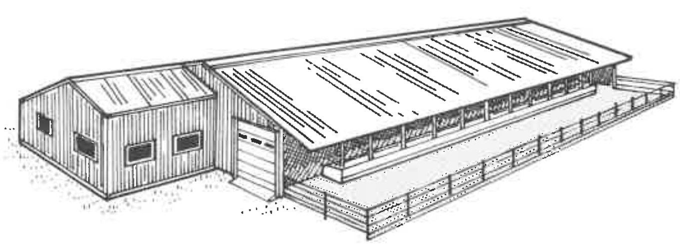
south and with proper roof overhang receives winter sunshine and is shaded from hot summer sun. Also orient the building ridge east-west to reduce exposure to summer afternoon sun.

When choosing a site, allow for expansion which may double the size of the building. Also space buildings 50' to 75' apart to reduce the spread of a possible fire, to give room to fight a fire and, in some cases, to reduce insurance rates.

If possible, avoid a site with rocks or ledge where special anchorage is needed. Digging a few holes to see if posts can be set 4' deep might help plan construction.

Topsoil is usually removed for later use and finish grading. It is replaced with less valuable fill to help keep water away from buildings. To keep floors high and dry, place an extra 6" of fill under and around buildings.

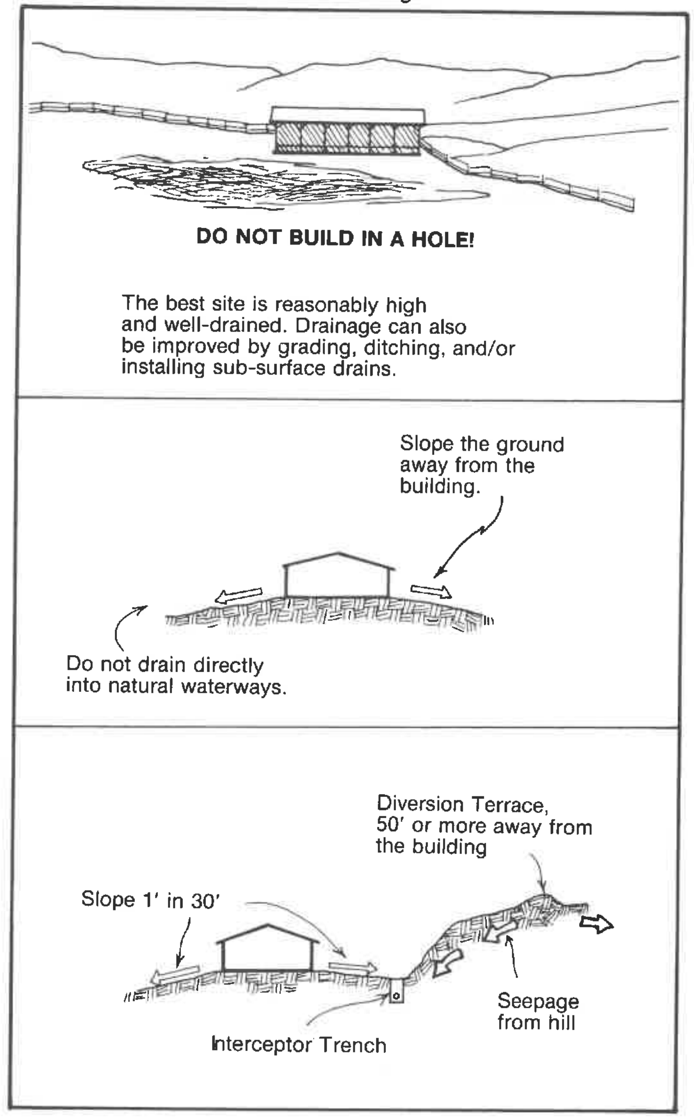
Grade the surrounding area with a 3-5% slope to drain away from the building in all directions. Diversion terraces intercept surface drainage and divert it from the building site. Locate the terrace 50' or more from the barn so it does not interfere with traffic.



FREE STALL DAIRY SYSTEM

Water seepage from an excavated hillside can be diverted with an interceptor trench. A 3' deep trench, sloped 1% with 4" tile laid in gravel or crushed stone and covered with 2' of gravel and 6" of earth will work. The gravel base beneath the tile maintains a true slope without sags and rises. Tile may be crushed beneath traffic lanes, so use steel culverts or cast iron pipe where drain is crossed by heavy equipment. (Figure 4)

Figure 4. Site Selection and Drainage



Materials

Poles or Posts

A round pole with natural taper is usually more economical, stronger and available in longer lengths than sawn timber posts. Machines peel the bark and trim knots flush with the surface of poles. They are seldom uniform in size and taper, so straight and plumb walls can be difficult to construct. The natural taper of poles provides a greater butt area for bearing and a larger cross section close to the ground where the greatest bending stress occurs.

Poles are divided into classes based on their top circumference. They range from class 7 with a 15" top circumference to class 1 with a 27" circumference. Larger, heavy class poles up to H-6 or 39" circumference are seldom used for agricultural buildings. Poles 8' to 20' long are available in multiples of 2' lengths. Longer poles are available in 5' increments.

The uniformity of sawn timber posts makes stacking and transportion easier than with poles, thus saving warehouse space and handling costs. Construction is normally faster since the uniform posts are easier to line up and connect to other structural members. In addition, many people prefer the straight, uniform appearance of posts. Pressure treated posts larger than 6"×8" and longer than 30' are difficult to find. Common sizes of 4×6 (3.5"×5.5"), 6×6 (5.5"×5.5") and 6×8 (5.5"×7.5") in lengths to 20' are in stock at many lumber yards.

Poles and posts act both as columns and projecting beams which are restrained in the ground and by framing and roofing at the top. As columns they must resist both crushing and buckling. To prevent buckling, bracing is used. When properly braced, wood posts will safely carry 1000 pounds for each square inch of cross section. For example, a well-braced 3.5"×3.5" post, can carry 12,200 lbs, or a load that equals a uniform load of 40 pounds per square foot spread out over an area of 300 square feet. The vertical column load is less critical than the loads carried by through connectors and fastenings, especially where girders and trusses are fastened to posts and poles.

Round poles loaded as beams will take greater stress than sawn timber posts. Poles of Western Larch, Southern Pine, Douglas Fir, Western Hemlock, Red or Norway Pine and Jack Pine have an allowable bending stress of 2100 psi or greater. The allowable stress for sawn timber posts is 1500 psi, nearly 30 percent less than for poles. If it is necessary to substitute poles for posts or vice versa, use Table 1 to select the proper sized substitute. Usually a building has fewer posts across it than along it; so the larger dimension of the post counters sidewall winds at right angles to the ridge.

Table 1. Sizes of Posts and Poles with the same Bending Resistance

		Equivalent Pole Size	
Post Size (in x in)	**Bending Resistance** (ft-lbs)	**Ground Line Circumference** (in)	**Diameter** (in)
5.5 x 9.5	10300	26.5	8.4
7.5 x 7.5	8800	25.1	8.0
6.0 x 8.0	8000	24.3	7.75
5.5 x 7.5	6400	22.6	7.2
6.0 x 6.0	4500	20.1	6.4
5.5 x 5.5	3500	18.4	6.0
4.0 x 6.0	3000	17.6	5.6
3.5 x 5.5	2200	15.8	5.0
4.0 x 4.0	1300	13.4	4.3
3.5 x 3.5	900	11.7	3.75

Note: Bending resistance is proportional to the width and to the depth squared.

Pressure Treatment

Wood in contact with soil must be treated with a preservative to prevent rotting. The pressure preservative treatment process (PPT) uses large pressure vessels to force chemicals into the wood. This treatment gives wood excellent resistance to termite attack and decay. Service life of over 50 years is common for PPT treated wood. Oilborne chemicals and water-borne salts are two major groups of wood preservatives. Cleanliness, paintability, color and odor are factors to consider when choosing a preservative treatment.

Creosote, used since 1838, is very effective against decay and termite damage. Creosote has a pungent odor and tastes bad. It is often used for horse stalls and fences to discourage animals from chewing on the wood. Illness from eating creosote has not been reported, although it can irritate the skin. Creosote tends to bleed from treated wood, so painting is difficult without washing or weathering the surfaces. Cleaner treatments are generally replacing creosote and pentachlorophenol in oil treatments.

Pentachlorophenol has been used since the 1930's and extensively since World War II. Penta in heavy petroleum oil is best for preservation, but is not paintable. Penta dissolved in light petroleum solvents is fairly clean and paintable.

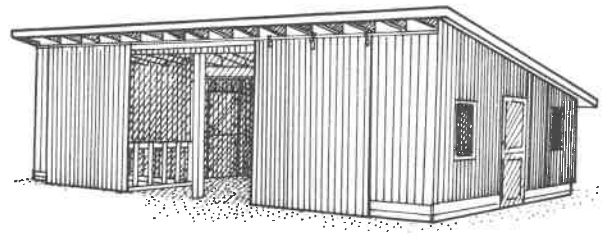
During 1976–77 in Michigan, eight dairy herds with extensive health problems were quarantined after pentachlorophenol was identified in tissue cultures and dioxin was suspected as a toxic contaminant in the penta. No other reports of animal illness from penta are known.

Water-borne salt preservatives include salt compounds of arsenic, chromium, copper and zinc. These preservatives are suitable where clean, odorless and paintable surfaces are necessary. Water, ammonia, or volatile acids are used as carriers of dissolved salts. The carrier evaporates after the treatment, leaving the dry salt within the wood.

The type and amount of preservative used varies with conditions of use, species of wood and, sometimes, the thickness of lumber. Timber piles subject to marine borer attack need more preservative than land or fresh water foundation piles. Lumber in contact with soil needs more preservative than lumber above ground. Softwood species and sapwood is easier to treat than hardwood and heartwood.

Structural poles and posts treated with chromated copper arsenate (CCA) or ammoniacal copper arsenate (ACA) are approved by the American Wood Preserving Association. Trade names for these treatments include Chemonite, Erdalith, Greensalt, Langwood, Boliden CCA, Tanalith NCA, Tanalith Oxide B, Koppers CCA, Osmose K-33, Chrome-As-Cu (CAC), Wolmanac CCA, and Woodlast CCA. Waterborne salts like acid copper chromate (ACC), chromated zinc chloride (CZC) and fluorchrome arsenate phenol (FCAP) are not recommended for soil contact because the chemicals may leach from the post.

Currently many lumber yards carry lumber treated with 0.4 pcf CCA for above ground or non soil contact use. Its service life when in contact with soil is not known. Test stakes treated with less than 0.6 pcf CCA or ACA do not last well in contact with soil. After 25 years in Mississippi, 10% of the test stakes with 0.44 pcf CCA showed termite damage.



SHEEP and LAMBING SHED

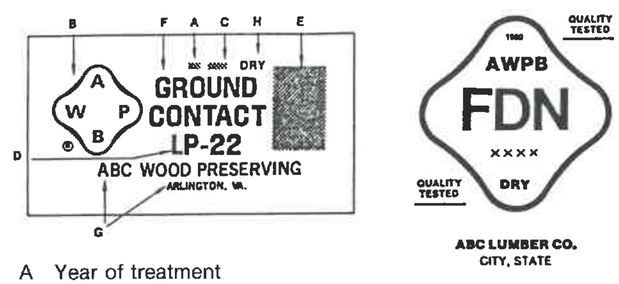
Table 2 summarizes the amounts of preservative that should be retained in wood used on farms as recommended by the American Wood Preservers Association Standard C 16-82. Special orders may be needed to get lumber with recommended treatments. Lumber that is stamped with the American Wood Preservers Bureau initials complies with the industry's quality standards. Presently, most water-borne salt treated posts, almost no penta treated lumber and no poles are AWPB stamped. (Figure 5)

Table 2. Recommended Minimum Preservative Retention for Wood use on farms, lb per cubic foot.[1]

	Creosote and Creosote Solutions	Pentachlorophenol	Acid Copper Chromate (ACC)	Ammoniacal Copper Arsenate (ACA)	Chromated Copper Arsenate (CCA)
Round Poles as structural members					
Southern Pine, Ponderosa Pine	7.5	0.38	NR	0.6	0.6
Red Pine	10.5	0.53	NR	0.6	0.6
Coastal Douglas-Fir	9.0	0.45	NR	0.6	0.6
Jack Pine, Lodgepole Pine	12.0	0.60	NR	0.6	0.6
Western Red Cedar, Western Larch, Inter Mountain Douglas-Fir	16.0	0.80	NR	0.6	0.6
Posts, Sawn Four Sides as Structural Members					
All softwood species	12.0	0.60	NR	0.60	0.60
Lumber, All Softwood Species					
In contact with Soil	10.0	0.5	0.62	0.40	0.40
Not in contact with soil	8.0	0.4	0.25	0.25	0.25
Plywood					
In contact with soil	10.0	0.5	0.62	0.40	0.40
Not in contact with soil	8.0	0.4	0.25	0.25	0.25
Foundation	NR	NR	NR	0.60	0.60
Greenhouses					
Above ground	NR	NR	NR	0.25	0.25
Soil contact	NR	NR	NR	0.40	0.40
Structural Posts	NR	NR	NR	0.60	0.60

[1]As recommended by the American Wood Preservers Association. Standard C 16-82.
NR - Not Recommended

Figure 5. American Wood Preservers Bureau Stamp



- A Year of treatment
- B American Wood Preservers Bureau trademark
- C The preservative used for treatment
- D The applicable American Wood Preservers Bureau quality standard
- E Trademark of the agency supervising the treating plant
- F Proper exposure conditions
- G Treating company and plant location
- H Dry or KDAT if applicable

Source: American Wood Preservers Association C16 1983

CAUTION

All preservative chemicals are toxic and treated wood should not be used where there is danger of contaminating food or animal feed. Handle preservatives and treated wood with care. Preservatives that contact the skin may cause rashes and burns, especially creosote in hot weather or wet pentachlorophenol. The solvents or carriers may contain napthalene or other vapors which irritate the eyes and respiratory tract. Keep baby pigs and other young animals away from freshly treated wood. Creosote and pentachlorophenol seriously injure plants, so copper salt preservatives, typically green in color, are recommended in greenhouses.

Lumber

• Species

Common eastern softwoods include:

Eastern Spruce such as Red, White and Black spruce
Balsam Fir
Eastern White and Northern Pine including Jack, Pitch, Norway and Red pine
Eastern Hemlock and Tamarack
Northern White Cedar
Aspen including Bigtooth and Quaking Aspen which are "soft" hardwoods.

Western woods include:

Douglas Fir-Larch
Lodgepole, Ponderosa, Sugar and White Pine
Engelmann Spruce - Alpine Fir
Mountain and Western Hemlock
Sitka Spruce
Western Cedars
Redwood

Various species of Southern Pine are used extensively for construction. Several softwood species are marketed mainly in combinations or groups. Douglas Fir-Larch, Southern Pine, Hem-Fir and Spruce-Pine-Fir represent typical combinations.

• Size

Lumber is sold by nominal size. Most commercial lumber is dressed or planed smooth so it is 1/2" to 3/4" smaller than the nominal, or rough sawn, size. Table 3 lists sizes of commonly available construction lumber.

Table 3. Nominal and Surfaced Sizes of Dimension Lumber and Timbers.

	Dimension Lumber & Timber Size, in x in	
	Nominal Size	Actual Size
DIMENSION LUMBER	2 x 4	1.5 x 3.5
	2 x 6	1.5 x 5.5
	2 x 8	1.5 x 7.25
	2 x 10	1.5 x 9.25
	2 x 12	1.5 x 11.25
	4 x 4	3.5 x 3.5
	4 x 6	3.5 x 5.5
TIMBERS	6 x 6	5.5 x 5.5
	6 x 8	5.5 x 7.5
	8 x 8	7.5 x 7.5

A **board foot** is the unit of measurement of lumber. Multiply the nominal thickness by the nominal width in inches by the length in feet and divide by 12 to obtain the number of board feet in a piece of lumber. (W"×T"×L' ÷12=Board Feet)

Lumber is commonly available in 8' to 20' lengths in 2 foot multiples. Longer lengths are available, but cost more. Nominal thickness is basically as follows:

Boards - Lumber less than 2" thick.

Dimension - Lumber from 2" to less than 5" thick.

Timbers - Lumber 5" or thicker in the smallest dimension.

• Grades

Lumber is classed as 1) stress-graded, 2) non stress-graded and 3) appearance lumber. Most softwood dimension or framing lumber is visually stress graded but increasing amounts are machine stress rated. Other stress-graded products include timbers, posts, stringers, beams, decking, and some boards.

Stress-graded dimension lumber is used as framing lumber for girders, rafters, girts, purlins, and bracing, where strength, stiffness and uniform size are important. Usually, only one or two of the general purpose construction woods such as Douglas Fir, Hemlock or Spruce are stocked in retail yards.

An example of how visually graded softwood dimension lumber is classed by thickness, width and grades related to bending strength is shown in Table 4. Use number 2 or better grades of lumber for rafters, joists or truss members that support a load. Use dry lumber for construction. Green, undried lumber warps as it cures and often causes wavy eaves, roofs or sidewalls.

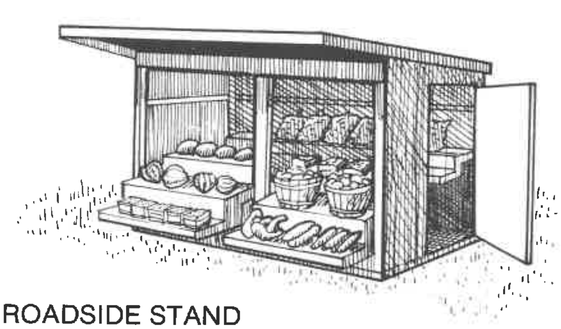
Table 4. Bending Strength of typical dimension lumber according to Size Classification and Grade.[1]

		Bending Strength, lb/sq in	
Size Classification[2]	**Commercial Grade**	**Douglas Fir Southern Pine**	**Eastern Hemlock, Northern Pine**
Structural Light Framing, 2" to 4" wide	Select Structural	2100	1800
	No. 1	1750	1500
	No. 2	1450	1250
	No. 3	800	700
Light Framing, 4" wide	Construction	1050	900
	Standard	600	500
	Utility	275	250
	Stud (10' or less)	800	700
Structural Joists and Planks, 6" and wider	Select Structural	1800	1550
	No. 1	1500	1300
	No. 2	1250	1050
	No. 3	725	625

[1]Adapted from the National Design Specification for Stress-Graded Lumber and its Fastenings.
[2]All sizes 2" to 4" thick.

Some lumber is stress rated by a machine which measures its stiffness or modulus of elasticity. A stiff board, or one with a high modulus of elasticity is stronger than one with a low modulus. Usually machine stress rated lumber is more uniform in strength than visually graded lumber. It normally must be special ordered.

Non stress-graded lumber does not have assigned strength properties and is used in construction as boards, battens, siding, shelving or paneling.



ROADSIDE STAND

• Ungraded Lumber

Sometimes ungraded lumber is available from a local sawmill. Select lumber for strong structural members by using the following selection guide. This method will eliminate the weakest pieces, or about 25% of a normal lot of ungraded lumber.

1. Select lumber with knots or knotholes with a diameter smaller than one-quarter the nominal width of the piece.

Table 5. Maximum Recommended Knot Size.

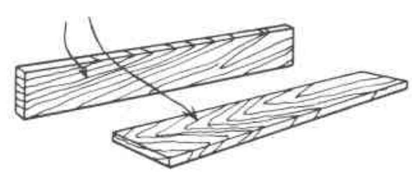
Lumber Size				Maximum Recommended Knot Size
		2 x 4	-	1"
		2 x 6	-	1 1/2"
2 x 8	2 x 10	2 x 12	-	2"

2. Reject pieces with 2" or larger knots

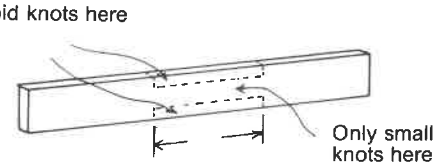
3. Reject rotted, split, checked, warped, or undersized pieces.

4. Reject cross grain that slopes more than 1 in 10.

Avoid grain slope greater than 1 in 10



5. Avoid knots along the edge of the middle half of the lumber.



Weaker pieces of native lumber can be used for sills, braces, studs, pens and partitions.

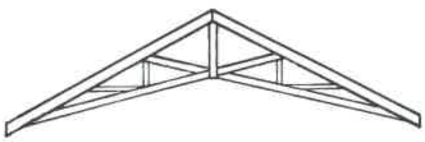
Roof Trusses

Roof trusses, either prefabricated or built on site, provide economical clear-spans from 20' to 60' wide. Wood roof trusses for single spans exceeding 80' need special design, are costly and are difficult to ship and handle.

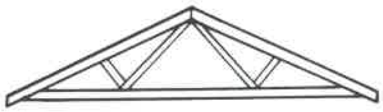
Combinations of gable trusses in the center and single slope trusses for one or both sides are often used for wider buildings. Simple wood rafters are economical for spans up to 20′. Interior supporting poles and girders are needed for wide buildings without trusses. Truss style varies with span and design load. (Figure 6)

Figure 6. Common Truss Configurations

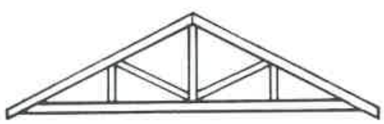
Single Slope (Mono pitch)—Spans 20′ to 35′.



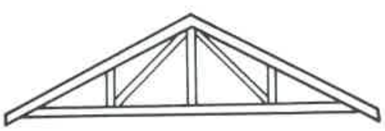
Scissors —Used where high center clearance is desired. Spans 20′ to 40′.



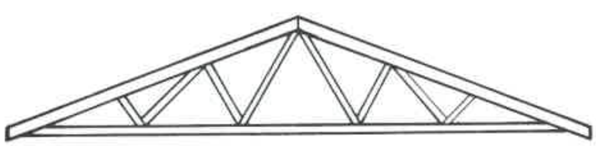
Fink (W)—A popular, efficient design for spans of 20′ to 50′.



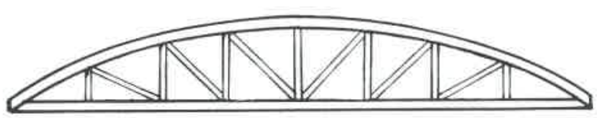
Howe —Spans 20′ to 50′ for heavier ceiling loads than carried by the Fink truss.



Pratt —Spans 20′ to 60′. For use with or without ceilings.



Belgian (Double or Triple Fink)—Spans up to 80′.



Bowstring —Generally used for spans from 40′ to 120′.

• Slopes and Spacing

Roofing sheets and shingles shed snow and rain better with slopes greater than 3 in 12. For worker safety and economy, slopes are limited to 6 in 12. Roof trusses are commonly spaced 2′ or 4′ apart; although spacing may be increased to 8′ or more. Wider spacings require stronger trusses and roof purlins, so professional design is recommended. Usually stress-graded Douglas Fir or Southern Pine dimension lumber is selected for truss construction due to its high strength and ability to hold fasteners.

• Fasteners

Trusses may be joined with nailed gussets, glued and nailed gussets, bolts, split ring connectors or metal plate connectors. Roof trusses can be built on the job site, but quality control is difficult, especially if glue is used. Quality trusses manufactured in a shop under controlled conditions are available in most areas. Many manufacturers use pressed metal plate connectors to provide an economical roof truss with design and quality assurance from the Truss Plate Institute.

• Ordering Trusses

When ordering trusses specify the loads to be carried, service conditions and critical dimensions such as truss span, overhang, roof slope and desired spacing. The total roof load, usually between 20 and 40 pounds per square foot (psf), includes both the snow load and the dead weight of the roofing, purlins anad trusses.

Tell the supplier if the truss is to support a ceiling with insulation, a roof deck with asphalt shingles, suspended equipment or other loads which may require a stronger truss. Also specify how the building will be used; livestock buildings, for example, often have a high moisture, corrosive atmosphere which may weaken trusses.

Deeper trusses, like deeper girders, are stronger than shallower trusses of the same materials. Usually joint connections are the weakest part of a truss—larger members do not always assure added strength. Larger and stiffer gussets or splice plates strengthen a truss.

When the truss is in place the upper chord members are loaded in compression and the bottom lower chord members are loaded in tension. Gable trusses cannot be inverted or installed upside down without high risk for failure. Instead, use a properly designed single slope shed truss for the required roof load.

Inspect trusses upon delivery for sound lumber and tight joints. Reject any questionable trusses. Truss members may be cracked or their joints loosened during erection. Handle trusses carefully and brace them as they are erected so wind gusts will not blow them down.

Roofing and Siding

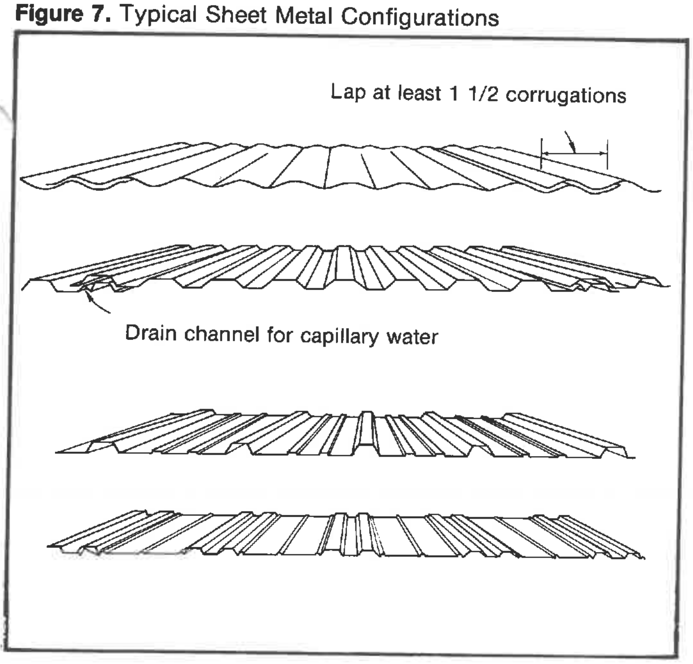
A variety of roofing and siding materials are suitable for pole and post buildings. Aluminum sheets, galvanized steel sheets, asphalt products or wood products are most frequently used.

Nearly all roofing and siding materials are sold by the "square" (100 sq ft). Sometimes a purchased square is exactly 100 sq ft and does not include material for joints or laps. Other materials are sold based on coverage so the necessary overlaps are included. Check this difference when determining the cost of roofing and siding materials.

• Metal Sheets

Ribbed or corrugated metal sheets provide channels for drainage and have greater lengthwise stiffness for direct installation on spaced roof purlins or wall girts. Aluminum and steel sheets up to 4′ wide with lengths from 8′ to 40′ are readily available. Both are available with natural finish (silvery gray) or color coatings such as baked-on enamels. (Figure 7)

Figure 7. Typical Sheet Metal Configurations



White painted steel or aluminum roofing sheets reflect solar heat and help buildings cool. In some livestock shelters rigid insulation installed between the roofing and roof girts reduces solar heat gain and interior condensation. Of course any insulation should be protected from damage by birds or animals.

For more rapid building coverage buy fewer, large sheets. On many buildings, with long sheets, an entire side of the roof can be installed without end joints. However, as temperature changes, metal sheets expand and contract, stressing the fasteners. Limit the length of roofing sheets to 24′ to minimize failures and roof leaks.

The ribs in metal sheets are commonly 1/2″ to 3/4″ deep. Sheets with deeper ribs carry rain away better on long slopes and allow supports to be spread farther apart. However, before increasing purlin spacings, check that the strength of the purlins is enough to support the heavier load.

For best performance install corrugated metal sheets on roofs with 3 in 12 slope or greater. This reduces flooding of corrugations and seepage through the side or end joints during heavy rainfall or snow melt.

Steel alloys are stronger, heavier and expand less with temperature changes than aluminum alloys. Steel does require durable coatings to prevent rusting. Zinc galvanizing protects steel from corrosion and varies in thickness. Minimum zinc-galvanized coating standards from the Zinc Institute, Inc. are 1.25 oz. and "Seal of Quality" or 2.00 oz. of zinc per sq ft of sheet. Exposure tests in rural atmospheres show a useful life before "first signs of rust" of 7 years for 1.25 oz. and 15 years for 2 oz. zinc coatings. In industrial areas the useful life is reduced.

Aluminum plating, polyesters and other factory applied enamel paints are now available to protect steel with performance warranties up to 20 years.

"Seal of Quality" sheets are more expensive and may require a special advance order for your building project. Because zinc thickness cannot be measured by visual inspection, look for the Zinc Institute seal or request a written certification from the manufacturer.

Aluminim alloys oxidize and become less reflective with age, but do not need coatings for weather protection. Roofing sheets made from high strength aluminum or steel alloys tend to be brittle. This brittleness causes some alloys to crack or split rather than dent or bend if hit too hard or if stepped on incorrectly.

Generally aluminum and galvanized steel covered roofs require little maintenance, but keep lead, zinc, manure, salt, and other corrosive materials away from them. Instead install wood or concrete siding where corrosive conditions occur.

Only use the special nails or screws with sealing washers designed to fasten metal roofing and siding. Follow manufacturers' application instructions to reduce roof leaks and corrosion. Dissimilar metals such as steel or aluminum that contact each other corrode rapidly. Use galvanized nails with lead heads or neoprene washers with galvanized steel sheets and aluminum fasteners with aluminum sheets.

Nails punch or depress the metal so nail through the top or ridge of the corrugation for best performance and to reduce leaks. Self drilling screws with flat sealing washers may be power driven in the flat or valley of the corrugation. Place sidewall fasteners in the valley of corrugated metal sheets.

• Installation

Applying roofing to spaced purlins is hazardous, particularly on windy or wet days. Step on sheets only where there is a purlin. Mark a line for nailing if necessary.

• Wood Products

Cedar shingles (or shakes) for roofing or siding are weatherproof, rustic and expensive. Usually shingles are nailed over a solid roof deck or wall sheathing which adds to the cost. Wood shingles perform well on roof slopes of 6 in 12 or greater. With lesser slopes they must be overlapped more.

Roof sheathing for shingles must be adequately supported to prevent sag or failure from snow loads. Graded plywood has an identification index (pair of numbers separated by a slash). The first number gives the maximum spacing, in inches, for roof decking supports with the face grain across the supports. The second number tells the maximum spacing for residential subflooring supports. Typical 1/2" plywood requires roof supports every 32" or less; 3/8" plywood requires roof supports every 24" or less.

For low cost structures, rough cut green lumber makes an attractive inexpensive board and batten siding. Boards are positioned vertically over the nailing girts and nailed in place along one edge only. After one year of curing batten strips are nailed over the cracks, resulting in a weather tight building.

Individual vertical boards (with or without battens over joints), plywood, textured plywood, drop siding, shiplap, etc. make attractive siding materials.

Pressure preservative treated or exterior plywood laid like large shingles has been satisfactory for roofing some temporary shelters, but sealing joints is very difficult. Wood is normally painted or stained to assure long life. Unfinished native woods erode from weathering about 1/8" per 100 years to provide the attractive raised grain texture and dull gray color.

• Asphalt Products

Asphalt shingles and roll roofing are not commonly used on pole-type buildings because a continuous decking or wood sheathing is required. Asphalt shingles are asphalt-saturated felt or fiberglass that is surfaced with colored granules on the exposed side. Light colored shingles reflect solar heat better and last longer than dark ones. Interlocking or self sealing shingles are best for windy areas. Roofs with less than a 3 in 12 slope require more care during installation, less tab exposure, and a roofing underlayment (asphalt saturated felt).

Shingles are usually sold by the bundle which is one-third of a square (100 sq ft of coverage). High quality shingles weigh about 300 lb per square and last more than 20 years. Install at least 240 lb. shingles.

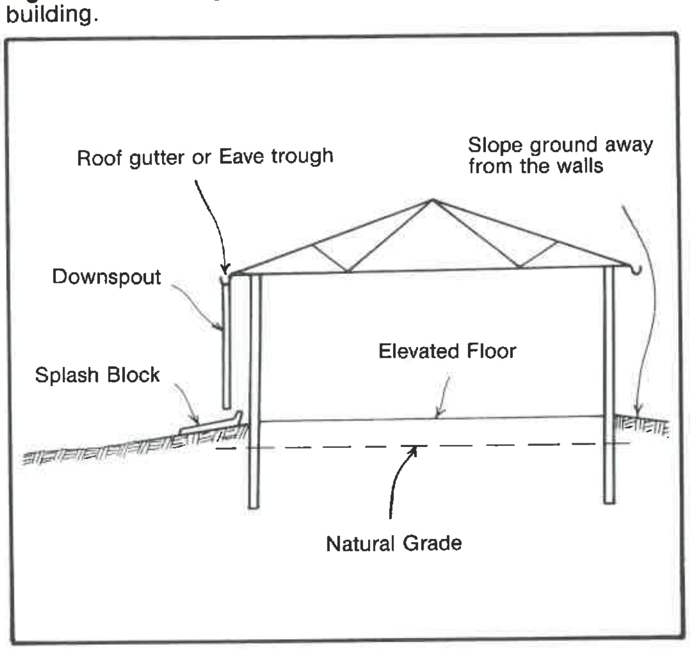
Corrugated asphalt sheets can be installed on spaced purlins or spaced sidewall girts. They are available in widths of 32" and lengths of 6', 6" (2 meters). If used on roofs where the slope is less than 3 in 12 or in areas with high temperatures and intense sun, space roof purlins 12" on center to reduce sag.

Roof Drainage

Roof gutters and downspouts collect and divert rain and melted snow from the roof. Often they are omitted from utility buildings since distributed roof drip is sometimes more desirable than concentrated flow from downspouts. In colder regions with heavy snowfall, gutters are seldom used because snow and ice dams form along the gutter and the edge of the roof, especially if the building is heated.

Install gutters or eave troughs if roof water is to be collected for storage or to protect doorways, foundations and basements. A 5" gutter with 3" diameter downspout for every 1000 sq ft of roof area is satisfactory. Position the gutter to avoid damage from sliding ice and snow and fasten according to manufacturers' instructions. At the base of the downspout install an elbow and extension pipe or splash block to divert water at least 30" away from the building. (Figure 8)

Figure 8. Eave troughs divert rain and snowmelt from the building.



Doors

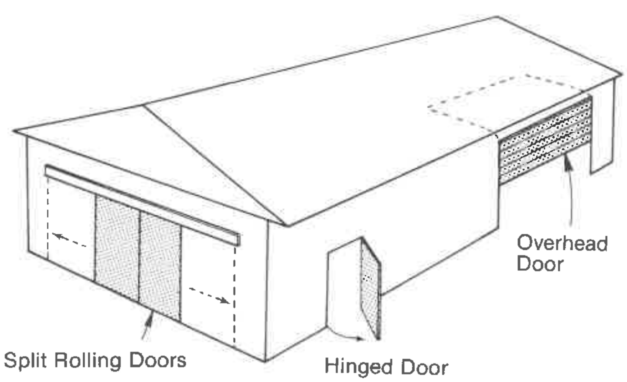
Durable doors, door frames and hardware are needed to resist the rough service, moisture, impacts and corrosion that typically occurs. To protect door jambs and overhead door tracks from animals or equipment, set posts close to the doorway in concrete. Auxiliary inside gates in barns not only help protect the inside of doors but also allow better ventilation during warm weather. Install insulated doors and/or a storm door on buildings that will be kept above freezing in cold climates.

Swinging, sliding or overhead doors are common in agricultural buildings, the choice depending largely upon use, size and cost. Table 6 summarizes the minimum and recommended sizes, types and use of doors.

Table 6. Minimum and Recommended Sizes, Types and Uses of Doors.

User	Size (Width x Ht) Minimum	Recommended	Door Type
Personnel & small animals	2' x 6'	3' x 7'	Swing
Single cows & horses	3' x 7'	4' x 8'	Swing or Sliding
Two lines cows & horses, medium sized tractors, autos, pick-up trucks	7' x 7'	8' x 8'	Sliding or overhead
Mixer or side unloading wagons	10' x 10'	12' x 13'	Overhead w/ automatic opener
Tractors w/ cabs, trailer trucks, field equipment	10' x 13'	12' x 13'	Sliding or Overhead

Note: Large field equipment may require doorways 16' to 24' wide and small airplanes may need 40' wide doors.



Prefabricated metal or wood doors for personnel or single animals are readily available, but buy only durable units. Lightweight aluminum storm and screen doors or hollow core wood doors often need replacement within two years. A durable door can be built on site from exterior A-C plywood with Z framing. The "Dutch" door is often used in horse barns.

Rolling or sliding doors are hung from two trolleys on a track. Rolling doors are easier to secure against wind gusts than large hinged doors. Guides at the lower corners of doorways and latches help to keep wind damage low.

Rolling doors are usually built on site with plywood or metal sheathing on a wood or metal frame. Large doors can be divided for easier operation or so the track is on both sides of the doorway. Consider two or more door sections if the opening is over 16' wide.

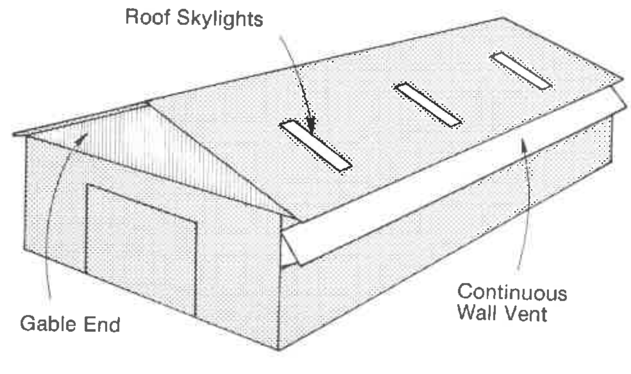
Prefabricated overhead doors are easier to operate but more expensive than rolling doors. Curved side tracks guide hinged panels beneath ceilings or roof trusses as the door is raised. When closed, the door wedges tightly against the door jamb. Protect the door track and posts with pipe or angle iron posts set in concrete and consider electric door openers where vehicles move in and out several times daily.

Skylights and Windows

Fiberglass reinforced plastic (FRP) panels shaped to match metal roofing and siding panels are available in several colors, commonly green, yellow and white. These panels are not clear enough to see through, but they transmit enough daylight to improve the interior appearance or working conditions.

FRP panels are thicker and several times more costly than metal panels. Roof skylight joints must be well sealed to prevent leaks. The skylight area should not exceed 5% of the roof area to keep the solar heat gain reasonable. FRP panels installed in the gable ends and sidewalls helps to eliminate problems of leaks and solar gain from roof skylights. They also may improve the appearance and function of agricultural buildings. Continuous sidewall vents may be opened to reduce heat stress on animals in barns.

Insulated and fan ventilated livestock barns often have clear glass sliding windows. In cold climates rigid plastic or polyfilm storm windows help conserve heat.



Design

Loads from snow, wind, the building itself, stored products, and any hanging or concentrated loads must be transferred through building framing to the ground. Generally a concrete pad, or casing is needed to spread the load in the ground and keep the pole from settling. In the mountains and much of the northern U.S., snow is the major roof load on a building. The weight of metal roofs and framing seldom exceed eight pounds per square foot (psf). Equipment, such as poultry cages hung from roof trusses, add an extra load.

The weight of the building materials and any continuous gravity loads are called dead loads. Other loads which come and go are live loads. These loads may act in any direction against a building or its components but vertical snow loads and horizontal wind loads are most critical. Fortunately the maximum wind load does not occur at the same time as the maximum snow load.

If a building code applies, use it to select the proper size posts, footings, framing members and fasteners. If no code applies, consider local construction practice or use this manual as a guide for design. In any case, first find the snow load and design wind speed for the building site from local sources or Figures 9 and 10.

Figure 9. Basic Wind Speed, miles per hour.

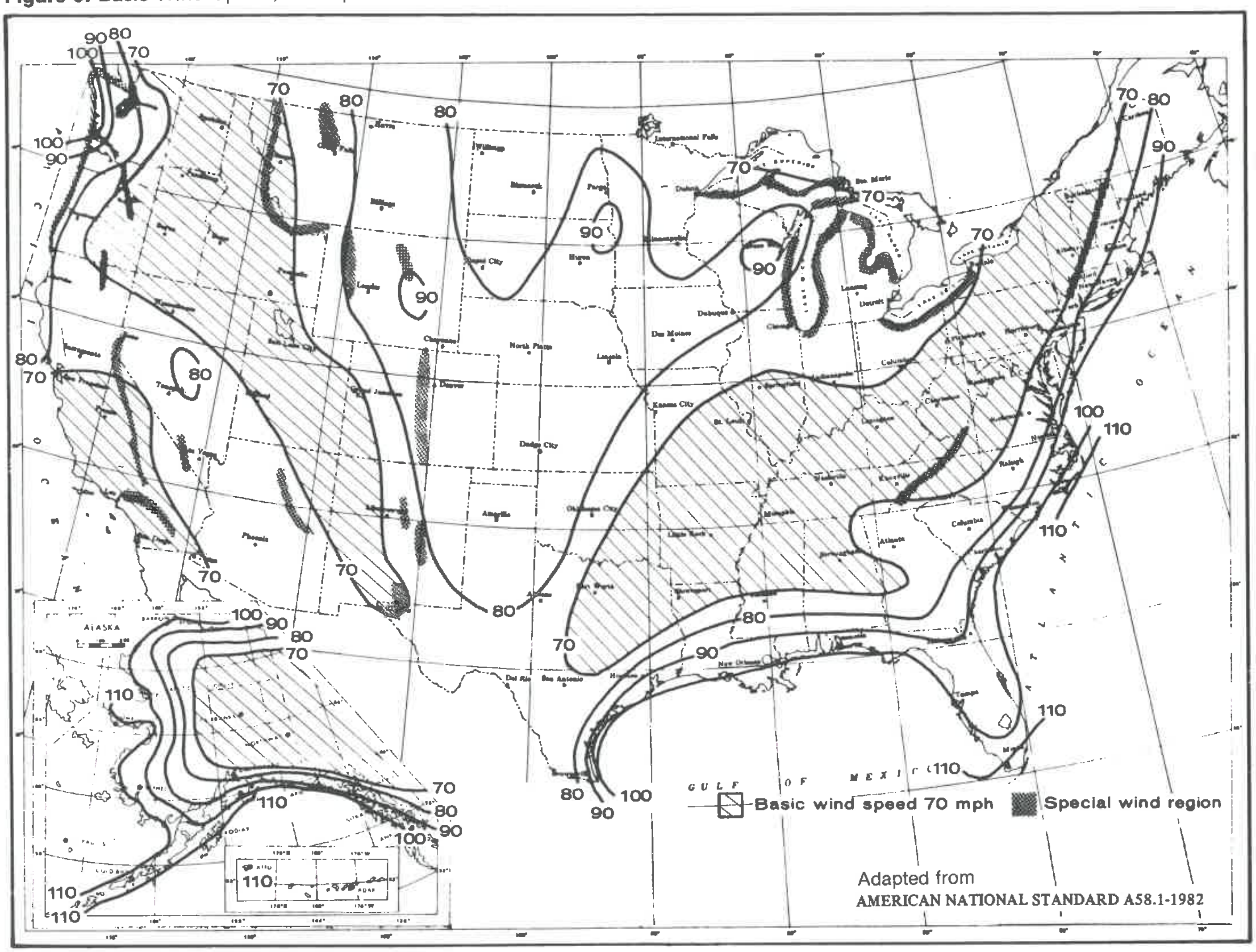
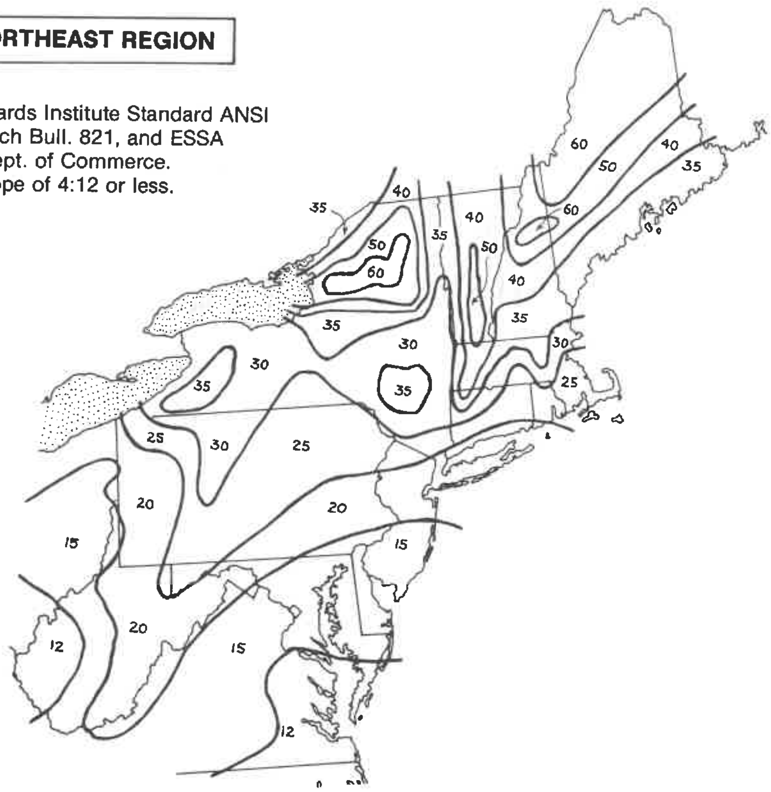
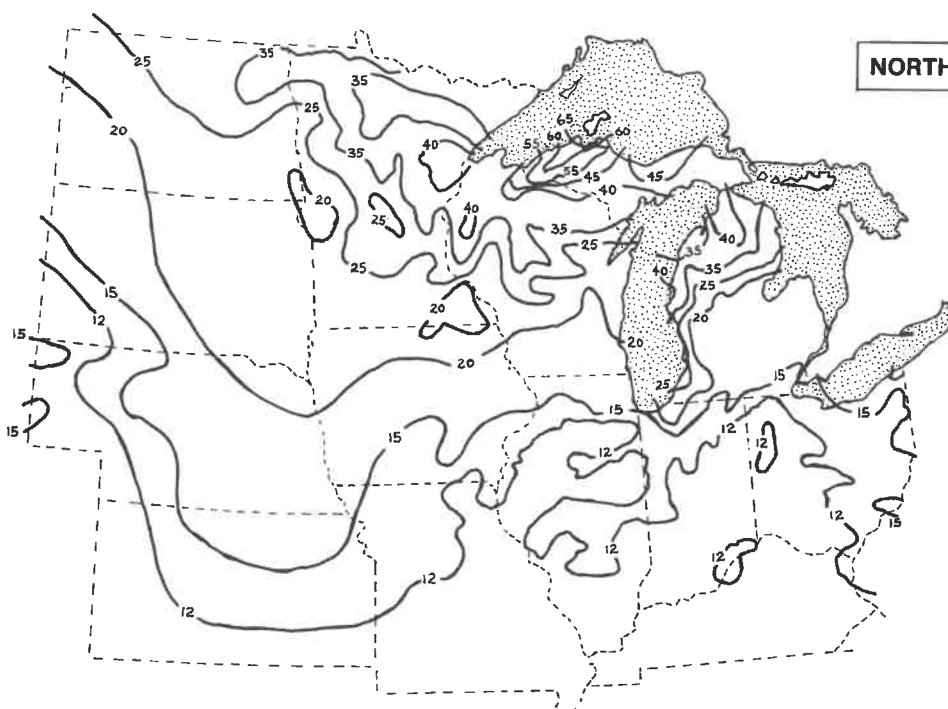


Figure 10. Estimated Snow Loads on the Roof, pounds per square foot (psf), 50 year recurrence.



Adapted from American National Standards Institute Standard ANSI A58.1–1982, Northeast Regional Research Bull. 821, and ESSA Tech. Memo EDSTM 12, by the U.S. Dept. of Commerce. Estimated snow load on roofs with a slope of 4:12 or less.



Data derived from a study by the University of Missouri and the National Climatic Center for the U.S. Nuclear Regulatory Commission. Snow loads for the four western states are estimates not included in the study.
Roof loads range from 0.65 to 0.8 of the ground load.

Wind Loads

The wind map (Figure 9) shows expected maximum wind speeds 33' above the ground in open country. Winds flowing over mountains or through valleys in the special wind regions could have much higher speeds than shown. Consider increasing the design wind speed for these areas.

Snow Loads

Snow loads vary greatly and are difficult to predict. Nearby obstructions, wind, roof slope and the type of storm all affect snow loading. Light, freshly fallen snow may have only 1/20 the density of water; granular late season snow packs may have a density one third that of water.

When local information or code requirements are not available, snow loads can be estimated from the snow load map (Figure 10). The map shows snow load on the roof based on probability of the load occurring in any year as 0.04. Farm buildings which represent low risk to human life are often designed for this probability of annual occurrence.

Drifting snow causes uncertain and unbalanced loads which have collapsed buildings. Two to four times normal loads may occur where drifts, ice dams, or sliding snow build up:

- Near projections above the general roof level,
- At intersecting roofs,
- At sheds below and beside a higher roof or silo, or
- On projecting eaves.

Pole Size and Spacing

Follow these steps to calculate the size and spacing of poles or posts.

Step 1. Use the wind map (Figure 9) to find the wind speed at the building site.

Step 2. Calculate effective height. For roof slopes 4 in 12 or less, the effective building height is the vertical distance from grade level to the eave. For roof slopes greater than 4 in 12 the effective building height is the vertical distance from grade level to the eave height **plus** half the roof height.

Step 3. Use Table 7 to decide pole or post size and spacing. Availability of posts or poles often dictates the size you choose. In some areas poles may not be readily available. Dressed 4×6, 6×6, and 6×8 PPT posts are available in most areas.

Step 4. Table 7 lists maximum spacings for Douglas Fir or Southern Pine poles to resist wind. If other wood species are used, multiply spacings by strength factors shown in Table 8.

Footings

Often each pole supports 8000 lbs or more of vertical load. The cross sectional area of timber posts and the butt area of poles is between 0.1 (4 x 4) and 0.7 sq ft (11" diameter). The heavy load bearing on this small area will cause the post to settle in most soils. Concrete pads increase this bearing area and prevent settling.

A **cast-in-place** or **butt encased footing** works well for most farm buildings. When compared to a tamped earth backfill with no footing, a butt encased footing increases resistance to wind uplift by four times or more. It also reduces deflection from wind to less than 2/3 that of a tamped earth backfill.

Precast footings settle more than cast-in-place footings unless the bottom of the post hole is flat and level and all loose soil is removed.

A **concrete casing** reduces embedment requirements by a foot or more in good soils. Deflection is reduced to a fifth that of tamped earth backfill and uplift strength is more than six times that of tamped earth. Use concrete casings on:

- posts next to large doors
- poorly drained soils
- poles that cannot be fully embedded because of isolated rock.

Poles for wide, open front buildings on poor soils sometimes are encased. Drill two or more holes through the post and insert short #5 reinforcing bars or pipe to get a good concrete-to-post bond.

• Calculating Footing Size

The size of footings can be calculated by these steps.

Step 1. Find the snow load expected at the building site (Figure 10).

Step 2. Calculate the roof area supported by each pole and multiply by the snow load plus building load (5 psf is a typical building load).

Step 3. Determine any additional loads of hanging equipment, suspended floors, etc. carried by each pole and add to the load calculated in Step 2.

Step 4. Find the vertical soil bearing capacity of the building site. Use test borings or estimate from Table 9.

Step 5. Use Table 9 to find concrete pad size needed to support the loads calculated in Steps 2 and 3. In all cases dig post holes at least 8" larger in diameter than the post butt.

Table 7. Spacing of Douglas Fir, or Southern Pine[1] Poles and Posts for Wind Loads on Closed Gable Roofed Buildings.

Wind Load = 10 psf (70 mph)[2] — Effective Building Height in Feet[3] / Pole or Post Spacing in Feet[5]

POST SIZE[4]	9.0	10.5	12.0	13.5	15.0	19.0
4.0 x 4.0	8.8	6.4	4.9	3.9	3.2	
3.5 x 5.5	14.5	10.7	8.2	6.5	5.2	3.3
4.0 x 6.0	19.7	14.5	11.1	8.8	7.1	4.4
5.5 x 5.5	22.8	16.8	12.8	10.1	8.2	5.1
6.0 x 6.0		21.8	16.7	13.2	10.7	6.6
5.5 x 7.5			23.9	18.9	15.3	9.5
6.0 x 8.0				23.4	19.0	11.8
7.5 x 7.5				25.7	20.8	13.0
5.5 x 9.5					24.5	15.3
POLE CLASS Top Diam.						
7 4.8"	18.6	14.4	13.2	11.8	10.2	8.1
6 5.4"	25.4	19.9	16.2	14.8	12.7	10.0
5 6.0"			21.6	19.5	16.6	13.5
4 6.7"				25.0	21.3	17.0

Wind Load = 12 psf (77 mph) — Effective Building Height in Feet[3] / Pole or Post Spacing in Feet[5]

POST SIZE[4]	9.0	10.5	12.0	13.5	15.0	19.0
4.0 x 4.0	7.3	5.4	4.1	3.2		
3.5 x 5.5	12.1	8.9	6.8	5.4	4.4	
4.0 x 6.0	16.5	12.1	9.3	7.3	5.9	3.7
5.5 x 5.5		14.0	10.7	8.4	6.8	4.3
6.0 x 6.0		18.1	13.9	11.0	8.9	5.5
5.5 x 7.5				15.7	12.7	7.9
6.0 x 8.0					15.8	9.8
7.5 x 7.5					17.4	10.8
5.5 x 9.5						12.8
POLE CLASS Top Diam.						
7 4.8"	15.5	12.0	11.0	9.8	8.5	6.8
6 5.4"		16.6	13.5	12.3	10.6	8.3
5 6.0"				16.2	13.8	11.3
4 6.7"					17.7	14.2

Wind Load - 15 psf (86 mph) — Effective Building Height in Feet[3] / Pole or Post Spacing in Feet[5]

POST SIZE[4]	9.0	10.5	12.0	13.5	15.0	19.0
4.0 x 4.0	5.8	4.3	3.2			
3.5 x 5.5	9.7	7.1	5.4	4.3	3.5	
4.0 x 6.0	13.2	9.7	7.4	5.8	4.7	
5.5 x 5.5	15.2	11.2	8.5	6.8	5.5	3.4
6.0 x 6.0		14.5	11.1	8.8	7.1	4.4
5.5 x 7.5			15.9	12.6	10.2	6.3
6.0 x 8.0				15.6	12.6	7.9
7.5 x 7.5				17.1	13.9	8.7
5.5 x 9.5					16.3	10.2
POLE CLASS Top Diam.						
7 4.8"	12.4	9.6	8.8	7.9	6.8	5.4
6 5.4"	16.9	13.2	10.8	9.9	8.5	6.6
5 6.0"			14.4	13.0	11.1	9.0
4 6.7"				16.7	14.2	11.4

Note: The spacings for poles and posts are based on uniform wind loads with the load shared equally between two rows of cantilever posts. The critical section or maximum bending stress occurs at floor level. Pole bending stress (2100 psi) and post bending stress (1500 psi) are increased by one third for wind loads.
Wind velocity pressure equals 0.00256 times the wind speed (mph) squared. The pressure on the building is this basic pressure multiplied by a closed gable roofed building shape pressure coefficient of 1.1, a height factor of 0.8 for a building in open terrain, and a probability of risk factor of 0.9 for farm buildings. The resulting pressure on the building is 0.00203 times the wind speed squared.

[1]Multiply spacing by values in Table 8 for other wood species.
[2]In areas with 20 lb/sq ft (psf) wind loads (99 mph) use half the 10 psf spacing.
[3]For roof slopes 4 in 12 or less, the effective height is the vertical distance from grade level to the eave. For roof slopes greater than 4 in 12 the effective building height is the vertical distance from grade level to the eave, **plus** half the roof height.
[4]The larger post dimension is in the same direction as the wind or parallel to the building width.
[5]Spacing greater than 16' or less than 4' not recommended.

Table 8. Relative Bending Strength of Clear Lumber.

Species	Relative Bending Strength
Aspen	.63
Birch	1.00
Cottonwood	0.50
Douglas Fir-Larch	1.00
Elm: American	0.73
Hemlock, All	0.87
Hemlock - Fir Mix	0.63
Hickory	1.25
Maple - Black & Sugar	1.00
Oak - Red & White	1.00
Pine	
White, Ponderosa, Red	0.67
Lodgepole	0.73
Northern	0.8
Southern	1.00
Spruce	
Engelmann	0.67
Sitka, Eastern	0.75
Spruce - Pine - Fir Mix	0.7
Yellow Poplar	0.67

Example: A 30′ wide clear-span building has poles spaced 8′ on center. The expected snow plus dead load is 40 psf. Soil is well drained clayey sand. What size bearing pad is needed?

Table 9 shows this soil should support 4000 lb/sq ft . Each pole carries the basic load×building width/2×pole spacing=40×30÷2×8=4800 lbs. Table 9 shows that a 16″ diameter concrete pad, 6″ thick, will carry 5600 lbs and a 14″ pad carries 4200 lbs. Therefore, a 15″ diameter pad will support the load.

Example: A surfaced 6×8 timber post has a butt area of 0.29 sq ft—the same as 7.25″ diameter circle. A soil that supports 10,000 psf would hold 2,900 lbs over this area. This load is equivalent to a 40 psf load over a 6′×12′ roof. A soil that supports only 2000 psf would need a pad 16″ in diameter and 6″ thick to support 2,900 pounds.

Table 9. Load Carrying Capacity of Circular Concrete Footing Pads in Different Soils.

Soil Description[1]	Bearing Capacity ksf[2]	12	14	16	18	20	22	24
		Minimum Pad Thickness, inches						
		5	5	6	6	7	8	8
		---Load Carrying Capacity, 1000 pounds---						
Soft limestone, partially cemented gravels & hardpan	16	12.6	17.1	22.3	28.3	34.9	42.2	50.3
Well drained gravel or gravel sand mixtures in natural thick beds with little clay or silt (GW, GP)	12	9.4	12.8	16.8	21.2	26.2	31.7	37.7
Well drained sand with little or no clay or silt (SW, SP)	8	6.3	8.6	11.2	14.1	17.4	21.1	25.1
Well drained gravel with silt or clay (GM, GC)	6	4.7	6.4	8.4	10.6	13.1	15.8	18.8
Well drained sand with silt or clay (SM, SC)	4	3.1	4.3	5.6	7.1	8.7	10.6	12.6
Well drained soft clay, silts or fine sand (CL, MH, ML)	3	2.4	3.2	4.2	5.3	6.5	7.9	9.4
Poorly drained soft clay (CH)	2	1.6	2.1	2.8	3.5	4.4	5.3	6.3
Organic soils, fills	By test only							

(Pad Diameter, inches: 12, 14, 16, 18, 20, 22, 24)

[1]Unified Soil Classification System. Letters in parentheses are symbols for the Unified Soil Classification System. The Soil Conservation Service (SCS) of the USDA has classified soils to depths of 4' to 6' in many areas.
[2]ksf equals 1000 pounds per square foot.

A butt encased footing for buildings with 4×4 or 4×6 posts in average soils may be constructed as follows. Drill a 12" diameter post hole. Place a half bag (40 lb) of dry concrete mix in the hole to form a 5" thick pad. Drill holes about 3" from the butt of the post and at right angles to each other for two 9" long #5 reinforcing bars or 5/8" diameter pipe. After the posts are set, place another half bag of dry concrete mix around the base of the post to form a 7" or 8" high collar. Finally, backfill the hole with moist soil tamped in 8" layers.

• Embedment

Proper embedment of poles is necessary to resist uplift and deflection from winds. Complex formulas may be used to calculate embedment depth where poles carry heavy loads, soils are soft, ground slopes are greater than 1 in 3 (rise/run), or the building is for human occupancy. Table 10 shows the minimum embedment depth for various soils and types of buildings. **In all cases, set poles and posts below frost line to avoid frost heaving.**

If the building site is on an earth fill placed less than 2 years before construction, extend poles at least 1.5' into undisturbed soil. (Figure 11)

On sloping sites, a suspended floor transfers lateral loads to the shorter, uphill poles. Embed the uphill poles 2' deeper than the longer downhill poles to carry this additional load.

Figure 11. Typical Embedment Methods

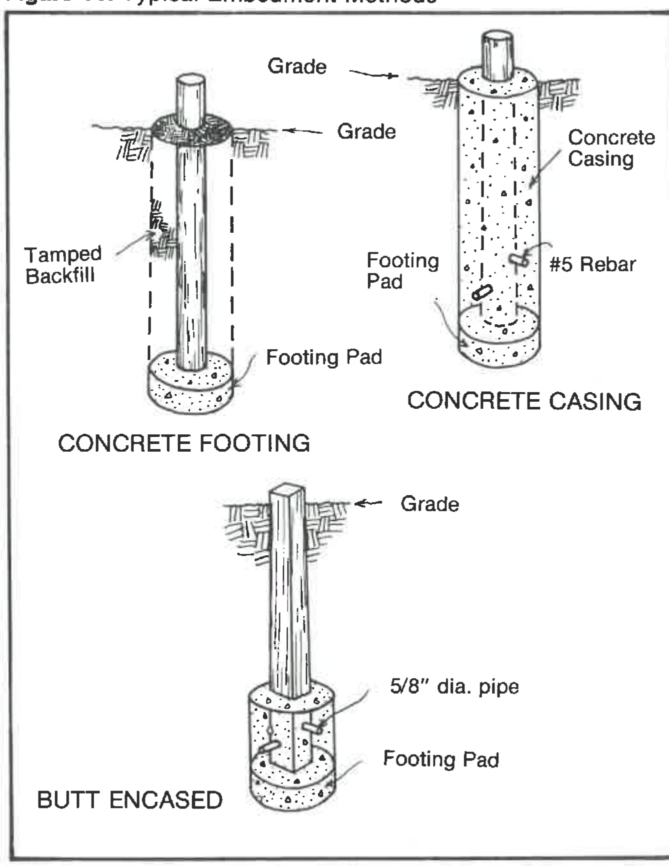


Table 10. Minimum Pole Embedment Depths. In all cases, set poles and posts below the frost line.

Building Condition	Soil Class: Excellent	Average	Poor
	Embedment Depth in feet		
For wind resistance exterior & interior poles	3	4	5
Building with suspended floor	4	5	6
Building with suspended floor on sloping ground			
Downslope poles	4	5	6
Upslope poles	6	7	8
Building on new earthfill	At least 1.5 feet into undisturbed soil.		

• Drainage

Drainage away from buildings is very important. Interior poles in dry soil seldom settle even when supporting very heavy building loads. Good drainage around the building site and perimeter will help prevent outside poles from settling.

• Backfill

Poles can be embedded by backfilling with soil from the construction site. Tamp moist soil backfill in 8" layers. Initially backfill only one-third the depth until girders are securely fastened (see Construction Procedure). Some building codes require sand, soil/cement, or concrete backfill. Use these backfill materials if building site is on poorly drained soft clay.

Framing Members

The load that wood beams can carry may be limited by shear, bending or deflection. For short spans or deep beams, the load carrying capacity is limited by horizontal shearing (h) between wood fibers along the grain. For intermediate spans, the bending stress (f) is critical and for long spans or shallow beams, deflection limits the supported load.

Table 11 can be used to select girders, rafters, joists, girts and purlins which are braced or sheathed to prevent twisting and buckling. It can also be used to limit the span, or determine the spacing and number of pieces to support a known load on a specific area. Loads may be increased to 1.15 for members supporting snow only and to 1.33 for wind loads only.

Table 11 uses design values for visually graded No. 2 Douglas Fir-Larch, or Southern Pine. Native hardwoods such as Hickory, Sugar and Black Maple, Sweet and Yellow Birch are stronger than Douglas Fir-Larch. Rock Elm, White Ash, Red and White Oak have comparable strength to Douglas Fir-Larch.

The table may also be used to select species that are not as strong as #2 Douglas Fir or Southern Pine. Hemlock and Northern Pine have 80% to 90% the strength of Douglas Fir. Use Table 11 to select beams of these species if:

1. Number 1 grade or only straight, close grain, uniform size, well-seasoned lumber without knots greather than one- fourth the width of the piece and without splits are selected, or if

2. These members only support snow or wind loads.

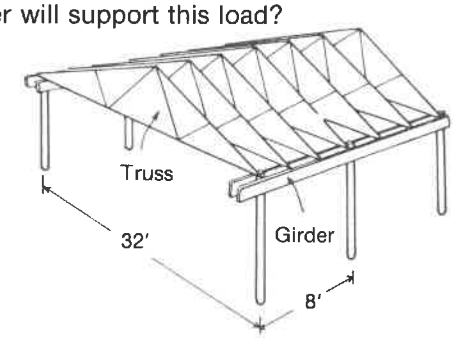
Most Spruces, American Elm, Lodgepole pine, Spruce-Pine-Fir mix, Red, White and Ponderosa pine and Yellow Poplar are about 67% to 75% as strong as Douglas Fir. Use Table 11 for beams of these species when:

1. They support a wind load, rather than a permanent load, or if

2. They are number 1 or better grade and only support a snow load.

Example. Use of Table 11 to Select Girders.

A 32′ wide clear-span building uses trusses spaced 4′ apart and poles spaced 8′ apart. Snow load on the roof is 30 psf. Dead load is 5 psf. What size girder will support this load?



Step 1. The snow load is of short duration so all the values in the girder selection Table 11 can be increased by 1.15. For simplicity, divide the snow load by 1.15 instead. Snowload=30÷1.15=26

Step 2. Compute roof load supported per foot of girder span.

Load/ft=truss span/2×(snow+dead load)

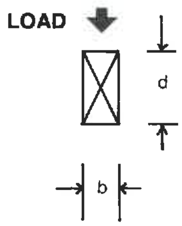
=32/2×(26+5)=500 lb/ft

Step 3. Girder will span 8′ so enter Table 11 under 8′ span column. None of the lumber listed will support 500 pounds per lineal foot (plf) on an 8′ span so more than one girder must be used.

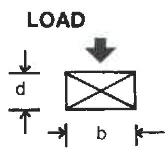
If two girders are used the load supported by each girder is 500÷2=250 lbs. Table 11 shows that two dressed 2×12's or two full sized 2×8's will support the load. Also three dressed 2×8's or three full sized 2×6's will support the load.

Table 11. Uniform Load Carrying Capacity for Girders, Rafters and Girts.

GIRDERS and RAFTERS (single span)



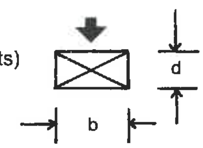
Actual Size b x d in x in	Span, feet 4	6	8	10	12	14	16	18	20
	Uniform Load, pounds per lineal foot								
2 x 12	800	534	400	320	266	228[h]	175	138	112
2 x 10	666	444	333	266[h]	216	159	122	96[f]	74
1.5 x 11.25	563	375	281	225	188[h]	151	115	91	74
1.5 x 9.25	463	308	231	185[h]	139	102	78[f]	60	44
2 x 8	533	356	267[h]	199	138	102[f]	74	52	38
1.5 x 7.25	363	242	181[h]	123	85[f]	62	41	29	21
2 x 6	400	267[h]	175	112[f]	74	47	31	22	16
1.5 x 5.5	275	183[h]	110	71[f]	43	27	18	13	9
2 x 4	266[h]	138[f]	74	38	22	14	9	6	5
1.5 x 3.5	179	79[f]	37	19	11	7	-	-	-



WALL GIRTS (single span or two supports)

Size b x d in x in	Span, feet 4	6	8	10
	Load, pounds per lineal foot			
6 x 2	222	66	28	14
4 x 2	148	44	18	10
5.5 x 1.5	86	25	11	6
2 x 2	74	22	9	-
3.5 x 1.5	55	16	7	-

ROOF PURLINS (two span or three supports)
Construction Grade or better



Size b x d in x in	Span, feet 4	6	8
	Load, pounds per lineal foot		
4 x 2	122	54	31
5.5 x 1.5	105	47	24[f]
3.5 x 1.5 or 2 x 2	61	27	15

Table Design Values:
Bending stress = 1400 psi
Horizontal shear = 100 psi
Modulus of elasticity = 1,200,000 psi
Deflection = span ÷180

[h] indicates critical stress changes from horizontal shear to flexure.
[f] indicates critical stress changes from flexure to modulus of elasticity for deflection.

Bracing

Temporary and permanent bracing strengthens and adds rigidity to the building frame. Temporary braces hold the frame in place during erection. Permanent bracing is required for the structural integrity of many buildings.

• Wall Bracing

Post to girder braces attached at a 45° angle allow the girder to carry a heavier load, tie the girder down in heavy winds, and strengthen the building longitudinally. Generally post girder bracing is not required in buildings less than 30′ to 40′ wide and with posts spaced 8′ or less apart.

A girder properly braced at one third its span can carry 80% more load than one without braces. A 1/2″ bolt or four or five 30d-40d pole barn nails spaced 2″ apart are typical fasteners for the brace. (Figure 12)

Post to truss or **rafter braces** (lateral knee braces) fasten the truss to the post and stiffen the walls laterally across the building width. Fasten braces as shown in Figure 12. Note that the brace extends to the top of the rafter or upper chord of the truss. Fasten the truss securely with 1/2″ bolts with washers or 30d-40d deformed shank nails.

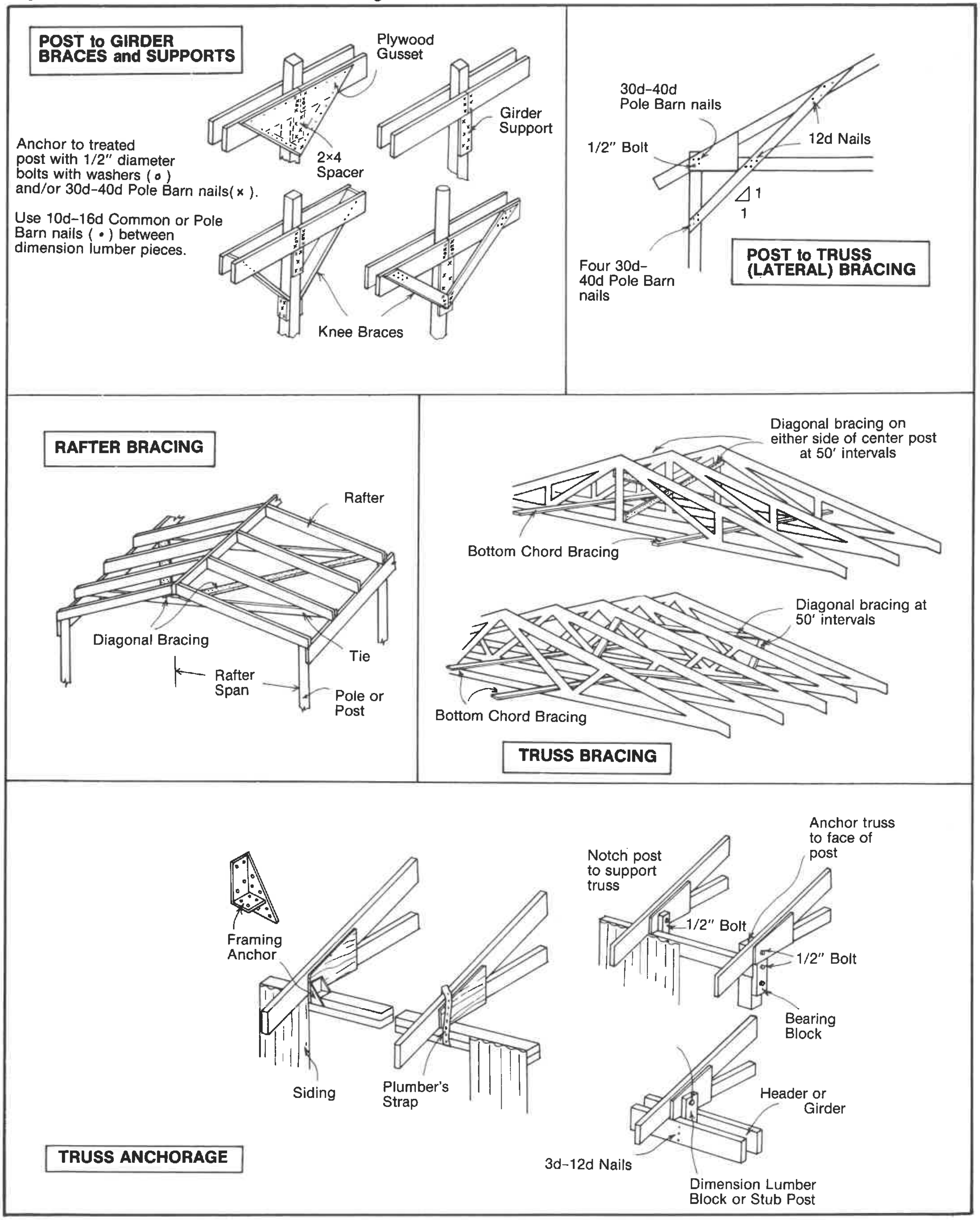
Braces must be stiff enough not to bow or deflect under load. Limit the unsupported length to 50 times the thickness (6′ for a dressed 2×4). Between 6′ and 12′ use a doubled 2×4 well nailed, or a 2×6. Usually a 2×4 is adequate for the girder to post bracing and a 2×6 for truss to post bracing.

The bracing used depends on building design, building size, whether the building has an interior liner, etc. Plywood wall sheathing and inside partition walls, 30–50′ apart, also stiffen the building.

• Truss Anchorage

Framing anchors, plumber's strapping, or bolts hold the

Figure 12. Braces, Supports and Truss Anchorage



truss down during wind loads. Typical fastening details are shown in Figure 12. For trusses up to 30′ wide use one framing anchor or 1/2″ bolt on each side of the truss to hold it down. Trusses up to 46′ wide need 2 anchors or 1 bolt per side. Trusses spaced 8′ apart need 2 anchors or 2 bolts per side.

• Roof Bracing

Roof bracing aligns trusses during construction and prevents buckling of members under load. Three types of bracing are needed in most utility buildings.

Diagonal bracing, also called wind or "X" bracing, keeps trusses vertical and prevents the trusses from buckling from wind loading. Install bracing at each end of the bulding and at 50 foot intervals of building length. Diagonal bracing from the peak to the eave is often installed on rafters or frames where X bracing is not practical.

Web bracing, usually specified by the truss manufacturer, prevents buckling of long compression web members in the truss.

Bottom chord bracing, or horizontal bracing, replaces a ceiling and prevents buckling of the bottom chord. Install 2×4's continuously the entire building length close to each bottom chord joint unless a rigid ceiling is installed.

• Construction Bracing

Install roof bracing as the trusses are being erected. Brisk winds come with little warning and have damaged many unbraced or poorly fastened trusses. Also install roofing material quickly to prevent wind damage.

Fasteners

• Nails

Pressure treated lumber, especially creosoted poles, do not hold nails as well as untreated lumber because the preservative acts as a lubricant. Spiral or annular ring shank nails are used because they have a higher withdrawal resistance. (Figure 13)

Four to five inch (20d to 40d) nails are used to fasten rafters, girders, cleats or braces to the pressure treated pole. Untreated framing members are fastened to each other with 10-12d nails. Examples include roof purlins to rafters, and tie-down cleats or braces to rafters or girders. Six inch (60d) nails are used to fasten 2 x 4 purlins on edge.

Load Capacity. The lateral load carrying capacity of typical nails fastening native lumber common to the Northeast is shown in Table 12. Loads can be increased 25% for Douglas Fir or Southern Pine. The loads are conservative to allow for poor nailing or poor wood. Small, clear, properly fastened wood specimens may carry six times these loads.

Figure 13. Types of Nails used for Treated and Untreated Lumber

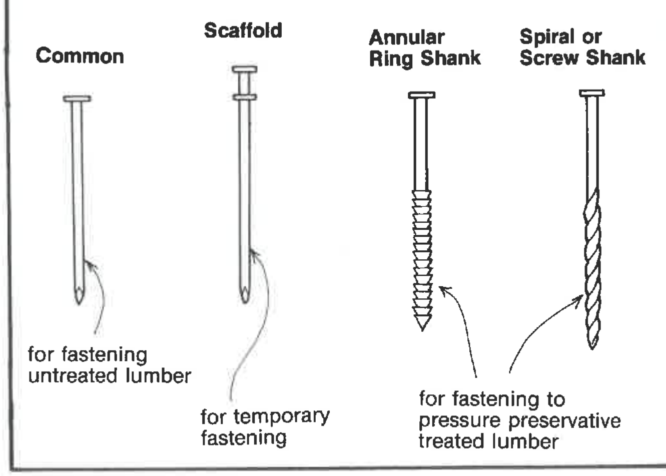
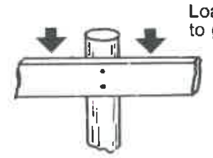


Table 12. Nails and Spikes. Safe lateral loads in Aspen, Eastern Hemlock-Tamarack, Eastern Spruce, Mountain Hemlock, Northern Pine, Red Pine and Yellow Poplar. Fastened members are 1 1/2" - 2" thick.



	Pennyweight	Length, Inches	Penetration into main member, Inches	Safe Lateral Load, Pounds
Spikes				
	40d	5	3.4	182
	30d	4.5	3.2	165
Common Wire Nails				
	40d	5	3.0	144
	30d	4.5	2.7	126
	20d	4	2.5	113
	16d	3.5	2.1	88
	10d or 12d	3-3.25	2.0	77
Pole Barn Nails				
	30-60	4.5-6.0	2.3	113

Main members are thick enough to keep nails from protruding.
Increase values 25% for Douglas Fir or Southern Pine.
Increase values 20% for snow loads and 33% for wind loads.

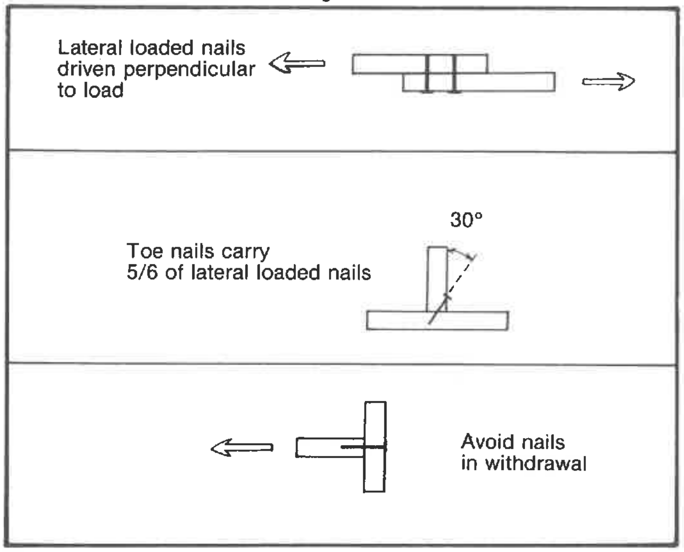
Reduce the allowable load 25% for unseasoned wood. Use bolts instead of nails in structural members where withdrawal loads occur.

Splitting. Nail in from the end and edge of the wood so it does not split. A nail that splits the wood has no load carrying strength. Lead holes not more than 3/4 the diameter of the nail can be drilled to prevent splitting without reducing the safe load carrying strength.

Clinching Nails. Driving nails completely through both members and clinching the protruding end will increase the lateral resistance. Normally no additional strength value is given because the nail is often driven back slightly as it is clinched.

Toe Nailing. A toe-nailed joint has 5/6 the lateral load shown in Table 12, if the wood does not split. Drive toe nails at approximately 30 degrees and start them at one-third the length of the nail from the end of the piece. (Figure 14)

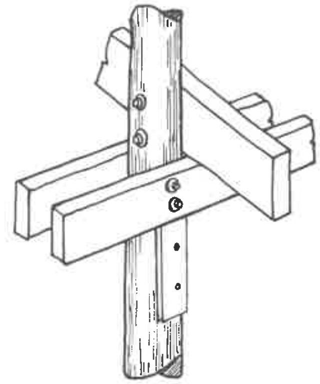
Figure 14. Methods of Driving Nails



• Other Fasteners

Bolts require more labor to install than nails. Do not forcibly drive bolts as the wood may split. Drill holes 1/32 to 1/16" larger than the bolt diameter. Use standard cut washers and tighten snugly but not enough to crush the wood fibers.

A split ring **timber connector** increases the effective shear area of a bolt so that the combination can carry



about three times the load of a bolt alone. Special grooving tools and additional labor are required to install connectors so they are seldom used in farm construction.

Lag screws are rarely used to fasten main structural members, although they can be. They are sometimes used to fasten doors, partitions, etc.

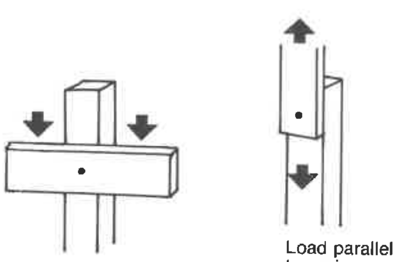
A variety of manufactured **metal framing anchors** or joist supports are available to simplify construction and save time and materials. Metal fasteners are expensive and properly designed wood braces and ties can often be used at less cost. The design load for the fastener should be obtained from the manufacturer. (Table 13)

• Glue

Glued joints can be as strong or stronger than the structural members glued. However, flaws in glued joints are difficult to see and may fail under design load. Another disadvantage is that glued joints require time to set before any load can be applied.

To make glued joints, use dry, smooth wood that is free

Table 13. Safe Load Capacity of Typical Wood Fasteners in Single Shear.



	Douglas Fir-Larch, Southern Pine		Eastern, Western & Mountain Hemlock; Hem-Fir; Spruce-Pine-Fir; Sitka & Eastern Spruce; Yellow Poplar; Northern & Lodgepole Pine	
Fastener	**Parallel to Grain**	**Perpendicular to Grain**	**Parallel to Grain**	**Perpendicular to Grain**
2 1/2 " timber connector	2730	1620	2290	1350
3/4" bolt	1320	540	1050	360
1/2" bolt	640	430	580	280
6" lag bolt, 1/2" diameter	600	390	430	280
4" lag bolt, 3/8" diameter	240	180	170	130

Fastened members are 1 1/2" to 2" thick.
Main members are 3 1/2" or thick enough to keep lag bolts from protruding.
Increase values 20% for snow loads and 33% for wind loads.

Source: Adapted from National Forest Products Association National Design Specification for Wood Construction, 1982 edition.

of dirt, oil, and other coatings. Most purchased lumber is planed sufficiently smooth for gluing. Generally, preservative-treated lumber is not glued or it must be planed prior to gluing for maximum holding power. Be sure the moisture content of the wood is below 15% before gluing it.

Waterproof glues (resorcinol resin) are recommended for farm construction where moisture is present (livestock confinement buildings, outdoor equipment). Water resistant glues (casein) may be used for storage buildings where the moisture content of the wood is consistently low.

Follow manufacturer's directions when gluing. Temperatures above 70°F are recommended for fast curing. Lower temperatures slow curing so the trusses must be clamped longer before they can be moved. Apply enough glue so some glue will be forced from the joint when pressure is applied. Do not skimp; the cost of the glue is a minor item in the total cost of construction.

Apply glue with a brush or paint roller. Put pressure uniformly on the entire joint with clamps, nails, screws, or other fasteners before wiping off the excess glue.

Keep joints under pressure for at least 4 to 8 hours to allow the glue to set. Do not apply design loads for at least 24 hours after gluing.

Suspended Floors

Pole-frame farm buildings are usually designed as single story structures with concrete slab or dirt floors. With proper design, two or three story pole frame structures can be built. Suspended floors are used in vacation homes, camps or residential structures where insulated floors are desirable or the construction site is on sloping ground. Barns with a second story hay loft or storage attic are useful for small-scale farms. (Figure 15)

• Floor Loads

Use Table 14 and 15 to estimate live load on floors and dead weight of floor systems. Obtain professional design assistance if (1) the roof eave height is greater than 15', (2) anticipated floor loads are greater than 40 psf, or (3) the suspended floor is to be more than 12' above the ground.

• Girder Sizes

Use Table 17 to select girders to support floor joists. Use Table 18 to size roof rafters and floor joists. Add the appropriate floor load and snow load on the roof to determine the load per foot of girder span. Girders requiring more than four pieces of lumber, or built-up box or I beams should be professionally designed. All lumber should be drier than 20% moisture content before construction.

Figure 15. Typical Suspended Floor Construction

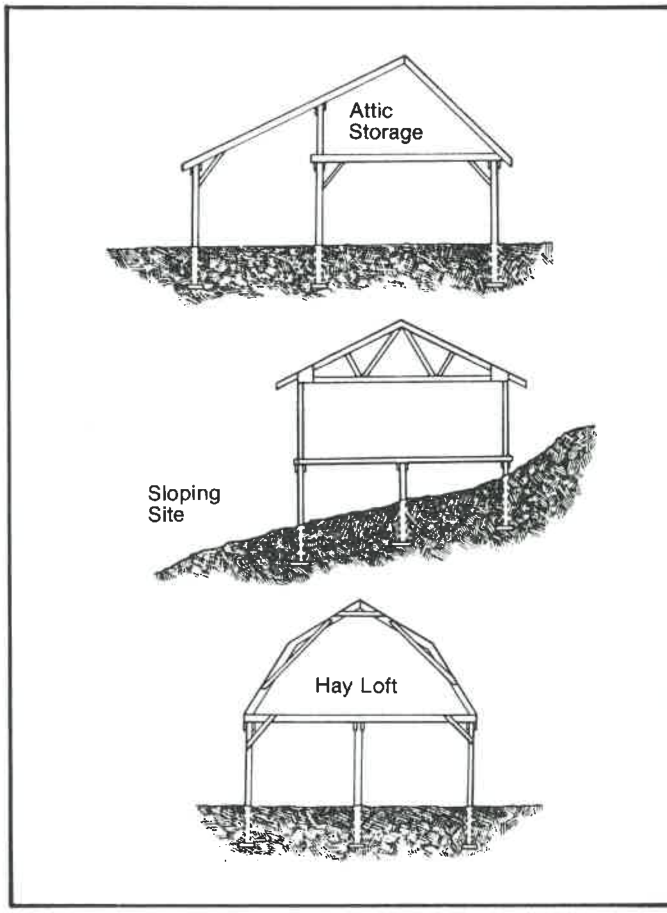


Table 14. Minimum Floor Loads based on Use.

Use	Floor Load, lb/sq ft
Livestock, Calves to 300 lb	50
Cattle or Horses	100
Sheep	40
Swine to 200 lb	50
Poultry	30
Greenhouses	50
Shops, maintenance or craft[1,2]	70
Attics, storage[3]	40
Farm vehicle storage[1]	
Automobiles, Light Trucks	100
Field Machinery	150
Large Tractors, Trucks	200
Residential Dwellings	40
Public Rooms	100
Floor dead weight[4]	10

[1]Special design required for concentrated load of heavy equipment, vehicles, hoists, etc.
[2]Increase minimum design loads by 50% where impact and vibrations of machinery or equipment cause floor vibrations.
[3]Assumed limited headroom and random product storage. Where a specific product is to be stored in quantity, use product density and height to be stored.
[4]Dead weight of floor may be calculated exactly from materials.

Table 15. Bulk Density of Selected Products. Multiply bulk density by depth of product stored to obtain the live floor load.

Product Stored	Bulk Density, lb/cu ft
Baled Straw or Hay	8-14
Wood Shavings, baled	20
Shelled Corn, Wheat	45,48
Oats, Ear Corn	26,28
Feed Grains & Supplement, mixed	32
High Protein Supplement	50
Linseed or Soybean Meal	30-40
Fruits and Vegetables	30-40
Concrete	150
Wood	25-50
Insulation	10
Books, or Paper, solidly packed	65
Hardware, packed	40
Furniture	20

Table 16. Spacing of Douglas Fir or Southern Pine[1] poles or posts for buildings with Suspended Floors.

Floor Load = 50 lb per sq ft (40 psf live + 10 psf dead load)

Wind Load = 10 lb per sq ft (70 mph)

	Floor Joists Span Up to 12 feet			Floor Joists Span 12 to 20 feet		
	Building Height, ft[2]			Building Height, ft[2]		
	10.5	12.0	15.0	10.5	12.0	15.0
POST SIZE						
3.5 x 5.5	9.2	7.3	4.8	8.4	6.8	4.6
4 x 6	12.3	9.7	6.5	11.1	9.0	6.2
5.5 x 5.5	14.4	11.4	7.6	13.1	10.6	7.2
6 x 6		14.7	9.8	16.8	13.6	9.3
POLE CLASS						
7 (4.8")	12.4	10.4	9.2	11.4	9.7	8.6
6 (5.4")		14.2	11.5	15.6	13.2	10.8
Wind Load = 15 lb per sq ft (86 mph)						
POST SIZE						
3.5 x 5.5	6.4	5.0		6.0	4.7	
4 x 6	8.7	6.8	4.4	8.1	6.4	4.3
5.5 x 5.5	10.1	7.8	5.2	9.5	7.5	5.0
6 x 6	12.9	10.2	6.7	12.1	9.6	6.5
5.5 x 7.5		14.3	9.5	16.6	13.3	9.0
6 x 8			11.7		16.5	11.2
POLE CLASS						
7	8.7	7.2	6.3	8.2	6.8	6.0
6	11.9	9.9	7.9	11.1	9.4	7.6
5	16.4	13.5	10.5	15.6	12.9	10.2
Wind Load = 20 lb per sq ft (99 mph)						
POST SIZE						
5.5 x 7.5	12.7	10.2	6.9	11.3	9.2	6.4
6 x 8	15.6	12.5	8.5	13.9	11.3	8.0
7.5 x 7.5				15.2	12.7	8.8
POLE CLASS						
4 (6.7")				14.1	11.8	9.4

[1]Multiply spacing by values in Table 8 for other wood species.
[2]For roof slopes 4 in 12 or less the effective height is the vertical distance from grade level to the eave. For roof slopes greater than 4 in 12 the effective building height is the vertical distance from grade level to the eave **plus** half the roof height.

Table 17. Girder Selection for Suspended Floors. Total floor load is 50 psf (40 psf live plus 10 psf dead).

Actual Lumber Size in x in	Width of Floor Supported, ft					
	8	10	12	14	16	20
	Girder Span, feet					
8 x 12				18.2	14.2	8.0
7.5 x 1.5 (8 x 12)			19.2	15.8	12.0	7.7
7.5 x 11.25 (5-2 x 12)			18.8	15.1	11.5	7.4
6 x 12		19.2	16.0	13.7	10.5	6.7
8 x 10		21.3	17.3	12.7	9.7	6.0
6 x 0 x 11.25 (4-2 x 12)		18.0	15.0	12.0	9.2	6.0
5.5 x 11.5 (6 x 12)		16.9	14.1	11.6	8.8	5.7
6 x 10	20.0	16.0	13.0	9.5	7.3	4.4
4 x 12	16.0	12.8	10.6	9.1	7.0	4.5
4.5 x 1.25 (3-2 x 12)	16.8	13.5	11.3	9.1	7.0	4.4
6.0 x 9.25 (4-2 x 10)	18.5	14.8	11.1	8.1	6.2	
5.5 x 9.5 (6 x 10)	17.4	13.9	10.7	7.8	6.0	
3.5 x 11.25 (4 x 12)	13.1	10.5	8.7	7.0	5.4	
3 x 12	12.0	9.6	8.0	6.8	5.2	
4 x 10	13.3	10.6	8.6	6.3	4.9	
4.5 x 9.25 (3-2 x 10)	13.8	11.1	8.3	6.1	4.7	
3.0 x 11.25 (2-2 x 12)	11.2	9.0	7.5	6.0	4.6	
3 x 10	10.0	8.0	6.5	4.8		
2.5 x 11.25 (3 x 12)	9.4	7.6	6.3	5.0		
3.0 x 9.25 (2-2 x 10)	9.2	7.4	5.5	4.0		

Note:
Girders may be one or more pieces laminated or spaced apart, but full depth.
Members listed in bold face type use the least lumber for a given span.

• Bracing and Connectors

Post to girder bracing and pole embedment are important in buildings with suspended floor loads to prevent failure by buckling and sway. Braces also strengthen the floor. Whenever possible, use bracing in both directions on all load bearing poles. Detailed examples of bracing are shown in Figure 12.

The girder to pole connection often is a weak spot in any design. Poles can be notched to carry the girders as shown in Figure 17 as long as the pole cross section is not decreased more than 50% and the cross member fits snugly in the notch. A 1 1/2" by 5 1/2" notch will carry 9000 lbs if the members are securely fastened and can not move out of position.

Sloping Sites

Pole frame buildings can be built on steeply sloping sites if there is no danger from landslides. Have a soil expert check the site to be sure it is safe for building. Wet silty or clay soil often slide at a 1:2 slope (rises 1 foot for every 2 feet of horizontal distance), but sandy and gravel soil

Figure 16. Girder and Joist Span and Spacing

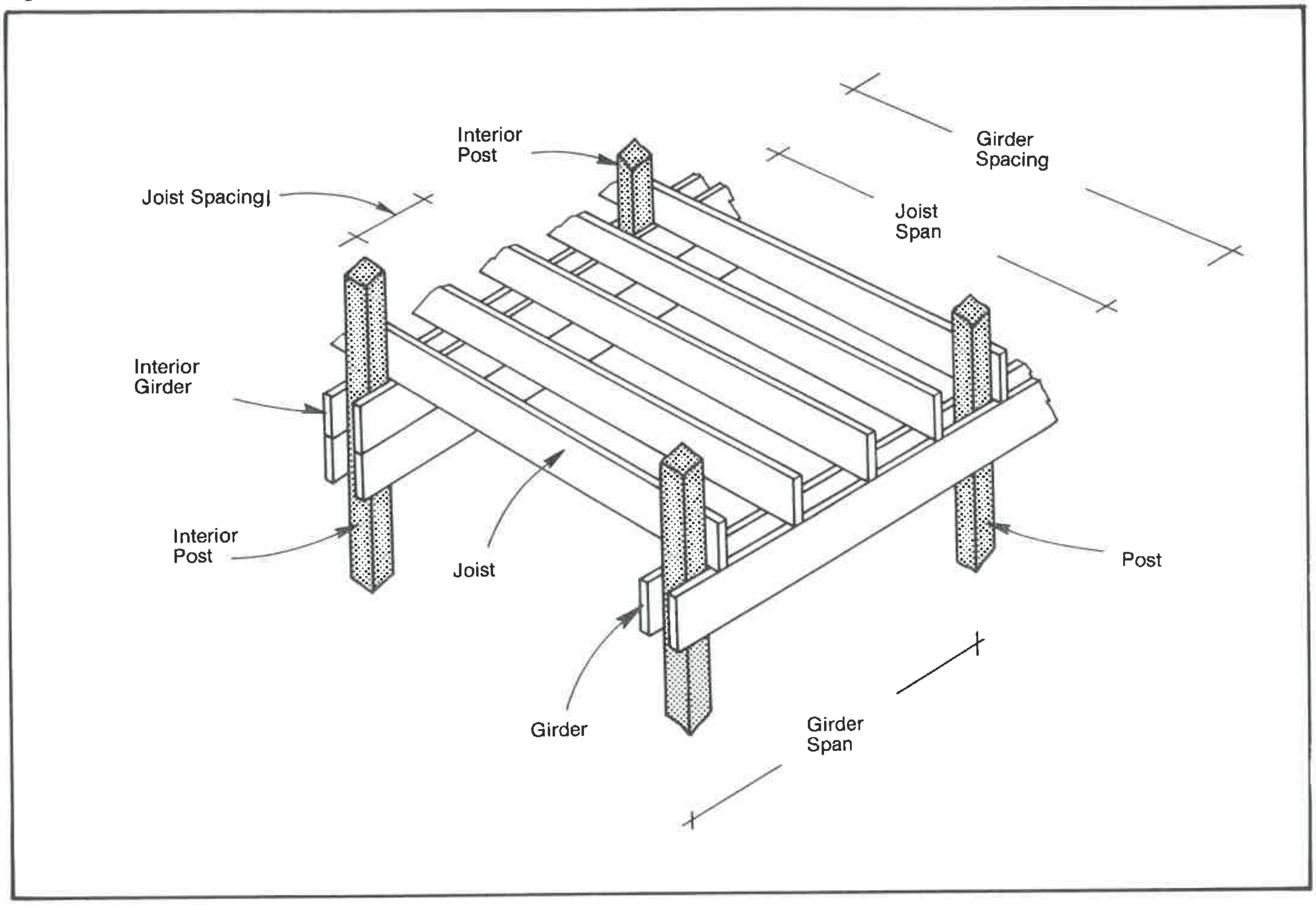
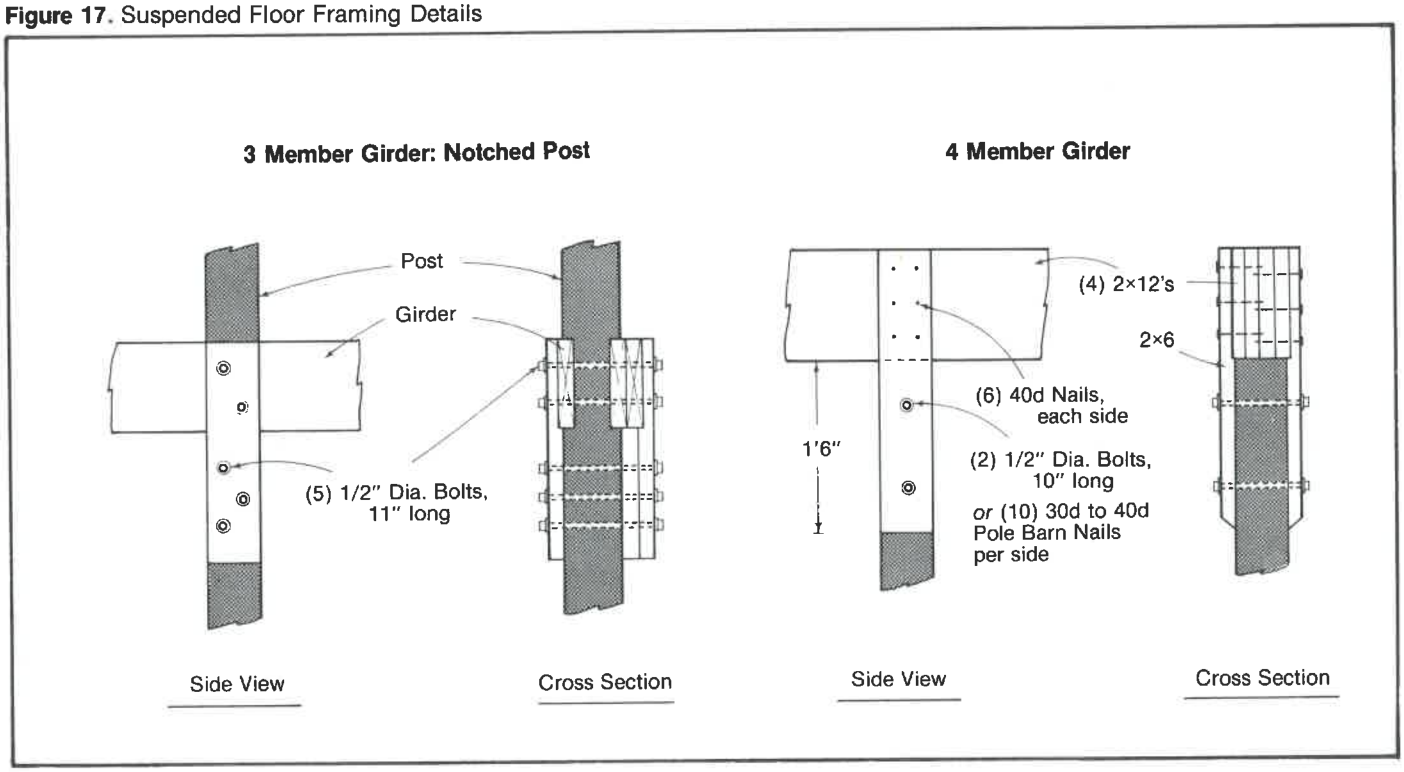
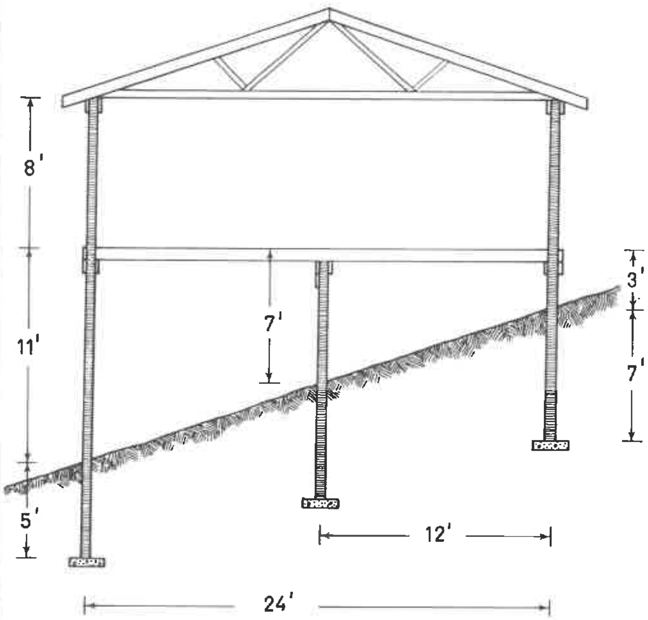


Figure 17. Suspended Floor Framing Details



may be stable at a 1:1 slope. Slides and erosion can be prevented with careful construction and drainage control. Protect natural vegetation and drainage patterns around the structure to reduce erosion.

Example: Select the poles, girders and joists for a recreation home. The building site has well drained sand with clay soil and is located near Philadelphia.



• Selecting Poles

Step 1. Calculate the effective building height. The wall height is 8'. The average height above grade is 7'. The roof slope is 4:12 so the effective building height is the average height above grade plus the wall height, or 8'+7'=15'.

Step 2. Use the wind map (Figure 9) to find the wind speed for the area, as 77 mph.

Step 3. Refer to Table 16 to decide pole spacing. Building height from step 1 is 15'. The floor joists span 12'. Table 16 shows that class 6 poles spaced 7.6' apart will support the building in an 86 mph (15 psf) wind. Wind is only about 77 mph so space class 6 poles 8' apart.

• Selecting Girders

Step 1. Determine the width of floor each girder supports. The center girder supports 12' of floor while outside girders each support 6' of floor span.

Step 2. Use Table 17 to calculate size of center girder. Poles are spaced 8' apart, so girders span 8'. Center girder supports 12' of floor so a full sized 3×12 or three 2×10's will work.

Step 3. The outside girders support a load smaller than shown on Table 17 so use Table 11 to size them. Each girder supports 6' of floor times 50 psf or 300 lb per lineal foot. Enter Table 11 under 8' span column. A single 2×8 (1.5"×7.25") will support 181 pounds per lineal foot, so two 2×8 will work.

• Selecting Floor Joists

Use Table 18 to decide joist size and spacing. Joist span is 12'. Surfaced 2 x 8's (1.5" x 7.25") spaced 16" on center can be used to span up to 13' 4".

• Embedment

Refer to Table 10 for recommended pole embedment. Soil is average, so down slope poles should be embedded 5' and upslope poles 7'.

• Pad Size

Step 1. Refer to Snow Load Map (Figure 10). Philadelphia is in about a 15 psf snow load area.

Step 2. Calculate snow load on outside poles. Snow load per pole is half the roof width times pole spacing times the snow load or: 24/2×8×15= 1440 lb.

Step 3. Calculate floor load on outside poles. Floor load is 50 psf times the width of floor supported times the pole spacing or: 50×12/2×8=2400 lb.

Step 4. Snow load plus floor load is total load carried by the pad or: 1440+2400=3840 lb.

Step 5. Use Table 9 to calculate pad area. A 14" diameter pad 5" thick will support 4300 lb on a well drained sand with clay soil.

Table 18. Floor Joist Selection. Total load is 50 psf (40 psf live plus 10 psf dead).

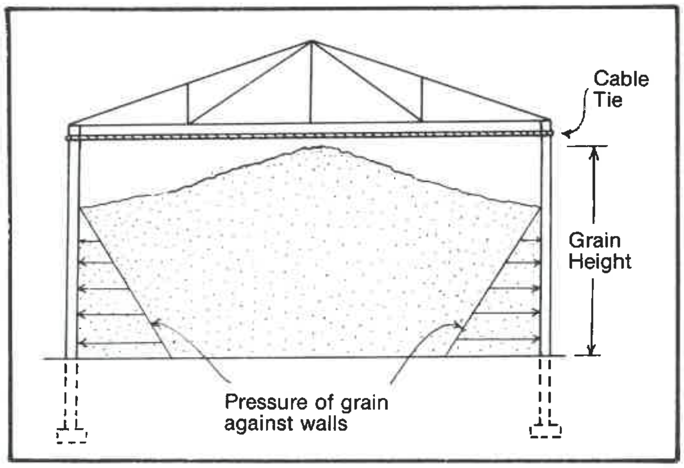
Actual Lumber Dimensions in. x in.	Joist Spacing 12"	16"	24"
	Maximum Joist Span, ft-in		
1.5 x 11.25		20 - 9	18 - 1
2 x 10		20 - 3	17 - 8
1.5 x 9.25	18 - 9	17 - 0	14 - 10
2 x 8	17 - 10	16 - 3	14 - 2
1.5 x 7.25	14 - 8	13 - 4	11 - 8
2 x 6	13 - 4	12 - 2	10 - 8
1.5 x 5.5	11 - 2	10 - 1	8 - 10
2 x 4	8 - 11	8 - 1	7 - 1

Design criteria are for #2 Douglas Fir, #2 Southern Pine, or **carefully selected** Eastern Hemlock, Eastern Spruce, Northern Pine and Red Pine Lumber.
Bending Stress - 1400 psi times 1.15 for repetitive members.
E = 1,200,000 psi.
Deflection is limited to the span divided by 240.

Grain Storage

Pole type bulk storage buildings are popular because they often cost less than other types of structures. Figure 18 shows how poles or posts support horizontal pressures from bulk stored products. Feed contamination from wood preservatives has not been observed in these buildings.

Figure 18. Bulk Grain Storage. Bolt or fasten trusses with framing anchors or use a cable to tie post tops together or walls may pull apart from roof.



Grain is assumed to be piled to the filling angle of repose. Even though grain will pile, it presses against the wall much like a fluid. The pressure grain exerts per foot of depth, called equivalent fluid density, is listed in Table 19.

Table 19. Equivalent Fluid Density of Bulk Products.

	Level Fill	Piled to Filling Angle
Barley, Eastern	14.5	18.0
Corn, shelled	18.0	22.5
Oats		
Central U.S.	10.3	12.9
Pacific NW & Canada	10.8	13.5
Rough rice,		
American Pearl	10.8	13.6
Rye	18.1	23.3
Soybeans	16.7	20.5
Wheat		
Soft red winter	18.3	22.9
Hard red spring	18.8	23.8
Hard red winter	19.2	24.0
Potatoes		
Dry	11.0	
Wet	13.0	
Dry Russet	9.0	
Onions	16.0	

Horizontal pressure may reach 225 lb/sq ft at the bottom of a storage with corn that has been heaped and is 10' deep. Leveled grain exerts about 20% less pressure than grain piled to the filling angle.

Tables 20, 21 and 22 list maximum product depths for various sized poles and posts. The produce is assumed to push on only one wall and the walls are tied together at the eave by a well secured truss or cable. Grain piled to the filling angle is assumed to come up to 0.8 times the height of the tie. Leveled grain comes up to the tie. Potatoes and onions come up to 0.8 times the height of the tie.

Nominal two inch (1.5") tongue and groove decking or center matched planks are often used to withstand high lateral pressures at the bottom of bulk storages. Combinations of wood and metal lining materials or additional supports may be needed for larger post spacings. Table 23 lists the maximum uniform load for plywood and plank lining with supports spaced at 2', 4', 6' and 8' apart. Install plywood sheets or planks long enough to cover at least two spans (3 posts); pieces that only span between two posts may deflect excessively under load.

To determine the maximum grain depth against the lining material, divide the maximum uniform load by the equivalent fluid density in Table 19. For example, 3/4"

Table 20. Maximum Level Grain Depth supported by Douglas Fir-Larch or Southern Pine Posts and Poles.

		Oats				Corn, Wheat, Rye			
		Post or Pole Spacing, Feet							
		2	4	6	8	2	4	6	8
POSTS									
5.5 x 9.5				11.6	10.5		11.2	9.8	9.0
7.5 x 7.5				11.0	10.0		10.7	9.3	8.5
6.0 x 8.0			12.2	10.6	9.7		10.3	9.0	8.2
5.5 x 7.5			11.4	9.9	9.0	12.1	9.6	8.4	7.6
6.0 x 6.0			10.1	8.8	8.0	10.8	8.5	7.5	6.8
3.5 x 7.25		12.0	9.5	8.3	7.6	10.2	8.1	7.1	6.4
5.5 x 5.5		11.6	9.2	8.0	7.3	9.9	7.8	6.8	6.2
4.0 x 6.0		11.1	8.8	7.7	7.0	9.4	7.5	6.5	5.9
3.5 x 5.5		10.0	7.9	6.9	6.3	8.5	6.7	5.9	5.4
4.0 x 4.0		8.5	6.7	5.9	5.3	7.2	5.7	5.0	4.5
POLES									
Circumference	**Diameter**								
30	9.5				11.9			11.1	10.1
28	8.9			12.2	10.0		11.9	10.4	9.4
26	8.3			11.4	10.3		11.0	9.6	8.7
24	7.6		12.0	10.5	9.5		10.2	8.9	8.1
22	7.0		11.0	9.6	8.7		9.3	8.2	7.4
20	6.4		10.0	8.7	7.9	10.7	8.5	7.4	6.7
18	5.7	11.3	9.0	7.9	7.1	9.6	7.6	6.7	6.0

Note:
Decrease grain depths 12% for native wood posts or poles.
Reduce grain depths on the wall 8% if grain is piled at the filling angle of repose.
Tie post tops together with properly designed truss or cable to keep walls from pulling apart from the roof. Do not overtighten cable or truss will buckle.

C-C Exterior plywood supported by posts spaced 4' apart will safely hold shelled corn at a level depth of 2' 4" (42 psf÷18 pcf=2.33'). Spruce-Pine-Fir decking with posts 4' apart allows corn to be piled so it is 9' 2" high on the sides (206 psf ÷ 22.5 pcf).

Table 21. Maximum Depth on Side Walls of Corn piled to the filling angle. Grain depth on walls is 0.8 times the height of the wall tie.

		Post or Pole Spacing, Feet			
POSTS		2	4	6	8
7.5 x 7.5			10.6	9.2	8.4
6.0 x 8.0			10.2	8.9	8.1
5.5 x 7.5		12.0	9.5	8.3	7.5
6.0 x 6.0		10.6	8.4	7.4	6.7
3.5 x 7.25		10.1	8.0	7.0	6.3
5.5 x 5.5		9.7	7.7	6.8	6.1
4.0 x 6.0		9.3	7.4	6.4	5.8
3.5 x 5.5		8.4	6.6	5.8	5.3
4.0 x 4.0		7.1	5.6	4.9	4.5
POLES					
Circum-ference	**Diameter**				
30	9.5		11.3	9.9	9.0
28	8.9		10.5	9.2	8.3
26	8.3		9.8	8.5	7.7
24	7.6	11.3	9.0	7.9	7.1
22	7.0	10.4	8.3	7.2	6.5
20	6.4	9.5	7.5	6.5	6.0
18	5.7	8.5	6.7	5.9	5.4

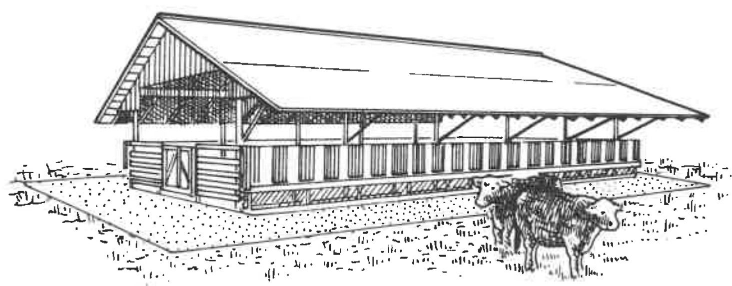
Table 22. Maximum Depth of Wet Potatoes and Onions in Pole Buildings. Product height is 0.8 times the height of the wall tie.

		Wet Potatoes				Onions			
		Post or Pole Spacing in Feet							
POSTS		2	4	6	8	2	4	6	8
5.5 x 9.5			13.4	11.7	10.6	15.7	12.5	10.9	9.9
7.5 x 7.5		16.0	12.7	11.1	10.1	14.9	14.8	10.4	9.4
6 x 8		15.5	12.3	10.8	12.2	14.5	11.5	10.0	9.1
5.5 x 7.5		14.4	11.4	10.0	9.1	13.5	10.7	9.3	8.5
6 x 6		12.8	10.1	11.1	10.1	11.9	9.5	8.3	7.5
3.5 x 7.25		12.1	9.6	8.4	7.6	11.3	9.0	7.9	7.1
5.5 x 5.5		11.7	9.3	8.1	7.4	10.9	8.7	7.6	6.9
4 x 6		11.2	8.9	7.7	7.0	10.4	8.3	7.2	6.6
3.5 x 5.5		10.1	8.0	7.0	6.4	9.4	7.5	6.5	6.0
4 x 4		8.5	6.8	5.9	8.0	6.3			
POST									
Circum-ference	**Diameter**								
30	9.5		13.5	11.8	10.8	15.9	12.6	11.0	10.0
28	8.9	15.9	12.6	11.0	10.0	14.9	11.8	10.3	9.4
26	8.3	14.8	11.7	10.3	9.3	13.8	11.0	9.6	8.7
24	7.6	13.7	10.8	9.5	8.6	12.7	10.1	8.8	8.0
22	7.0	12.5	9.9	8.7	7.9	11.7	9.3	8.1	7.4
20	6.4	11.4	9.0	7.9	7.2	10.6	8.4	7.4	6.7
18	5.7	10.2	8.1	7.1	6.5	9.6	7.6	6.6	6.0

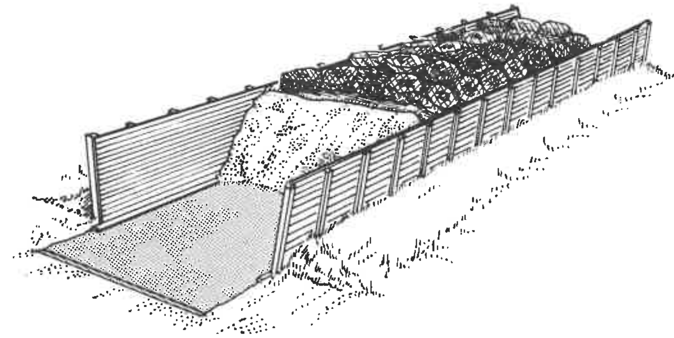
Table 23. Load-Span for Heavy Wood Sheathing and Flooring Materials.

	Maximum Uniform Load in lb/sq ft with Supports Spaced at:			
Lining Material	2'	4'	6'	8'
3/4" Unsanded Plywood Exterior 48/24, f = 2000 psi	167	42	NR	NR
9/8" Unsanded Plywood 2-4-1 with Ext. Glue, f = 2000 psi	349	87	NR	NR
1.5" Spruce-Pine-Fir Commercial Decking, f = 1100 psi	825	206	92	51
1.5" Southern Pine Commercial Decking, f = 1750 psi	1313	328	145	82
2" Red or White Oak Planks f = 2050 psi	2733	683	303	170
2.5" Southern Pine Commercial Decking , f = 1750 psi	3545	911	405	227

NR = not recommended
f = bending stress in psi



HAY STORAGE and FEEDING SHED



BUNKER SILO

Construction Procedure

A pole building can be constructed several ways. One set of steps is listed below. The success of any building project depends upon prior planning, efficient use of labor and machinery, convenient location of materials and components, good drainage and weather. The first job may take twice as long as subsequent projects. Experienced builders find many short cuts for faster construction.

The following procedure will be helpful for the first job and should be helpful to review procedures after several jobs. With careful organization of the construction crew, and depending on weather, some steps can be interchanged or proceed together with others.

Layout and Excavation

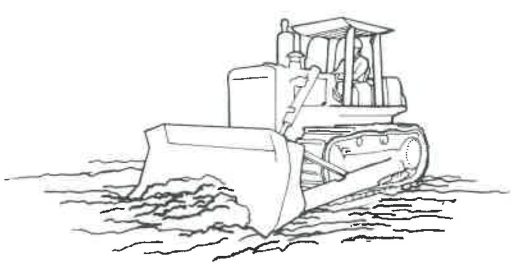
1. Select the site.

2. Remove sod, fill, compact and grade with bulldozer or tractor scoop. The amount of site preparation depends on the use of the building. Little site preparation may be needed for a storage structure except to keep runoff water away. In contrast, the site for a livestock barn with concrete floors requires good drainage and a good base for a concrete floor.

3. Lay out building with batter boards and building (nylon) lines (Appendix A). The building line is normally at the edge of the wall girts. (1 1/2" from pole edge).

4. Mark pole locations with ground limestone or a small stake. Remove stretched string lines.

5. Bore holes with truck-or tractor-powered 14"-24" diameter auger the depth required by the plan or design notes. Dig holes wide and deep enough to install pad or casing or at least 8" larger than the pole butt. If earth is stoney, use a backhoe.



Concrete Pads

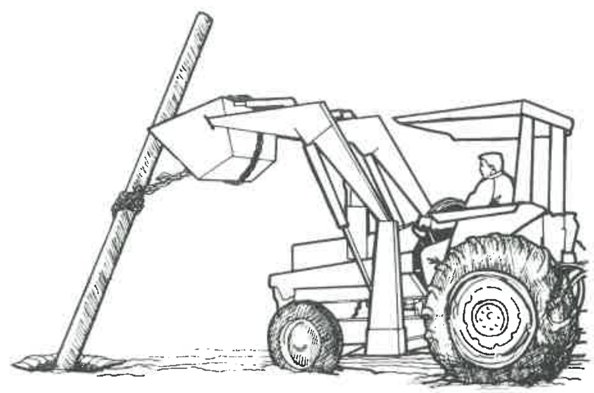
6. Remove water or loose material from bottom of holes so they are smooth and level.

7. Place pad of concrete in bottom of hole and let cure for one day.

Setting Poles or Posts

8. Select 4 straight corner poles or timbers.

9. Place poles in holes. Raise poles with a tractor hydraulic loader and timber hitch or nonslip sling attached above the mid-height of pole. Let poles lean toward inside of building. **Caution**: Creosote may blister skin.



10. Replace string lines and plumb the two outside edges of corner poles with a carpenter's level and straight edge. Keep pole at preset distance from string lines, usually the width of the girt or 1 1/2".

11. Drive 2×4 stakes outside building lines. Brace poles with 2×4's. (Figure 20)

Backfill with dry mix concrete or tamp moist earth with a 2×4 in 4" to 6" layers to half the hole depth. Remeasure building length and width.

12. Nail 2×4 spacer to top of corner posts and tie a building line around the top of the corner posts.

13. Determine spacing between posts and, either on center to center or clear distance basis, mark pairs of 2 x 4 supports to locate posts.

Figure 19. Location of poles or posts and string lines

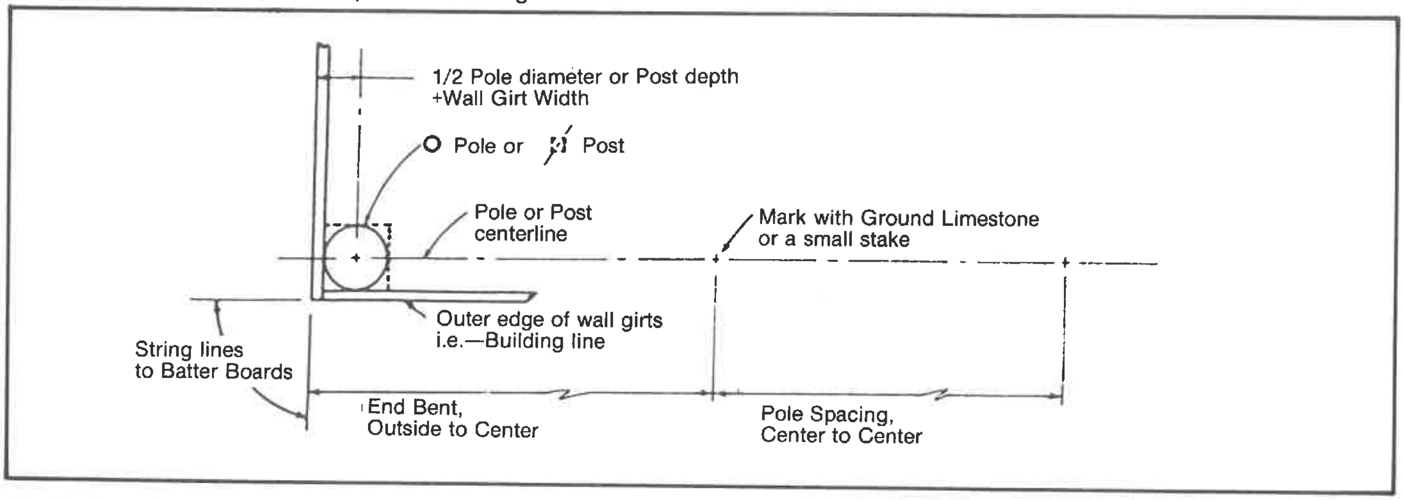
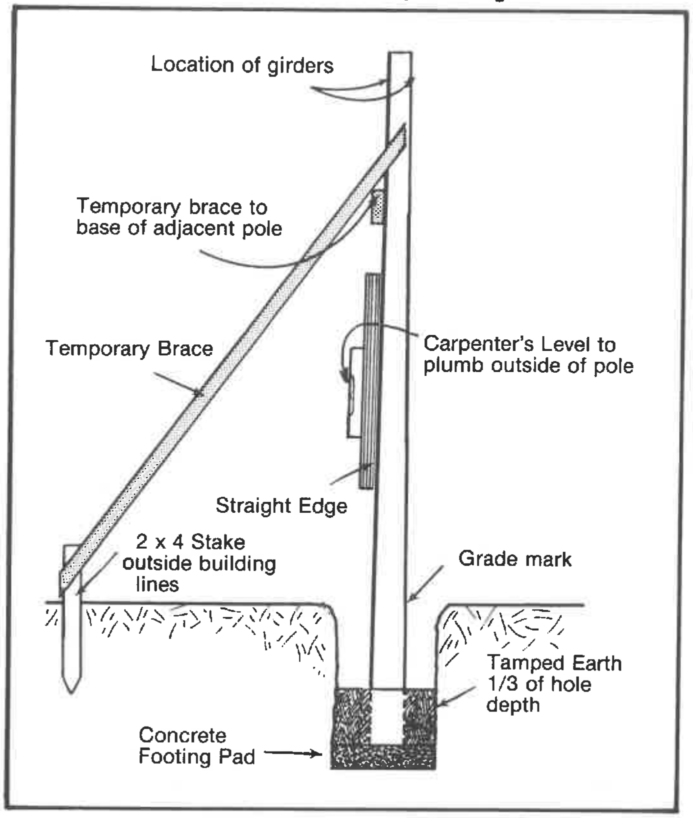


Figure 20. Alignment and Temporary Bracing of Poles



Note: The distance from the corner post to the next post is often shorter than interior posts because spacing may run from the outside of end wall girts to the center of the second pole.

14. Locate and plumb outside edge of all posts using plumb lines as a guide. Be sure to face the straight side out. Use previously marked 2×4's to space posts. Brace with 2×4 to driven stakes. Fasten with duplex (double head) nails. Place braces so they will not interfere with girder and truss installation. Backfill to 1/3 the hole depth as in Step 12.

15. Mark datum level with nail driven partly into outer edge of each post. Level can be set with builder's level and rod.

Girders (Truss Supports)

16. Measure and mark with a partly driven nail the desired height to the top of the girder. Cut a straight board or 2×4 to this dimension for fast and consistent marking from the nails driven to mark the datum level in step 15.

17. Replumb corner posts.

18. Attach girders to posts with the proper number and size of fasteners. To keep the posts stable run diago·.al braces from bottom of one post to near top of next post at 40' to 50' intervals.

19. Trim posts as specified on the plan.

20. Recheck that corners are plumb and walls are straight.

Trusses

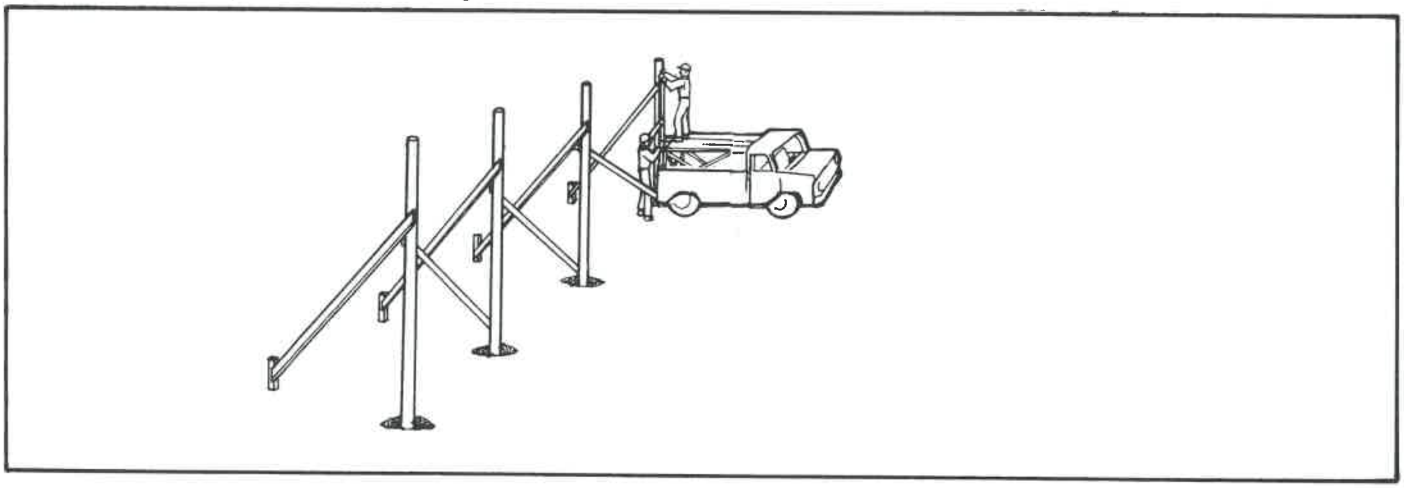
21. Mark the width at the building centered on the bottom chord of each 'truss (outside to outside of girders).

22. Lift a gable end truss in place with a crane, boom truck or front end loader. Use the erection equipment to hold the truss in alignment while attaching it at one end. When attached to the other end the corner post brace may need to be loosened to align the width mark on the truss with the post.

23. Mark 2×4 purlins the exact spacing between trusses.

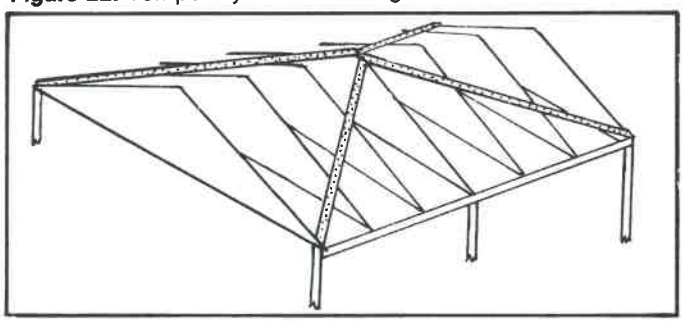
24. Set the second truss in place and attach at one end. Fasten purlin to peak of end truss and second truss with duplex head nails. On 40' or longer trusses, fasten a temporary spacing member half way between the eave and the peak.

Figure 21. Temporary Pole or Post Bracing



25. Extend 2×4 temporary bracing from the corner post at a 45° angle to the next truss. (Figure 22)

Figure 22. Temporary Truss Bracing



26. Continue setting trusses. Secure at each end and brace with 2×4 spacers and diagonal bracing. After one set of diagonal bracing reaches the peak, run the next set at a 45° angle from the peak down to the wall in a zig-zag pattern.

27. Backfill posts as time and labor becomes available.

28. Recheck the gable end truss and replumb if necessary.

29. Sight along top chords of each truss and straighten by readjusting bracing.

Purlins and Braces

30. Fasten purlins working from the eaves toward the peak. Use wood gauges to obtain proper spacing.

31. Reinstall diagonal braces with duplex nails on top of purlins to keep the building stable.

32. Install any interior truss supports or members that span openings so they touch the bottom of the truss. Install any knee braces.

33. Nail diagonal wind bracing to the underside of the top chord. As a minimum, extend bracing at a 45° angle from each corner to the peak and at 50′ intervals. As an alternative, run the bracing in a continuous zig-zag pattern the length of the roof. Internal wind bracing may be installed as the trusses are set in step 26.

Roofing

34. Determine roofing overhang at the eave line, fasten spacer blocks every 30′ to 50′ along eave and stretch a building line between corners to mark roofing overhang.

35. Mark purlins at 20′ intervals to check alignment of roofing sheets.

36. Install roofing starting at lower corner of downwind end so side laps are away from the strongest winds. Follow manufacturer's fastening instructions. For example, lap each side of corrugated sheets one and one-half corrugations and lap ends 6″ to 9″. Nail through the tops of the corrugations with nails that penetrate at least 1″ into the purlin.

37. Finish installing any truss stiffeners, internal vertical X bracing at 50′ intervals, lower chord stiffeners running the length of the building at 20′ intervals across the building or as the plans or truss manufacturer specify.

Siding and Finishing

38. Nail pressure treated base planks at uniform distance from the previously established datum line.

39. Remove temporary pole bracing and use as wall girts.

40. Install siding starting from the downwind end. A temporary 2 x 4 ledger tacked down the distance the siding overlaps the base plank assures proper alignment.

41. Install trim, doors and other accessories.

42. Install concrete floor and approach apron.

43. Clean all debris from building site and complete final grading and seeding.

Building Layout

The layout of the building establishes exact reference lines and elevations. Care in layout makes construction easier and helps keep the building square.

• Tools and Materials

Two 100′ steel tapes, crow bar, hatchet, sledge hammer, level, at least twenty 2 x 4 stakes 35″ long, eight 2×4 batter boards 8′ long, building line or cord (length= building perimeter+100′), 12d nails, and builder's level and rod.

• Procedure

1. Stake out a base line at the front edge or side of the building.

2. Locate and set front corner stake A on base line. Drive a nail in the top of the stake as a reference point. (Figure 23)

3. Measure the building length along the base line. Stake A and set corner Stake B. Use a surveyor's level and drive Stake B level with Stake A. Drive a nail in the top of the stake at the exact length of the building.

4. Make the end wall perpendicular to the front wall as follows. Measure 30′ along the base line from Stake B and set a temporary stake. The point 50′ from this temporary stake and 40′ from Stake B is perpendicular to the base line (Figure 23). Set a temporary stake at this point.

5. Measure the width of the building along this line and set the third corner Stake C. Drive Stake C level with Stakes A and B. Drive a nail in top of the stake at the exact width of building.

6. From Stake C measure the building length. From nail in Stake A measure building width. Where these two measurements meet drive fourth corner Stake D. Drive nail at exact corner point.

7. Check tops of all stakes; all should be level. Then measure: (1) baseline length AB, (2) triangulation at second corner (ABC), (3) widths BC & AD, and (4) length CD. Adjust nails or stakes B, C, D as necessary.

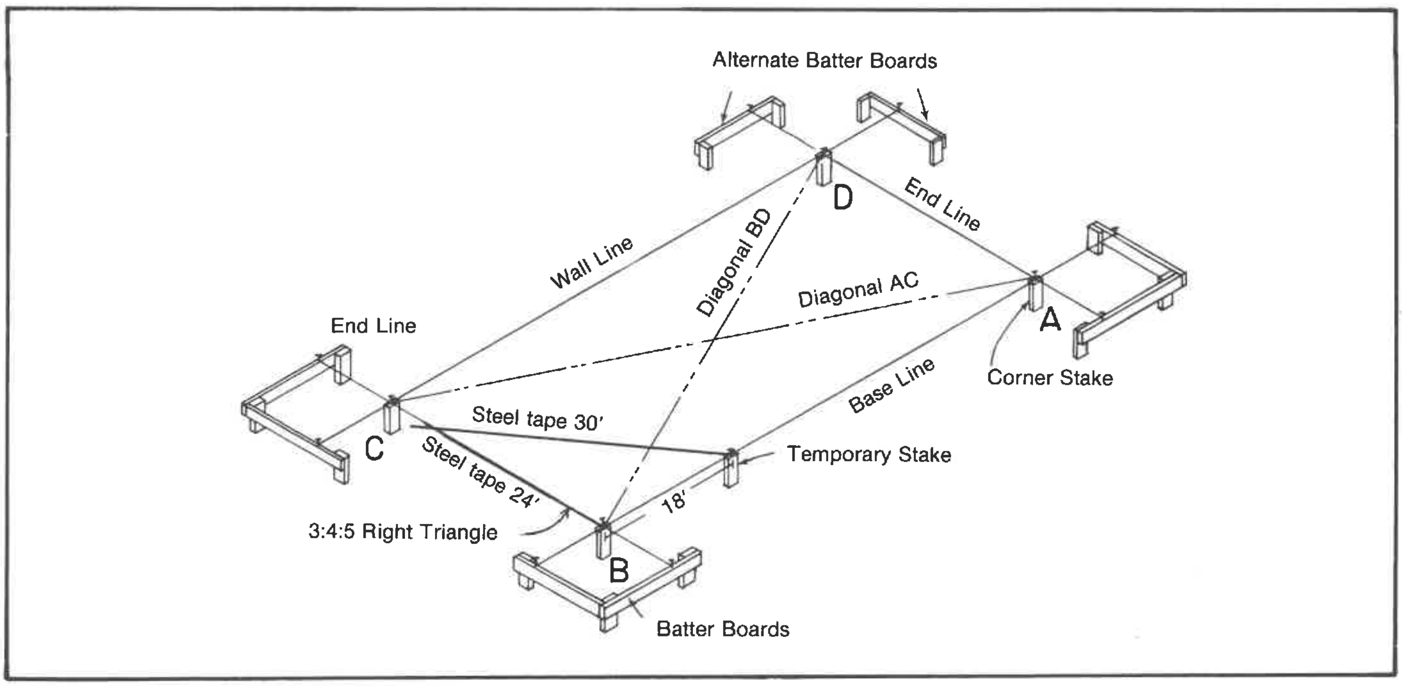
8. Check that diagonals AC and BD are equal for a rectangular building. Make diagonals equal by shifting C and D along rear wall line. Keep width BC and CD equal. Check level of shifted stakes.

9. Drive batter board stakes 8′ to 12′ from all corners. Batter boards provide a level reference plane for the building layout. They should not interfere with excavation or construction and should remain undisturbed until the building frame is complete.

10. Level and fasten batter boards to stakes at same height as tops of corner stakes.

11. Stretch building cord between batter boards to just touch nails on top of stakes. Drive nail or make saw kerf in top of batter boards to line up string. Corner marking stakes can then be removed and corners located where lines cross.

Figure 23. Building Layout with Batter Boards



Construction Check List

	Responsible Person	Assistance From	COMPLETION DATE Planned	Actual
CONSTRUCTION				
1. Excavation				
2. Drainage				
3. Fill				
4. Grading				
5. Setting poles (foundation)				
6. Retaining walls				
7. Loading Docks				
8. Concrete floors				
9. Paving				
10. Framing				
11. Trusses				
12. Roofing				
13. Siding				
14. Windows				
15. Doors				
16. Inlets & vents				
17. Other openings				
18. Finish & trim				
19. Eaves troughs				
20. Lightning rods				
21. Insulation				
22. Ceilings				
23. Partitions				
24. Interior skin				
25. Finish floors				
UTILITIES				
1. Plumbing				
2. Waste disposal				
3. Wiring				
4. Inspections				
5. Install equipment				
6. Heating				
7. Ventilating				
8. Cooling				
9. Other				
MISCELLANEOUS				
1. Painting				
2. Cleanup				
3. Landscaping				
4. Supervise construction				
5. Check materials				
6. Check time				
7. Approve changes				
8. Final acceptance				

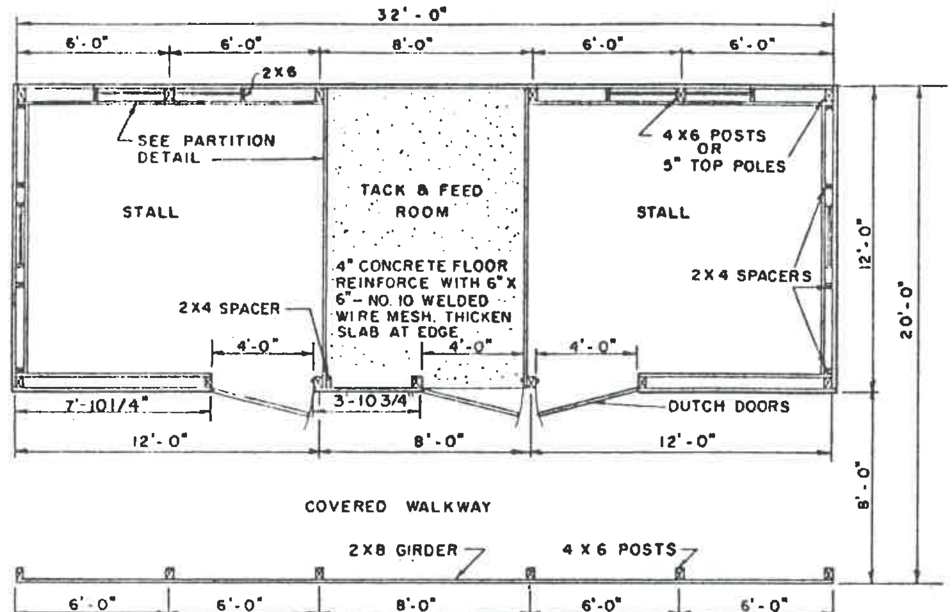
Plans

Detailed plans for pole and post utility and recreation buildings are available from the extension agricultural engineer in your state or from any of the universities listed on the inside front cover of this publication. There may be a small charge to cover cost of printing.

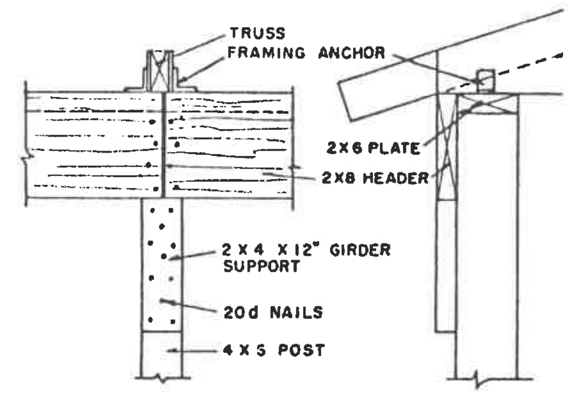
The following pages illustrate some of these plans and show the versatility of pole-type construction. Several complete plans are included for design ideas to show construction details. Most are designed for 20 to 30 psf snow loads and 15 psf wind loads. Space rafters or trusses closer together or use larger lumber in areas with greater snow loads.

Plans are also available from some farm supply stores, farm and suburban magazine publishers, trade associations for wood construction, and metal roofing and siding manufacturers.

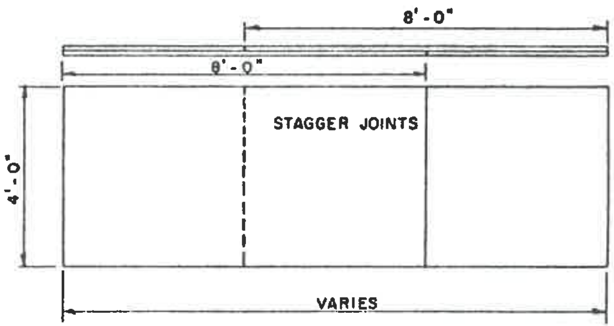
Plan No.	Description
6118	2 Stall Horse Barn
5832	Pole Building - 26′, 39′ or 52′ wide
6285	Gambrel Roofed Pole Barn
6111	Drive Through Free Stall Barn
5930	Two Car Garage



PLAN

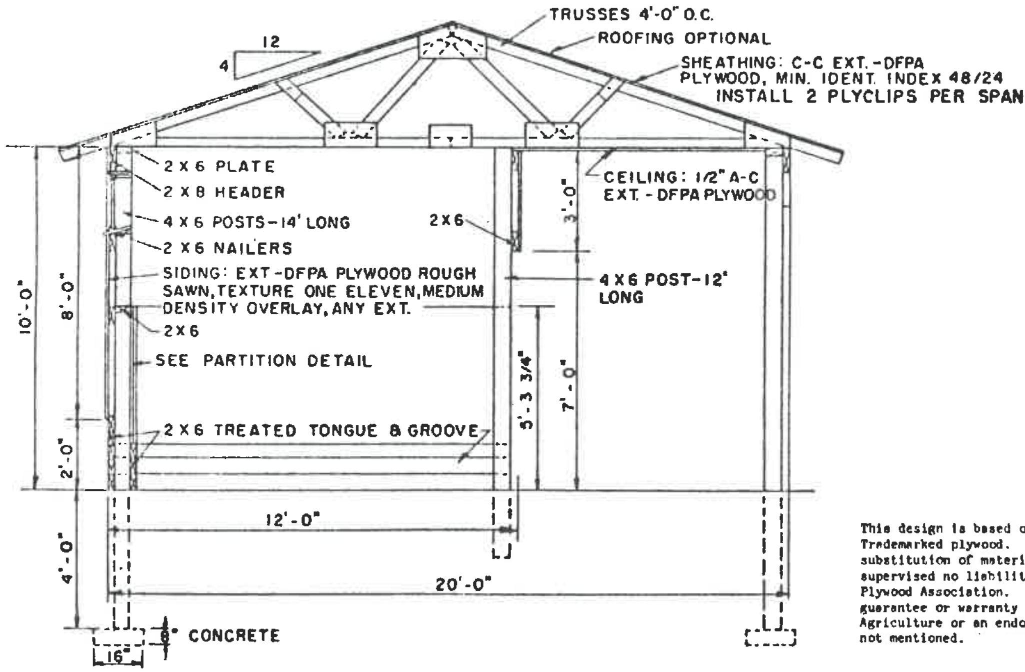


GIRDER DETAIL



PARTITIONS & INNER WALL LINER

5/8" C-C EXT-DFPA PLYWOOD. FASTEN PANELS TOGETHER WITH PANEL ADHESIVE AND NO. 10 WOOD SCREWS 1" LONG, THREE ROWS SPACED 12" O.C. IN EACH ROW.



SECTION THRU DOOR

NOTE:
CONSULT LOCAL HEALTH AUTHORITIES BEFORE STARTING CONSTRUCTION TO BE SURE THAT THE PLAN CONFORMS WITH LOCAL CODES AND REGULATIONS

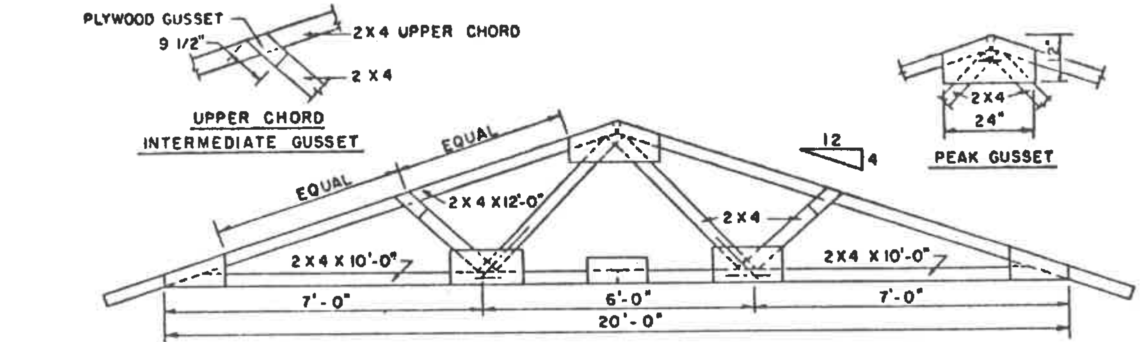
This design is based on the use of American Plywood Association Grade-Trademarked plywood. Structural deficiencies may result with the substitution of materials. Because erection of the structure cannot be supervised no liability can be assumed by the designer or the American Plywood Association. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

AMERICAN PLYWOOD ASSOC.
FORM NO. 70-160

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

HORSE BARN
2 STALL PLYWOOD

APA '71	6118	SHEET 1 OF 3



TRUSS

TRUSS SPECIFICATION

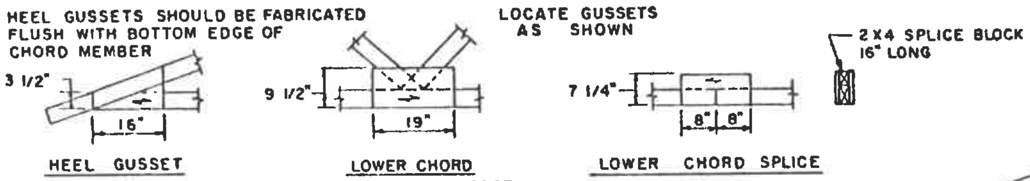
LUMBER:

UPPER CHORD 2 X 4 — 1500f LUMBER
LOWER CHORD 2 X 4 — 1200f LUMBER

WEB 2 X 4 CONSTRUCTION GRADE DOUGLAS FIR, LARCH, HEMLOCK OR NO. 2 SOUTHERN PINE

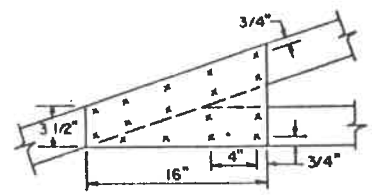
GLUE:
RESORCINOL RESIN TYPE

NAILS:
6d SPACED 4" O.C. TWO ROWS FOR 2 X 4 MEMBERS

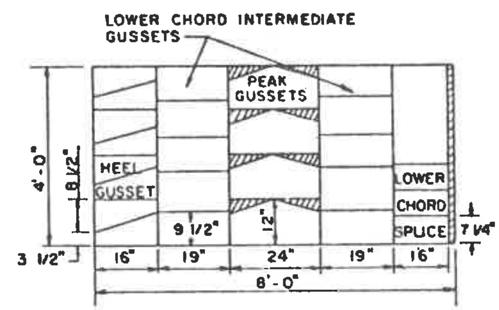


GUSSETS

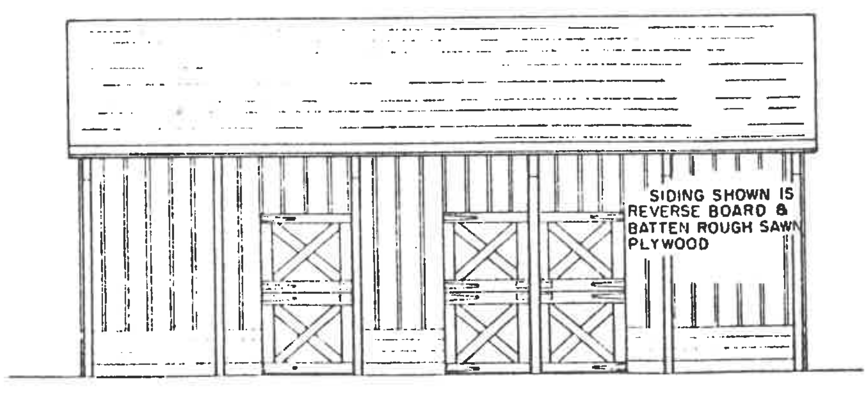
GUSSETS ARE CUT FROM PLYWOOD (EXT.-DFPA) 1/2" C-C STRUCTURAL I. FACE GRAIN IS HORIZONTAL ON ALL GUSSETS. ALL PLYWOOD GUSSET PLATES ARE ON BOTH SIDES OF TRUSS.



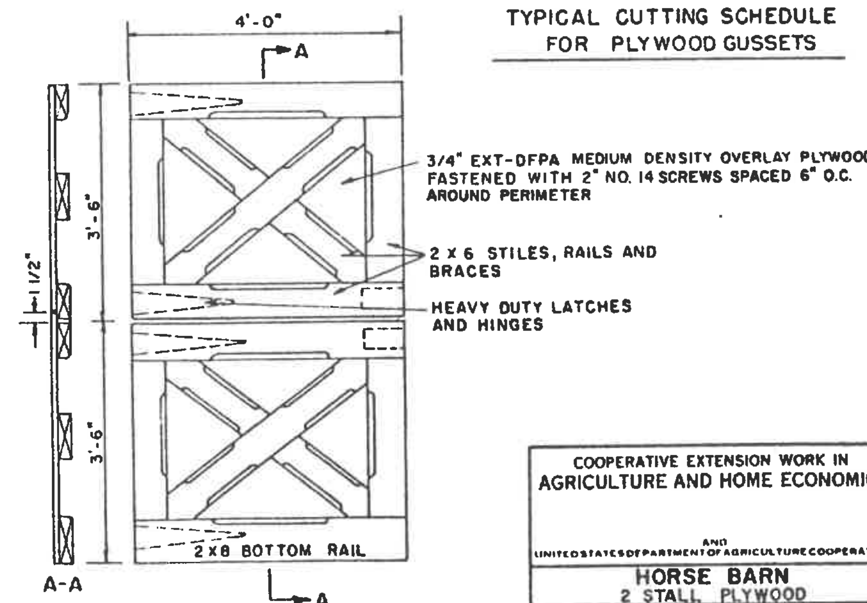
TYPICAL NAIL PATTERN



TYPICAL CUTTING SCHEDULE FOR PLYWOOD GUSSETS



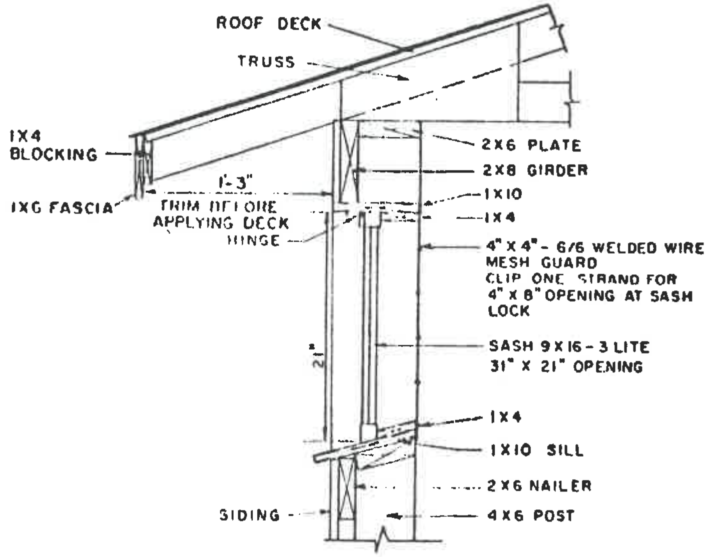
SIDE ELEVATION



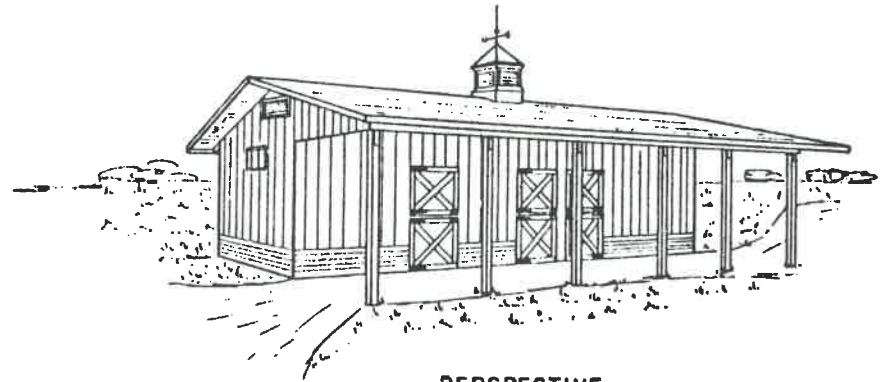
STALL DOOR DETAILS

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

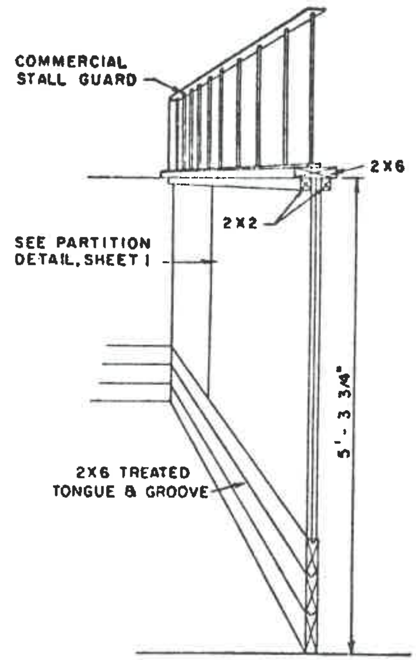
HORSE BARN 2 STALL PLYWOOD			
APA	'71	6118	SHEET 2 OF 3



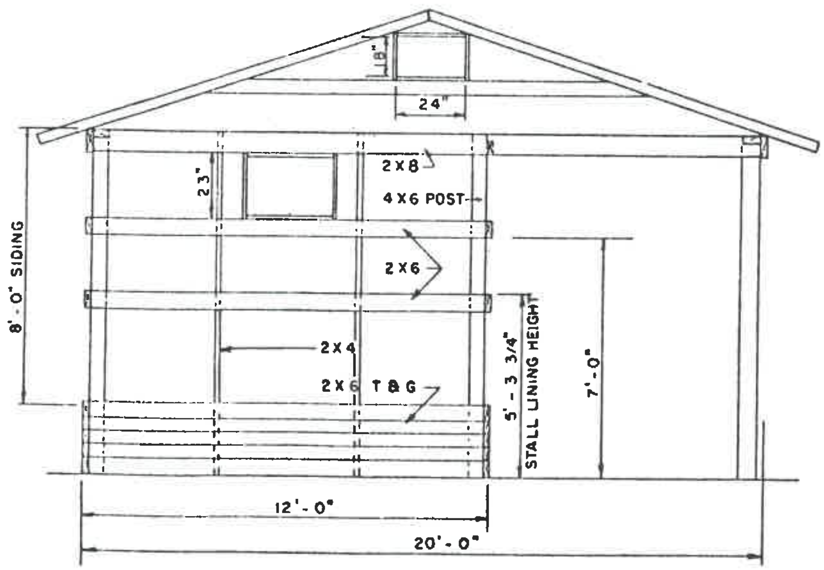
WINDOW DETAIL



PERSPECTIVE



STALL PARTITION DETAIL



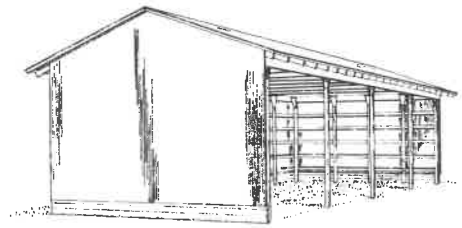
END FRAMING DETAIL

Note: Interior posts and partitions may be removed to convert the barn to other uses.

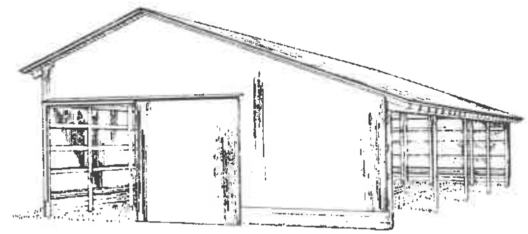
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

HORSE BARN
2 STALL PLYWOOD

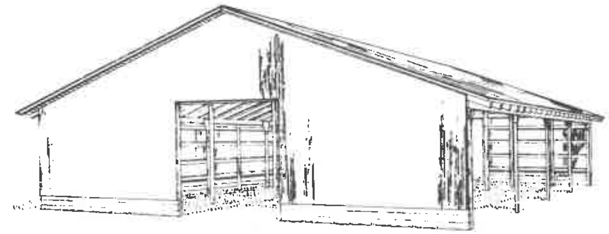
APA	'71	6118	SHEET 3 OF 3



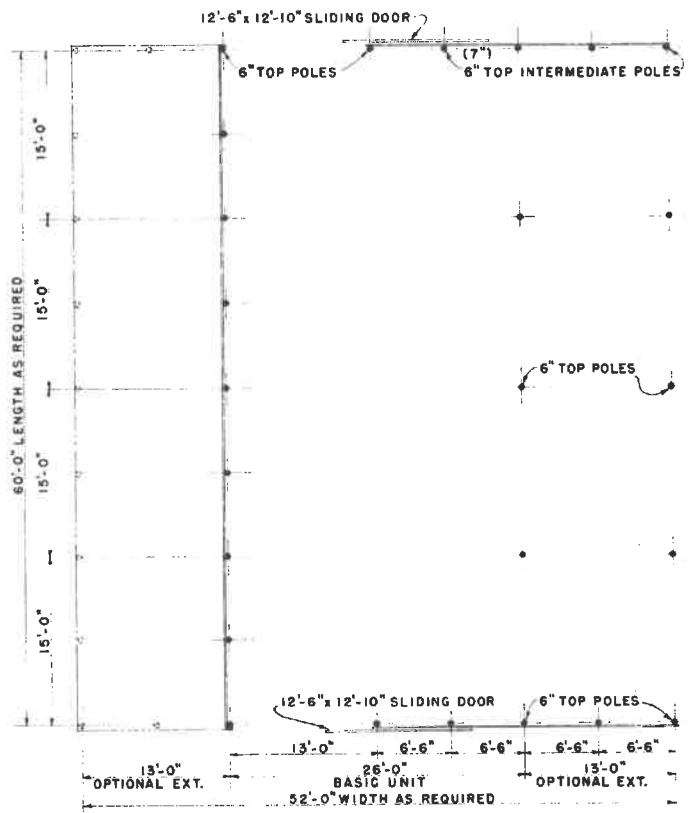
26 FOOT WIDTH
(BASIC UNIT)



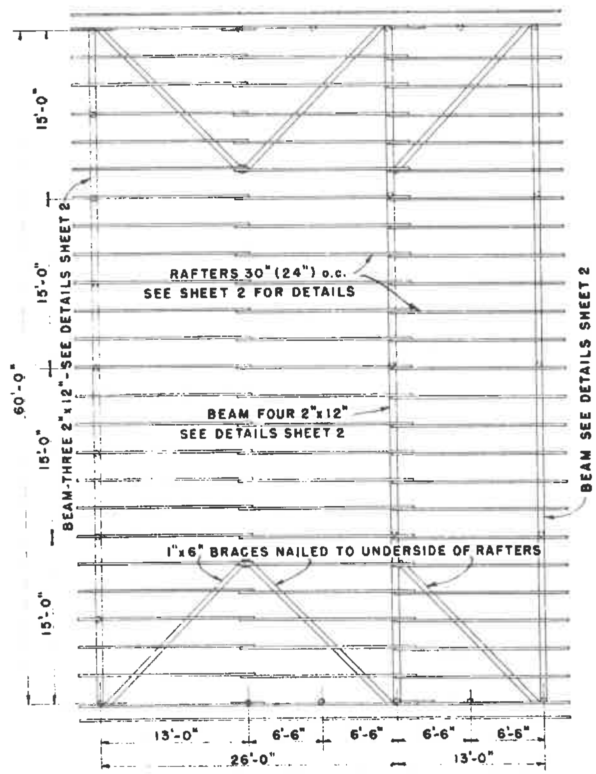
39 FOOT WIDTH



52 FOOT WIDTH



FLOOR PLAN
SCALE: 1/8"=1'-0"



ROOF FRAMING PLAN
SCALE: 1/8"=1'-0"

NOTE:

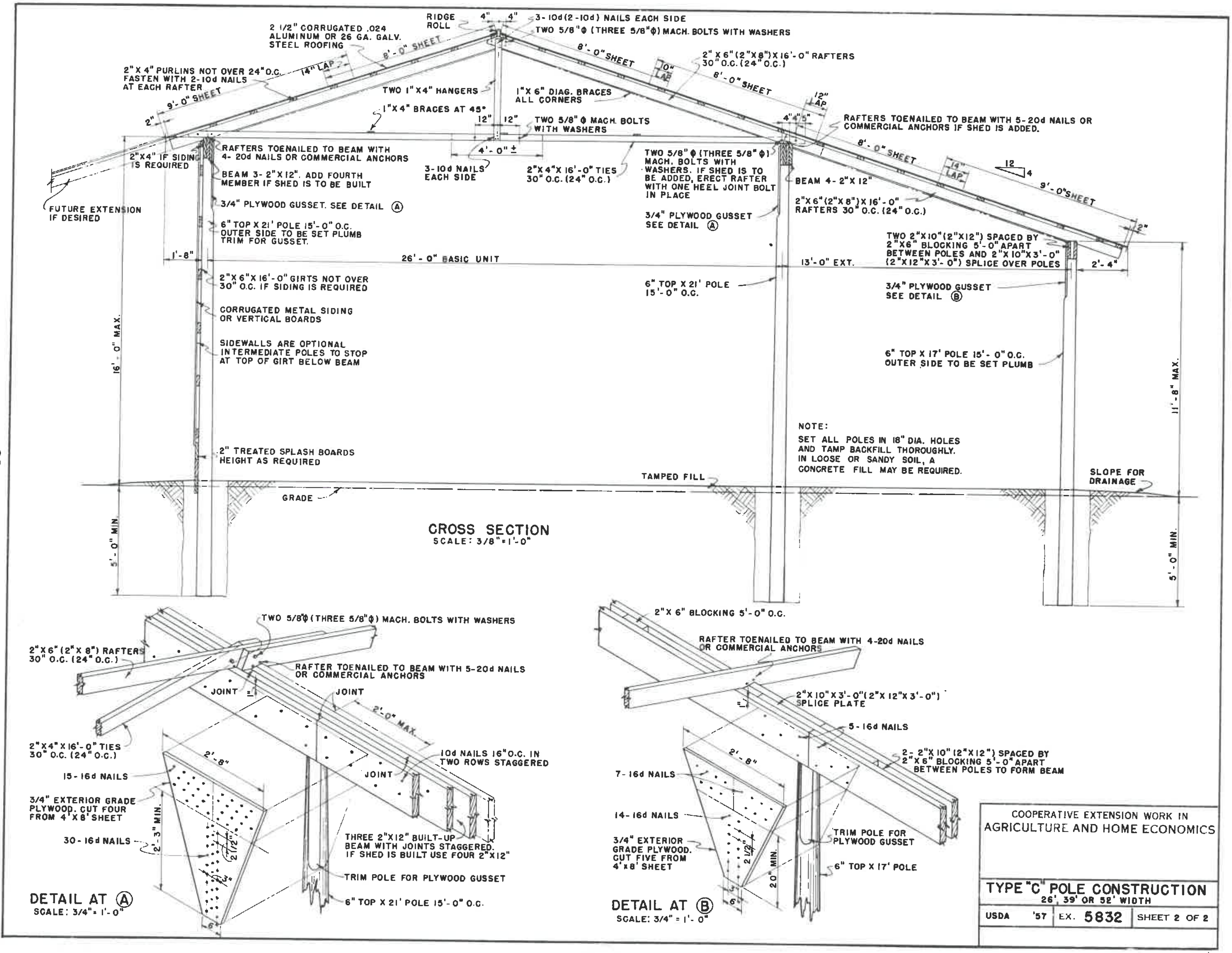
LENGTH OF THE BUILDING MAY BE VARIED IN UNITS OF 15 FEET.

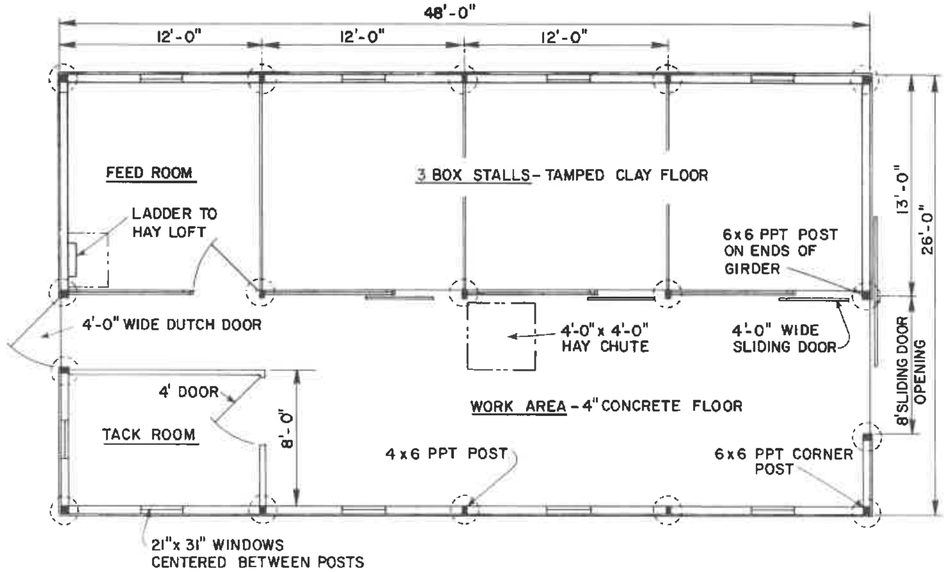
THIS STRUCTURE IS PRIMARILY INTENDED FOR USE IN AREAS WHERE THE SNOW LOAD DOES NOT EXCEED 20 LB. PER SQUARE FOOT AND WIND DOES NOT EXCEED 88 MILES PER HOUR. IN AREAS SUBJECT TO SNOW LOADS UP TO 30 LB. PER SQUARE FOOT OR HIGHER WINDS USE THE FIGURES SHOWN IN PARENTHESES (....) FOR FRAMING SIZES AND NAILS.

ALL POLES, SPLASH BOARDS AND OTHER WOOD IN CONTACT WITH THE GROUND OR MANURE TO BE TREATED WITH PRESERVATIVE.

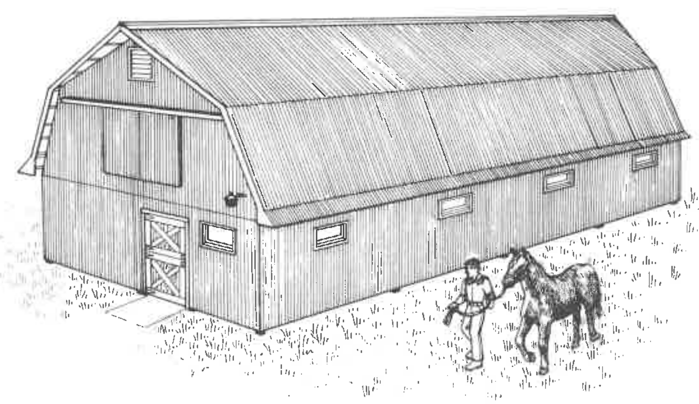
THE 2½" CORRUGATED METAL ROOFING IS APPLIED TO 2"x4" NAILING STRIPS SPACED NOT OVER 24" APART OR AS SPECIFIED BY THE MANUFACTURER.

COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS			
TYPE "C" POLE CONSTRUCTION 26', 39' OR 52' WIDTH			
USDA	'57	EX. 5832	SHEET 1 OF 2

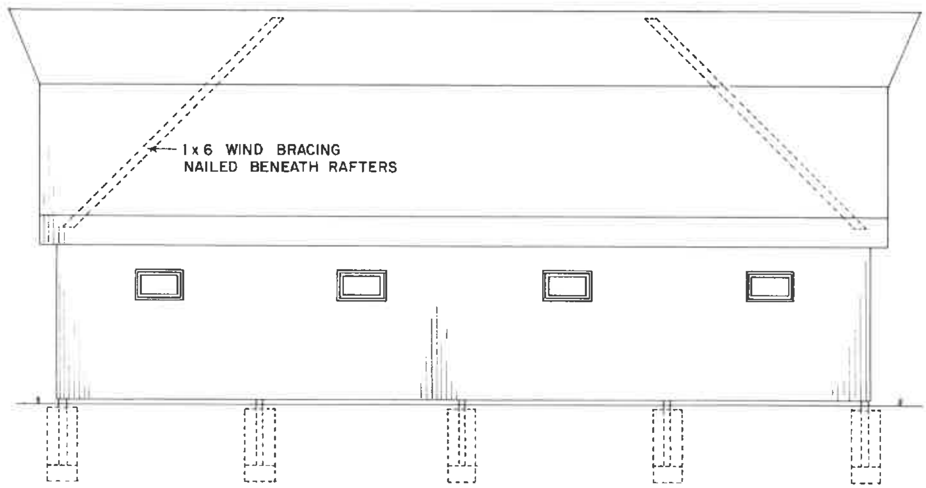

CROSS SECTION
SCALE: 3/8" = 1'-0"
RIDGE ROLL
4" 4"
3-10d (2-10d) NAILS EACH SIDE
TWO 5/8"ϕ (THREE 5/8"ϕ) MACH. BOLTS WITH WASHERS
2 1/2" CORRUGATED .024 ALUMINUM OR 26 GA. GALV. STEEL ROOFING
8'-0" SHEET
14" LAP
2" X 4" PURLINS NOT OVER 24" O.C. FASTEN WITH 2-10d NAILS AT EACH RAFTER
9'-0" SHEET
2"
TWO 1" X 4" HANGERS
1" X 6" DIAG. BRACES ALL CORNERS
1" X 4" BRACES AT 45°
12" 12"
TWO 5/8"ϕ MACH. BOLTS WITH WASHERS
4'-0" ±
3-10d NAILS EACH SIDE
2" X 4" X 16'-0" TIES 30" O.C. (24" O.C.)
8'-0" SHEET
10" LAP
2" X 6" (2" X 8") X 16'-0" RAFTERS 30" O.C. (24" O.C.)
8'-0" SHEET
12" LAP
4" 4" 5"
RAFTERS TOENAILED TO BEAM WITH 5-20d NAILS OR COMMERCIAL ANCHORS IF SHED IS ADDED.
8'-0" SHEET
14" LAP
12
4
9'-0" SHEET
2"
RAFTERS TOENAILED TO BEAM WITH 4-20d NAILS OR COMMERCIAL ANCHORS
2" X 4" IF SIDING IS REQUIRED
BEAM 3-2" X 12". ADD FOURTH MEMBER IF SHED IS TO BE BUILT
FUTURE EXTENSION IF DESIRED
3/4" PLYWOOD GUSSET. SEE DETAIL Ⓐ
6" TOP X 21' POLE 15'-0" O.C. OUTER SIDE TO BE SET PLUMB TRIM FOR GUSSET.
TWO 5/8"ϕ (THREE 5/8"ϕ) MACH. BOLTS WITH WASHERS. IF SHED IS TO BE ADDED, ERECT RAFTER WITH ONE HEEL JOINT BOLT IN PLACE
BEAM 4-2" X 12"
2" X 6" (2" X 8") X 16'-0" RAFTERS 30" O.C. (24" O.C.)
3/4" PLYWOOD GUSSET SEE DETAIL Ⓐ
TWO 2" X 10" (2" X 12") SPACED BY 2" X 6" BLOCKING 5'-0" APART BETWEEN POLES AND 2" X 10" X 3'-0" (2" X 12" X 3'-0") SPLICE OVER POLES
1'-8"
26'-0" BASIC UNIT
13'-0" EXT.
2'-4"
2" X 6" X 16'-0" GIRTS NOT OVER 30" O.C. IF SIDING IS REQUIRED
6" TOP X 21' POLE 15'-0" O.C.
3/4" PLYWOOD GUSSET SEE DETAIL Ⓑ
CORRUGATED METAL SIDING OR VERTICAL BOARDS
SIDEWALLS ARE OPTIONAL INTERMEDIATE POLES TO STOP AT TOP OF GIRT BELOW BEAM
6" TOP X 17' POLE 15'-0" O.C. OUTER SIDE TO BE SET PLUMB
16'-0" MAX.
11'-8" MAX.
NOTE:
SET ALL POLES IN 18" DIA. HOLES AND TAMP BACKFILL THOROUGHLY. IN LOOSE OR SANDY SOIL, A CONCRETE FILL MAY BE REQUIRED.
2" TREATED SPLASH BOARDS HEIGHT AS REQUIRED
TAMPED FILL
SLOPE FOR DRAINAGE
GRADE
5'-0" MIN.
5'-0" MIN.
DETAIL AT Ⓐ
SCALE: 3/4" = 1'-0"
TWO 5/8"ϕ (THREE 5/8"ϕ) MACH. BOLTS WITH WASHERS
2" X 6" (2" X 8") RAFTERS 30" O.C. (24" O.C.)
RAFTER TOENAILED TO BEAM WITH 5-20d NAILS OR COMMERCIAL ANCHORS
JOINT
JOINT
2'-0" MAX.
JOINT
2" X 4" X 16'-0" TIES 30" O.C. (24" O.C.)
2'-8"
10d NAILS 16" O.C. IN TWO ROWS STAGGERED
15-16d NAILS
3/4" EXTERIOR GRADE PLYWOOD. CUT FOUR FROM 4' X 8' SHEET
2'-3" MIN.
2 1/2"
30-16d NAILS
3"
6"
THREE 2" X 12" BUILT-UP BEAM WITH JOINTS STAGGERED. IF SHED IS BUILT USE FOUR 2" X 12"
TRIM POLE FOR PLYWOOD GUSSET
6" TOP X 21' POLE 15'-0" O.C.
DETAIL AT Ⓑ
SCALE: 3/4" = 1'-0"
2" X 6" BLOCKING 5'-0" O.C.
RAFTER TOENAILED TO BEAM WITH 4-20d NAILS OR COMMERCIAL ANCHORS
2" X 10" X 3'-0" (2" X 12" X 3'-0") SPLICE PLATE
5-16d NAILS
2-2" X 10" (2" X 12") SPACED BY 2" X 6" BLOCKING 5'-0" APART BETWEEN POLES TO FORM BEAM
2'-8"
7-16d NAILS
14-16d NAILS
3/4" EXTERIOR GRADE PLYWOOD. CUT FIVE FROM 4' X 8' SHEET
2 1/2"
20" MIN.
3"
6"
TRIM POLE FOR PLYWOOD GUSSET
6" TOP X 17' POLE
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS
TYPE "C" POLE CONSTRUCTION
26', 39' OR 52' WIDTH
USDA '57 EX. 5832 SHEET 2 OF 2



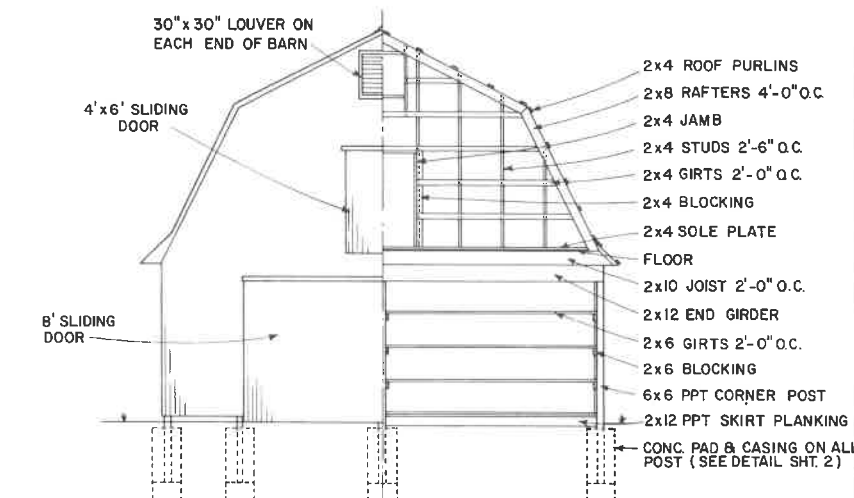
FLOOR PLAN



PERSPECTIVE



SIDE ELEVATION



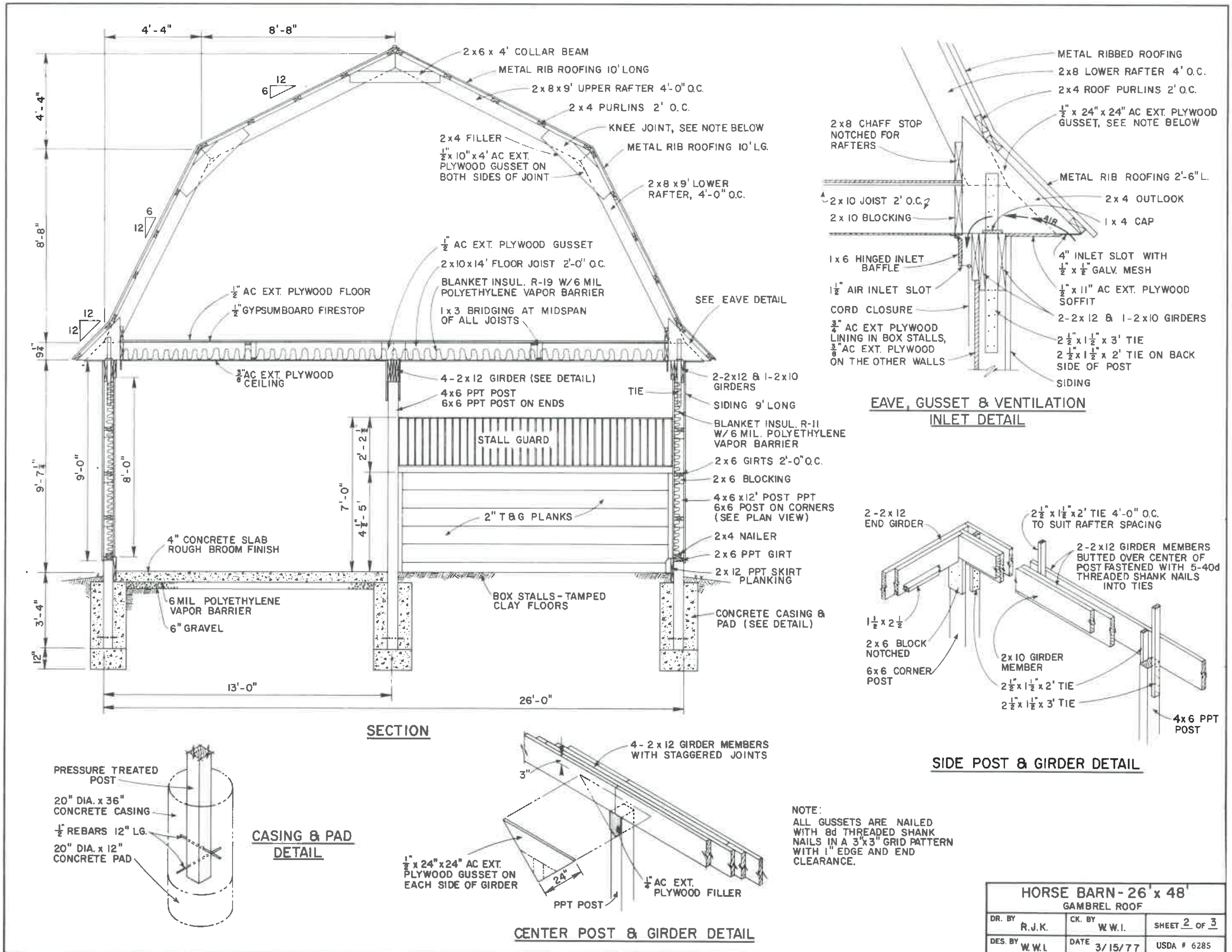
END ELEVATION & FRAMING

NOTES:

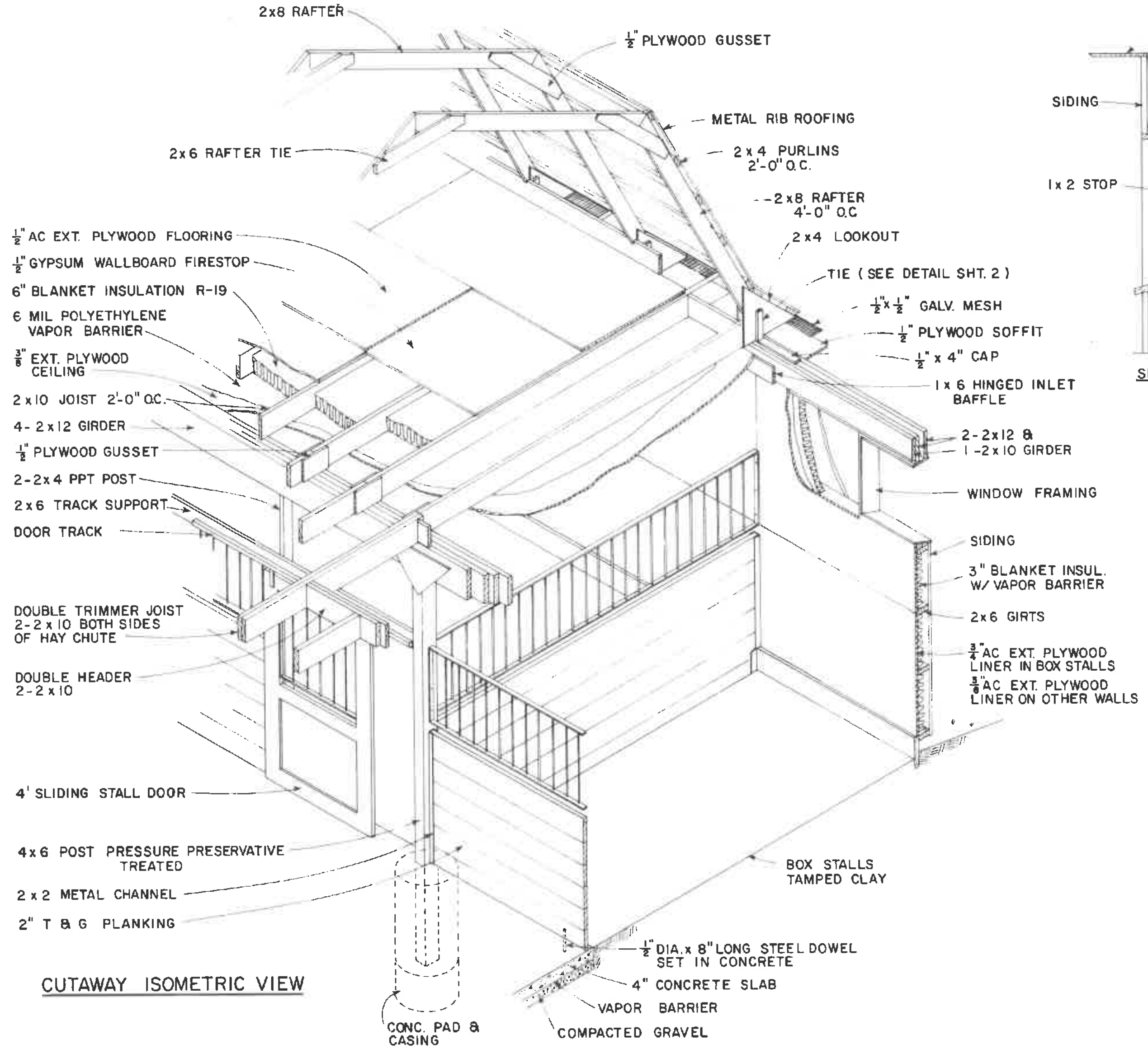
1) ROOF DESIGN LOAD 40 psf.
   MOW FLOOR DESIGN LOAD 70 psf.
   LUMBER BENDING STRESS 1500 psi.

2) ALL POST & PLANKING IN CONTACT WITH THE GROUND OR MANURE TO BE PRESSURE PRESERVATIVE TREATED (PPT)

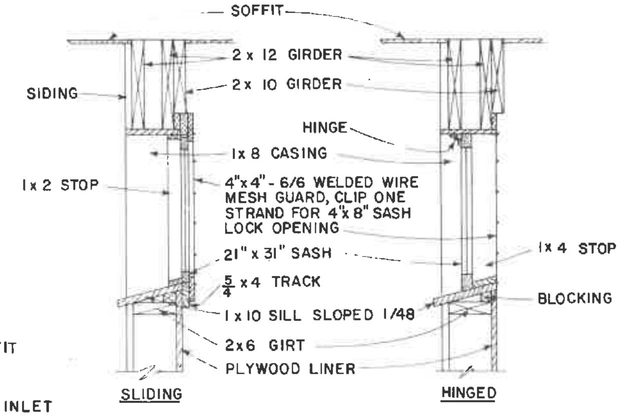
HORSE BARN- 26' x 48' GAMBREL ROOF		
DR. BY R. J. K.	CK. BY W. W. I.	SHEET 1 OF 3
DES. BY W. W. I.	DATE 3/15/77	USDA # 6285



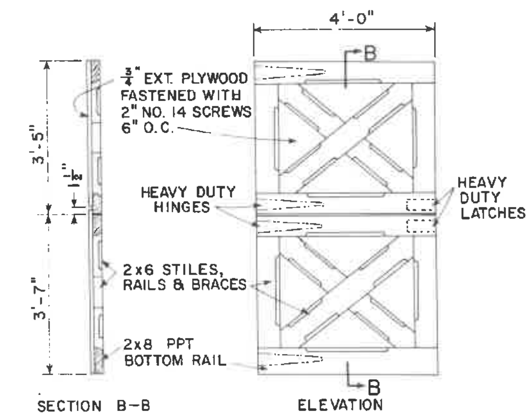
SECTION
4'-4"
8'-8"
9¼"
9'-7¼"
3'-4"
12"
9'-0"
8'-0"
2'-2¼"
4¾'-5'
7'-0"
13'-0"
26'-0"
2x6 x 4' COLLAR BEAM
METAL RIB ROOFING 10' LONG
2x8x9' UPPER RAFTER 4'-0" O.C.
2x4 PURLINS 2' O.C.
KNEE JOINT, SEE NOTE BELOW
METAL RIB ROOFING 10' LG.
2x4 FILLER
½"x 10"x 4' AC EXT. PLYWOOD GUSSET ON BOTH SIDES OF JOINT
2x8x9' LOWER RAFTER, 4'-0" O.C.
½" AC EXT. PLYWOOD GUSSET
2x10x14' FLOOR JOIST 2'-0" O.C.
BLANKET INSUL. R-19 W/6 MIL POLYETHYLENE VAPOR BARRIER
1x3 BRIDGING AT MIDSPAN OF ALL JOISTS
½" AC EXT. PLYWOOD FLOOR
½" GYPSUMBOARD FIRESTOP
SEE EAVE DETAIL
⅜" AC EXT. PLYWOOD CEILING
4-2x12 GIRDER (SEE DETAIL)
4x6 PPT POST
6x6 PPT POST ON ENDS
TIE
2-2x12 & 1-2x10 GIRDERS
SIDING 9' LONG
BLANKET INSUL. R-11 W/6 MIL. POLYETHYLENE VAPOR BARRIER
2x6 GIRTS 2'-0" O.C.
2x6 BLOCKING
4x6x12' POST PPT
6x6 POST ON CORNERS (SEE PLAN VIEW)
STALL GUARD
2" T&G PLANKS
2x4 NAILER
2x6 PPT GIRT
2x12 PPT SKIRT PLANKING
4" CONCRETE SLAB ROUGH BROOM FINISH
6 MIL POLYETHYLENE VAPOR BARRIER
6" GRAVEL
BOX STALLS - TAMPED CLAY FLOORS
CONCRETE CASING & PAD (SEE DETAIL)
EAVE, GUSSET & VENTILATION INLET DETAIL
METAL RIBBED ROOFING
2x8 LOWER RAFTER 4' O.C.
2x4 ROOF PURLINS 2' O.C.
½" x 24" x 24" AC EXT. PLYWOOD GUSSET, SEE NOTE BELOW
2x8 CHAFF STOP NOTCHED FOR RAFTERS
METAL RIB ROOFING 2'-6" L.
2x10 JOIST 2' O.C.
2x10 BLOCKING
2x4 OUTLOOK
1x4 CAP
AIR
1x6 HINGED INLET BAFFLE
4" INLET SLOT WITH ½" x ½" GALV. MESH
1½" AIR INLET SLOT
½" x 11" AC EXT. PLYWOOD SOFFIT
CORD CLOSURE
2-2x12 & 1-2x10 GIRDERS
¾" AC EXT PLYWOOD LINING IN BOX STALLS, ⅜" AC EXT. PLYWOOD ON THE OTHER WALLS
2½"x 1½" x 3' TIE
2½"x 1½" x 2' TIE ON BACK SIDE OF POST
SIDING
SIDE POST & GIRDER DETAIL
2-2x12 END GIRDER
2½" x 1½" x 2' TIE 4'-0" O.C. TO SUIT RAFTER SPACING
2-2x12 GIRDER MEMBERS BUTTED OVER CENTER OF POST FASTENED WITH 5-40d THREADED SHANK NAILS INTO TIES
1½ x 2½
2x6 BLOCK NOTCHED
6x6 CORNER POST
2x10 GIRDER MEMBER
2½"x 1½" x 2' TIE
2½"x 1½" x 3' TIE
4x6 PPT POST
CASING & PAD DETAIL
PRESSURE TREATED POST
20" DIA. x 36" CONCRETE CASING
½" REBARS 12" LG.
20" DIA. x 12" CONCRETE PAD
CENTER POST & GIRDER DETAIL
4-2x12 GIRDER MEMBERS WITH STAGGERED JOINTS
3"
½" x 24" x 24" AC EXT. PLYWOOD GUSSET ON EACH SIDE OF GIRDER
24"
PPT POST
¼" AC EXT. PLYWOOD FILLER
NOTE: ALL GUSSETS ARE NAILED WITH 8d THREADED SHANK NAILS IN A 3"x3" GRID PATTERN WITH 1" EDGE AND END CLEARANCE.
HORSE BARN - 26' x 48'
GAMBREL ROOF
DR. BY R.J.K.
CK. BY W.W.I.
SHEET 2 OF 3
DES. BY W.W.I.
DATE 3/15/77
USDA # 6285



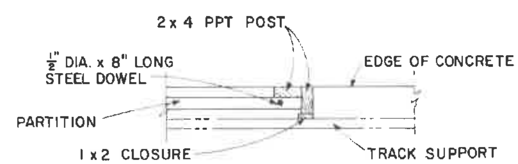
CUTAWAY ISOMETRIC VIEW



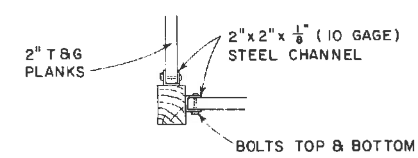
WINDOW DETAIL



DOOR DETAIL

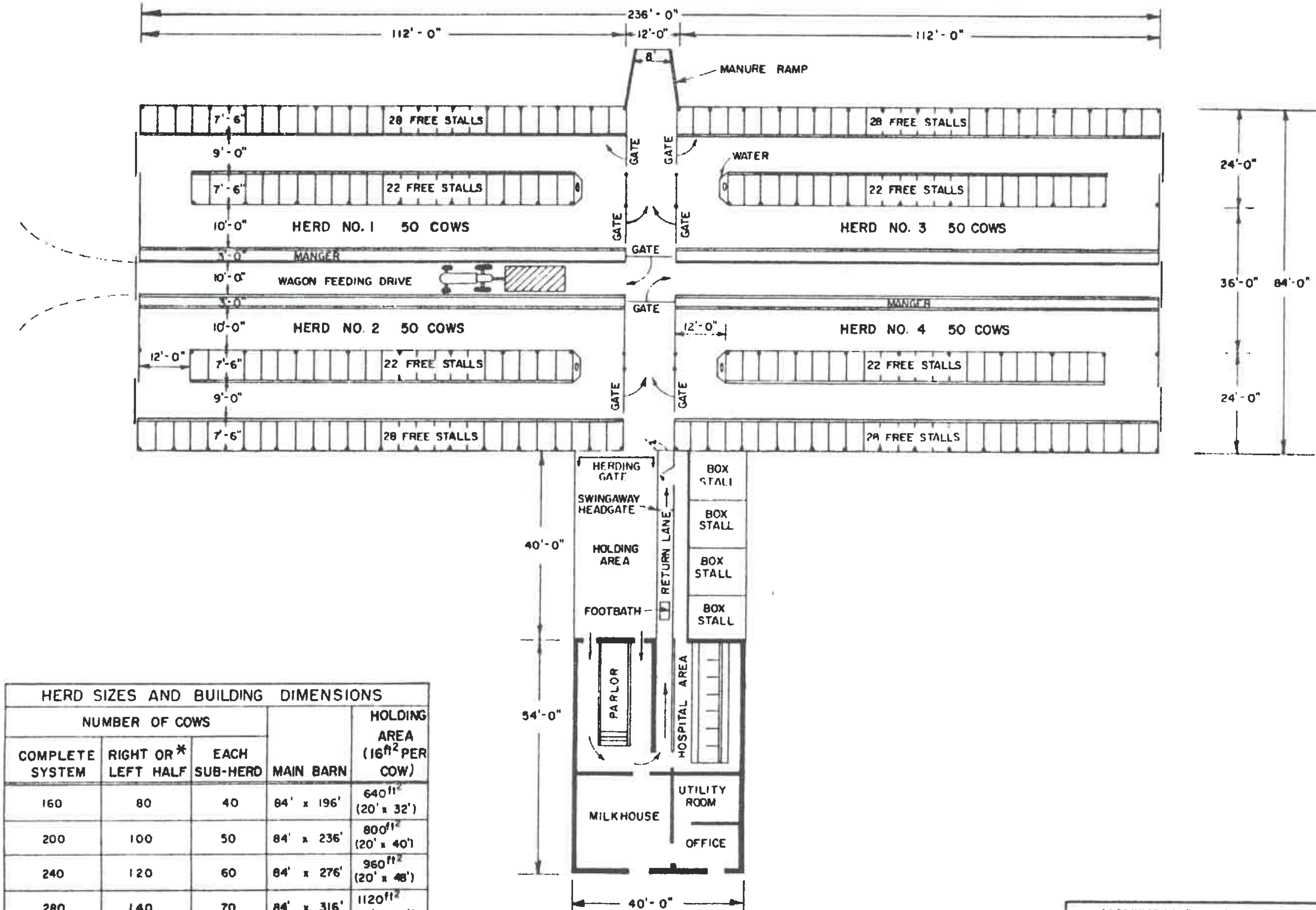


STALL DOOR POST DETAIL



STALL PARTITION ANCHOR

HORSE BARN – 26 x 40 GAMBREL ROOF		
DR BY R. J. K.	CK. BY W. W. I.	SHEET 3 OF 3
DES. BY W. W. I.	DATE 3/15/77	USDA # 6285



FLOOR PLAN

HERD SIZES AND BUILDING DIMENSIONS				
NUMBER OF COWS				HOLDING AREA (16ft² PER COW)
COMPLETE SYSTEM	RIGHT OR* LEFT HALF	EACH SUB-HERD	MAIN BARN	
160	80	40	84' x 196'	640ft² (20' x 32')
200	100	50	84' x 236'	800ft² (20' x 40')
240	120	60	84' x 276'	960ft² (20' x 48')
280	140	70	84' x 316'	1120ft² (20' x 56')
320	160	80	84' x 356'	1280ft² (20' x 64')

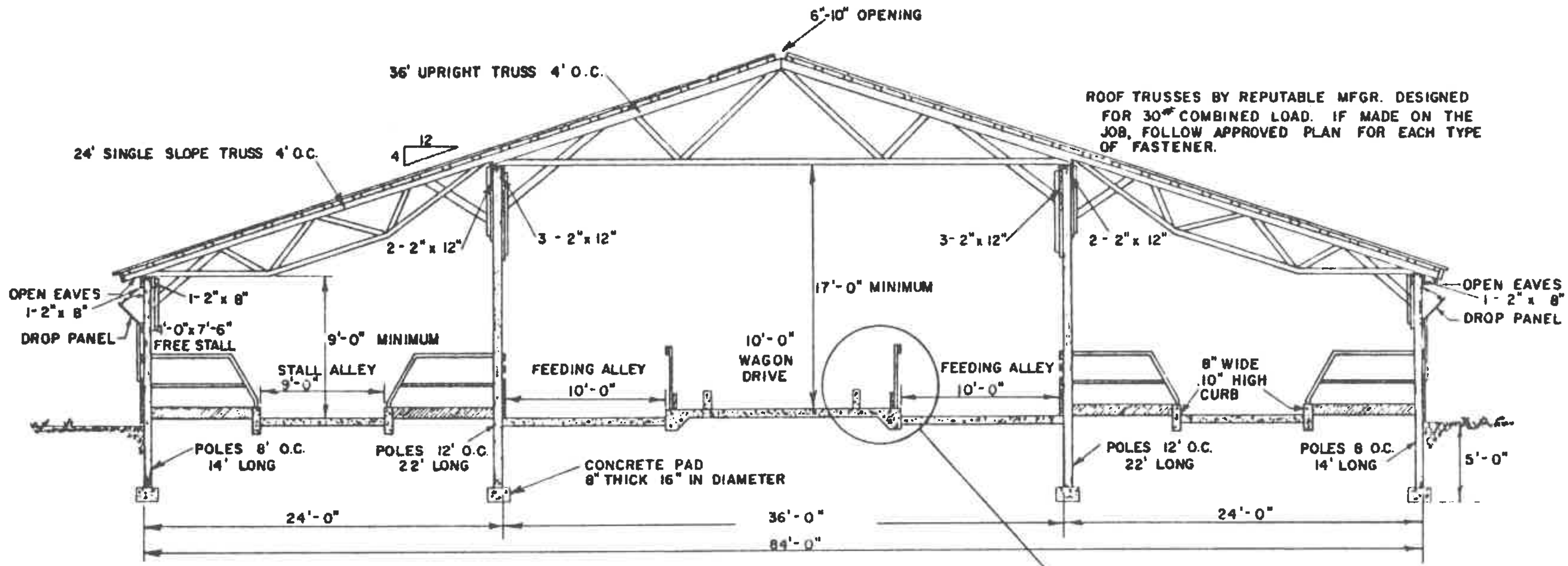
*BUILD EITHER THE RIGHT OR LEFT HALF OF THE FREE STALL BARN AND DIVIDE THE HERD INTO TWO GROUPS.

PENNSYLVANIA STATE UNIVERSITY NO. 723 - 335

COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
DEPARTMENT OF AGRICULTURAL ENGINEERING
UNIVERSITY OF MARYLAND
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

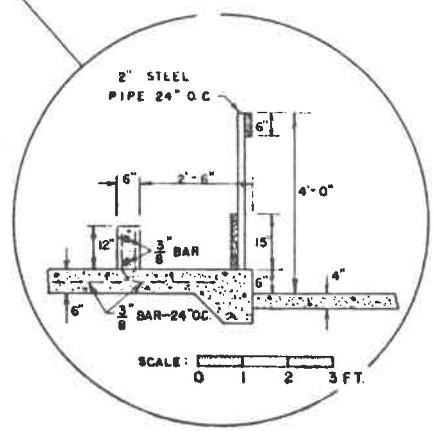
FREE STALL BARN
DRIVE-THRU TYPE

PA.	'71	6111	SHEET 1 OF 3

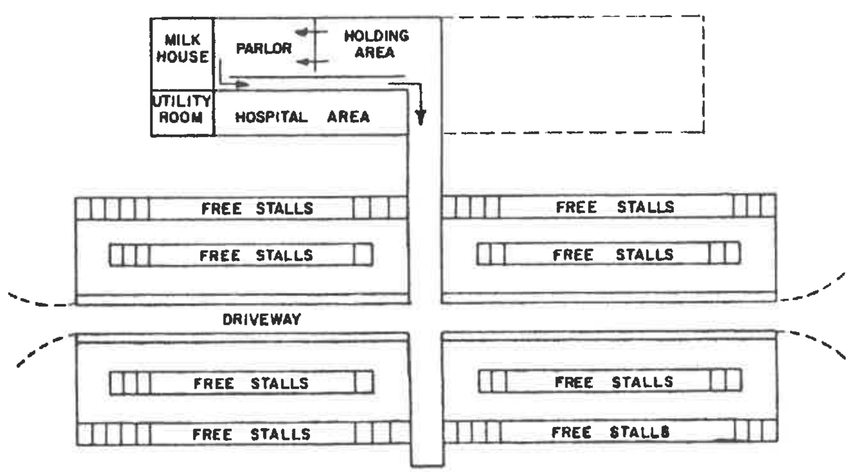


CROSS SECTION

MANY OTHER TYPES OF BUILDINGS CAN BE USED - METAL FRAME, LAMINATED RAFTERS, ETC.



MANGER DETAIL



ALTERNATE LOCATION FOR THE MILKING CENTER, HOLDING AREA AND HOSPITAL AREA.

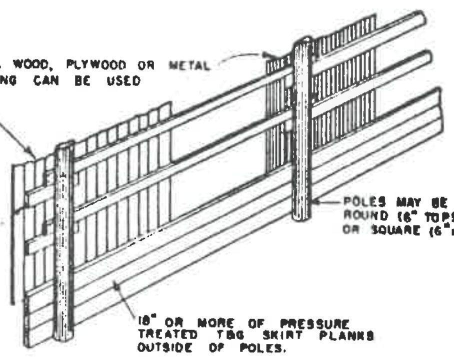
COOPERATIVE EXTENSION WORK IN
AGRICULTURE AND HOME ECONOMICS
DEPARTMENT OF AGRICULTURAL ENGINEERING
UNIVERSITY OF MARYLAND
AND
UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING

FREE STALL BARN
DRIVE-THRU TYPE

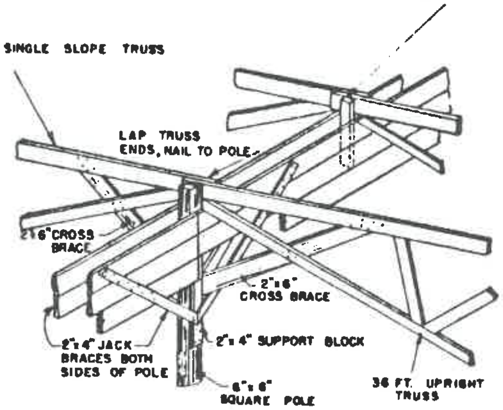
PA	'71	6111	SHEET 2 OF 3

SIDE WALL DETAIL

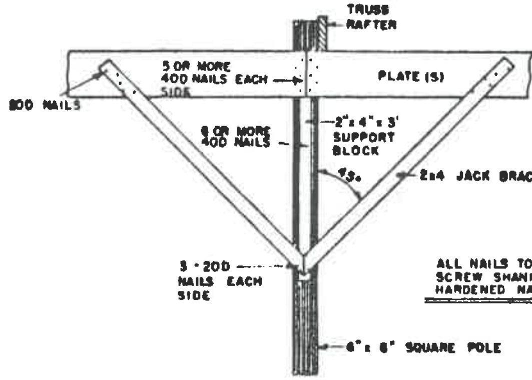
POLES MUST BE PRESSURE TREATED FOR 50 YEAR LIFE. UNTREATED OR COLD TREATED POLES WILL HAVE A SHORT LIFE. POLES MAY BE ROUND (6" TOPS) OR SQUARE (6" x 6").



INTERIOR POLE BRACING AND RAFTER DETAIL

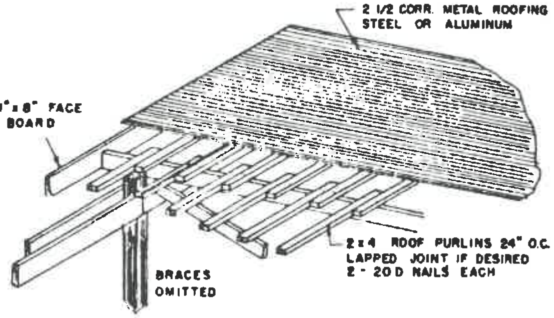


SIDEWALL POLE BRACING AND NAILING DETAIL

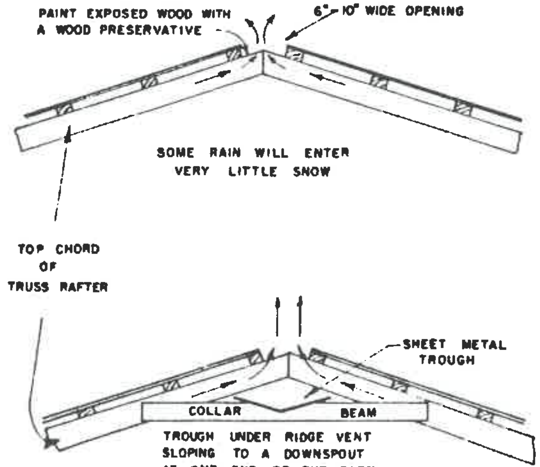


ALL NAILS TO BE SCREW SHANK HARDENED NAILS

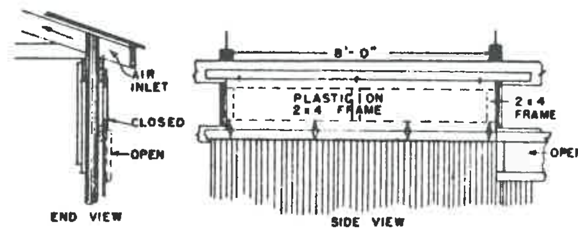
ROOFING DETAIL WITH PURLINS AND METAL ROOFING



OPEN RIDGE VENT DETAIL

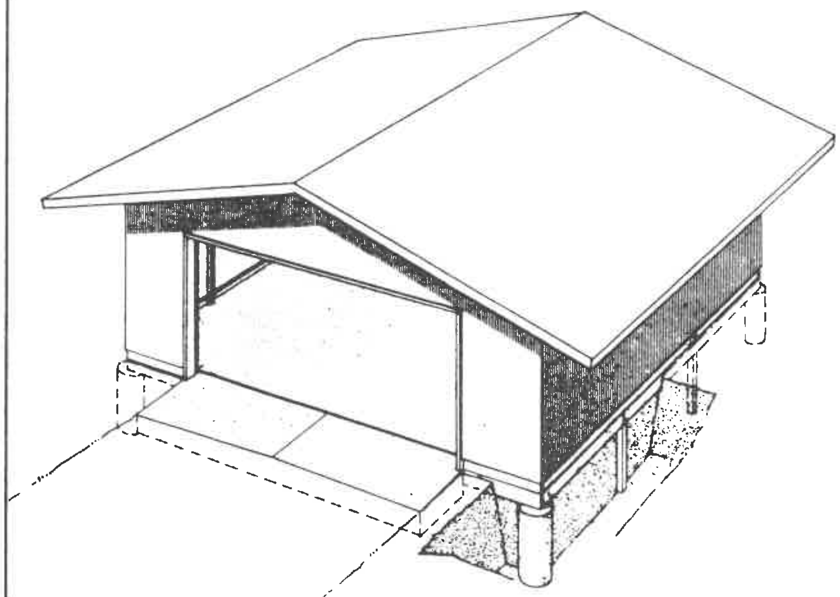


PANEL WINDOW DETAIL

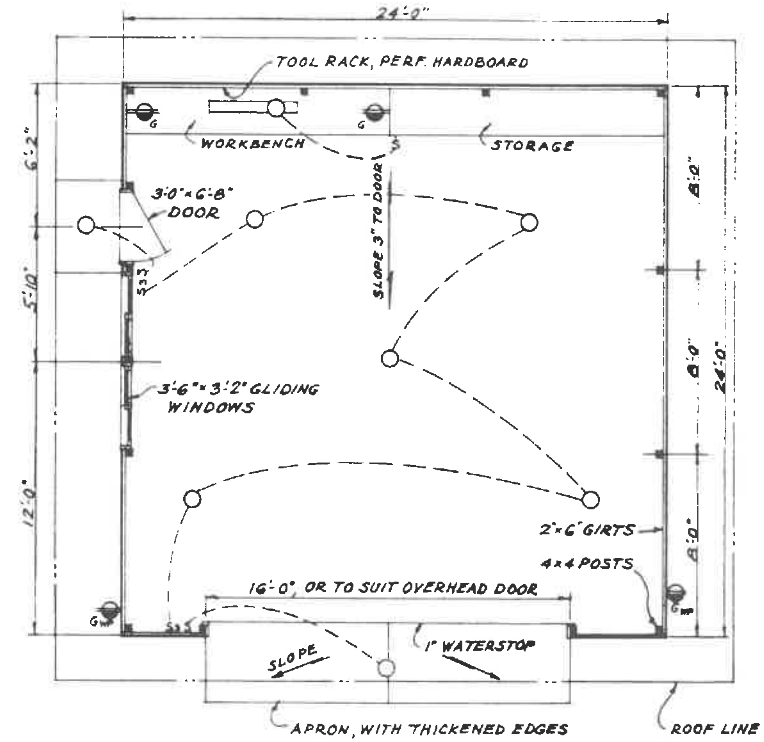


PANELS MAY BE HINGED EITHER AT THE BOTTOM OR TOP.

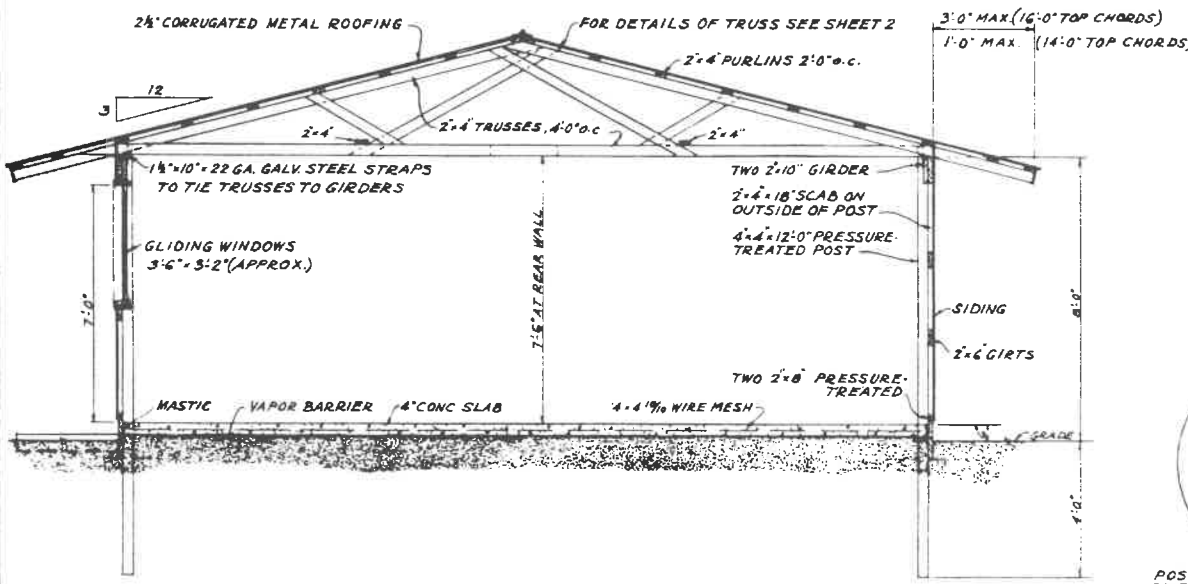
COOPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS DEPARTMENT OF AGRICULTURAL ENGINEERING UNIVERSITY OF MARYLAND AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING
FREE STALL BARN DRIVE-THRU TYPE
PA. '71 | 6111 | SHEET 3 OF 3



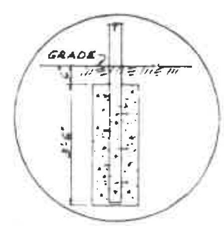
PERSPECTIVE



PLAN



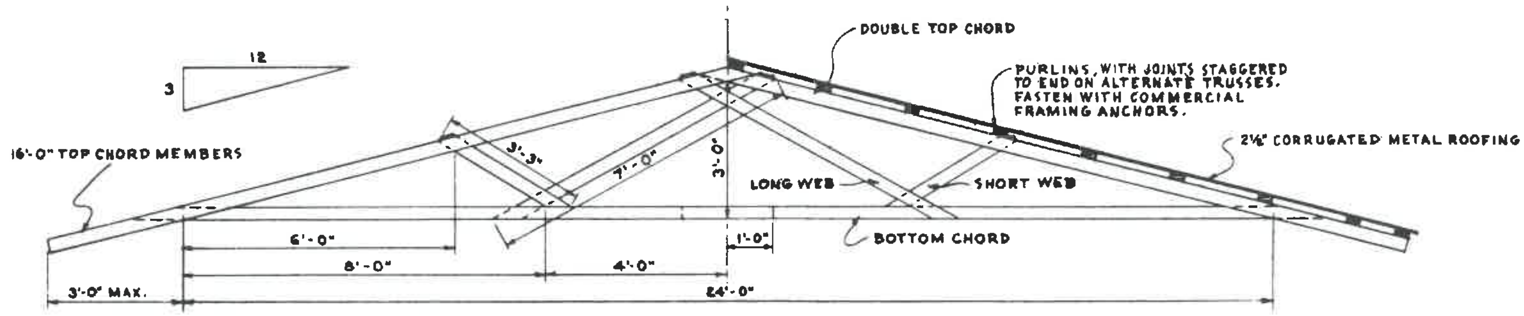
SECTION



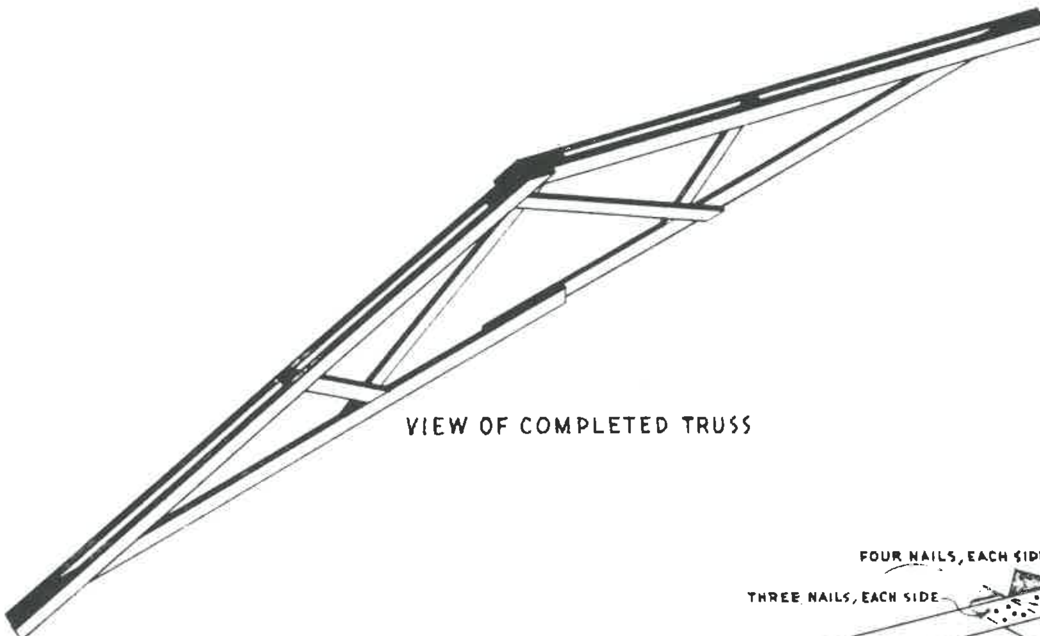
POST IS BONDED TO PIER WITH TWELVE 20d NAILS DRIVEN HALF-LENGTH INTO POST.

16" DIAMETER CONCRETE PIER AT EACH CORNER POST.

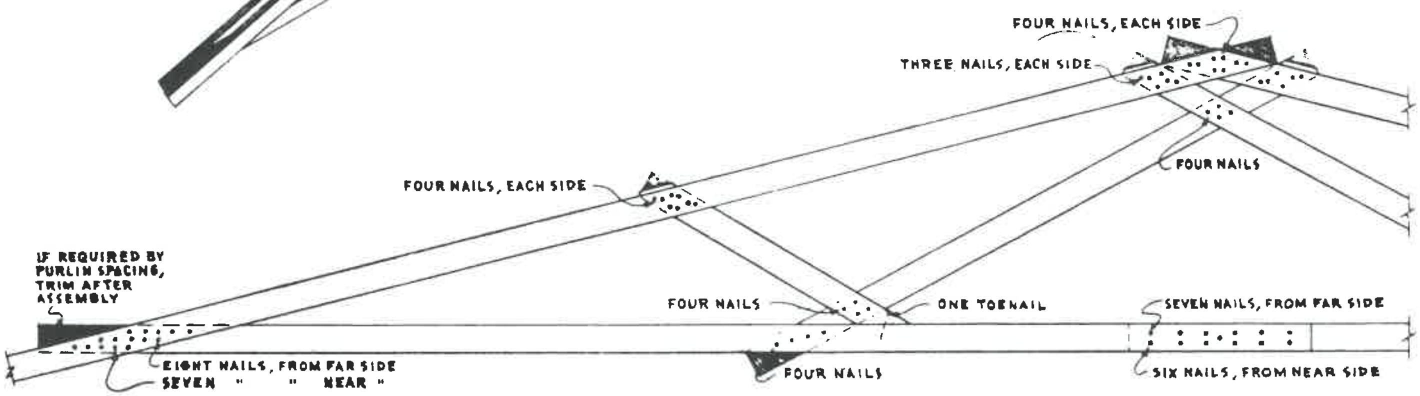
TWO-CAR GARAGE POST CONSTR.		
USDA '61	EX. 5930	SHEET 1 OF 2
ORDER NO. 740-5930		



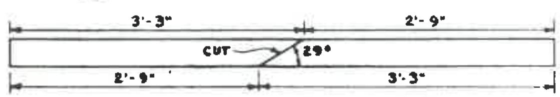
ELEVATION



VIEW OF COMPLETED TRUSS



JOINT DETAILS



CUTTING DIAGRAM FOR SHORT WEBS
CHECK ANGLE ON THE JOB.
ALL OTHER CUTS ARE MADE AFTER THE TRUSS IS ASSEMBLED.

THIS TRUSS IS DESIGNED TO SUPPORT LOADS UP TO 120 LBS PER FOOT OF SPAN, INCLUDING THE WEIGHT OF PURLINS AND ROOFING.

ALL LUMBER SHALL BE STRESS GRADED TO PROVIDE 1500 PSI FIBER STRESS IN BENDING, AND 1350 PSI IN COMPRESSION.

MATERIALS FOR ONE TRUSS:

TOP CHORD	4 PCS.	2"x4"x 16'-0"
BOTTOM CHORD	2 "	2"x4"x 14'-0"
LONG WEBS	1 "	2"x4"x 14'-0"
SHORT WEBS	1 "	2"x4"x 6'-0"

NAILS.......... 3⅓ LBS. 20d COMMON

ALL PROJECTING NAILS ARE TO BE CLINCHED.

TRUSSES SHOULD BE SECURELY ANCHORED TO THE SUPPORTING STRUCTURE.

TWO-CAR GARAGE POST CONSTR.		
USDA '61	EX. 5930	SHEET 2 OF 2
ORDER NO. 740-5930		

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