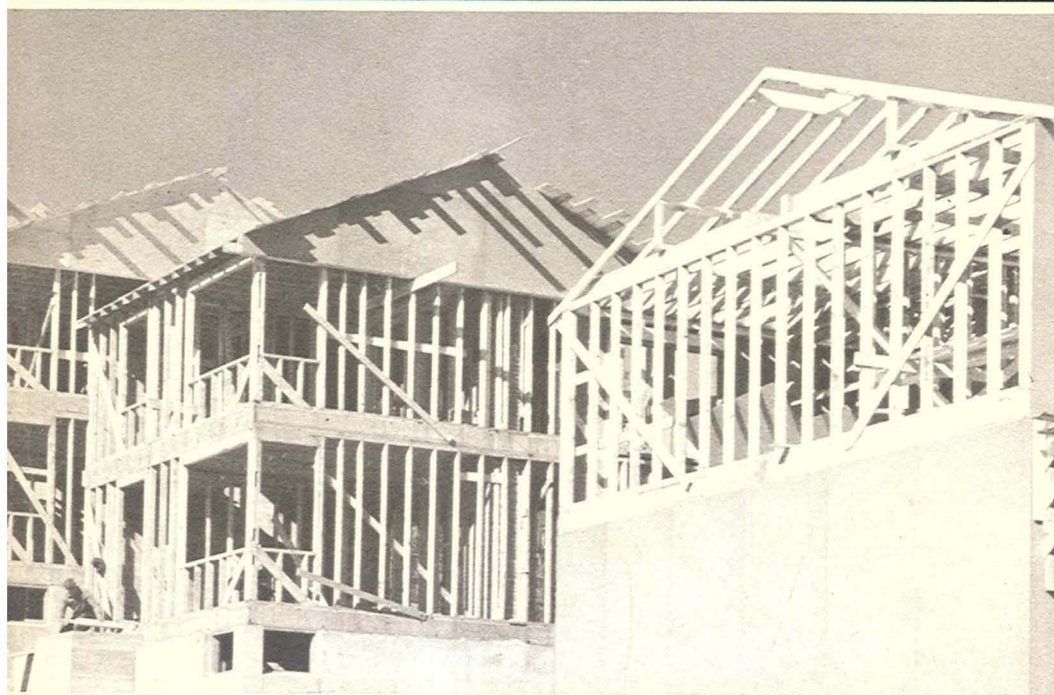
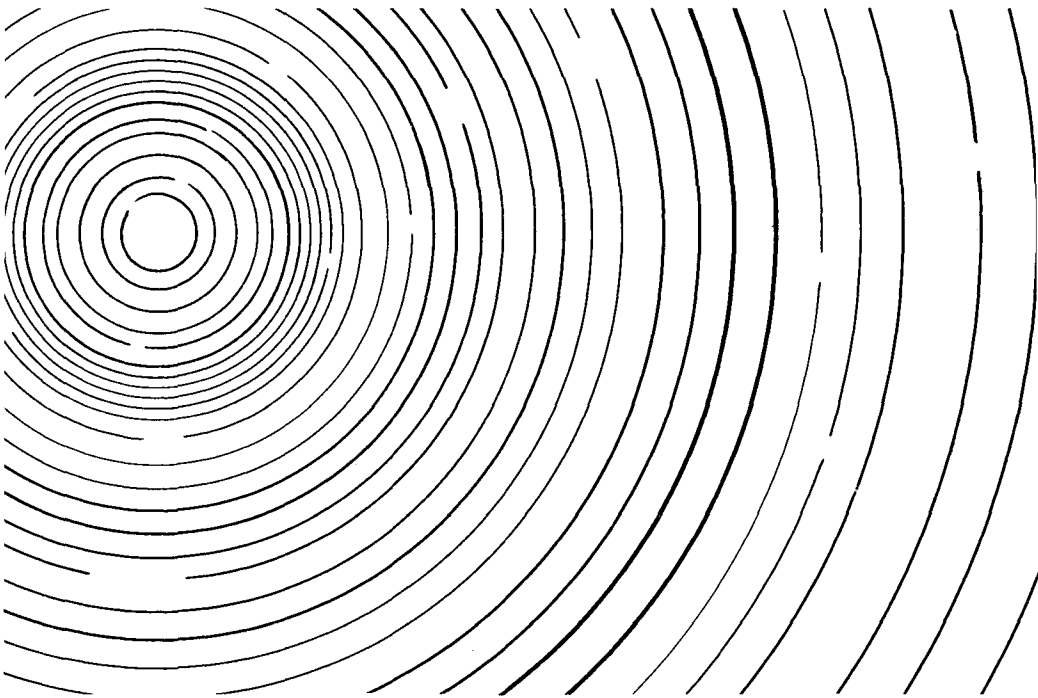


CANADIAN WOOD-FRAME HOUSE CONSTRUCTION



CANADIAN WOOD-FRAME HOUSE CONSTRUCTION



CENTRAL MORTGAGE AND HOUSING CORPORATION

FOREWORD

This publication is intended to fill a need which has existed for some time. It explains in detail how a wood-frame house is put together in Canada. The text is liberally supplemented with illustrations to make understanding easier.

The Division of Building Research of the National Research Council and the Forest Products Laboratory, Ottawa, of the Department of Forestry and Rural Development have co-operated with Central Mortgage and Housing Corporation in the preparation of this manual. Their assistance has been invaluable in determining the scope and content of the book and in suggesting changes and corrections to the drafts.

The book has been developed from the Agriculture Handbook No. 73, published by the U.S. Department of Agriculture, whose permission to make full use of the text and illustrations is gratefully acknowledged. Substantial changes and additions have been made to bring the material into conformity with current Canadian practice.

I hope many Canadians and interested people abroad, both those who have and those who have not had previous experience in house construction, will find this book useful and informative.

H. W. HIGNETT, President

CENTRAL MORTGAGE & HOUSING CORPORATION

CONTENTS

LOCATION AND EXCAVATION —	1
Condition of site — Placement of the house — Height of foundation walls — Excavation.	
CONCRETE WORK —	3
FOUNDATIONS —	5
Footings — Concrete foundation walls — Concrete-block foundation walls — Notch for wood beams — Foundation drainage — Window wells — Sill anchors — Brick and stone veneer	
BASEMENTLESS HOUSES —	14
Houses with a crawl space — Concrete floor slabs on grade —	
FLOOR FRAMING —	18
Columns and beams — Beam-joist installation — Foundation wall and joist connection — Floor joists — Joist restraint — Subfloor — Floor framing at projections	
WALL FRAMING —	30
Platform construction — Exterior corner and wall-intersection details — Nailing support for interior finish — Balloon frame construction	
CEILING AND ROOF FRAMING	38
Flat roofs — Pitched roofs — Gable-end framing	
WALL SHEATHING —	49
Types and installation of sheathing — Wall sheathing paper	
ROOF SHEATHING —	52
Installation of roof sheathing — Roof-sheathing details	
ROOF COVERINGS —	55
Installation of asphalt shingles on slopes of 4 in 12 or greater — Installation of asphalt shingles on slopes of less than 4 in 12 — Installation of wood shingles — Finish at ridge and hips — Built-up roofs — Sheet metal roofing	
BASEMENT FLOORS —	61
EXTERIOR TRIM AND MILLWORK —	61
Eave Projections — Gable-end projections — Eave and gable-end intersections — Window frames and sash — Exterior door frames and doors	
EXTERIOR SIDING AND STUCCO —	69
Lumber siding — Plywood siding — Hard-pressed fiberboard siding — Asbestos-cement sheet siding — Corner treatment for siding — Wood shingles and machine-grooved shakes — Asbestos-cement shingles — Stucco side-wall finish — Metal siding — Masonry veneer	
FRAMING DETAILS FOR PLUMBING, HEATING AND WIRING —	77
Cutting of framing members — Framing details for plumbing systems — Framing details for heating systems — Warm-air systems — Hot water systems — Electric heating systems	
WIRING —	83
Box location — Switches — Receptacles	
VAPOR BARRIERS —	84
INSULATION —	85
Where to insulate — How to insulate	

VENTILATION —	90
Size of ventilators — Crawl-space ventilation and soil cover	
INTERIOR WALL AND CEILING FINISH —	93
Plaster base and finish — Dry-wall finish	
FLOOR COVERINGS —	101
Wood-strip flooring — Wood tile flooring — Underlay for resilient flooring — Installation of resilient floor covering — carpeting — Ceramic tile	
INTERIOR DOORS, FRAMES AND TRIM —	106
Doors, frames and trim — Installation of door hardware — Window-trim installation — Base moldings — Millwork — Kitchen cabinets — Closets	
STAIRS —	114
Terms — Ratio of rise to run — Design of stairway — Stringers — Newels and handrails — Basement stairs — Exterior steps and stoops	
FLASHING —	120
GUTTERS AND DOWNSPOUTS —	124
GARAGES AND CARPORTS —	124
CHIMNEYS AND FIREPLACES —	127
Chimneys — Fireplaces	
SURFACE DRAINAGE, DRIVEWAYS AND WALKS —	131
Surface drainage — Driveways — Walkways	
PROTECTION AGAINST DECAY AND TERMITES —	132
PAINTING —	133
PROTECTION AND CARE OF MATERIALS ON THE BUILDING SITE —	134
MAINTENANCE —	135
APPENDIX —	137
Tables — Design Roof Loads Across Canada — Roof Trusses	
GLOSSARY —	187
INDEX —	194

CANADIAN WOOD-FRAME HOUSE CONSTRUCTION

INTRODUCTION

This manual is devoted exclusively to the construction of detached wood-frame housing, as currently practised in Canada. It deals essentially with the more common established construction methods and does not attempt to cover all the variations which may be used in different parts of the country. However, where details of construction do vary, the fundamental principles which apply are still the same.

While the publication does not include suggested methods and materials used in fire and sound separations between attached houses, established methods of providing these separations can easily be used in conjunction with this publication for semi-detached and row houses.

The three primary essentials for the building of a satisfactory house are (1) an efficient design (2) suitable materials, and (3) sound construction. The house may be large or small, elaborate or unpretentious, modern or traditional in style, yet without all three of these essentials it may be neither permanent nor satisfactory. While design and planning are beyond the scope of this publication, the information on materials and building practice will be a guide in the erection of a good house.

Every effort has been made to ensure that the construction details included do not conflict with Residential Standards Canada 1965 (Supplement No. 5 to the National Building Code of Canada) which are the minimum standards required by Central Mortgage and Housing Corporation for houses built under the National Housing Act. However, this manual is not intended to take the place of Residential Standards, whose provisions must be met in NHA house construction. It is intended rather to describe how wood-frame houses are built and to provide suggestions for selecting suitable materials.

The information is presented in a manner that may be understood by those without previous construction experience and for this reason it is hoped it will be useful as a training aid for building-trade apprentices and students of building technology.

Useful tables, reprinted from Residential Standards, are an appendix to the book, and reference to the tables appear throughout the text. Detailed drawings of selected roof truss designs have also been included in the appendix.

LOCATION AND EXCAVATION

Condition of Site

Two factors which can affect the cost of building a house and have a direct bearing on its final appearance are the sub-soil conditions and the placement of the house on the lot. Before starting to excavate, the sub-soil conditions should be determined by checking with others who have built in the same area or by test borings. Rock may be encountered necessitating expensive removal.

Some types of soil become semi-plastic when wet and squeeze out from under the footings, causing irregular settlement of the foundations. The water table or natural ground water line may be close to the surface, particularly in areas near lakes. This water table level may be the deciding factor in determining the depth of the basement or location of sewer pipes.

Where fill of any kind has been used at the site, the foundation should extend through the fill to undisturbed soil or be specifically designed for this condition.

Placement of the House

Before the exact location of the house on the site is decided, check the local codes for minimum setback and sideyard requirements; these

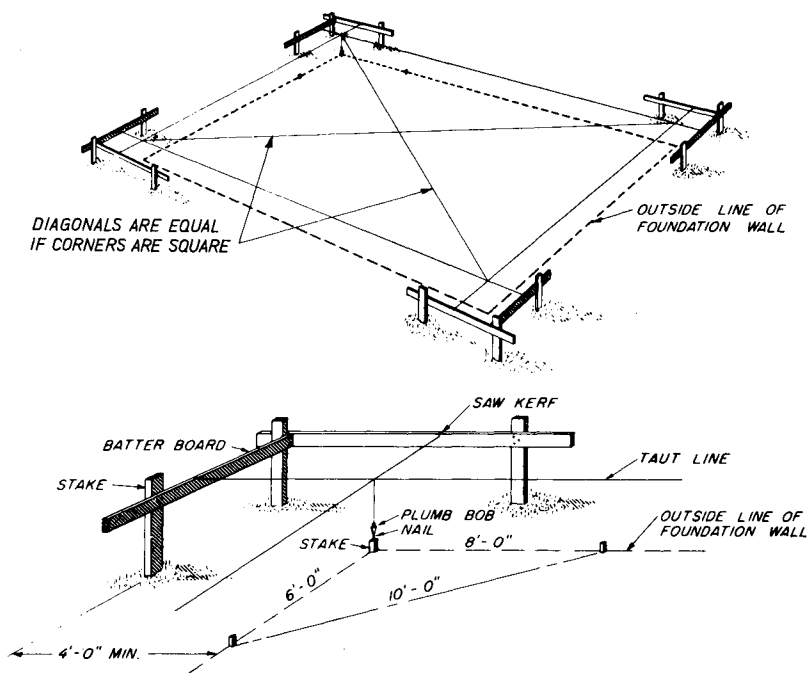


FIGURE 1.—Method of staking and laying out the house.

can be determining factors in locating the house. In some cases the setback may be established by lining up with existing houses on adjacent property.

After the site is cleared, the locations of the outer walls of the house are marked. Usually, before work begins, a survey is made of the plot of land by a qualified surveyor who will stake the corners of both the lot and the house.

The next step is to establish lines and grades to help keep the work true and level. Figure 1 shows a convenient arrangement of batter boards for this purpose.

To do this small stakes are first accurately located at each corner of the house with tacks driven in their tops, indicating the outside line of the foundation walls. To assure square corners, measure the diagonals. If the diagonals are equal the building corners are square. Another method is to measure along one side a distance in 3-foot units and along the adjacent end the same number of 4-foot units. The diagonal will have an equal number of 5-foot units when the corner is square.

After locating the corners, drive three 2- by 4-inch stakes of suitable length at each corner at least 4 feet beyond the lines of the foundations; then nail 1- by 6-inch boards horizontally so the tops are all level. Twine or stout string (called carpenter chalkline) is next held across the top of opposite boards at two corners and adjusted exactly over the tacks in the corner stakes at either end; a plumb bob is handy for setting the lines. Cut saw kerfs $\frac{1}{4}$ -inch deep or drive nails where the lines touch the boards so that the lines may be replaced if broken or disturbed. After similar cuts are made in all eight batter boards, the lines of the house will be established. Check the diagonals again to make sure all corners are square.

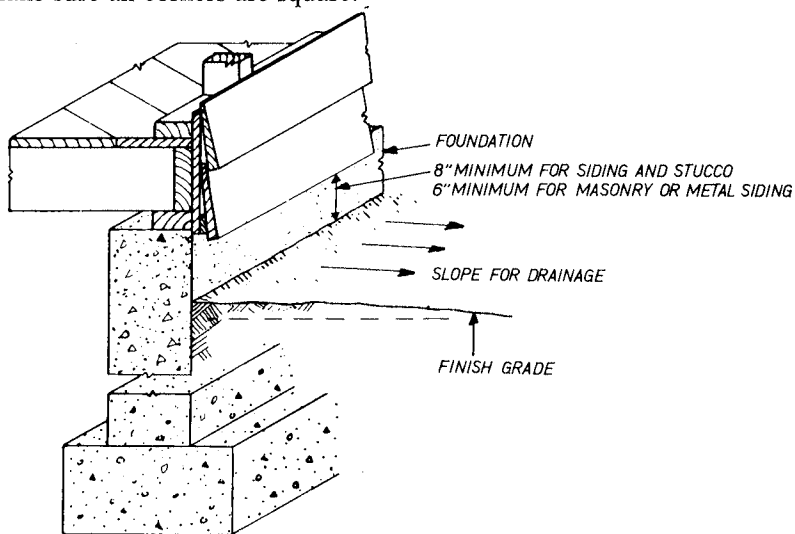


FIGURE 2.—Finish grade sloped for drainage.

Height of Foundation Walls

The depth of the excavation and consequently the top of the foundation usually depends on the street elevation, sewer and water services and the profile of the lot. The finished grade around adjoining houses and surface drainage patterns must also be considered.

Foundation walls should be extended high enough above the finished grade around the outside of the house to adequately protect the wood finish and framing members from soil moisture (Fig. 2).

For houses with basements, crawl spaces or concrete slab floors on grade, the top of the foundation should be at least 6 inches above the adjacent finished grade. The finished grade should be sloped away from the foundation wall of the house and provision made to carry the surface water off the property. A swale (a gently sloping ditch) is used for this purpose where the drainage slope around the house meets a reverse slope. For example, if a lot slopes up from front to rear, the swale would be located at the rear of the house so that the surface water would flow along the swale and out towards the street. Keep the rough grade around the house at least 4 inches below the line established for the finished grade to allow for subsequent placing of top soil or paving material.

Excavation

In most cases the quickest and cheapest way to excavate is to use bulldozers or power shovels. Before this is done, however, all top soil should be stripped and stored for re-use.

When a granular base is to be used under the basement floor slab, the excavation is made deep enough to accommodate this base. When a damp-proofing membrane is used instead, the excavation is stopped at the level established for the underside of the floor slab. Trenches for the footings are then excavated by hand shortly before the footings are placed.

The excavation should be large enough to provide space for workmen to construct and waterproof the wall and to lay the drain tile (Fig. 3). The steepness of the back slope of the excavation is determined by the subsoil encountered. With clay or other stable soil, the back slope can be nearly vertical. When sand is encountered a flatter slope is required to prevent caving.

CONCRETE WORK

Concrete, both plain and reinforced, is used for a variety of purposes in houses.

In most locations ready-mix concrete will be available, but where mixing is done on the site, water and aggregates should be clean and free of organic materials or other substances which will damage the concrete. For plain concrete do not use more than $4\frac{1}{2}$ imperial gallons of water for each $87\frac{1}{2}$ lb. sack of cement. For reinforced concrete use not more than 4 imperial gallons of water for each $87\frac{1}{2}$ lb. sack of

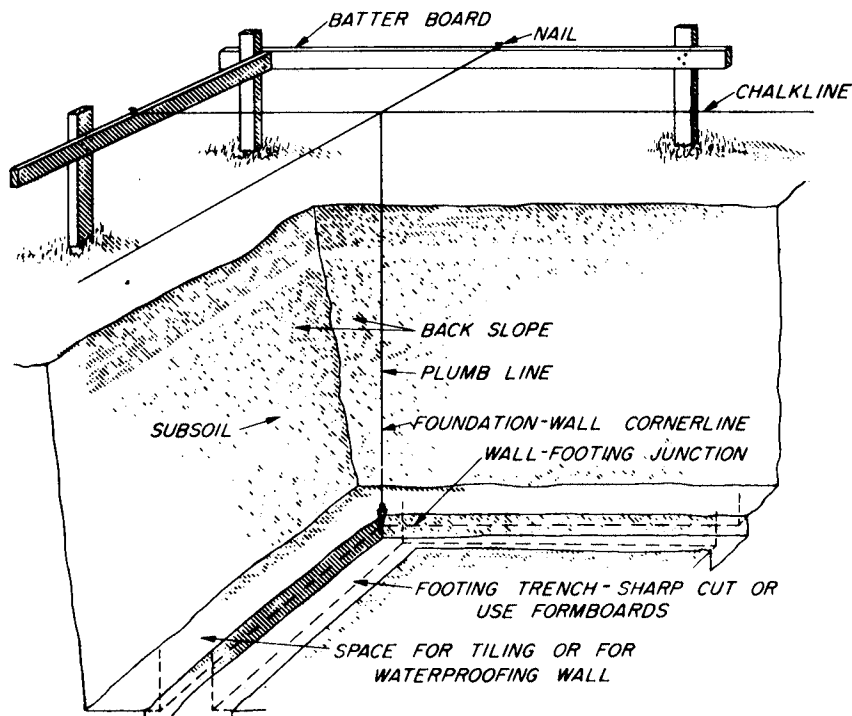


FIGURE 3.—Method of setting batter boards and establishing corners for excavation.

cement. These amounts are based on average moisture content in the aggregate.

The proportions of fine and coarse aggregate, cement and water should be adjusted to produce a mixture that will work readily into angles and corners and around reinforcement without allowing the materials to segregate or free water to collect on the surface. After curing for 28 days plain and reinforced concrete should have minimum compressive strengths of 2,000 and 2,500 pounds per square inch respectively.

Aggregates which usually consist of sand, gravel and crushed rock should be well graded. The proportions of cement, sand and coarse aggregates vary somewhat depending upon the maximum size of the aggregate. Proportions shown in Table 1 are generally considered to be acceptable.

Whenever possible place the concrete continuously and keep it level throughout the area being placed. When it is necessary to interrupt operations for more than a few hours, be sure to clean, score and wet the top surface of the concrete already placed before adding fresh concrete. All vertical joints should be keyed. Spade, rod and work the

concrete to remove air pockets and force the concrete into all parts of the forms.

In hot weather, protect concrete from rapid drying. Concrete should be kept moist after it is placed because rapid drying lowers the strength and may injure the exposed surface of walks and driveways.

When the air temperature is below 40°F. the concrete should be kept at a temperature of not less than 50°F. while being mixed and placed and maintained at this temperature for 72 hours while curing. To do this, heat the water and aggregate, cover the forms and supply heat while the concrete is setting.

FOUNDATIONS

Foundation walls form an enclosure for basements or crawl spaces and carry wall, floor, roof and other building loads. The two types of walls most commonly used are concrete and unit masonry.

Wall thicknesses and types of construction are ordinarily controlled by local building codes. Thickness of concrete and unit-masonry walls may vary from 6 to 12 inches, depending upon their depth below grade and the lateral support provided by the floor framing system. Table 2 shows minimum foundation wall thicknesses for stable soils. Where unstable soils are encountered the walls and footings should be specially designed or local practices which have been successful should be followed.

Wall height should be sufficient so that the basement height measured from the surface of the finished basement floor to the underside of beams or joists is at least 6 feet 4 inches, to provide adequate head-room.

Footings

Footings act as the base of the foundation and transmit the loads to the soil. The type and size of footings should be suitable for the soil condition and far enough below ground level to be protected from frost action. Heat loss through the foundation wall near the footings

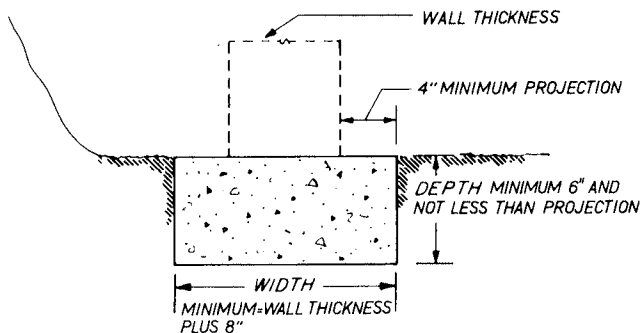


FIGURE 4.—One method often used to determine size of footings.

provides some protection from frost action. The depths of foundations should not be less than those shown in Table 3. Where fill has been used, the foundation should extend below the fill to undisturbed earth or be designed to suit the condition of the fill. In areas having unstable soil, the footings and foundations should be specially designed or local practices that have proven successful should be followed.

Wall footings.—The size of the wall footings should comply with local code requirements. One method of determining the size with average stable soil is shown in Figure 4. Footings should project beyond each side of the wall at least 4 inches. If the soil is of low load-bearing capacity, wider reinforced footings may be required.

A few rules that apply to footing design and construction are:

1. Footings must be at least 6 inches thick.
2. If footing excavation is too deep, make up with concrete — never fill with excavated material.
3. Use side forms for footings where soil conditions prevent sharply cut trenches.
4. The minimum depth of footings below grade is established from soil conditions and the depth of frost penetration. (see Table 3)
5. Reinforce footings with steel rods where they cross pipe trenches which are not well compacted.
6. In freezing weather protect concrete with a thick layer of straw or other insulating material.

Column Footings.—Footings for posts or columns (Figures 5 and 6) should be centered under the member which they are supporting. Footings vary in size depending on the allowable soil pressure and the load they support. On average stable soil common sizes are 4 square feet

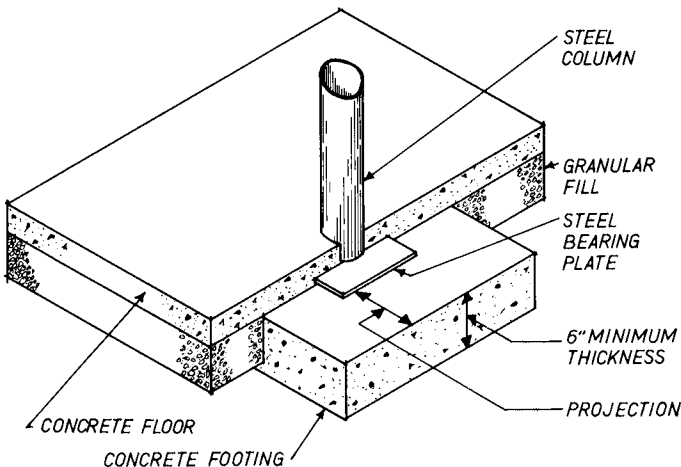


FIGURE 5.—Steel column supported on steel bearing plate resting on footing. Base of column embedded in concrete floor.

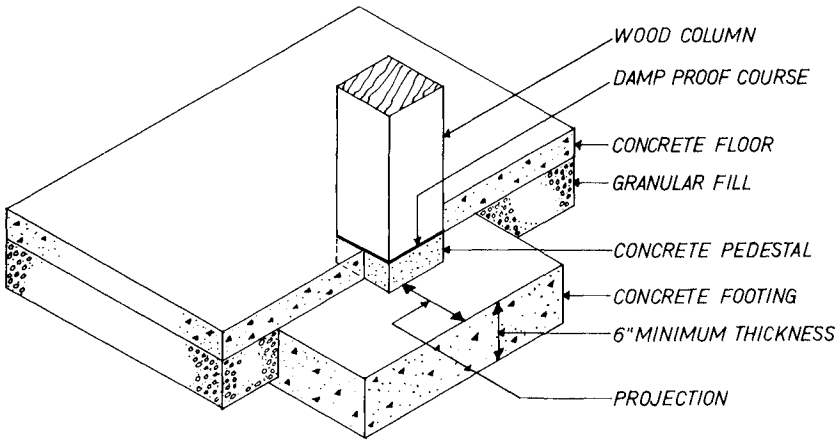


FIGURE 6.—Wood column supported on concrete pedestal set flush with top of basement floor. Dampproof course separates wood from concrete.

for one-storey houses and 6 square feet for two-storey houses. The minimum thickness should be 6 inches and not less than the projection.

Footings for fireplaces and chimneys are ordinarily placed at the same time as other footings.

Stepped Footings.—On steeply sloping sites, or where an unstable soil is encountered in part of the excavation, stepped footings may be re-

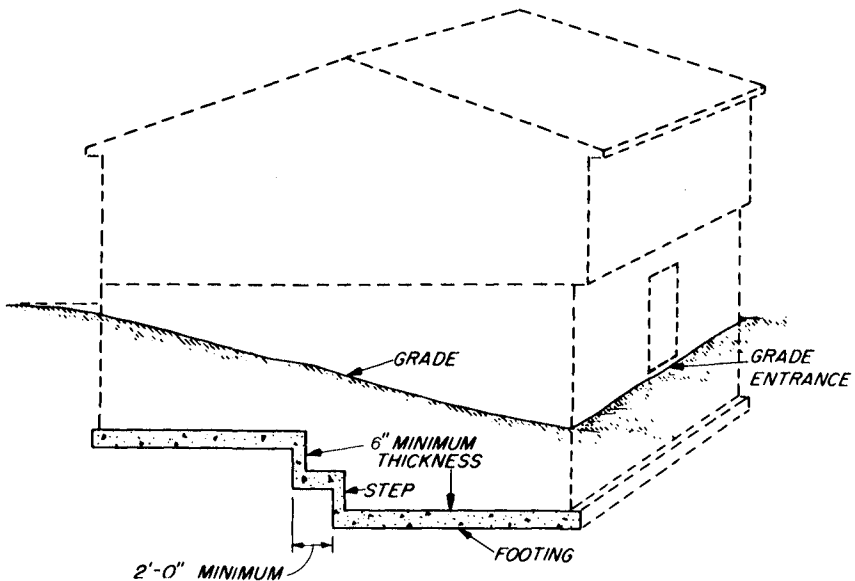


FIGURE 7.—Stepped footings.

quired. The vertical part of the step should be placed at the same time as the footing. The bottom of the footing is always placed on undisturbed soil with each run level.

The vertical connection between footings at the step should be of concrete at least 6 inches thick and the same width as the footings (Fig. 7). On steep slopes more than one step may be required. Except in rock the vertical distance between steps should not exceed 2 feet and the horizontal distance between steps should be not less than 2 feet. For very steep slopes, where these limitations cannot be maintained, special footings may be required.

Concrete Foundation Walls

Formwork for concrete walls must be tight, well braced and tied to withstand the pressure of the concrete before setting.

Concrete walls should be double-formed, i.e. formwork used for each wall face. The forms, which may be made of either lumber (tongue-and-groove or shiplap) or plywood, together with the necessary framing members, can be built in sections and then erected. Re-usable forms of plywood or steel can also be used.

Combination steel bar ties and separators are generally used both to hold the forms together and to maintain the necessary width. Where wire ties are used, wood spacer blocks of a length equal to the finished thickness of the wall are placed between the faces of the forms. The wire ties hold the forms rigidly against the separators.

Frames for basement windows, doors and other openings along with boxes that will form notches for the ends of floor beams are set in place when the forming is built. Framing and bracing are used to keep the forms in place until the concrete is set. Where a chimney is to be incorporated in the outside walls provision should be made at this stage of construction.

Nails may be used in wood forms to show the height to which the concrete will be placed. The concrete should be placed continuously without interruption. During the placing operation, it should be continuously tamped to remove air pockets and to work the material under window frames and other blocking. Where wood spacer blocks are used, they must be removed and not permitted to become buried in the concrete. Anchor bolts for sills should be placed while the concrete is still in a plastic condition.

Forms should not be removed until the concrete has acquired sufficient strength to support loads imposed during early construction. At least 2 days are required but a week is preferable.

Concrete walls can be damp-proofed with one heavy coat of bituminous material applied on the outside from the footings to the finish grade-line. Such coatings are usually sufficient to make the wall watertight against ordinary seepage, as may occur after a rainstorm. In poorly drained soils a type of membrane described for concrete-block walls may be necessary.

Concrete-Block Foundation Walls

Blocks are available in various sizes and shapes, but those most widely used come in sizes 8 inches high, 16 inches long, and 6, 8, 10, or 12 inches wide; the actual size is somewhat less than the stated size to allow for the joint.

Concrete-block walls require no formwork. Block courses (rows) start at the footing and are laid up with $\frac{3}{8}$ -to $\frac{1}{2}$ -inch mortar joints. No joint should exceed $\frac{3}{4}$ -inch and all joints should be tooled smooth to resist water seepage. Full bed and head joints should be used in the bottom course. Succeeding courses may be laid with mortar applied only to the contact surfaces of the block. When pilasters (column-like projections) are required by building codes to strengthen a wall or support a beam, they project on the interior of the wall and terminate at the bottom of the beams they support. Basement door and window frames should be set with keys for rigidity and to prevent air infiltration (Fig. 8).

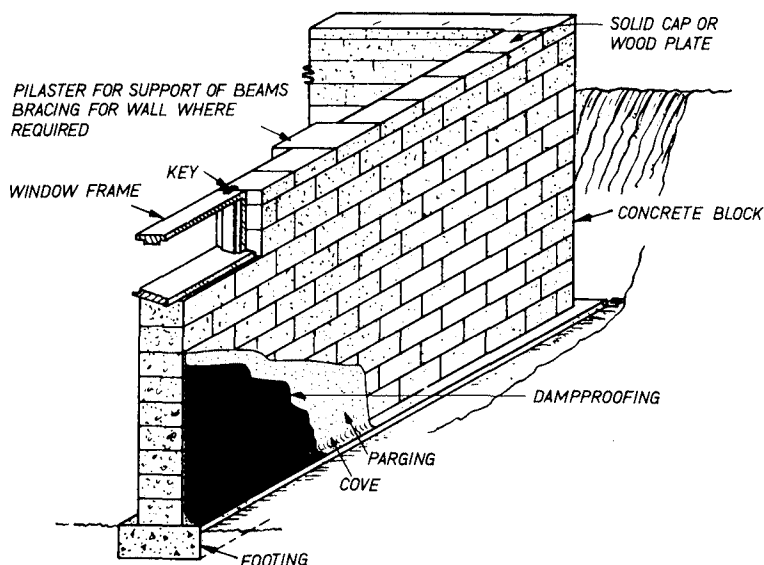


FIGURE 8.—Concrete-block walls.

Block walls should be capped either with 2 inches of solid masonry or concrete, or by filling the top course of blocks with mortar. Alternatively, a wood plank 2 inches thick and the same width as the wall or a 2-by-4-inch sill plate may be used. In the latter case the siding should overlap the foundation wall by at least $\frac{1}{2}$ -inch. Pilasters supporting beams should be capped with 8 inches of solid masonry.

Freshly laid block walls should be protected in temperatures below freezing. Freezing of the mortar before it is set will result in low ad-

hesion, low strength, and joint failures. Mortar mix proportions should conform to those shown in Table 4.

Concrete-block walls should be parged on the outside with at least $\frac{1}{4}$ -inch of Portland-cement plaster from the footings to the gradeline. A cove should be formed at the joint between the footing and the wall (Fig. 8). The wall should then be damp-proofed by applying at least one heavy coat of bituminous material over the parging. For added protection where quantities of water accumulate in the soil, two layers of bituminous-saturated membrane may be mopped on and coated overall with a heavy coating of bituminous material. This covering will prevent leaks if minor cracks develop in the blocks or joints between the blocks.

Notch for Wood Beams

When wood beams at or below grade are not treated to prevent decay, the wall notch or pocket for such beams should be big enough to allow at least $\frac{1}{2}$ -inch of clearance at sides and ends of the beam for ventilation (Fig. 9). There is a decay hazard where beams are so tightly set in wall notches that moisture cannot readily escape.

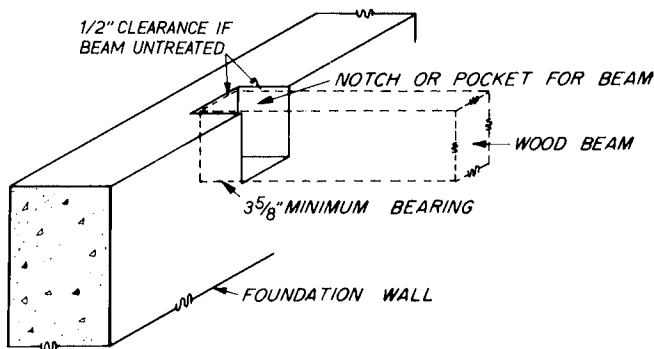


FIGURE 9.—Notch in foundation wall for wood beam.

Foundation Drainage

In most locations, it is necessary to drain away any subsurface water to prevent damp basements and wet floors. Where drainage is required, drain tile or perforated pipe is laid around the perimeter of the wall footings.

Lay the drain tile or perforated drain pipe on solid undisturbed soil around the footing, making sure the top of the tile or pipe is below the level of the basement floor or crawl space, with a slight slope to the outlet. Perforated drain pipe is laid with the perforations down. Tiles are laid with open joints of about $\frac{1}{4}$ -inch and the top portion of the joint is covered with a 3-inch strip of roofing felt to keep gravel and sand out of the tile while still allowing water to seep through. The drainpipe or tile is then covered with 6 inches of gravel or crushed rock (Fig. 10).

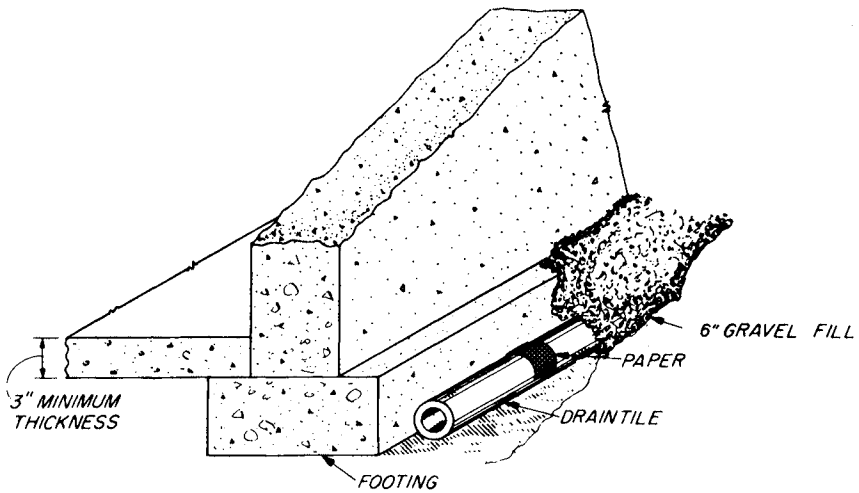


FIGURE 10.—Drain tile for drainage of soil at foundation wall.

The draitile should be connected with a tight-joint pipe to a sump, storm sewer or other satisfactory outlet.

Window Wells

Basement windows that extend below ground level require window wells (Fig. 11). Galvanized sheet steel, corrugated for added strength,

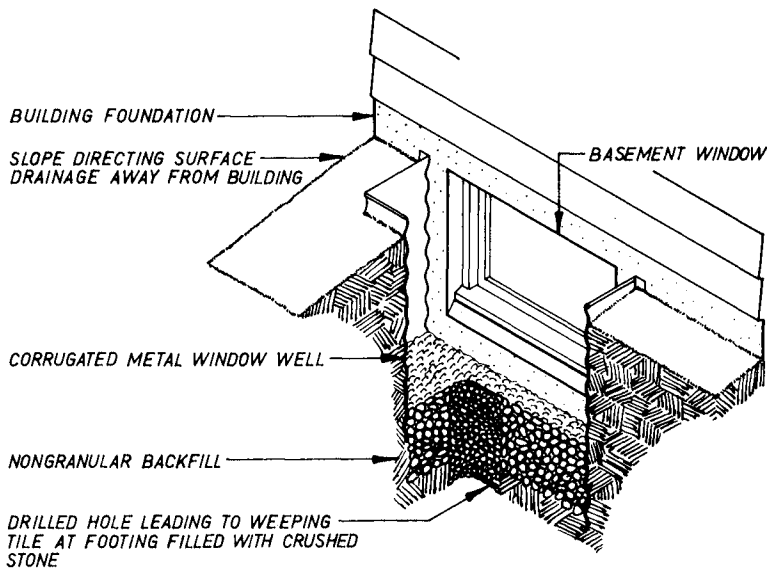


FIGURE 11.—Window well at basement wall.

is commonly used for this purpose. This type of window well is available in a variety of sizes to suit various window openings.

For concrete window wells, which are sometimes used, forms are installed and the concrete placed after the backfill has been compacted.

As with foundation walls, surface drainage should be directed away from the window wells.

When the backfill is not a granular material, the bottom of the window well should be drained by drilling a 6-inch diameter hole down through the backfill material to the footing tile and filling it with crushed stone.

Sill Anchors

In wood-frame construction, the sill plate should be carefully levelled on a bed of mortar that evens off irregularities on the top of the concrete. It is then anchored to the foundation wall. This is commonly done with $\frac{1}{2}$ -inch anchor bolts spaced not more than 8 feet apart with at least 2 bolts in each sill piece around the perimeter of the wall (Fig. 12).

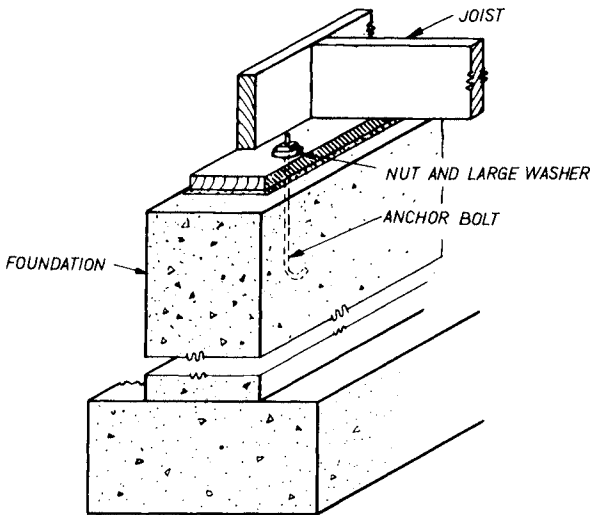


FIGURE 12.—Method of anchoring floor system to concrete walls, showing anchor bolt for wood sill.

Anchor bolts should be embedded at least 4 inches in the foundation wall. The end of the anchor bolt embedded in the concrete or masonry joint should be deformed to prevent withdrawal. After the concrete or mortar has set, a large flat washer is placed on the sill before the nut is tightened in place.

Brick and Stone Veneer

If masonry veneer is used for the outside finish, the foundation must include a supporting ledge or offset (Fig. 13) wide enough to allow a space of about 1 inch between the masonry and the sheathing paper. A base flashing should extend from the outside face of the wall over the top of the ledge and at least 6 inches up the wall behind the sheathing paper. Corrosion-resistant metal ties, nailed to the studs and embedded in the masonry, should be used to tie the veneer to the framework. These are usually spaced 32 inches apart horizontally and 16 inches vertically or 24 inches horizontally and 20 inches vertically depending on the stud spacing.

Weep holes are provided about 2 feet apart in the bottom course of veneer by leaving the mortar out of vertical joints (Fig. 13). Masonry veneer should be at least $3\frac{3}{4}$ -inches thick.

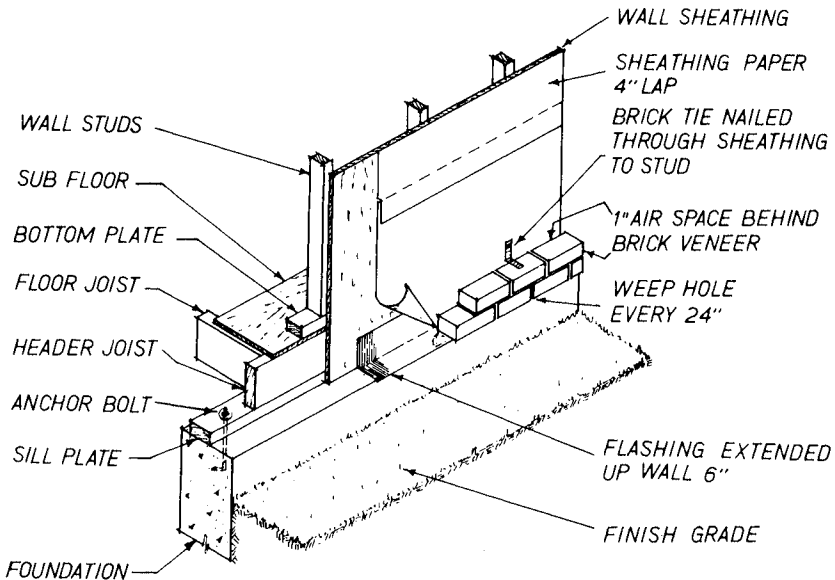


FIGURE 13.—Ledge in foundation wall for support of brick-veneer or other masonry finish.

Select a type of brick which is hard, absorbs little water and is intended for exposure to the weather. Stone veneers should be selected from materials known locally to be durable.

Brick or stone should be laid in a full bed of mortar, care being taken to avoid dropping mortar into the space between the veneer and sheathing paper. Outside joints are tooled to a smooth finish to get maximum resistance to water penetration. Mortar mix proportions should conform to those shown in Table 4.

Masonry laid during cold weather should be protected from freezing until after the mortar has set.

BASEMENTLESS HOUSES

Traditionally the function of a basement has been to provide space for a central heating furnace and for the storage of solid fuels such as wood or coal, as well as space for laundry facilities, bulk storage etc. However, with the present wide use of oil and gas fuels and the increasing use of electrical heating the need for solid fuel storage is less. Now, modern compact heating systems, as well as laundry and storage facilities, can easily be installed on the ground floor. Consequently, more houses are being built without basements. But, since a basement provides low-cost extra space which can be used for storage, living accommodation or recreational rooms, most houses being built in Canada still have basements.

Basementless houses can be built either on a concrete floor slab on grade or on a foundation wall with a crawl space beneath the ground floor. In split-level houses, a crawl space under one part of the house is often combined with a basement under the other part.

Houses with a Crawl Space

Houses with a crawl space are supported on a foundation wall that is carried at least 6 inches above the outside finished grade. The floor is framed in the same way as for the basement-type house. Between the ground and the underside of the beams and joists, there should be at least a 12-inch clearance, and in addition access trenches must also be provided to service heating equipment, plumbing cleanouts and traps. The clearance may be provided either by setting the first floor level sufficiently high above the ground (Fig. 74) or by excavating to the necessary depth over the area of the house before the foundation walls are built.

Trenches are dug for the foundation walls and the footings placed at a depth below grade determined by soil conditions and frost penetration. (See Table 3). The sizes of the footings are generally the same as those used to support basement walls. The foundation walls may be built of concrete or unit-masonry but, since the inside grade is never much lower than the outside grade, the thickness of the foundation walls is usually less than those enclosing a basement. Table 2 shows minimum foundation wall thicknesses for stable soils.

Footings for columns supporting the floor beams should also be supported on solid ground and this may require some excavation. Concrete or masonry columns are generally used to support the beams and the excavated area backfilled around the base of the columns and footings when the crawl space floor is leveled.

Where the crawl space floor is below the level of the outside finished grade, the foundation walls should be damp-proofed. Drain tile is then installed around the footing and connected to a drain as previously described for basement walls. The floor of the crawl space and access trenches is graded towards a drain and a vapor barrier of 4-mil polyethylene or 45-pound roll roofing installed over the surface with the joints lapped at least 4 inches. The vapor barrier serves as a

ground cover which prevents ground moisture from entering the crawl space area. The crawl space should also be ventilated as described on page 92.

In cold climates the crawl space area is usually heated, to prevent the plumbing pipes from freezing. In milder climates the crawl space may be left unheated and insulation added under the floor as shown in Figure 74.

Concrete Floor Slabs on Grade

Certain basic requirements should be met in the construction of concrete floor slabs on grade. These requirements are as follows:

1. Establish finish-floor level at a sufficient height above the natural grade so the finished grade will provide good drainage away from the house. Top of slab should be at least 6 inches above finished grade.
2. Remove all debris, topsoil, stumps and organic matter and provide a smooth surface free from pockets. Tamp soil where loose.
3. Install sewer, water, gas or oil supply lines and other subsurface work before the slab is placed. Compact backfill in trenches.
4. Put at least 5 inches of crushed rock or coarse gravel under the slab.
5. Lay a vapor barrier over the gravel or crushed rock to prevent soil moisture from working into and through the slab, and cement fines from working into the voids in the fill. The vapor barrier must be sufficiently strong and so placed as to prevent any perforation during construction operations and the placing of the concrete.
6. Install a permanent, waterproof, non-absorptive type of rigid insulation around the perimeter of the wall.
7. Combined slab and foundation should be designed for the existing soil conditions according to accepted engineering practice.
8. Where an independent slab on grade is used with a foundation wall, reinforce the slab with not less than $\frac{3}{8}$ -inch diameter steel spaced 24 inches on center in both directions or with 6-by-6 inch No. 6 gauge wire mesh.
9. Concrete slabs on grade should be at least $3\frac{1}{2}$ -inches thick exclusive of topping. The slab may be trowelled to a smooth even finish before it has set or a topping consisting of 1 part of cement to 3 parts of sand, not less than $\frac{3}{4}$ -inch thick, trowelled to a smooth, level finish may be applied after it has set.

Combined Slab and Foundation.—The combined slab and foundation, (Fig. 14) sometimes referred to as the thickened-edge floating slab, consists of a shallow perimeter reinforced footing or beam placed integrally with the slab. The bottom of the footing should be at least 1 foot below the natural gradeline and be supported on solid, unfilled, and well-drained ground. The slab is usually designed to support interior

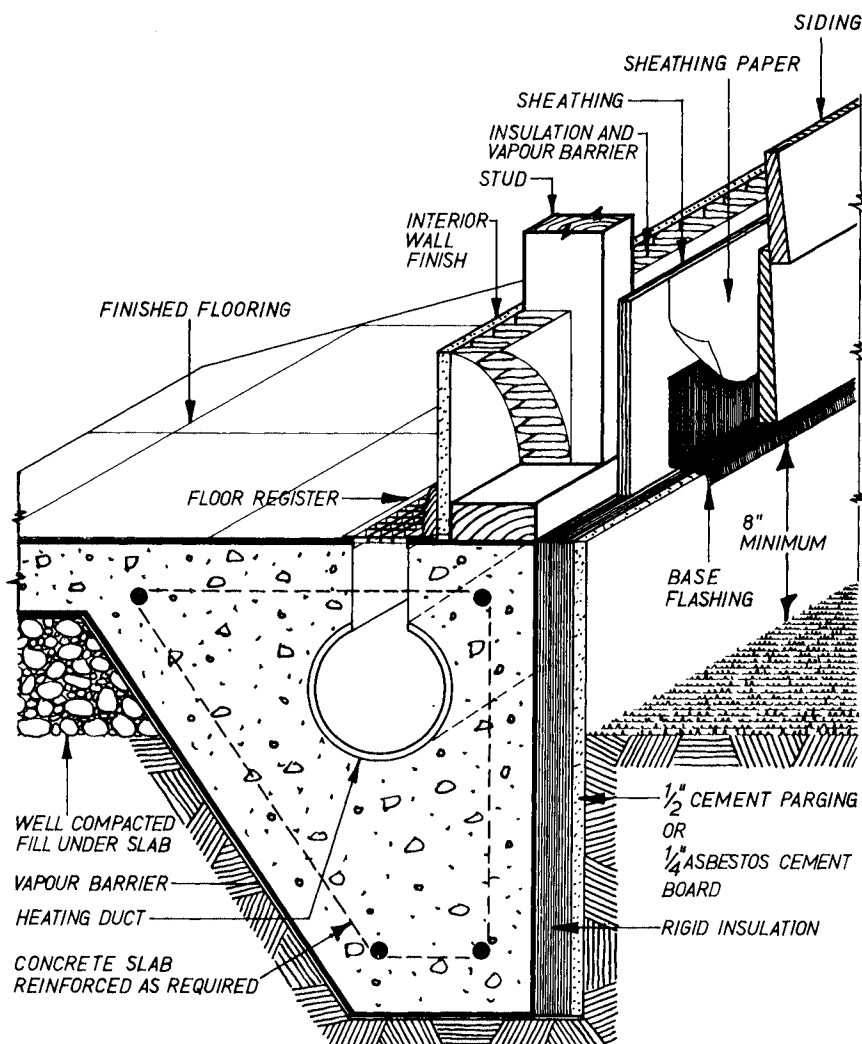


FIGURE 14.—Combined slab and foundation supported on 5 inches of coarse granular fill, well compacted.

bearing partitions and a masonry chimney or fireplace. Anchor bolts are provided for securing the sill plates to the slab.

Independent Concrete Slab and Foundation Walls.—This consists of an independent foundation and interior bearing walls which are installed prior to placing the floor slab (Fig. 15). A ledge is usually formed in the walls to receive the slab. Separate footings should be provided for the support of heavy concentrated loads, such as a masonry chimney

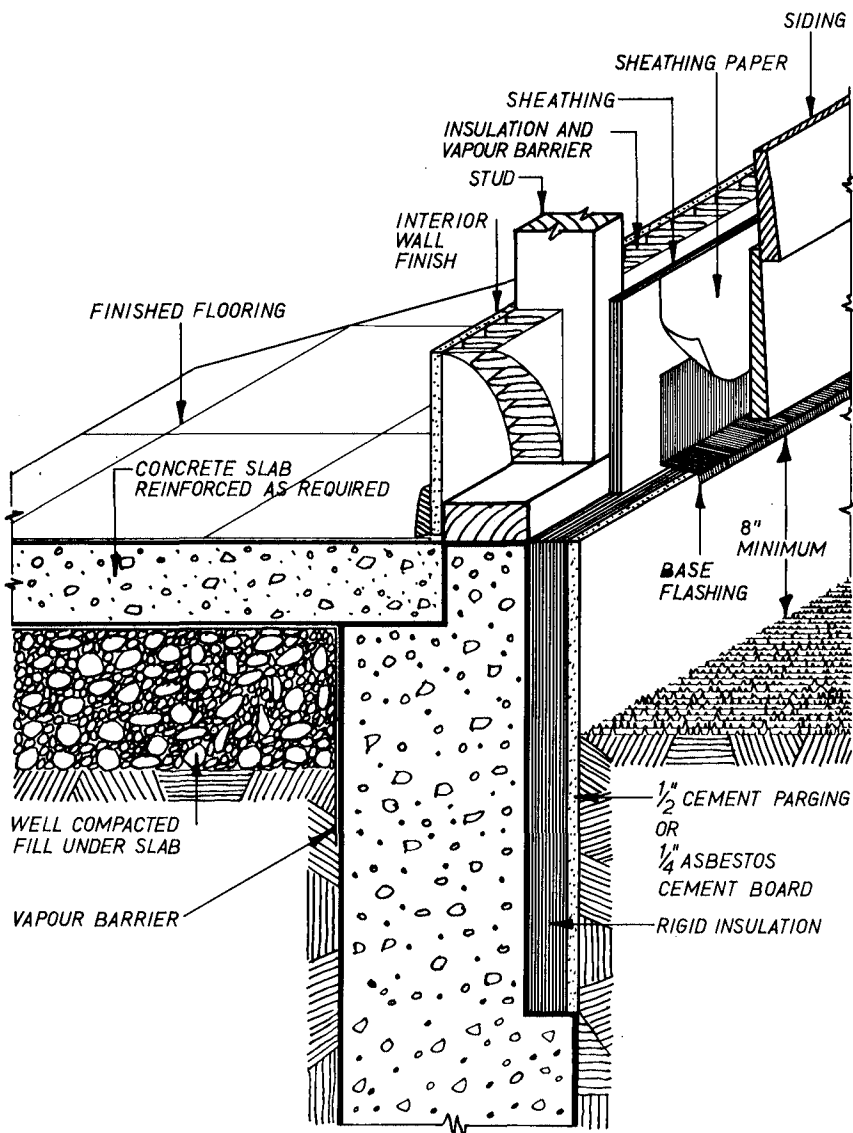


FIGURE 15.—Independent concrete floor slab and foundation wall. Slab is supported on 5 inches of coarse granular fill and on a ledge formed in the foundation wall.

or fireplace. Anchor bolts are provided for securing the wood sill to the foundation.

Damp-proofing Concrete Slabs on Grade.—The properties desired in a damp-proofing material are high resistance to vapor transmission,

resistance to damage from moisture, and ability to withstand rough usage before concrete is poured. Materials having these properties to a high degree are; (a) 6-mil polyethylene, (b) 4-mil polyethylene applied over sheathing paper, and (c) 45-pound roll roofing. The damp-proofing material should be lapped at least 4 inches at the joints.

Insulation Requirements for Concrete Slabs on Grade.—The proper location of insulation for concrete floor slabs on grade is shown in Figures 14 and 15. The thickness of the insulation will depend upon the requirements of the climate and upon the material used for insulation. Rigid insulation about 2 inches thick will normally be sufficient.

The properties desired in insulation for floor slabs are high resistance to heat transmission, permanent durability when exposed to dampness and frost and some resistance to crushing. The insulation (such as formed polystyrene) should be inert to the action of the soil and not absorb or retain moisture. Insulation generally extends from the sill plate to 12 inches below grade and is covered with $\frac{1}{2}$ -inch of cement parging on wire lath or $\frac{1}{4}$ -inch asbestos cement board to protect the insulation from damage.

Heating Installation for Slabs on Grade.—Forced warm air is generally used to heat houses with concrete slab floors on grade. One common method is to install a perimeter duct below the concrete slab around the outside walls (Figure 14). Warm air enters the rooms through registers connected to this duct. Unless the ducts are encased in at least 2 inches of concrete, the joints and ducts should be crush resistant. The system should be installed so that water will not accumulate in the ducts.

Forced hot water or electric radiant heating is sometimes used. Small copper water pipes or resistive electric wires are embedded in the concrete slab in a serpentine pattern throughout the floor. Such systems should be carefully installed and protected while the floor slab is being placed.

FLOOR FRAMING

In a wood-frame house the floor framing consists of sills, beams and joists. Masonry or stud walls are sometimes used instead of columns and beams to support the floor joists and center-bearing partition. All framing lumber should be well seasoned and have a moisture content not exceeding 19 percent at the time of installation.

Columns and Beams

Wood or steel columns are generally used in the basement to support beams, which in turn support the inner ends of the first-floor joists.

Round, adjustable, structural-steel columns fitted with plates at both ends are commonly used. The top plate should be as wide as the beam it supports and either be bolted to the flange where a steel beam is used or nailed to a wood beam. Columns may be adjusted to length

after installation to compensate for movement in the soil or settling caused by shrinkage in the framing members.

Wood columns at least 6-by-6-inches may be solid, glued-laminated, or built up of 2-inch lumber. Generally $3\frac{1}{4}$ -inch nails, spaced at 12 inches on center, are used to fasten the built-up members together. Wood columns should be the same width as the beam they support and cut to ensure even bearing at top and bottom. Each column is nailed to the beam at the top and separated from the concrete base at the bottom by damp-proofing material such as 2-mil polyethylene film or 45-pound roll roofing.

Columns are generally spaced 8 to 10 feet on center, depending on the loading and strength of the beam they support.

Both wood and steel beams are used in present-day house construction. One advantage of steel is the absence of shrinkage. For steel beams, the I-beam is the commonly used shape. (See Table 28) Wood beams are of three types: solid, glued-laminated and built-up. The built-up beam (Fig. 16) is usually made of three or more pieces of 2-inch

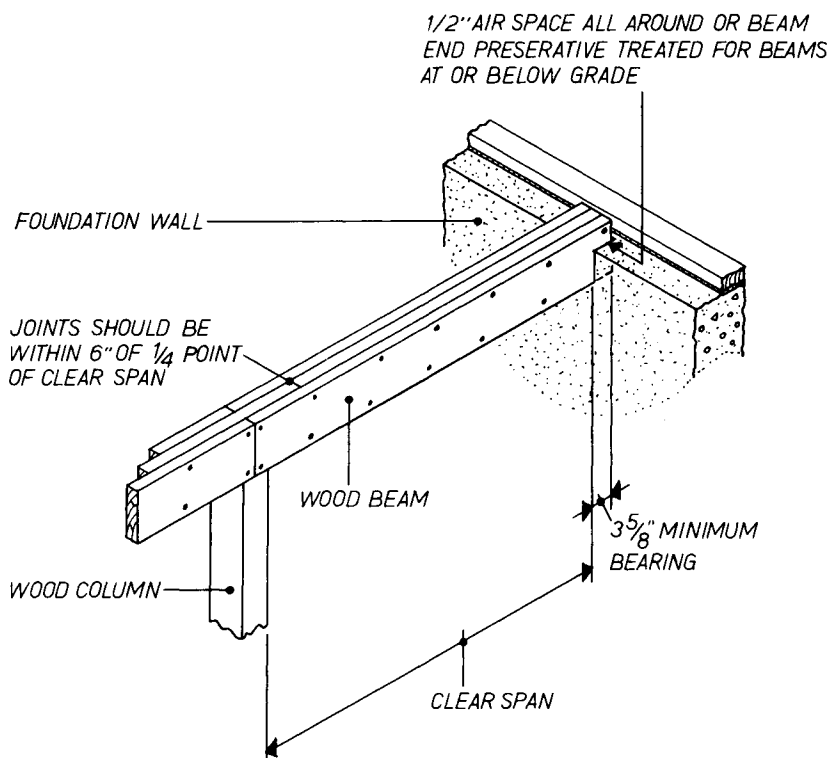


FIGURE 16.—Built-up wood beam.

lumber set on edge and spiked together from each side with 3½-inch nails. The first two nails are driven near the end of each piece of lumber. Additional nails are driven not more than 18 inches apart in each row. Butt joints in each leaf are located over a supporting post or within 6 inches of the quarter points in the span. (See Tables 26 and 27).

Ends of beams should bear at least 3½-inches on masonry walls or columns. Ends of wood beams, located at or below grade and framing into masonry or concrete walls, should be treated to prevent decay or a ½-inch air space provided at the ends and sides.

Beam-Joist Installation

The simplest method of beam and joist framing is to have the joists rest on top of the beam (Fig. 17), in which case the top of the beam is

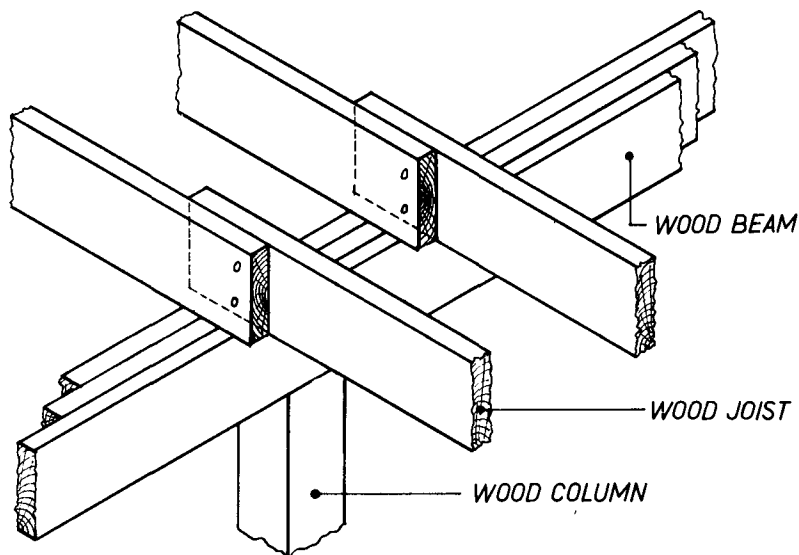


FIGURE 17.—Joists supported on top of wood beam and fastened to the beam by toe-nailing. Two ¾-inch nails used for each joist.

level with the top of the sill plate (Fig. 16). This method is used where the basement height will provide adequate headroom below the beam.

Where more clearance under a wood beam is desired 2-by 3-inch ledger strips are securely fastened to each side of the beam to support the joists (Fig. 18). A 2-by 2-inch splice at least 2 feet long is nailed to opposing joists or the joists are notched, lapped and nailed to each other to provide support for the sub-floor (Fig. 19). Care should be

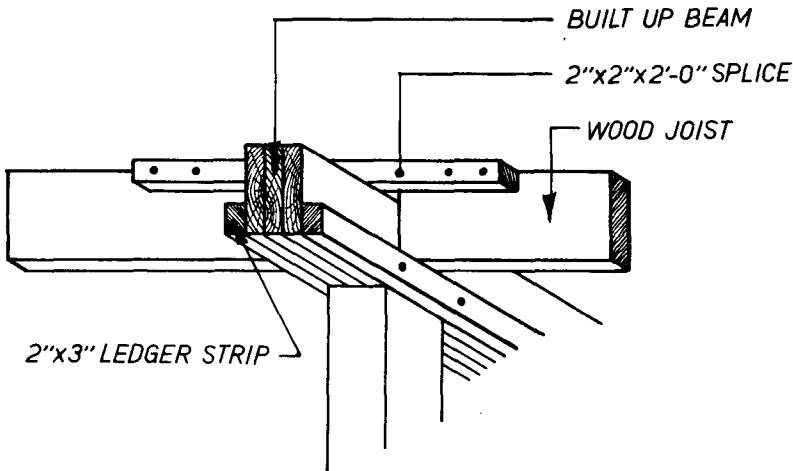


FIGURE 18.—Joists supported on ledger strip nailed to beam with two $\frac{3}{4}$ -inch nails per joist. Splice nailed to joists with two $\frac{3}{4}$ -inch nails at each end.

taken to obtain full bearing on top of the ledger strip. Joists may also be supported by joist hangers or other structural connectors attached to the beam.

Joists framing into the side of a steel beam may be supported on the bottom flange or on a 2-by 2-inch ledger strip bolted to the web with $\frac{1}{4}$ -inch bolts spaced 24 inches on center. The joists should be spliced as shown in Figure 18 and a $\frac{1}{2}$ -inch space provided on top of the beam to allow for joist shrinkage.

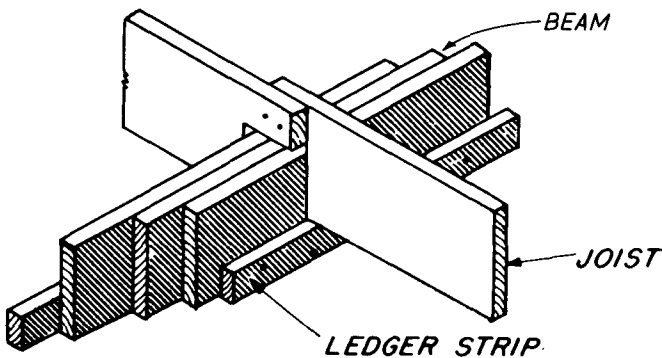


FIGURE 19.—Joists supported on ledger strip nailed to beam with two $\frac{3}{4}$ -inch nails per joist. Joists lapped and nailed together with two $\frac{3}{4}$ -inch nails.

Foundation Wall and Joist Connection

The two general types of floor joist construction used over the foundation wall conform either to platform or balloon framing construction. Platform framing is by far the most common type used.

In platform framing, two methods of wall and joist connection are used and are generally referred to as the box-sill method and the joist-embedded method.

Box-sill method.—This method can be used with either concrete or unit masonry foundation walls. It consists of a wood-sill plate anchored to the foundation wall (Fig. 20), for the support and fastening

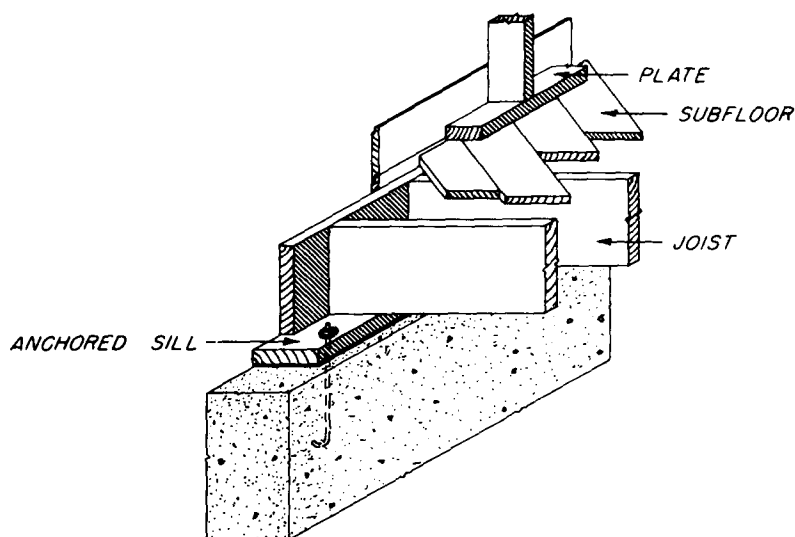


FIGURE 20.—Box-sill method used in platform construction.

of the joists and header at the ends of the joists. The sill plate is usually supported on the top of the foundation wall and in this case the bottom of the sill plate should be at least 6 inches above the finished grade.

Where it is desirable to lower the elevation of the main floor, the top of concrete foundation walls may be reduced to $3\frac{5}{8}$ -inches in thickness. If siding or stucco is used as an exterior finish the wall framing is supported on a sill plate anchored to the top of the wall and the floor joists rest on a separate plate located on a ledge formed in the wall (Fig. 21). Where a masonry finish is used, such as brick veneer, the masonry is supported on the top of the foundation wall and the wall framing is supported on the floor framing (Fig. 22). If the thickness of the wall is reduced as referred to above, the height of the reduced section should not exceed 14 inches.

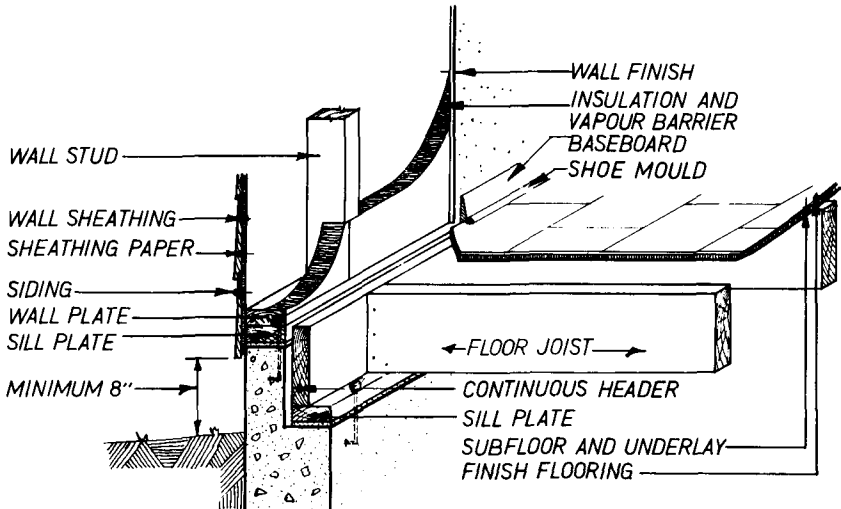


FIGURE 21.—Floor joists supported on a ledge formed in the foundation wall. Joists are toe-nailed to header and sill plate. Sill plate is anchored to top of foundation wall with anchor bolts. Wall plate supporting the wall framing is fastened to the sill plate with $3\frac{1}{4}$ -inch nails spaced 16 inches on center.

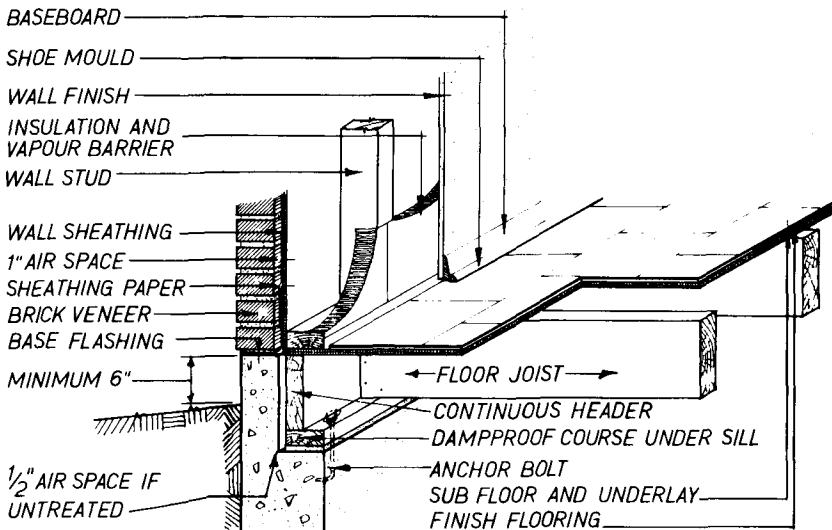


FIGURE 22.—Floor joists are supported on ledge formed in foundation wall. Joists are toe-nailed to header and sill plate. Masonry veneer supported on top of foundation wall. Wall framing supported on top of the subfloor.

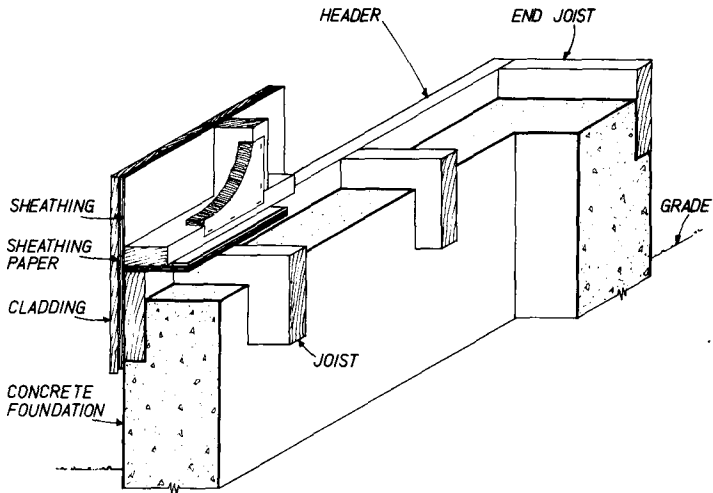


FIGURE 23.—Floor joists embedded in the top of foundation wall.

Joist-embedded method.—This method (Fig. 23) can only be used with concrete foundation walls. Beams, joists and headers are positioned before the concrete is placed. Floor framing is temporarily supported on the inside concrete form and wedges used to level the framing. Filler pieces placed between the floor joists and along the end walls keep the fluid concrete around the joists. These filler pieces are set flush

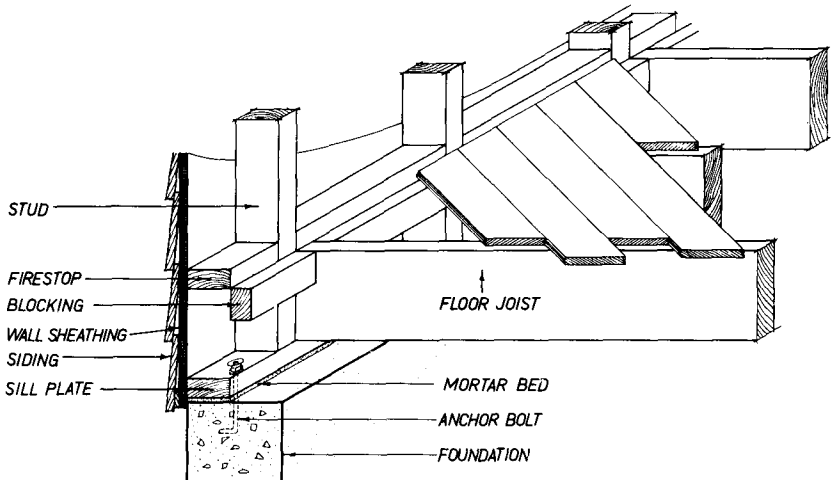


FIGURE 24.—Type of sill used in balloon-frame construction. Wall studs and floor joists are supported on the sill plate. Wall studs are toe-nailed to the sill plate with four $2\frac{1}{2}$ -inch nails, two each side. Floor joists are face-nailed to the studs and toe-nailed to the sill plate with two $3\frac{1}{4}$ -inch nails in each case.

with the inner face of the foundation wall. Joist headers and end joists serve as outside forms for the concrete. Beam ends are treated to prevent decay when they are located below grade. The concrete is then placed so that at least two-thirds of the depth of each joist is embedded in the concrete, thus providing suitable anchorage for the floor-framing members. The filler pieces are removed together with the wall forms once the concrete has set.

In balloon-frame construction the wall studs as well as the floor joists rest on the sill plate and are nailed to both floor joists and plate (Fig. 24). A firestop is fitted between the studs at the floor line. When lumber subflooring is laid diagonally, blocking is required between the joists at the wall lines to support the ends of the boards.

Floor Joists

Joists are selected to meet strength and stiffness requirements. Strength requirements are dependent upon the loads to be carried. Stiffness requirements are intended to limit plaster cracking under live loads. Stiffness is also of importance in limiting vibrations from moving loads — often a cause of annoyance to occupants.

Wood floor joists are generally of 2-inch (nominal) thickness and either 6-, 8-, 10- or 12-inch (nominal) depth. The size depends upon the loading, length of span, spacing between joists, the species and grade of lumber used and the deflection which may be allowed. Tables 18 and 19 show the spans which are allowable for the various grades and species of lumber and for different loading conditions etc. Table 16 gives the minimum design load which should be used for different rooms. The allowable spans shown in these tables are measured from edge to edge of the joist supports.

Where a box-sill is used the joists are installed after the sill plates have been levelled on the mortar bed and anchored to the foundation wall. Where joists are embedded in the top of the foundation wall, they are installed before the foundation wall is placed as already described. The joists are located and spaced in accordance with the design. (16-inch center-to-center spacing is most commonly used.)

Any joists having a slight bow edgewise should be placed with the crown on top. A crowned joist will tend to straighten out when the subfloor and normal floor loads are applied.

A header joist is end-nailed (Fig. 25) or toenailed (Fig. 21) to each joist. In addition, each joist including the end joist parallel to the exterior walls in platform construction (Fig. 25) is toenailed to the sill. The inner ends of the joists are supported on top of the beam (Fig. 17) or framed into the side of the beam (Fig. 18) depending on the type of connection used.

Where a load-bearing partition runs parallel to the floor joists, a beam is usually formed by nailing two or more joists together to carry the additional load.

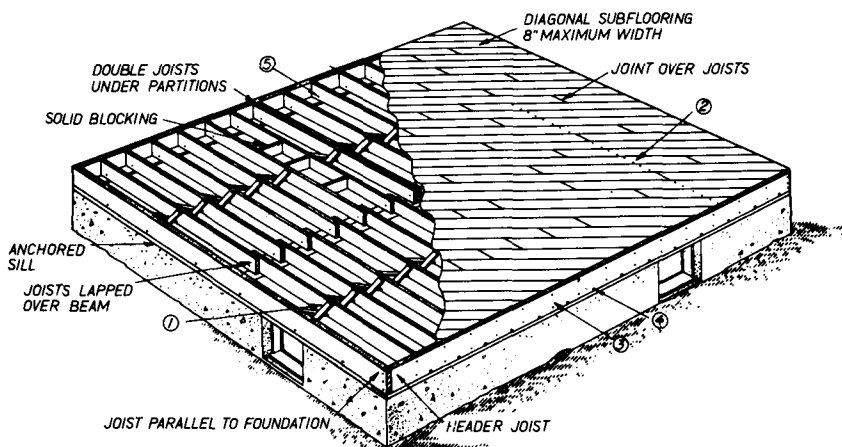


FIGURE 25.—Floor framing. (1) One by three inch bridging nailed at top and bottom with two $2\frac{1}{4}$ -inch nails at each end; (2) subfloor boards nailed with two or three 2-inch nails to each joist; (3) header joist end-nailed to joists with three $3\frac{1}{4}$ -inch nails; (4) header and end joists toe-nailed to sill with $3\frac{1}{4}$ -inch nails 24 inches on center; (5) floor joist toe-nailed to plate with two $3\frac{1}{4}$ -inch nails, one each side.

The floor plan often requires a load bearing partition to be located at right angles to the floor joists but offset from the joist support. No special provision is required to support such a wall if it is within one-quarter of the joist span from the joist support. However, when the offset is more than one-quarter of the joist span, the joist spacing should be reduced or the joist depth increased to support the additional load.

Joists should be doubled under non-load bearing partitions more than 6 feet long and containing openings such as doors, which are not the full height of the wall. The joists may be separated to allow pipes or ducts to go up through the wall. Blocking, 2- by 4-inch, is fitted in between the separated joists at 4 feet on center.

When framing for large openings, such as stair wells or fireplaces, trimmer joists are doubled if they support header joists more than 32 inches long. Header joists longer than 4 feet should also be doubled.

Where unusually large openings occur, trimmer joists that support header joists more than 6 feet 8 inches long, and header joists that are more than 10 feet 8 inches in length should be designed in accordance with accepted engineering practice.

Nailing and assembly methods generally used in the framing of floor openings are shown in Figure 26.

Joist hangers and timber connectors are often used to support long joist headers and tail joists.

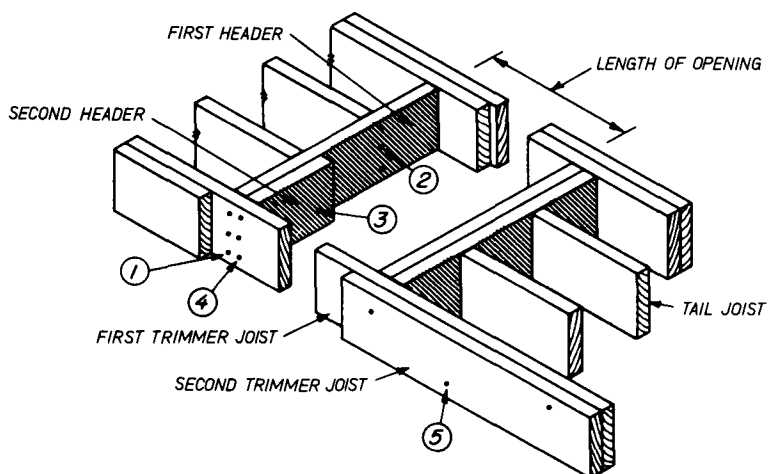


FIGURE 26.—Framing for floor openings where double headers and double trimmers are used. (1) First trimmer nailed to first header with three 4-inch or five $\frac{3}{4}$ -inch nails; (2) first header nailed to tail joists with three 4-inch or five $\frac{3}{4}$ -inch nails; (3) second header nailed to first header with $\frac{3}{4}$ -inch nails spaced 12 inches apart longitudinally; (4) first trimmer nailed to second header with three 4-inch or five $\frac{3}{4}$ -inch nails; (5) second trimmer nailed to first trimmer with $\frac{3}{4}$ -inch nails spaced 12 inches apart longitudinally.

Joist Restraint

Joists may be kept from twisting by furring strips or plywood fastened to the underside of the joists. Where plywood or furring is not used,

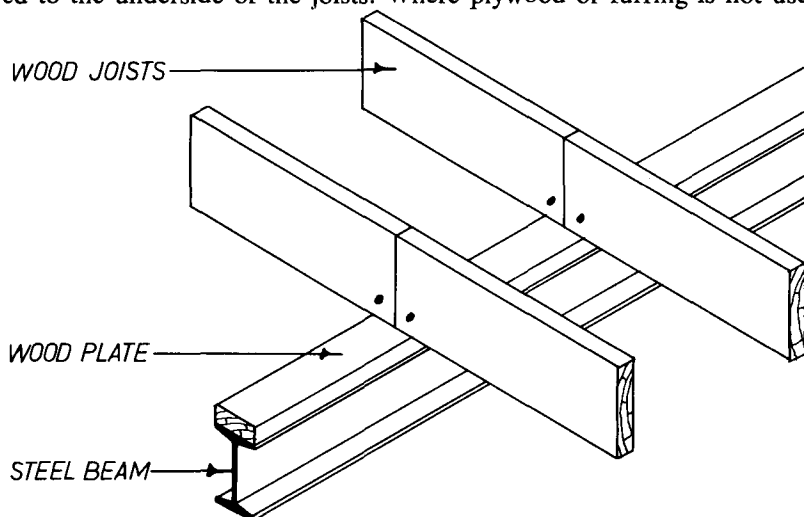


FIGURE 27.—Floor joist supported on 2- by 4-inch plate resting on top of steel beam. Bottom edge of joist held in place by $\frac{3}{4}$ -inch nails toe-nailed to the plate, one nail on each side of each joist.

necessary restraint should be provided at the end supports and at intervals of 7 feet between supports. Where possible, the inner ends of the joists may be toenailed on both sides to the beam or plate, (Fig. 27) and end nailed through the joist headers (Fig. 25).

Necessary restraint may also be provided at the end supports and intermediate locations by one of the following methods:

- (a) 1- by 4-inch continuous wood strapping nailed to the underside of each joist with two 2¼-inch nails (Fig. 28).

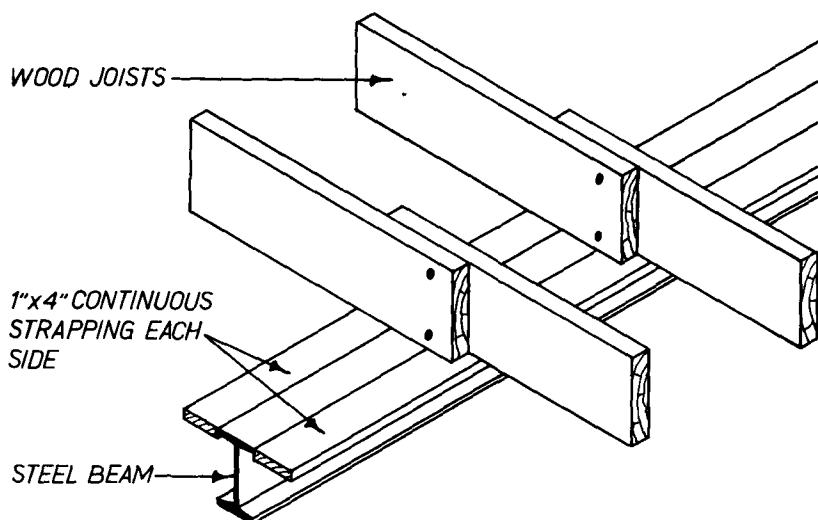


FIGURE 28.—Floor joists supported on top of steel beam. Bottom edge of joists restrained from twisting by 1- by 4-inch continuous strapping nailed to each joist with two 2¼-inch nails.

- (b) 1- by 3-inch or 1½- by 2-inch cross-bridging cut at an angle to fit diagonally between the joists and nailed at each end with two 2¼-inch nails (Fig. 25).
- (c) ½- by 1-inch continuous steel strapping nailed to the underside of each joist with two 2¼-inch nails.
- (d) Solid blocking cut to fit tightly between the joists and nailed in place (Fig. 25).

Subfloor

Subflooring should consist of (a) square-edge, shiplap or tongue-and-groove lumber no wider than 8 inches, (b) plywood or (c) particle board.

For lumber subfloor ¾-inch thick boards are generally used although this thickness may be reduced to 11⁄16-inch where joists are spaced at 16 inches on center. The boards should be applied so that the end

joints occur over the joists. End joints are usually staggered throughout the floor. Boards may be applied at right angles to the joists or diagonally at an angle of not less than 45 degrees. When the subflooring is laid at right angles to the joists, strip finish flooring should be placed at right angles to the subflooring unless an underlay is used. Diagonal subflooring permits finish strip flooring to be laid either parallel to or across the joists. Boards 6 inches and less in width are nailed with two nails at each support; three nails are used with 8-inch boards.

Where balloon framing is used, blocking should be installed between joists at the wall to support the ends of diagonal subfloor boards (Fig. 24).

Plywood is often used as subflooring under wood strip flooring or as a combination subfloor and underlay for resilient flooring, carpet or ceramic tile. When used as a combination subfloor and underlay, the side joints should be supported on 2- by 2-inch blocking fitted between the joists unless the edges of the panels are tongue-and-grooved.

Plywood panels should be installed with the surface grain at right angles to the floor joists and with the end joints staggered and nailed along the edges at 6 inches on center and 12 inches at intermediate supports. Annular grooved nails, which are designed to resist withdrawal and "nail popping", should be used where the panels provide a combination subfloor and underlay.

Particle board panels may also be used as subflooring and should be covered with an underlay except where wood strip flooring is used. The panels are staggered and nailed in the same way as plywood.

Minimum thickness of plywood and particle board panels are shown in Table 5.

Floor Framing at Projections

Floor joists sometimes project beyond the foundation wall to provide support for a bay-window or additional floor space in the upper rooms. The cantilevered portion of the floor framing does not usually exceed 2 feet. The subflooring is carried to and sawn flush with the outer framing members. Figure 29 shows a typical projection at the second floor.

Insulation should be carefully fitted and placed on top of the soffit finish under the cantilevered floor and up the inside face of the joist header and end joists. The vapor barrier should be placed on the warm side of the insulation and neatly fitted and fastened in place (Fig. 29).

The space between the insulation and subfloor is usually left open to let the warm air in the ceiling area circulate between the joist spaces. In this way the floor in the projected area is heated both from below and above, resulting in an even and comfortable floor temperature throughout the room.

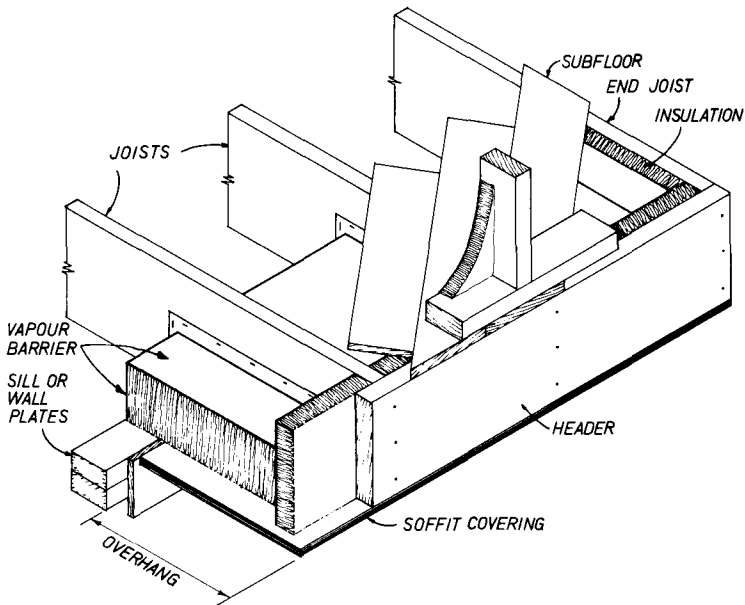


FIGURE 29.—Floor framing at projections.

To prevent air infiltration into the projected area, the soffit under the overhang and other parts of the trim should be carefully fitted and caulked where necessary.

WALL FRAMING

The term "wall framing" includes the vertical and horizontal members of exterior walls and interior partitions. These members, referred to as studs, wall plates and lintels, serve as a nailing base for all covering materials and support the upper floors, ceiling and roof. All framing lumber should be well seasoned and have a moisture content not exceeding 19 per cent. (See Table 29 for nailing practice).

Studs are the vertical members to which the wall sheathing and cladding are attached. They are supported on a bottom plate or foundation sill and in turn support the top plate. Studs generally consist of 2- by 4-inch lumber and are spaced at 16 inches on center. This spacing may be increased to 24 inches on center depending on the load and the limitations imposed by the type and thickness of the wall covering used. (See Table 6).

The studs are attached to horizontal top and bottom wall plates of 2-inch lumber the same width as the studs.

Lintels are the horizontal members placed over window, door and other openings to carry vertical loads to the adjoining studs. Lintels

are usually made up of two pieces of 2-inch lumber separated with spacers to the depth of the studs and nailed together to form a single unit. Solid members of the same width as the studs may also be used. The depth of a lintel is determined by the width of the opening and vertical loads supported. (See Table 7).

There are two general types of wall framing: "platform construction" and "balloon frame construction", but because of its simplicity, platform construction is by far the most popular and recent building techniques have developed almost entirely around the platform method.

Platform Construction

The chief advantage of platform construction is that the floor system, assembled independently from the walls, provides a platform or working surface upon which the walls and partitions may be assembled and erected. Since the studs are one storey in height, walls can easily be prefabricated off the site or assembled on the subfloor in sections and erected one storey at a time. The bottom and top plates which are an integral part of the wall framing provide fire stops at the floor and ceiling and also nailing support for wall sheathing and interior finish. This eliminates the need for cutting and fitting short pieces between each stud and joist as required in balloon frame construction. However, where studs are more than 8 feet long additional firestops should be included in the wall.

The method of framing wall sections horizontally on the subfloor prior to erection is widely used. The top and bottom plates are end-nailed with two nails to each pre-cut stud. Studs are doubled at openings, the inner stud being cut to receive the lintels which are placed and end-nailed through the outer studs. The wall sections are then raised and put in place (Fig. 30), temporary braces are added and the bottom plates nailed through the subfloor to the floor framing members. Wall sheathing is usually applied to the framing prior to erection thus eliminating the need to scaffold for this operation.

Once the assembled sections are plumbed, they are nailed together at the corners and intersections. A second top plate, with joints located at least one stud space away from the joints in the plate beneath, is added. This second top plate usually laps the first plate at the corners and partition intersections and, when nailed in place, provides an additional tie to the framed walls. Where the second top plate does not lap the plate immediately underneath at corners and partition intersections, these are usually tied with 20-gauge galvanized steel plates at least 3 inches wide and 6 inches long.

Interior partitions supporting floor, ceiling or roof loads are called "load bearing partitions", others are called "non-load bearing".

Load bearing partitions are framed in the same way as exterior walls. Studs are usually 2- by 4-inch lumber spaced at 16 inches on center. This spacing may be increased to 24 inches depending on the

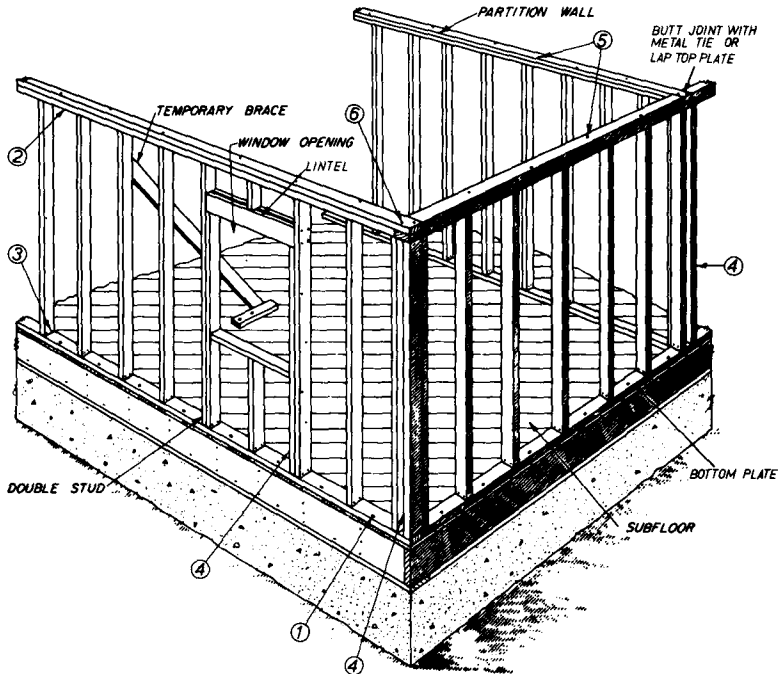


FIGURE 30.—Wall framing used with platform construction. (1) Bottom plate nailed to joist or header joist with $3\frac{1}{4}$ -inch nails 16 inches on center; (2) top plate end-nailed to stud with two $3\frac{1}{4}$ -inch nails; (3) stud toe-nailed to bottom plate with two $2\frac{1}{2}$ -inch nails on each side, or end-nailed with two $3\frac{1}{4}$ -inch nails; (4) doubled studs at openings and multiple studs at corners and intersections nailed with $3\frac{1}{4}$ -inch nails 30 inches on center; (5) top plates nailed together with $3\frac{1}{4}$ -inch nails 24 inches on center; (6) top plates at corners and partitions are lapped and nailed together with two $3\frac{1}{4}$ -inch nails or the plates are butted together and tied with a metal plate fastened to the top plates with three $2\frac{1}{2}$ -inch nails on each side of the joint.

loads supported and the type and thickness of the wall finish used. (See Table 6).

Non-load bearing partitions can be built with 2- by 3-inch studs spaced at 16 inches on center or 2- by 4-inch studs spaced at 24 inches on center depending on the type and thickness of the wall finish used. Where a partition does not contain a swinging door, 2- by 4-inch studs at 16 inches on center are sometimes used with the wide face of the stud parallel to the wall. This is usually done only for partitions enclosing clothes closets or cupboards, to save space. Since there is no vertical load to be supported by non-bearing partitions, single studs may be used at the door openings. The top of the opening may be bridged with a single piece of 2-inch lumber the same width as the studs. These members provide a nailing support for wall finish, door frames and trim. A single top plate may be used with non-load bearing partitions.

Exterior Corner and Wall-Intersection Details

A multiple-stud post made up of at least three studs, or the equivalent, is generally used at exterior corners and intersections to secure a good tie between adjoining walls and to provide nailing support for the interior finish and exterior sheathing.

Figures 31, 32 and 33 illustrate exterior corners and partition intersections commonly used.

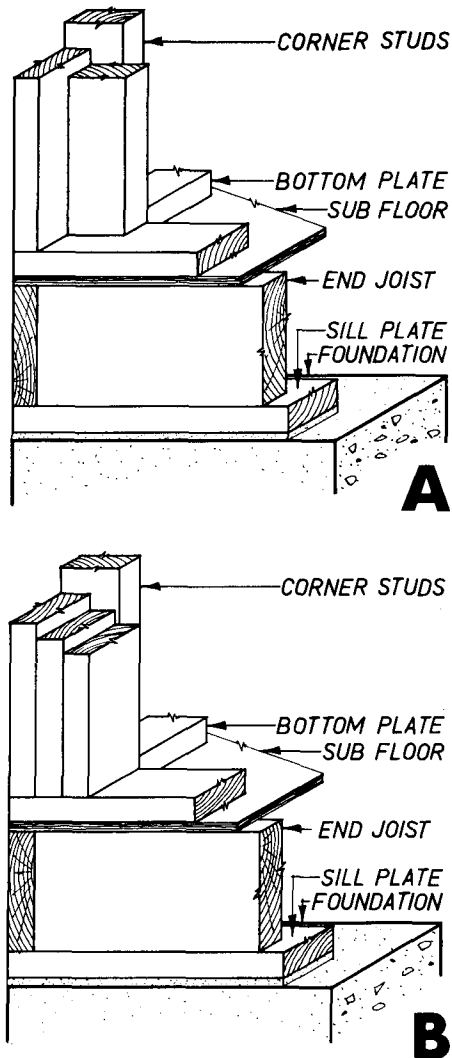


FIGURE 31.—Multiple stud arrangements at exterior corner. A, Insulation is installed at the corner after sheathing is applied; B, four studs used.

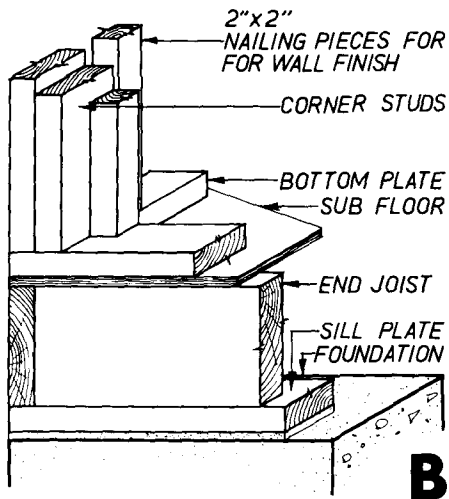
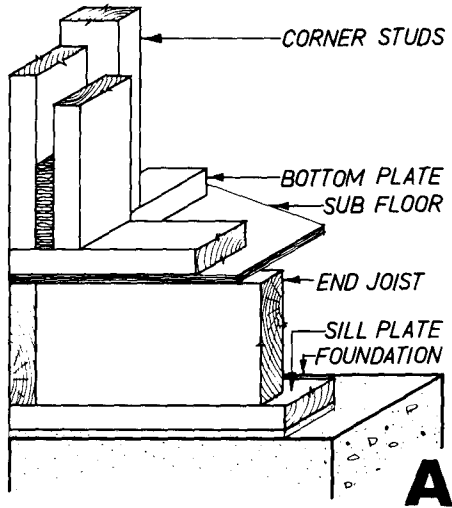


FIGURE 32.—Multiple stud arrangements at exterior corners. A, Insulation must be installed in the corners before sheathing is applied; B, equivalent of three studs used — two studs and two pieces of 2- by 2-inch as nailing supports; insulation is installed at the corners after sheathing is applied.

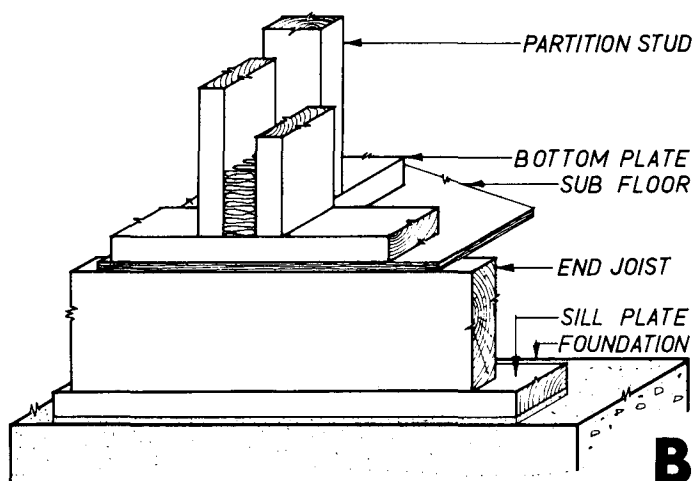
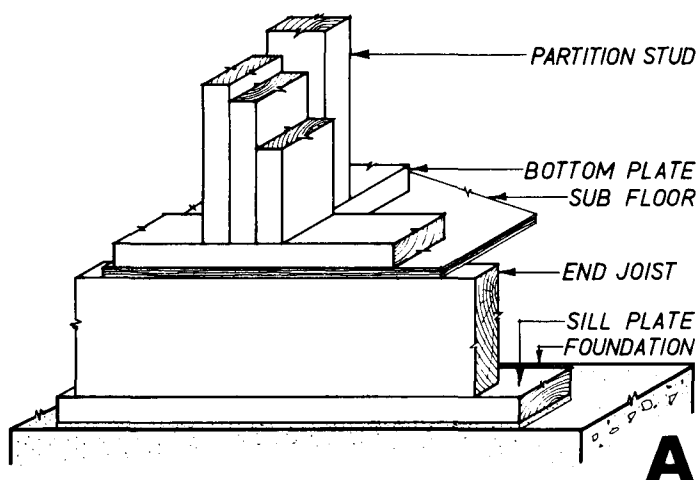


FIGURE 33.—Multiple stud arrangements at the intersection of an interior partition with an exterior wall. A, Four studs used; B, insulation must be installed before sheathing is applied.

Nailing Support for Interior Finish

Nailing support for the edges of the ceiling finish is required at the juncture of the wall and ceiling where partitions run parallel to the

ceiling joists. Figures 34 and 35 illustrate types of nailing support commonly used.

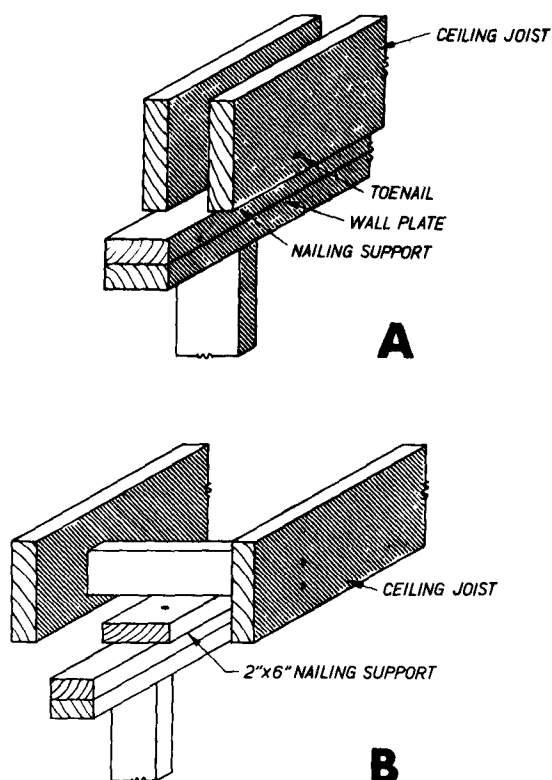


FIGURE 34.—Horizontal nailing support for interior finish. *A*, Nailing support formed by ceiling joists; *B*, nailing support provided by 2-inch lumber nailed to top plates with $\frac{3}{4}$ -inch nails at 12 inches on center.

Balloon Frame Construction

Balloon framing differs from platform framing in that the studs used for exterior walls are continuous, passing through the floors and ending at the top plates which support the roof framing. Both the studs and first-floor joists rest on the foundation sill plate (Fig. 36) and the center beam or bearing wall. Studs are toenailed to these supports; the joists in turn are nailed to the studs.

Second-floor joists bear on a 1- by 4-inch ribbon that has been let into the studs and the joists are nailed to the studs. The end joists

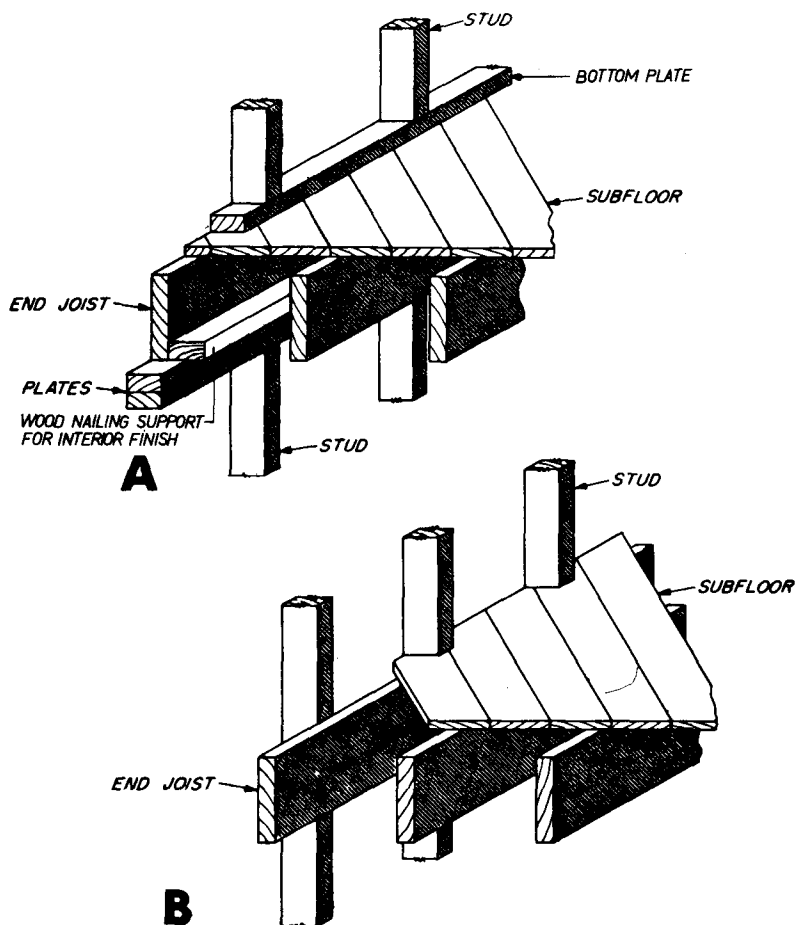


FIGURE 35.—End-wall framing and nailing support for interior finish. A, For platform construction; B, for balloon construction.

parallel to the exterior walls on both first and second floors are similarly nailed to the studs (Fig. 36).

As the spaces between the studs are not interrupted by wall plates (as in platform framing), fire stops are required at floor and ceiling levels to eliminate continuous passages in the wall and thus resist the spread of fire. Lumber blocking 2 inches thick is commonly used for this purpose.

Since the connections between the floor joists and studs in balloon framing do not lend themselves to pre-fabrication or easy assembly on the site, this method of framing houses is rarely used. However, some of the techniques involved in balloon framing may be used with the platform framing method. For example, ceiling joists for dropped

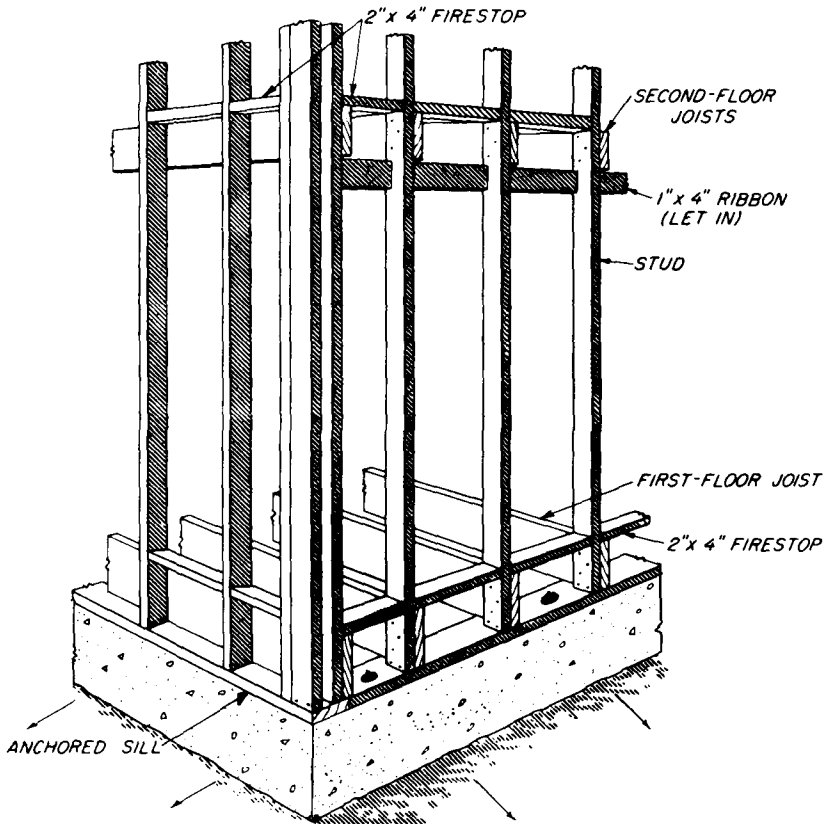


FIGURE 36.—Balloon framing.

ceilings may be supported on a 1- by 4-inch ribbon let into the studs or floor joists may be similarly supported where the level of the floors are offset at an adjoining wall in split-level houses.

CEILING AND ROOF FRAMING

There are two basic types of roofs, flat and pitched, but each type has many variations; the so-called flat roof should actually have some slope for drainage. Roof slope is generally expressed as the number of inches of vertical rise in 12 inches of horizontal run, the rise being given first, as for instance 4 in 12. For purposes of definition, flat roofs might be classed as those having less than a 3 in 12 slope. Pitched roofs may vary in slope from 3 in 12 to 12 in 12 or more, depending on the roof covering and the use of the attic space.

The dimensions of roof joists and rafters for the various grades and species of lumber and for the different live loads (snow loads) en-

countered are given in Tables 20 to 25. The snow load (live load) for which roofs in locations throughout Canada should be designed are shown on a drawing included in the Appendix.

Flat Roofs

Roof joists for flat roofs are commonly laid level, with roof sheathing and roofing on top and with the underside utilized to support the ceiling. A slope may be provided for roof drainage by tapering each joist or by adding a tapered strip to the top of the joists. The house design may call for an overhang of the roof beyond the wall or for a parapet wall carried above the roof. Insulation may be added just above the ceiling. In this case, the space above the insulation should be ventilated not only to help prevent condensation in the winter but also to help remove hot air in the summer. Alternatively rigid insulation may be installed on top of the roof sheathing and the roof covering placed on the insulation. In this case, the space above the ceiling is not ventilated. Figure 37A shows a simple type of flat roof in which roof joists are level, eliminating the need for separate ceiling joists.

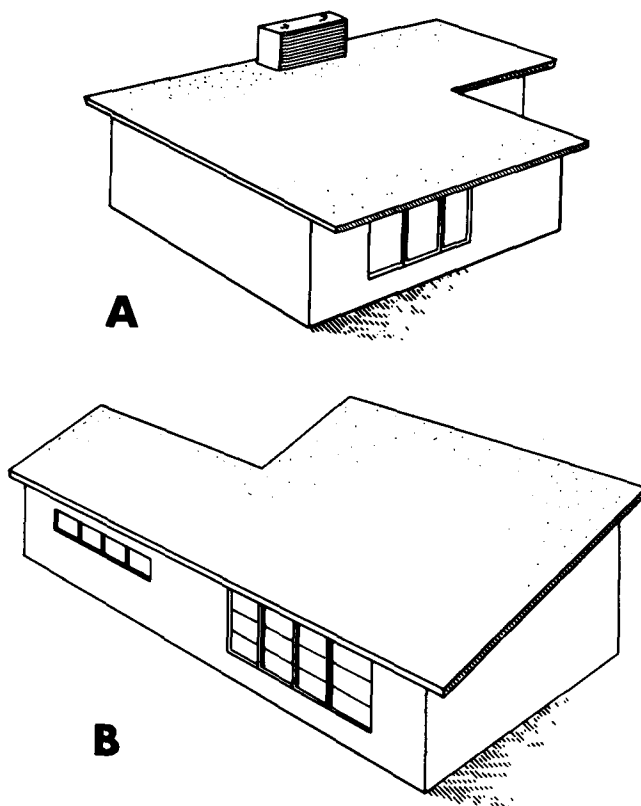


FIGURE 37.—Two flat-roof designs. Rafters may also serve as ceiling joists.

In flat-roof construction where rafters also serve as ceiling joists, they are called roof joists and the size established on the basis of both roof and ceiling loads. (See Tables 20 to 23). When an overhang is called for on all sides of the house, lookout rafters are ordinarily used (Fig. 38). These lookout rafters, which are usually twice as long as the

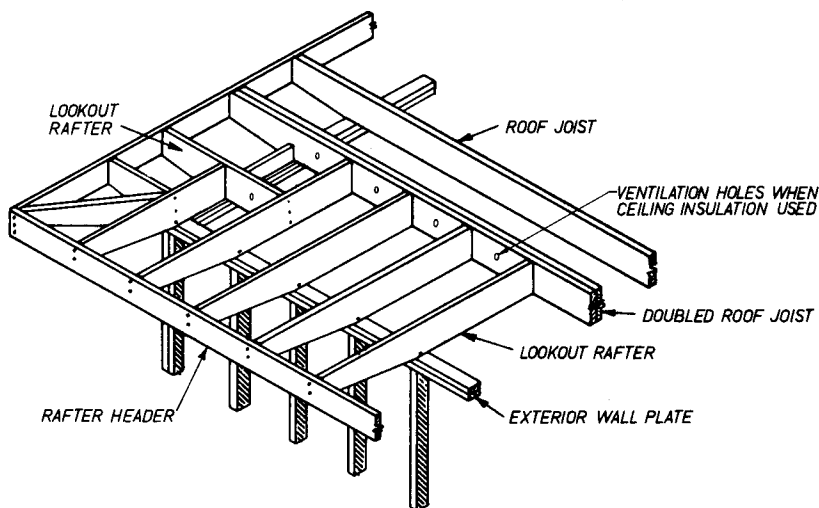


FIGURE 38.—Typical construction of flat roof with overhang. Ventilation holes are drilled in framing members to provide continuous ventilation over ceiling insulation.

overhang, are toenailed to the wall plate and end-nailed to the first roof joist. If the lookout rafters project into the ceiling area more than one joist space, two roof joists are nailed together to form a header (Fig. 38). An outside joist header is then added and end-nailed to the lookout rafters and roof joists. This serves as a nailing support for the roof sheathing, fascia board and soffit covering. Such overhangs generally do not exceed 4 feet.

Flat roofs or roofs with a low pitch may be built with 2-inch matched plank as roof sheathing supported on large beams spaced about 6 feet apart with the plank and beams exposed on the underside. Double studs are used to support the beams. The exposed wood may be dressed smooth and finished with varnish or otherwise decorated. The roof is covered with a rigid insulation which is in turn covered with a built-up roof.

Sloped roofs, as shown in Figure 37B, may have a ceiling finish attached to the roof joists with the ceiling following the pitch of the roof.

Pitched Roofs

Of the pitched roofs, the simplest form is the gable roof (Fig. 39A and 40A). All rafters are cut to the same length and pattern and erection is straight forward. (Figure 40A shows typical framing for

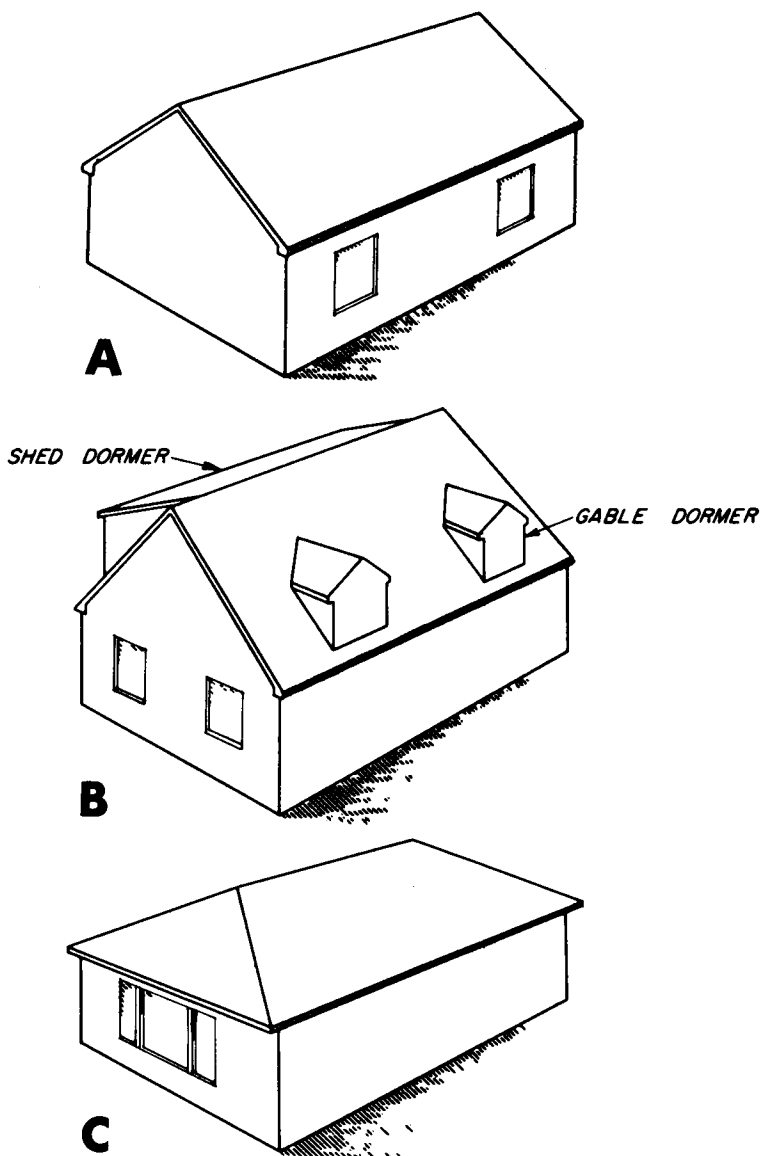


FIGURE 39.—Types of pitched roofs. A, Gable; B, gable with dormers; C, hip.

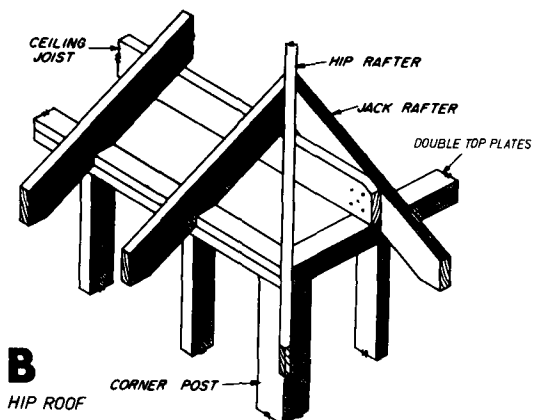
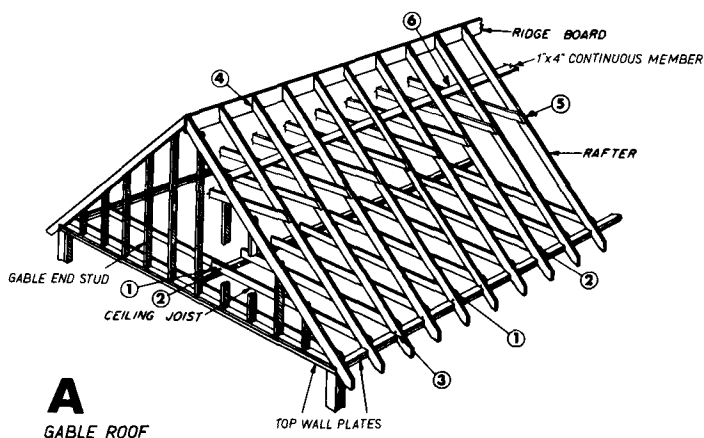


FIGURE 40.—A, Ceiling and Roof Framing with ridge board: (1) Ceiling joists toe-nailed to plate with two $3\frac{1}{4}$ -inch nails, one each side; (2) ceiling joists lapped over center-bearing partition and nailed together, joists also nailed to each pair of rafters (see Table 29 for nailing practice); (3) rafter nailed to plate with three $3\frac{1}{4}$ -inch nails; (4) each rafter toe-nailed to ridge board with four $2\frac{1}{4}$ -inch nails or end-nailed with three $3\frac{1}{4}$ -inch nails; (5) collar brace nailed to each pair of rafters with three $3\frac{1}{4}$ -inch nails at each end; (6) 1-inch by 4-inch strip nailed to top of collar braces at their center with two $2\frac{1}{4}$ -inch nails when the braces are more than 8 feet long; B, jack rafter nailed to hip rafter with three $3\frac{1}{4}$ -inch nails.

gable roofs). A variation of the gable roof may include dormers for additional light and ventilation in second-floor rooms (Fig. 39B). The shed dormer provides greatest possibilities for light, floor space and headroom.

The hip roof is shown in Figure 39C. Common rafters are fastened to the ridge board while hip rafters supply the support for the jack rafters (Fig. 40B).

Ceiling Joists.—Ceiling joists are used to support the ceiling finish and to act as ties between exterior walls and in some cases, opposing rafters. They may also act as floor joists for second or attic floors or provide support for roof loads, transferred to them by dwarf walls used as intermediate support for rafters. (See Tables 17 and 19 for ceiling joist spans).

In normal pitched-roof framing the ceiling joists are nailed in place after the interior and exterior wall framing is complete but before the rafters are erected, as the thrust of the rafters will otherwise tend to push out the outside walls.

Ceiling joists are generally used to tie the lower ends of rafters in pitched roofs that slope 4 in 12 or more. The rafter ends are prevented from moving outward by nailing the ceiling joist to the side of each pair of rafters (Fig. 40A). The joists are lapped and nailed together or spliced at the center bearing partition, thus providing a continuous tie across opposing rafters. The number of nails used in the connections depends upon the roof slope, rafter spacing, snow load and width of the house (See Table 29 for nailing practice).

The additional roof load imposed by dwarf walls that run at right angles to the ceiling joists (Fig. 41), should be taken into account

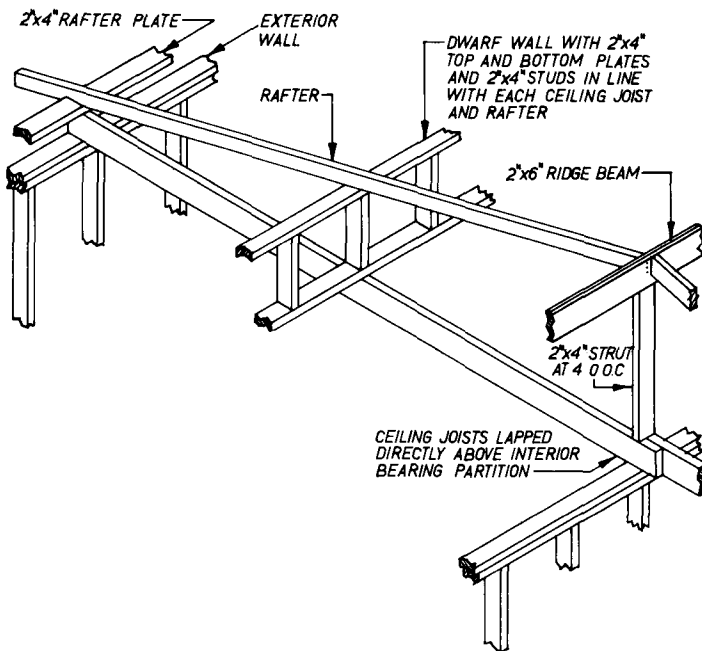


FIGURE 41.—Rafter heel supported on a rafter plate nailed to top of each ceiling joist with two 4-inch nails. Rafters are prevented from moving outward by ridge beam supported on roof struts. Dwarf wall used as intermediate support for rafters.

when the size of the joists are determined. An increase of one inch in the depth of the joists will usually provide the additional strength required where the roof slope is more than 3 in 12. When the slope is 3 in 12 or less, the size of the ceiling joists are determined from span tables for roof joists (Tables 20 to 23).

Since hip rafters are 2 inches deeper than the common or jack rafters, they reduce the space along the end walls to the extent that in low-slope roofs, there may not be enough room to install the outside ceiling joist at normal spacing from the wall. In this case doubled joists are used and positioned to suit the available space (Fig. 42).

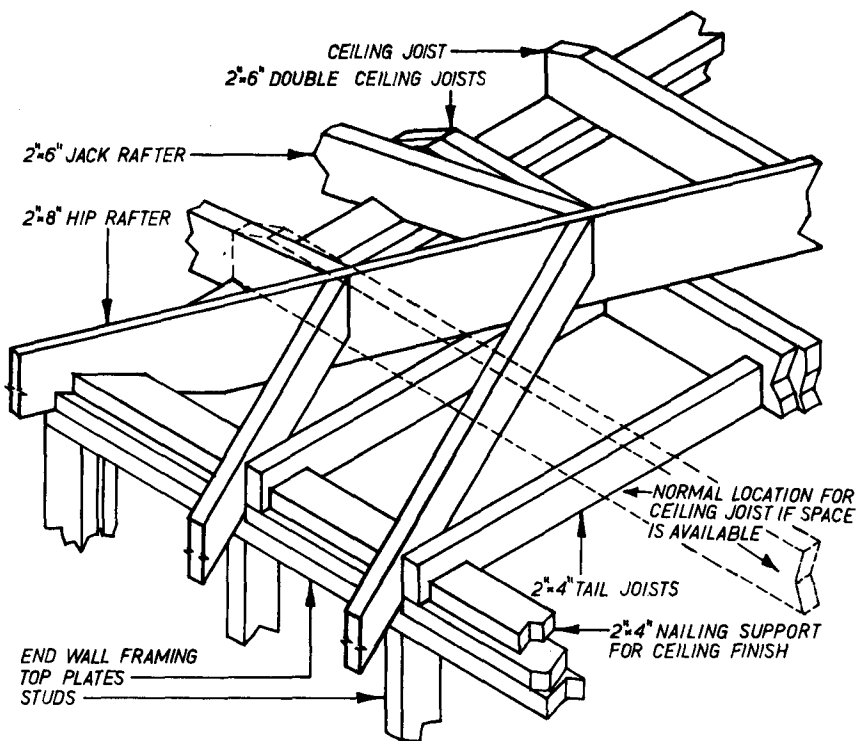


FIGURE 42.—Doubled ceiling joist and tail joists used where hip rafter reduces clear space near the end wall.

Tail joists are then added and toenailed to the outside wall plate and end-nailed to the double joists. The spacing of these tail joists is usually the same as the spacing of the main ceiling joists.

Rafters.—Rafters are precut to length with the proper angle cut at the ridge and eaves and with notches provided for the wall or rafter plates. The heel or lower part of the rafters should bear directly over

the exterior wall. Depending on the plan of the roof and the shape of the outside walls the rafters are placed:

- (a) directly on the wall plates (Fig. 40),
- (b) on a rafter plate nailed to the top of the ceiling joists (Fig. 41),
- (c) on a bearing wall supported on the exterior wall plate (Fig. 43).

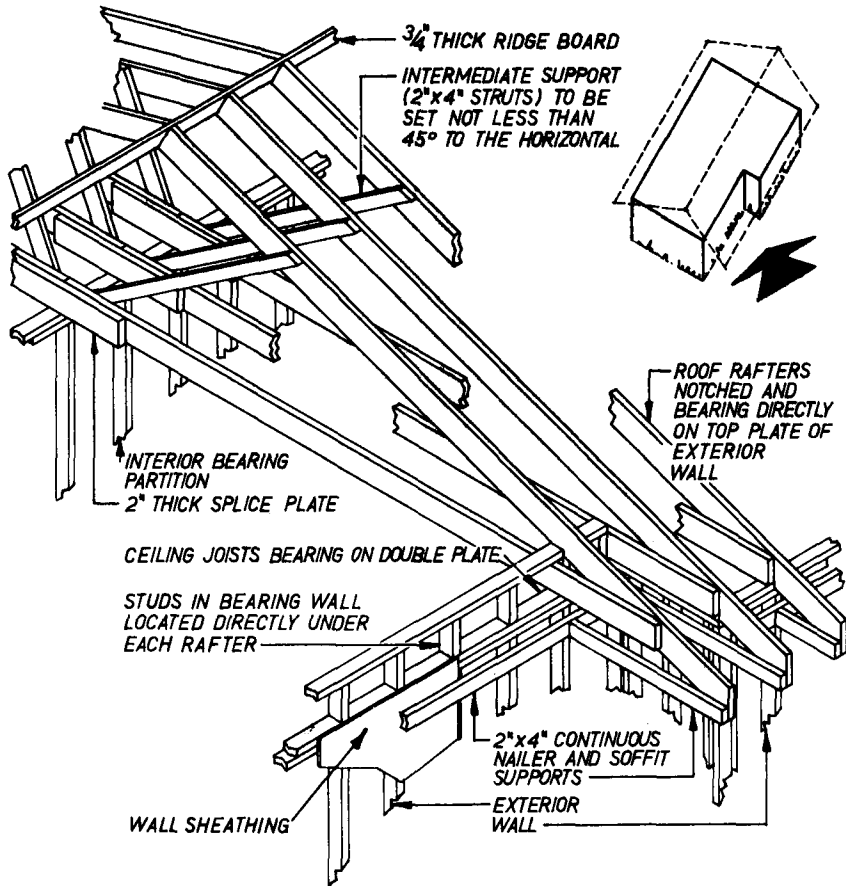


FIGURE 43.—Rafter heel supported on bearing wall. Ceiling joists project beyond the wall line and are nailed to the rafters (see Table 29 for nailing practice), 2- by 4-inch roof struts used as intermediate support for rafters. Struts are nailed to the side of the rafter with three $3\frac{1}{4}$ -inch nails and toe-nailed to bearing partition with two $3\frac{1}{4}$ -inch nails.

The last method is used where a portion of the outside wall is set back. In this case the ceiling joists are extended beyond the exterior

wall and nailed to the side of the rafters. This provides lateral support for the bearing wall and prevents the roof from spreading.

A ridge board (Fig. 40) or ridge beam (Fig. 41) is used to ensure a level ridge line and for ease in erection and alignment of the rafters. Rafters are erected in pairs and nailed to the ridge board or beam. The lower ends are toenailed to the wall plate. Each pair of rafters is usually located directly opposite each other. However, they may be offset at the ridge by their own thickness. This offsetting is required to maintain vertical alignment of the rafters when the lower ends are tied to ceiling joists that have been lapped (rather than butted together) at the center bearing partition (Fig. 41).

Roofs which slope less than 4 in 12 should be vertically supported at the peak. This can be accomplished by providing a 2- by 6-inch ridge beam, supported at 4-foot intervals by 2- by 4-inch vertical struts (Fig. 41). A bearing wall may be used instead of the ridge beam. Since these methods of support reduce the outward thrust of the roof continuous ties between the lower ends of opposing rafters are not necessary.

Intermediate Support for Rafters.—Intermediate support for rafters is generally installed between the ridge and exterior walls to reduce the span of the rafters. This reduces the size of the rafters which are required as the span is taken from this intermediate point to the ridge or eave support.

For rafters in roofs which slope 4 in 12 or more, intermediate support is generally provided by a 2- by 4-inch collar brace nailed to the side of each pair of rafters. Since these braces are in compression and subject to buckling they are supported against lateral deflection when more than 8 feet long, by nailing a 1- by 4-inch continuous member at right angles to the collar braces near their center (Fig. 40).

Intermediate support for rafters in roofs which slope less than 4 in 12 is usually provided by a bearing wall (Fig. 41), built in the same way as a load-bearing partition, except that a single top plate may be used where the rafters are positioned directly over the studs.

Struts may also be used as intermediate supports for rafters in pitched roofs. A 2- by 4-inch strut (Fig. 43) is nailed to the side of each rafter and supported on a load-bearing partition. The angle of the struts should not be less than 45° to the horizontal.

Rafters which run at right angles to the ceiling joists may be supported at an intermediate point by a dwarf wall sitting on a beam placed between the ceiling joists. The underside of the beam is raised at least one inch above the ceiling finish by inserting blocks under the ends of the beam at the exterior walls and center load-bearing partition. The space thus formed prevents the beam from damaging the ceiling finish when deflected at its center by the roof loads.

A beam similarly installed may also be used as intermediate support for hip and valley rafters. In this case a roof strut is used to transfer the load from the hip or valley rafter to the beam.

Where intermediate support is required for a few rafters in the end section on a hip-type roof, a simple form of support can be provided by a beam, sometimes called a "strongback", consisting of two 2- by 4-inch members nailed together, set on edge, and nailed to the bottom of the rafters. This beam is in turn supported at points along its length by 2- by 4-inch struts radiating from a common point of support on the center load-bearing partition. The angle of any strut should not be less than 45° to the horizontal. The ends are cut to fit the selected angle and securely nailed in place.

Hip and Valley Rafters.—Hip rafters (Fig. 40B) and valley rafters (Fig. 44) should be at least 2 inches deeper than the common rafters.

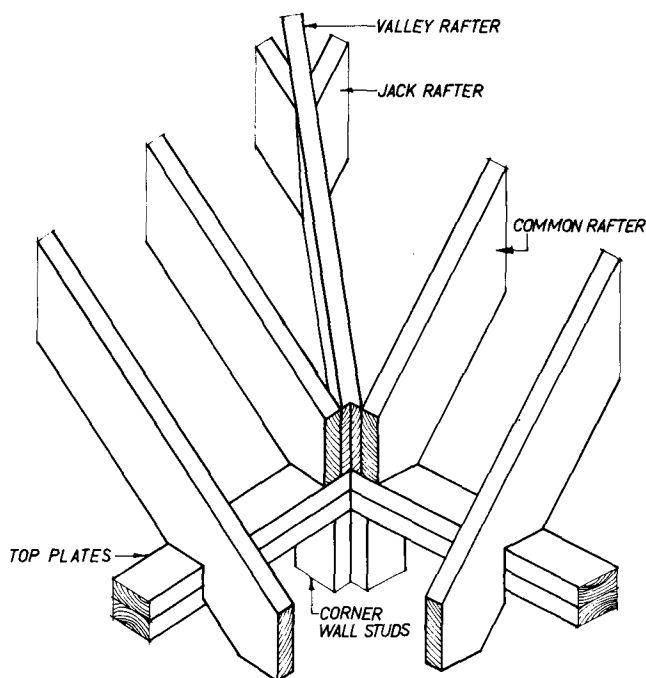


FIGURE 44.—Framing at a valley.

This additional depth provides full contact with the angle-cut of the jack rafters. In hip roofs the jack rafters are nailed to the hip rafters and wall plate. Where a valley occurs, the jack rafters are nailed to the valley rafter and ridge.

Dormers.—With small gable dormers, the rafters at each side are doubled to support the side studs and valley rafters. The top end of the valley rafters are supported by a header (Fig. 45). By far the most

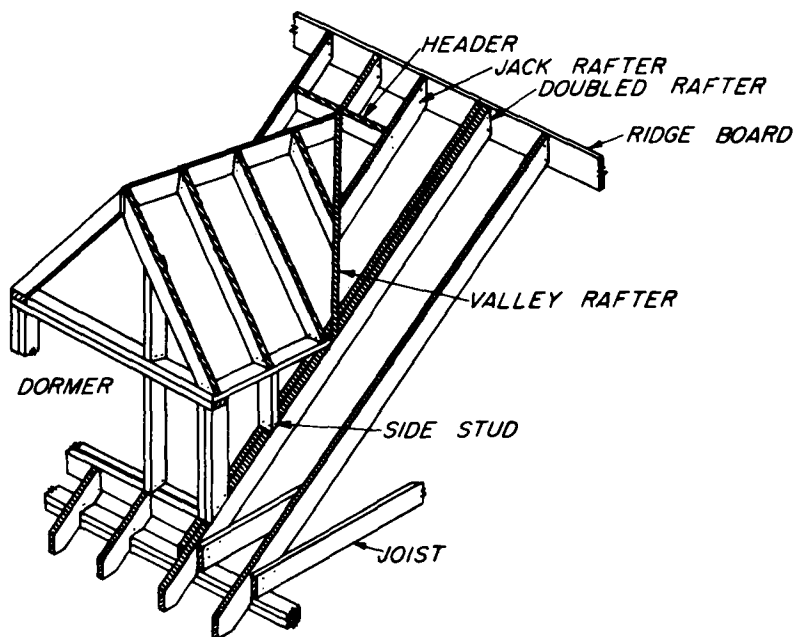


FIGURE 45.—Typical dormer framing. After roof sheathing is applied, blocking is added between side studs at roof line to provide nailing support for wall sheathing.

common method of construction is to install the roof sheathing before the dormer is framed then saw the sheathing flush with the framing members around the opening. A bottom plate added on top of the sheathing supports the side studs enclosing the dormer and also serves as a nailing base for the wall sheathing. If future expansion is contemplated or additional rooms are to be built in the attic, consideration should be given to framing future dormers when the house is built.

Lightweight Roof Trusses.—Experience has shown that lightweight roof trusses are suitable for houses. They save in material and can be quickly put in place, so that the house can be rapidly enclosed. In most cases trusses are designed to span from exterior wall to exterior wall and no intermediate bearing partitions are required. Thus the entire house may be used as one large workroom during erection. As well there is increased flexibility for interior planning, as partitions can be placed without regard to structural requirements.

Essentially trusses consist of top and bottom chords connected by suitable diagonal and vertical members. The truss members may be joined with nailed plywood or metal gussets. Pressed-on metal connectors with integral teeth are also widely used by truss manufacturers. Trusses are generally spaced 2 feet on center and toenailed to the top

plates of the exterior walls. A variety of truss designs suitable for use in houses are shown in the Appendix.

Gable-End Framing

After the roof framing members are up, the gable-end studs are cut to fit and nailed in place. Studs in unfinished attics may be placed with the wide face parallel to the wall. The ends of the studs are then cut to fit the angle of the rafter and are toenailed to the wall plate and to the underside of the rafter (Fig. 57).

WALL SHEATHING

Wall sheathing is the outside covering used over the wall framework and is nailed directly to the wall framing members. Although not always required, sheathing must be applied to the gable ends and walls where the exterior cladding is a type that needs solid backing. Five types of sheathing are used in present day construction; lumber, fiberboard, gypsum board, plywood and particle board.

Types and Installation of Sheathing

Lumber sheathing, which should not be less than $1\frac{1}{16}$ -inch thick, is used in boards 6- to 12-inches wide. It is milled in shiplap, tongue-and-groove or square-edge pattern. The boards are nailed at each stud crossing with 2 nails for the 6- and 8-inch widths, and 3 nails for 10- and 12-inch widths. End joints in the board must be placed over the center of the studs with the joints staggered on different studs. Lumber sheathing may be put on either horizontally or diagonally (Fig. 46A). Because of angle cuts there is more waste with the diagonal method. It is also a little slower as it involves more work.

Fiberboard sheathing should be at least $\frac{7}{16}$ -inch thick. It comes in sheets 4 feet wide and generally 8 or 9 feet long. It is coated or impregnated with an asphalt material to increase water resistance.

Gypsum board sheathing usually comes $\frac{1}{2}$ -inch thick in sheets 2 feet wide and 8 feet long. The sheets are applied horizontally across the studs and nailed to the framing members. This material comprises a gypsum filler faced on both sides with treated paper.

Plywood sheathing should be an exterior type, i.e. laminated with a waterproof adhesive. The type most commonly used, called "sheathing grade", is unsanded and may contain knots. The minimum thickness used is $\frac{5}{16}$ -inch; sheets are 4 feet wide and usually 8 feet long.

Particle board sheathing is made of wood particles bonded together with an adhesive and formed into sheets 4 feet wide and usually 8 feet long; the minimum thickness that should be used is $\frac{5}{16}$ -inch.

Panel-type sheathing such as plywood, fiberboard or particle board may be applied vertically or horizontally. When the sheets are applied horizontally, the vertical joints should be staggered wherever possible.

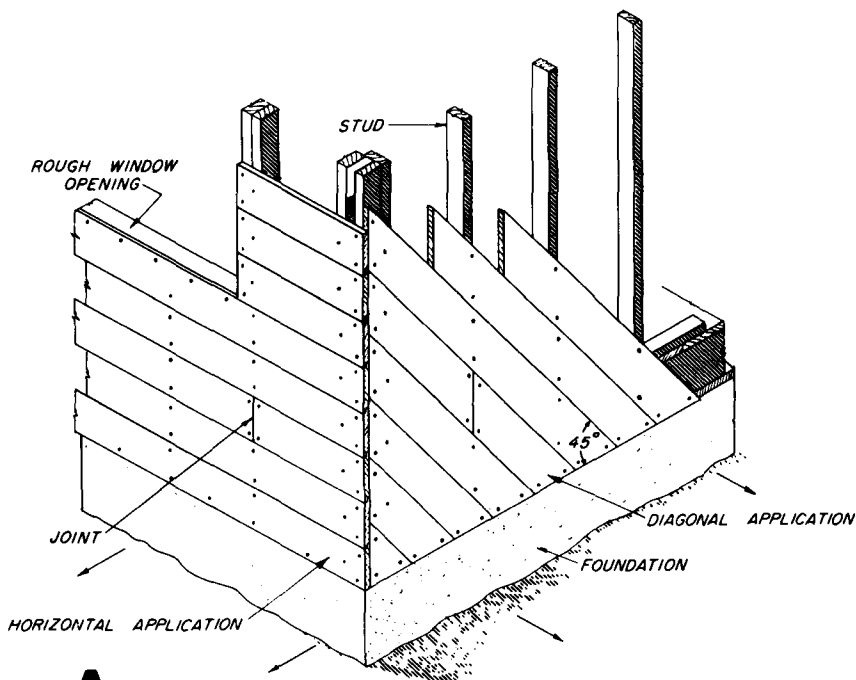
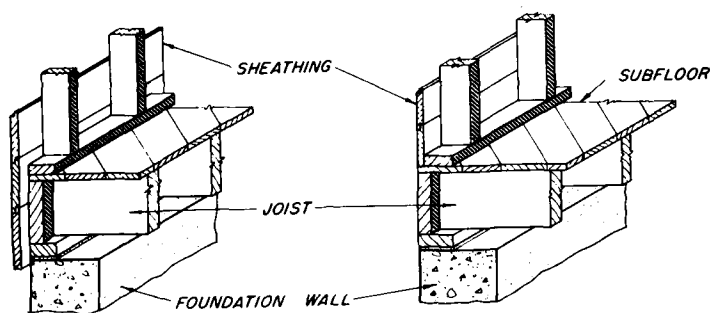
**A****B****C**

FIGURE 46.—Lumber sheathing application. A, Horizontal and diagonal; B, started at foundation wall; C, started at subfloor.

A space at least $\frac{1}{8}$ -inch wide should be left between the sheets to permit expansion without buckling. The panels are nailed to the framing members at 6 inches on center along the edges and 12 inches along the intermediate supports (Fig. 47).

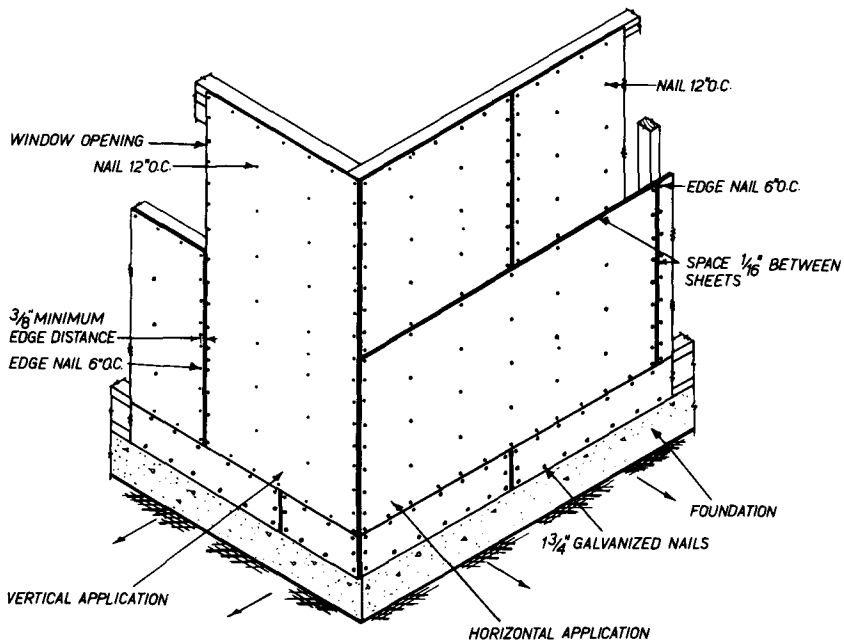


FIGURE 47.—Vertical and horizontal application of panel-type sheathing.

There are two methods of installing sheathing at the foundation sill. Either the sheathing is carried over the floor framing, (Fig. 46B) or it is started at the subfloor (Fig. 46C). The first method gives an additional tie between the wall framing and sill plate and is commonly used.

Wall Sheathing Paper

Sheathing paper should be water-resistant but not vapor-resistant. One layer of sheathing paper is generally used over wall sheathing and may be applied horizontally or vertically with 4-inch laps at the joints. At horizontal joints, and also over horizontal flashing, lap the upper sheet over the lower sheet to direct moisture outwards. At openings the edge of the paper is returned around the framing members and stapled in place.

Where wall sheathing is not used, two layers of sheathing paper are needed unless a large panel siding such as plywood is used. Both layers are applied vertically, with the joints lapped 4 inches at the studs. Both layers are stapled to the framing members, the top layer with staples spaced every 3 inches along the edges of the sheet to hold it securely in place.

ROOF SHEATHING

Roof sheathing is applied over the rafters or roof joists and usually consists of lumber, plywood panels or particle-board panels. Sheathing provides a nailing base for the roof covering and increases the rigidity of the roof framing.

Installation of Roof Sheathing

Under materials requiring solid and continuous support, such as asphalt shingles and built-up roofing, lumber sheathing must be laid closed (Fig. 48B). The boards are usually $\frac{3}{4}$ -inch thick but this thick-

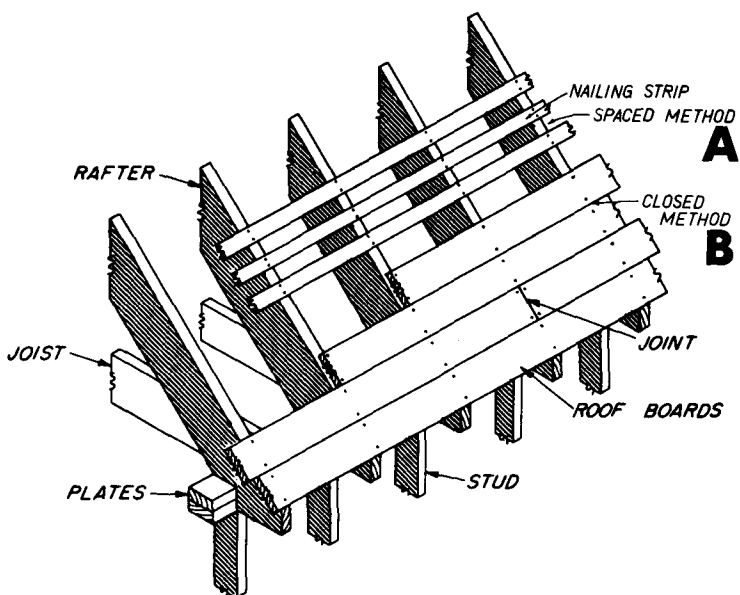


FIGURE 48.—Installation of wood-board roof sheathing. A, Spaced methods; B, closed method.

ness may be reduced to $1\frac{1}{16}$ -inch where supports are spaced at 16 inches on center. Boards 8 inches or less in width are nailed to the framing members with two nails per bearing. Those wider than 8 inches should be nailed with three nails per bearing. Boards wider than 12 inches should not be used for roof sheathing. For a wood-shingle roof, the roof boards may be spaced the same distance apart on center as the shingles are to be laid to the weather. This method (Fig. 48A), commonly used in damp climates, permits freer movement of air around the boards and under the shingles thus reducing the possibility of decay.

When plywood is used for roof sheathing it should be laid with the face grain at right angles to the rafters or roof joists (Fig. 49). Sheathing-grade (unsanded) plywood is ordinarily used for this purpose.

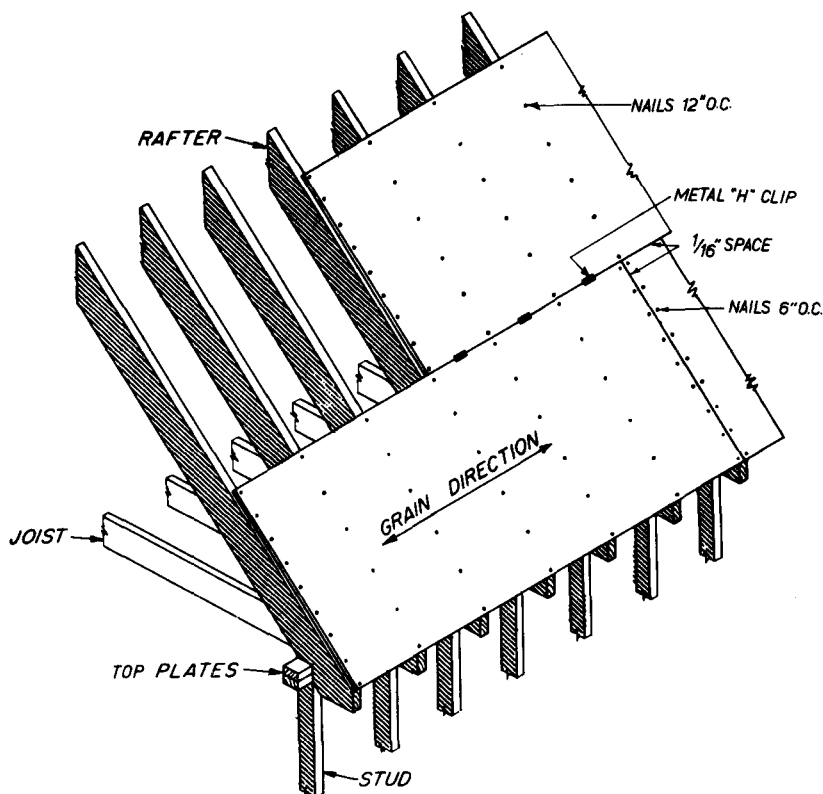


FIGURE 49.—Application of plywood roof sheathing.

To obtain a good tie across the roof framing the end joints of the panels should be staggered on the framing members. Separate the butting edges of the panels by at least $\frac{1}{16}$ -inch to prevent buckling when minor expansion occurs.

The thickness of plywood or particle board to use for roof sheathing depends to some extent on the spacing of the rafters or roof joists. To prevent damage to roof covering when thinner plywood is used, the joints running parallel to the face of the plywood should be supported by 2- by 2-inch blocking nailed securely between the roof framing members or by metal H-clips inserted between sheets. The latter method is widely used as the installation is simple and economical. Minimum thicknesses for plywood and particle roof sheathing are shown in Table 8.

Roof-Sheathing Details

Where chimney openings occur in the roof structure the roof sheathing should have a clearance of $\frac{1}{2}$ -inch from the finished masonry on all sides (Fig. 50). Framing members should have a 2-inch clearance

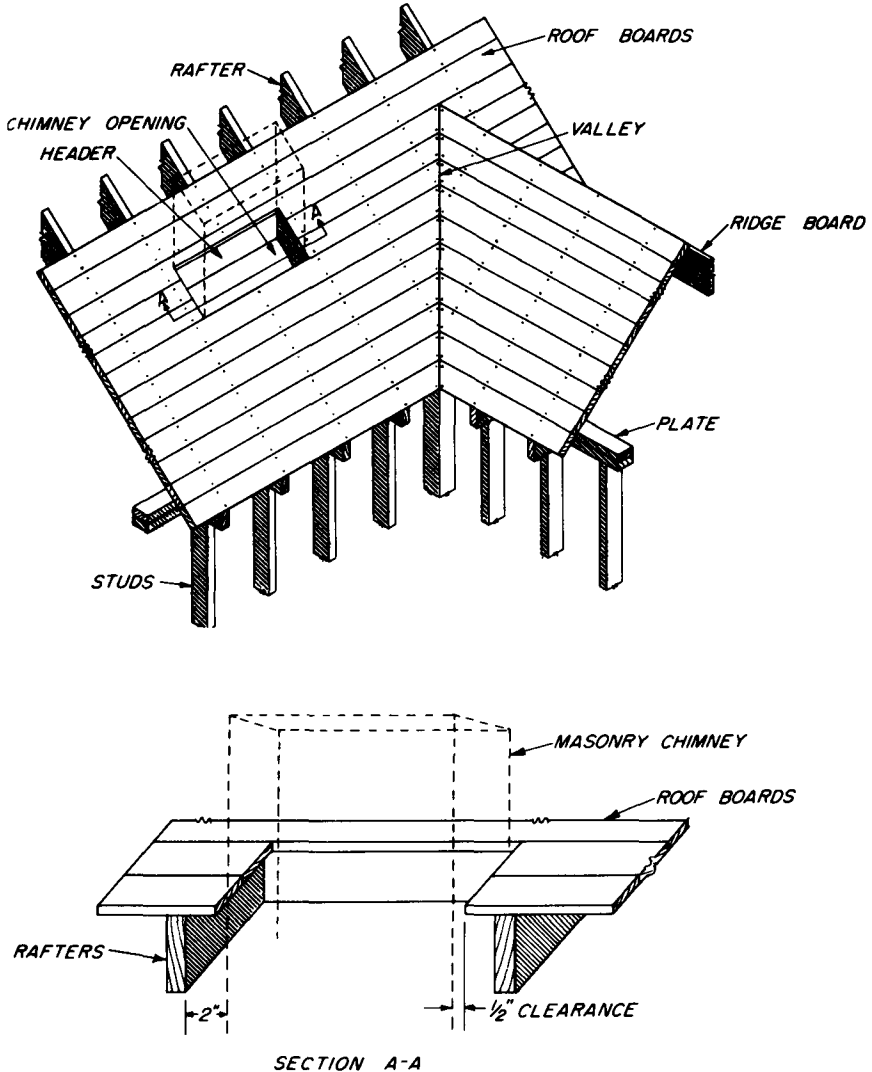


FIGURE 50.—Roof sheathing detail at a valley and at a chimney opening. Section A-A shows clearance from masonry chimney.

for fire protection. Sheathing should be securely nailed to the rafter and to the headers around the opening.

Roof sheathing at valleys and hips should be fitted to give a tight joint and should be securely nailed to the valley or hip rafter (Fig. 50). This will give a solid and smooth base for the flashing.

ROOF COVERING

Roof coverings should provide a long-lived, waterproof finish that will protect the building and its contents from rain and snow. Many materials have withstood the test of time and have proven satisfactory under various service conditions.

Asphalt shingles are most generally used for pitched roofs. Wood and asbestos shingles, hand-split shakes, tile and slate are also used. Sheet materials such as roll roofing, galvanized steel, aluminum, copper and tin are sometimes used. For flat or low-pitched roofs, built-up roofing with a gravel topping or cap sheet is frequently used. The choice of materials may be influenced by cost, local code requirements or local preferences based upon past experience.

In shingle application, the exposure distance is important and the exposure depends on the roof slope and the type and length of shingle used. The minimum slope on roofs is 2 in 12 for asphalt shingles (using a low slope application), 3 in 12 for wood shingles and 4 in 12 for asphalt shingles (using normal application), hand-split shakes and asbestos cement shingles. Built-up roof coverings are rarely used on roofs where the slope exceeds 3 in 12.

In order to avoid water damage, caused by melting snow which sometimes forms into ice dams at the eaves, shingle or shake-covered roofs should have additional protection when the overhang is less than 3 feet long. This protection usually consists either of 45-pound roll roofing laid with the joints lapped at least 4 inches and cemented together or by a continuous sheet of 6-mil polyethylene (Fig. 51). Placed over the eaves on the roof sheathing, this protective sheet extends from the edge of the roof to a line at least 12 inches inside the inner face of the exterior walls, thus providing a water-tight capping over the affected area.

Methods of flashing shingled roofs at valleys, chimneys and intersecting walls are described under "Flashing" on page 121.

Installation of Asphalt Shingles on Slopes 4 in 12 or Greater

The minimum recommended weight for asphalt strip shingles is the nominal 210-pound shingles. Square-butt strip shingles are usually 12-by-36 inches in size, have three tabs and should be laid with 5 inches of their width exposed to the weather. Since there are approximately 27 strips in a bundle, three bundles will cover about 100 square feet. Bundles should be piled flat for storage so that strips will not curl when

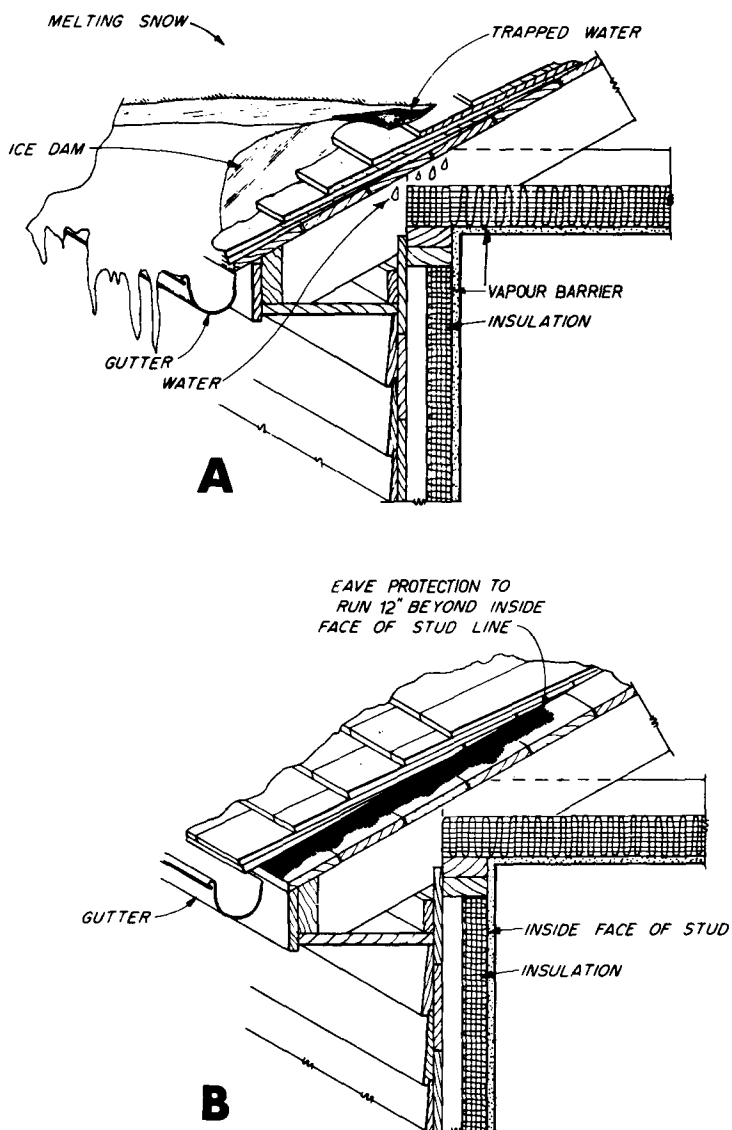


FIGURE 51.—A, Snow and ice dams. Ice dams often build up on the overhang of roofs and in gutters, causing water from melting snow to back up under shingles at the eaves; B, eave protection prevents water trapped by ice dams from entering the roof.

the bundles are opened for use. The method of laying an asphalt-shingle roof is shown in Figure 52.

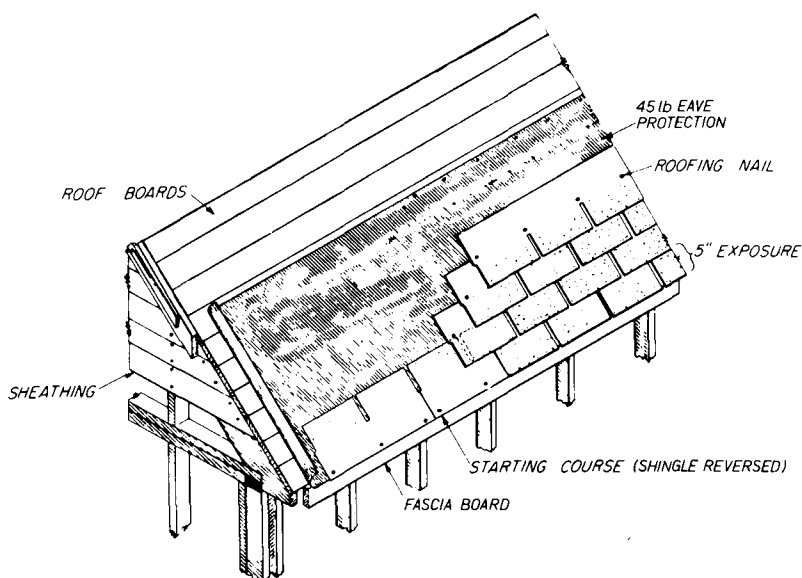


FIGURE 52.—Application of asphalt shingles.

Eave protection is provided by the method already described. A starter strip at least 12 inches wide is placed along the eaves under the first course of shingles, so that it extends at least $\frac{1}{2}$ -inch beyond the eaves and rake to form a drip edge. This projection prevents water from backing up under the shingles. A shingle strip laid with the tabs facing up the roof slope is generally used for this purpose. Mineral surfaced 85-pound roll roofing may be used as a starter strip and when continued up the roof slope will also serve as eave protection. The starter strip is nailed along the bottom edge at 12-inch intervals. The first course of shingles is then laid with the butt edge in line with the bottom of the starter strip.

Several chalklines will help align the shingle courses so that tabs and tab notches will be in a straight line for good appearance. Each shingle strip should be nailed with four 1-inch large-headed roofing nails. Good nailing is important. When a nail penetrates a crack or a knothole, another nail should be driven alongside into sound wood. Cementing the tabs of strip shingles is recommended for areas subject to high winds. Plastic cement can be used for this purpose with a spot, 1-inch or so in diameter, being placed under the center of each tab. Some shingles are manufactured with an adhesive strip on the underside of the tabs. Interlocking and other special shingles should be laid according to the manufacturer's directions.

Installation of Asphalt Shingles on Slopes of less than 4 in 12

Additional precautions must be taken on low slopes to ensure a waterproof roof covering. Except for the first two courses, three thick-

nesses of shingles are used on the entire roof including hips and ridges. This is achieved by using an exposure height of not more than one-third the full height of the shingle. A starter strip is first installed as described for the higher-sloped roofs. The first course of shingles is then cemented to the strip with a continuous band of cement that is 4 inches wider than the shingle exposure (e.g. use a 10-inch band when exposure is 6 inches). The succeeding courses of shingles are laid in a band of cement 2 inches wider than the shingle exposure (e.g. use an 8-inch band when exposure is 6 inches).

To avoid defacing the exposed surface of the shingles with cement, the band is located 1 inch above the butt edge of each succeeding course of shingles. Nail each shingle strip in place with four nails. Since all shingles are cemented together by continuous bands of cement no additional eave protection is required.

If cold application cement is used it should be applied at the rate of one gallon for each 100 square feet of cemented area. Hot application cement is applied at the rate of twenty pounds for each 100 square feet.

Installation of Wood Shingles

Wood shingles commonly used for houses are No. 1 and No. 2 grade. Western red cedar is the principal species of wood used for shingles, as its heartwood has high decay resistance and low shrinkage. Width of shingles as supplied varies but maximum width is 14 inches.

Figure 53 illustrates the proper method of laying a wood-shingle

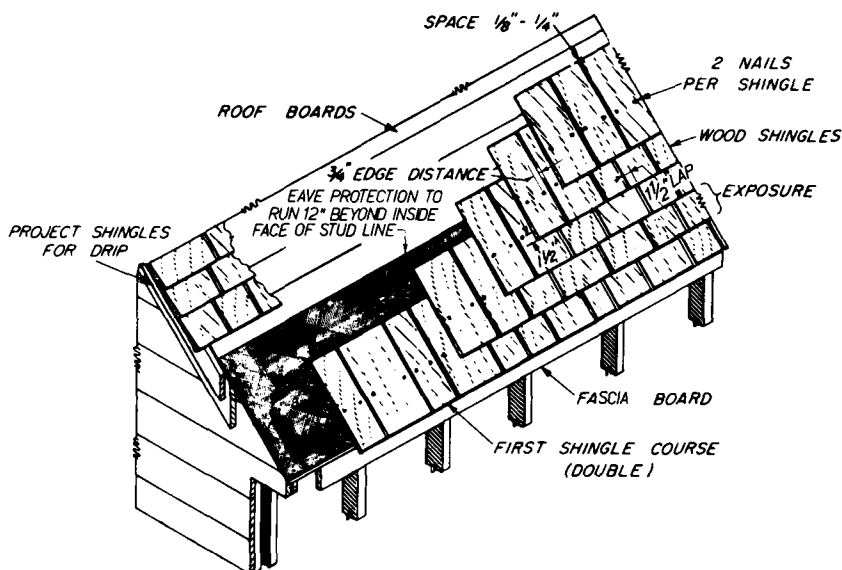


FIGURE 53.—Installation of wood shingles.

roof. Underlay or roofing felt is not usually required for wood shingles; but eave protection, as described previously, is installed. Maximum exposure for wood shingles is shown in Table 9.

The first shingle course should be laid double with the upper shingles overlapping the joints in the course beneath and both rows extending about 1-inch beyond the fascia boards at the eaves. This precaution will prevent water from backing up underneath the shingles. Shingles should be laid $\frac{1}{8}$ - to $\frac{1}{4}$ -inch apart to allow for swelling when wet, with the wider ones being the greater distance apart. The joints between shingles in one course should be overlapped at least $1\frac{1}{2}$ -inches by the shingles in the course above. The joints in succeeding courses should be spaced so that the joint in one course is not in line with the joints in the two previous courses laid.

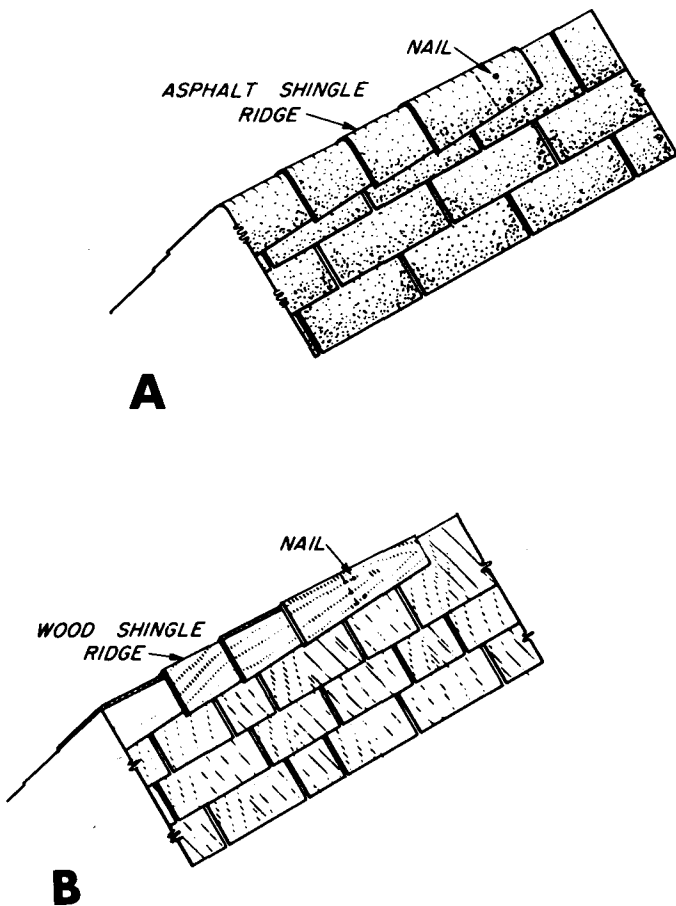


FIGURE 54.—Finish at ridge and hips. A, Asphalt shingles; B, wood shingles.

Only two nails should be used for each shingle. The distance of the nails from the butt edge of the shingle being nailed should be shingle exposure plus $1\frac{1}{2}$ -inches, with an edge distance of about $\frac{3}{4}$ - of an inch. For example, if the shingle exposure is to be 5 inches, add the $1\frac{1}{2}$ -inches, and thus the nail would be $6\frac{1}{2}$ -inches from the butt edge of the shingle being nailed. Shingles are fastened with 14-gauge galvanized or other corrosion-resistant shingle nails. Shingles wider than 8 inches are sometimes split and nailed as 2 shingles.

Finish at Ridge and Hips

The most common type of finish is shown in Figure 54A. Asphalt shingle squares (one-third of a strip) are used over the ridge or hip and blind-nailed. Each shingle is lapped to provide the same coverage as the roofing shingles.

In the case of wood shingles, 6-inch wide shingles are alternatively lapped and blind-nailed (Fig. 54B). Flashing is sometimes used under a wood-shingle ridge.

Built-Up Roofs

Built-up roof coverings are installed by roofing firms that specialize in this work. Roofs of this type may have three or more layers of roofing felts, each mopped down with tar or asphalt, the final surface being coated with the same material. It is then covered with gravel embedded in the asphalt or tar or with a cap sheet. Material combinations for built-up roofs are shown in Table 10.

The eave line of projecting roofs is usually finished with metal edging or flashing. A gravel stop or cant strip is used in conjunction with the flashing at the eaves when the roof is covered with gravel (Fig. 55A). Where built-up roofing is finished against another wall, (except masonry-clad walls) the roofing is mopped to the cant strip and turned up the wall at least 6 inches. The wall-sheathing paper and siding is then applied over the roof membrane (Fig. 55B).

Where a built-up roof intersects a masonry-clad wall, the roof membrane is similarly installed up the face of the masonry. Counter flashing

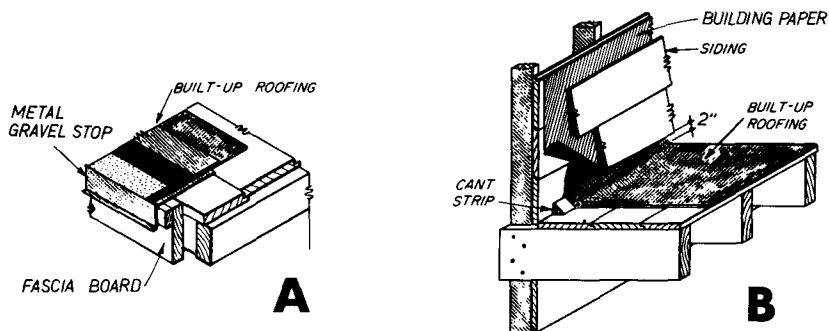


FIGURE 55.—Built-up roof. A, Eave flashing and drip; B, junction of built-up roof and wall covered with siding.

is then added. This flashing should be embedded in the mortar joints at least 1 inch, and extend down the wall about 6 inches, lapping over the roof membrane at least 4 inches.

Sheet Metal Roofing

Sheet metal roofing is available in sheet or shingle form and in a variety of designs. It should be installed in accordance with the manufacturer's recommendations. One layer of sheathing paper or asbestos paper is used between the roofing and sheathing.

BASEMENT FLOORS

Basement floors are usually installed after the roof cover is in place, sewer and water lines installed and the basement floor drain located. Concrete while curing gives off moisture which can seriously affect finish flooring or millwork. Therefore basement floors should be placed before finish flooring or millwork goes in and the basement should be ventilated to allow moisture to escape.

Basement floor slabs should be at least 3 inches thick and sloped towards the floor drain. At least one floor drain should be used and located near the laundry area.

A 5-inch layer of coarse granular fill such as gravel or crushed stone is generally laid under the floor slab to restrict the passage of moisture by wick action from the ground up to the slab. A vapor barrier as described on page 18 is sometimes used instead of the granular base or together with the base to damp-proof the floor; this additional precaution is especially desirable when a finish floor will later be attached to the slab by an adhesive.

EXTERIOR TRIM AND MILLWORK

Exterior trim (that part of the exterior finish other than the wall covering) includes such items as window and door trim, soffits, rake or gable trim and fascia. Much of this material is cut, fitted and nailed in place on the job. Other material or assemblies, such as louvers and shutters are usually shop manufactured.

The properties desired in materials used for trim are good painting and weathering characteristics, easy working qualities and maximum freedom from warp. Sealing the end joints or miters of members exposed to moisture is recommended.

Fastenings used for trim, whether nails or screws, should be rust-resistant, i.e. galvanized or aluminum. When finishing nails are used, they must be set and then puttied after the prime coat of paint. This method of fastening will generally prevent rust stains at nailheads.

Eave Projections

The eave over-hang gives some protection to the side wall and forms a connection between the roof and wall. Soffits are usually closed in with ¼-inch sanded plywood nailed at 6 inches on center along the edges and 12 inches at intermediate supports. The exterior finish is then butted up to the underside of the soffit. A fascia board added as a

finished covering for the rafter header usually extends $\frac{1}{2}$ -inch below the soffit covering to form a drip edge. The three general types of eave construction are shown in Figure 56.

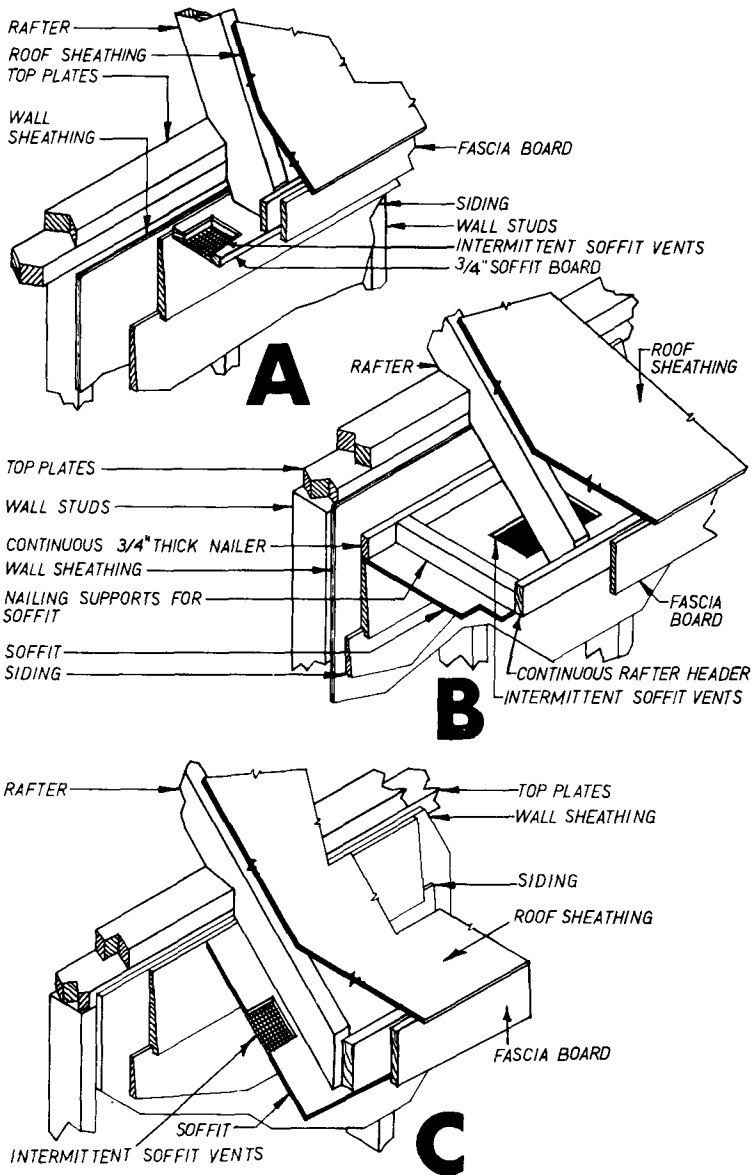


FIGURE 56.—Roof projection at eaves. A, Narrow eave projection; B, wide eave projection with horizontal soffit; C, wide eave projection with sloped soffit.

A narrow eave projection (Fig. 56A) is sometimes used with roofs having a steep slope. Here the rafters are projected a short distance over the wall plate and the ends are cut to suit the angle required for the rafter header and soffit covering. The soffit covering is nailed to the angled surface of the rafter. Since the soffit covering is usually less than 6 inches wide, a $\frac{3}{4}$ -inch board is generally used for this purpose, as the board does not require support along its edges.

When wider eave projections are used with a horizontal soffit, blocking is installed to support the soffit covering (Fig. 56B). A $\frac{3}{4}$ -inch nailing strip is placed on top of the sheathing along the wall and nailed to the framing. This strip provides support for the inner ends of the blocking and edges of the soffit covering. The blocking, which may consist of 2- by 2-inch material, is usually spaced at 24 inches on center. It is toenailed to the nailing strip and end-nailed to the rafter header. The soffit covering and fascia board are then nailed in place.

Where the blocking provides partial support for the roof overhang (Fig. 43) 2- by 4-inch material is used instead of 2- by 2-inch. The members are securely nailed to the side of each rafter and butted against a 2- by 4-inch nailing strip placed along the wall over the sheathing. This type of support is usually confined to overhangs of not more than 4 feet.

Sloped soffits which follow the line of the projected rafter (Fig. 56C) are sometimes used instead of horizontal soffits. In this case the soffit covering is nailed to the underside of the rafter, the outer edge of the soffit covering is nailed to the rafter header and the inner edge to 2- by 2-inch blocking placed between the rafters.

Gable-End Projections

Construction of roof projections commonly used at the gable ends are shown in Figures 57 and 58. As with eave projections the soffit is usually covered with $\frac{1}{4}$ -inch sanded plywood and fascia board is added to the outside framing member.

Roofs which project less than 16 inches over the gable-end wall usually terminate with a framing member sometimes called the rake rafter (Fig. 57). A $\frac{3}{4}$ -inch nailing strip is fastened to the rafter located above the gable-end wall. Blocking spaced at 24 inches on center is used to support the soffit covering. This blocking is toenailed to the nailing strip and end-nailed to the rake-rafter. The soffit covering is then installed and nailed to these supports. A fascia board is added in the manner previously described.

Gable-end projections extending more than 16 inches beyond the wall are usually supported by framing members called "lookouts" (Fig. 58). The gable-end studs are placed with the narrow face parallel to the sheathing and a top wall plate is added. The lookout members, usually the same size as the rafters, are spaced at 24 inches on center. The

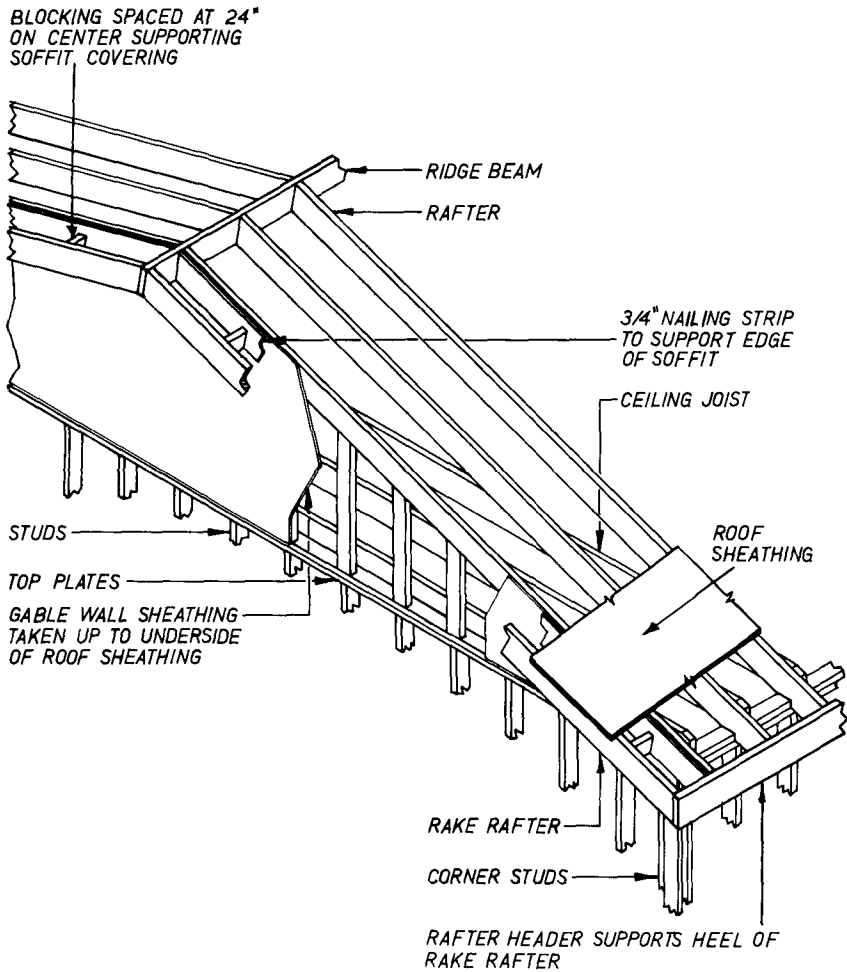


FIGURE 57.—Narrow projection at gable-end. Rake rafter supported by ridge beam, rafter header, blocking and roof sheathing.

ends are supported by end-nailing to the first rafter and to the header, and toenailing to the wall plate. Blocking is then fitted between the lookouts at the wall line to support the roof sheathing and inner edge of the soffit covering. The soffit covering is nailed to these supports and a fascia is added as previously described. The length of the lookout members should be about twice the width of the roof overhang. A double rafter is used to support the inner ends of the lookout members when they project into the roof more than one rafter spacing.

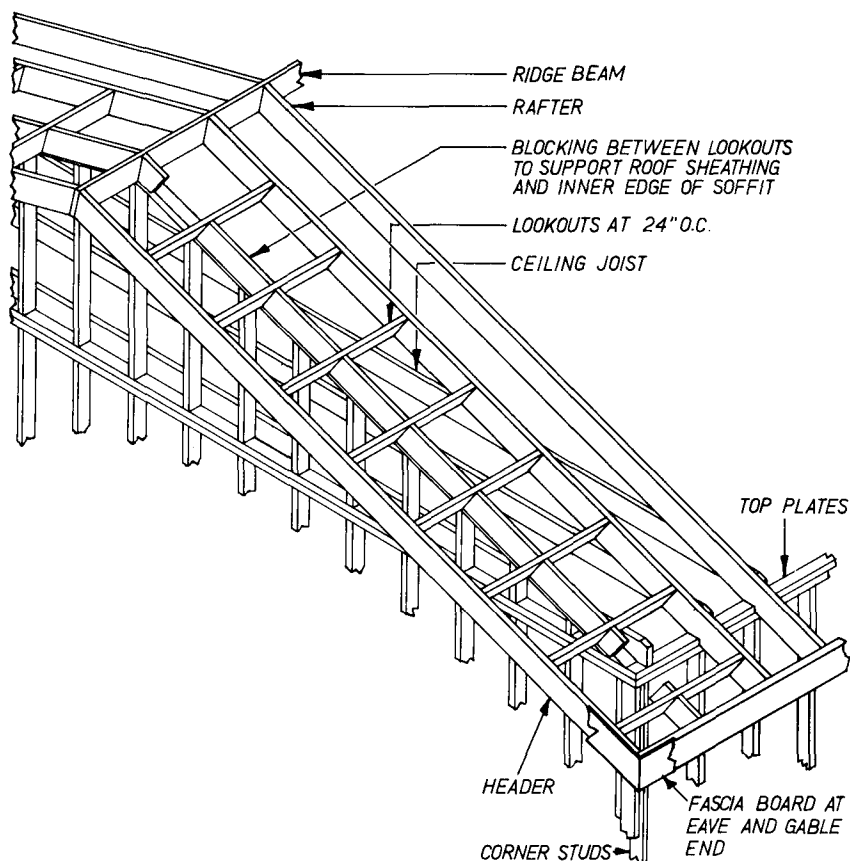


FIGURE 58.—Wide projection at gable-end supported by "look-out" rafters.

Eave and Gable-End Intersections

Eave and gable-end intersections depend largely on how the eave projection is finished. Figure 59 shows three types of intersections commonly used.

Where a sloped soffit is used at the eave projection, the soffit of the gable-end projection is carried through on the same plane as the eave soffit (Fig. 59B).

Where a horizontal soffit is used at the eave projection, the eave soffit may be carried through to the rake rafter (Fig. 59C). In this case the soffit of the gable-end projection is terminated at the side wall and returned down to intersect the eave soffit. The fascia board at the gable

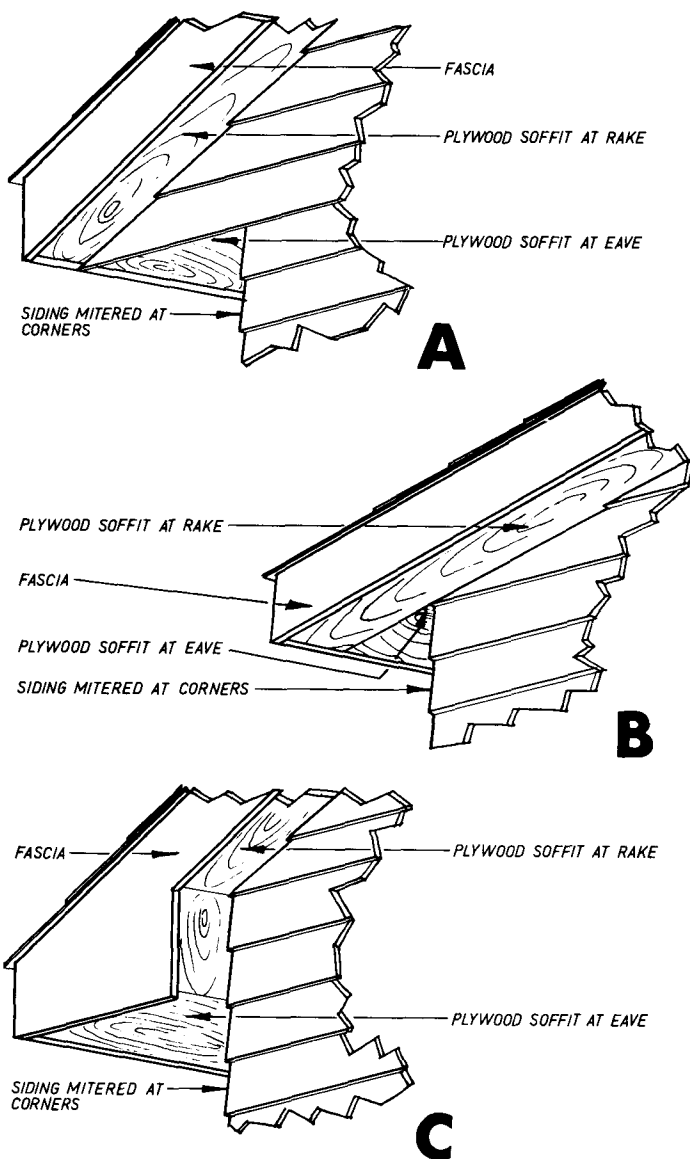


FIGURE 59.—Eave and gable-end intersections. A, Eave soffit is terminated at the wall line and gable-end soffit is continued to the fascia board at the eave; B, eave soffit is sloped on same plane as gable-end soffit; C, eave soffit carried out to rake rafter and gable-end soffit is returned down to meet the eave soffit.

end is increased in width at the eave to close in the end of the cave soffit.

Another type of intersection sometimes used with a horizontal eave soffit (Fig. 59A) has the eave soffit terminating at the side wall. The gable-end sheathing and siding is continued out to the edge of the eaves and serves as a covering for the end of the soffit. The gable-end soffit is carried down beyond the side wall and terminates at the eave.

Window Frames and Sash

Windows are used in a house principally to provide light and air, but they are also an important part of the architectural design. The glass area provided is usually at least 10 per cent of the floor area of the room being served. Windows are available in many types, each having its own advantages. The principal opening types are vertical sliding, horizontal sliding, casement and awning and these may be of wood, metal, or plastic.

Factory-sealed double-glazing made of spaced sheets of glass is available for insertion in window sash or frames. Double glazing consisting of one sheet of glass fixed in the sash and one removable sheet is also used. Both types of double-glazing insulate better than single-glazing and are less subject to condensation problems. Window units consisting of an inner and outer sash also give similar insulating values.

Since it is not practical to obtain an airtight fit where the sash contacts the frame, weatherstripping is often used at these points to reduce air infiltration. Many manufacturers make complete window units with sash fitted and glazed, with weatherstripping, operating balances and hardware installed. Units combining screens and storm sash are also available.

Wood window sash and frames should be treated to resist decay. This treatment ensures a longer life to the exposed parts and covered joints.

The exterior trim is usually added to the window frame before it is placed in the opening. To provide space for adjustment, the framework around the opening is usually slightly larger than the window. Wedges are used to adjust the frame in the opening and when in position the window frame is nailed through the wedges to the wall framing. The exterior trim is also nailed to the studs and lintel. The space around the window frame is later filled with insulation. Figure 60 shows a typical window frame installation.

Exterior Door Frames and Doors

Exterior door frames generally consist of 1 $\frac{3}{8}$ -inch thick side and head jambs and a 1 $\frac{3}{4}$ -inch sill. While a hardwood sill is more durable, a sill made of softwood with a metal threshold may also be used. Frames are rabbetted to form stops for the main door. Stops for the screen or combination door are provided by the edge of the jamb and the exterior trim.

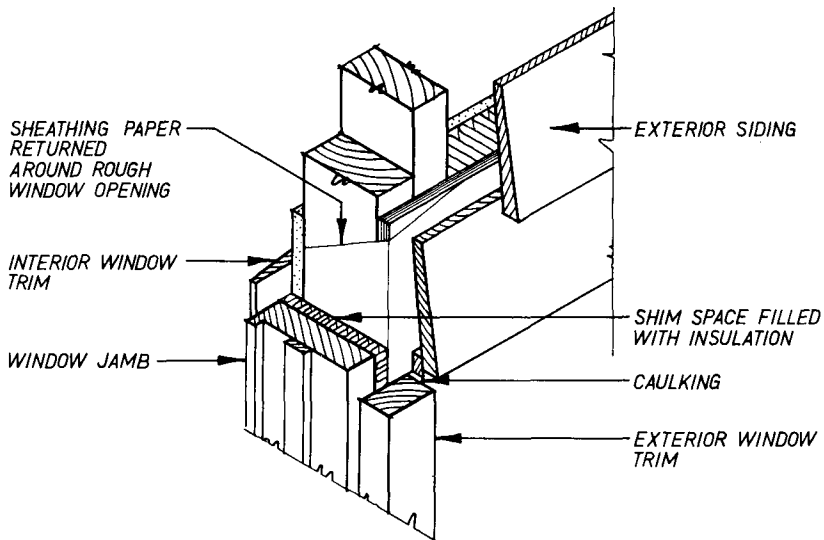


FIGURE 60.—Section through window frame at jamb.

The door sill should bear solidly on the floor framing (Fig. 61) and the frame should be well nailed to the opening framework. This is usually done by nailing through the frame and trim into the studs, using wedges, in the same way as described for window frames. Main doors should be weather-stripped at the top, bottom and sides.

Main doors should not be less than $1\frac{3}{4}$ -inches thick. They should be at least 2 feet 8 inches wide and 6 feet 8 inches in height. Wood storm doors should be $1\frac{3}{8}$ -inches thick and metal doors at least 1 inch thick.

Exterior doors are generally of the flush type or panel type. For methods of hanging doors and installing hardware see page 110.

Flush doors are made with plywood or other suitable facings applied over a light framework and core. A core built of solid pieces of wood is called a solid core; a core built as a grillage is called a hollow core. Solid-core construction is generally preferred for exterior doors particularly in cold climates because this method of construction minimizes warping from differences in humidity or temperature on opposite sides of the door. Glazed panels may be inserted in solid-core doors.

Panel doors consist of stiles (solid vertical members), rails (solid cross members), and panels (thinner parts filling these spaces between stiles and rails). Many types with various wood or glass panels are available.

Sliding doors, either fully or partially glazed, are sometimes used for access to patios or garden areas.

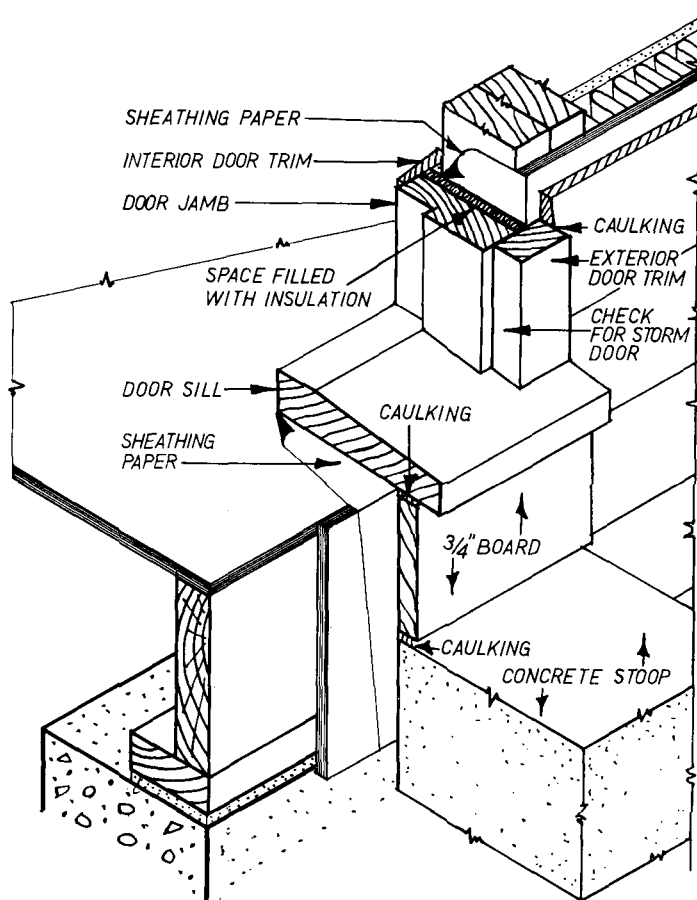


FIGURE 61.—Section through door frame at sill.

EXTERIOR SIDING AND STUCCO

Because the type of exterior covering used on the walls will greatly affect the appearance of the house and the cost of maintenance, it should be selected with care. Common types of cladding used are; lumber siding in various patterns, wood shingles and shakes, asbestos-cement shingles and sheets, plywood, hardpressed fiberboard, stucco, aluminum and steel. Siding which may be affected by moisture, such as lumber, plywood, hard-pressed fiberboard and stucco, should be kept at least 8 inches from the ground and 2 inches from an adjoining roof surface. Methods of flashing over window and door openings and between different types of wall covering are described under "Flashing" on pages 121, 122.

Lumber Siding

Lumber siding should be sound, free of knot holes, loose knots, checks or splits. Easy working qualities and freedom from warp are desirable features. The species most commonly used are the cedars, pines and redwood. The moisture content of the siding at the time of application should be the same as it will experience in service, i.e. about 12 to 18 per cent, depending upon the climate.

Horizontal Application. — Bevel or feather edge siding (Fig. 62A) generally starts with the bottom course of boards blocked out as shown

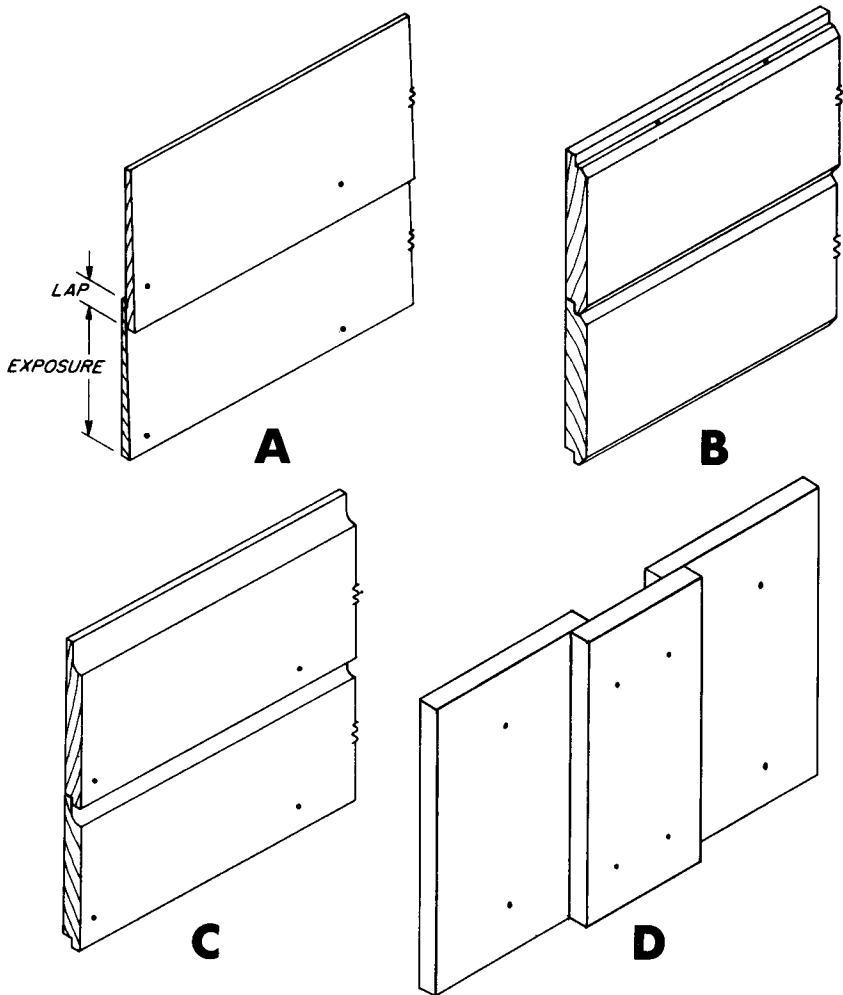


FIGURE 62.—Types of wood siding. A, Bevel; B, tongue and groove with V-joint; C, drop siding; D, board-on-board.

in Figure 63B. A $\frac{1}{4}$ -inch thick furring strip is used for this purpose. Each succeeding course overlaps the upper edge of the lower course, the minimum lap being usually 1 inch. Spacing for the siding should be carefully laid out before the first board is applied. To determine the maximum board spacing (or exposure) deduct the minimum lap from the overall width of the siding. The number of board spaces between the soffit and the bottom of the first course at the foundation wall should be such that the maximum exposure will not be exceeded. This may mean that the boards will have less than the maximum exposure. Where possible, the bottom of the board that is placed over the top of the windows should coincide with the top of the window cap (Fig. 63A).

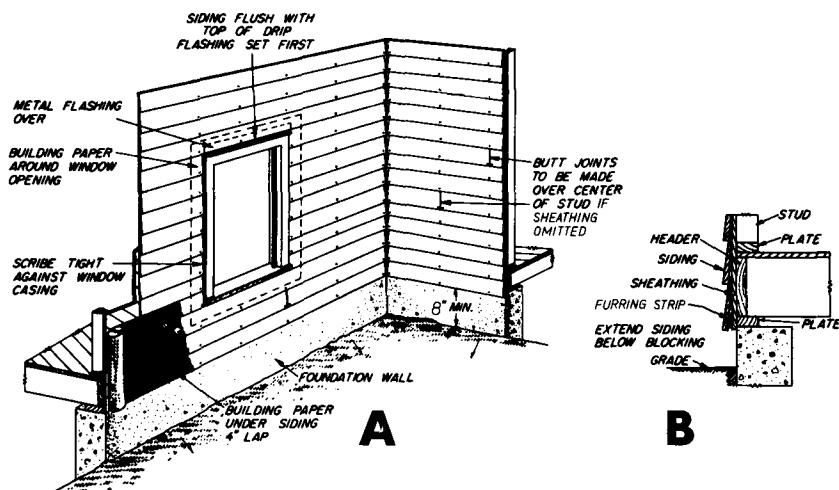


FIGURE 63.—Installation of siding. A, Method of application; B, starting course.

Bevel siding should have a butt thickness of at least $1\frac{5}{32}$ -inch for 4-, 5-, 6-, and 8-inch widths and $\frac{9}{16}$ -inch for 10- and 12-inch widths. The top edge should not be less than $\frac{3}{16}$ -inch thick.

Drop siding should be at least $\frac{9}{16}$ -inch thick and 8 inches or less in width. It comes in a variety of patterns with matched or shiplap edges. Figure 62C shows a common pattern of drop siding.

Where bevel or drop siding is used, the butt joints between boards in adjacent courses should be staggered as much as possible. Butt joints must always be made on a stud unless lumber sheathing is used. The siding should be carefully fitted and be in close contact with other members and adjacent pieces. Ends should be sealed. Loose-fitting joints allow water to get behind the siding which can cause paint deterioration around the joints and lead to decay at the ends of the boards. One method sometimes used to obtain a tight joint is to place a small bead of caulking compound or putty along the end of each board after it is nailed and press the next board into the compound. The excess compound is then struck off leaving a smooth waterproof

joint. Joints occurring elsewhere, such as at window or door trim, can be similarly treated.

Bevel and drop siding should be face-nailed to lumber sheathing or studs, the size of the nail depending on the thickness of the siding and the type of sheathing used. One method of nailing often used is to drive the nail through the siding just above the lap so that the nail misses the top edge of the piece of siding beneath. This method permits each siding board to expand and contract as the moisture content changes. Thus there is less tendency for the boards to split as may occur when both edges of the board are nailed. Since the amount of swelling or shrinking is proportional to the width of the wood siding, nailing above the lap is more important with wide boards than with narrow boards.

Vertical Application. — Lumber siding that can be applied vertically includes; plain matched boards, patterned matched boards, square-edge boards covered at the joints with a batten strip or square-edge boards spaced apart and covered with another board. Vertical siding is usually $\frac{3}{4}$ -inch thick, although $\frac{9}{16}$ -inch thickness is sometimes used. Boards should not be wider than 12 inches. Vertical boards may be fastened to lumber sheathing, 2- by 2-inch blocking fitted between the studs or to horizontal furring strips. Butt joints are mitered to prevent the entry of water into the joint.

When the spaced method (sometimes called "board-on-board") is used (Fig. 62D), the boards next to the wall are normally wider than the top boards and are fastened with one row of nails near the center of each board. The top board is then applied so that it laps the edges of the first board at least 1 inch. These top boards are fastened with two rows of nails driven slightly outside the edges of the boards underneath. This method of nailing permits the wider boards to expand and contract without splitting.

The board and batten method uses square-edge boards which are ordinarily 8 inches or less in width. The boards are applied with the edges at least $\frac{1}{4}$ -inch apart and fastened with one row of nails near the center of each board. To cover the joint a narrow batten is used which laps the edges at least $\frac{3}{4}$ -inch. This batten is fastened with one row of nails driven in the joint between the two boards, so that the boards may swell or shrink without splitting either the boards or the batten strip. Since the batten also serves to prevent the board edges from curling outwards, the nailing should be secure and closely spaced.

Tongue-and-groove matched siding (Fig. 62B) is commonly 8 inches or less in width. The first board is face-nailed near the grooved edge and angle-nailed through the tongue. Each successive board is driven in closely and angle-nailed through the tongue. A nail set is used to finish off the nailing.

Nails cost little compared with the cost of the siding and labor, but the use of good nails is important. It is poor economy to buy siding that will last for years and then fasten it with nails that will rust badly

within a short period. Corrosion-resistant nails such as galvanized nails will hold the siding permanently and will not disfigure the paint surface. Casing or siding nails are normally used for this purpose. Heads are driven flush with the face of the siding and later covered with paint. If finishing nails are used the heads should be set below the surface and the hole filled with putty after the prime coat of paint is applied. The length of the nails depends on the thickness of the siding and the type of sheathing used. Nails should be long enough to penetrate at least $\frac{3}{4}$ -inch into the nailing support.

Plywood Siding

Exterior type plywood is also used as a wall covering. The plywood sheets are made with a plain or grooved surface and are usually applied vertically. The joints may be V-grooved or flush or may be covered with a molded batten. Plywood sheets are sometimes cut into strips 12 or 16 inches wide and installed horizontally as lap siding. Plywood is available with a resin-impregnated kraft paper laminated to the face. This provides a smooth, moisture-resistant surface which resists checking or splitting after painting.

The minimum thickness of plywood applied to sheathing is $\frac{1}{4}$ -inch. It may also be applied directly to unsheathed wall framing, in which case the minimum thickness used is $\frac{3}{8}$ -inch for stud spacings of 16-inch centers and $\frac{1}{2}$ -inch for 24-inch centers.

When plywood is applied horizontally as lap siding the minimum thickness used is generally $\frac{3}{8}$ -inch. Bevelled strips 2 inches wide should be provided behind each vertical joint and at corners. Wood shingles broken into strips are often used for this purpose.

After cutting and fitting the plywood panels or strips, all edges should be protected with a sealer before installation. A $\frac{1}{16}$ -inch space between the sides and ends of the panels and the butted ends of the strips will permit expansion without bulging. Vertical joints are filled with caulking or covered with a batten. Horizontal joints are flashed or lapped at least 1 inch.

The edges of plywood panels should be supported and fastened with corrosion-resistant nails, which are usually 2 inches long. The nails are spaced 6 inches along the edges and 12 inches at intermediate supports. Corrosion-resistant nails should also be used when the plywood is applied in strips.

Hard-Pressed Fiberboard Siding

Hard-pressed fiberboard is produced in sheets and may be applied over sheathing or to unsheathed walls. As with plywood, it may be installed in panels or cut in strips and applied in the form of lap siding. The minimum thickness should be at least $\frac{1}{4}$ -inch when applied over sheathing and $\frac{5}{16}$ -inch if applied without sheathing on supports that are not more than 16 inches on center. It is fastened to the framing member or to lumber sheathing with corrosion-resistant nails at least

2 inches long. Nails are spaced 4 inches along the edges and 8 inches along intermediate supports.

Hard-pressed fiberboard is installed in the same way as plywood.

Asbestos-Cement Sheet Siding

Asbestos-cement sheets are usually applied in panel form. The minimum thickness used over sheathing is $\frac{1}{8}$ -inch. When the panels are applied directly to the studs $\frac{3}{16}$ -inch is used on supports spaced 16 inches on center and $\frac{1}{4}$ -inch for stud spacings up to 24 inches on center. Methods of installation and nailing are the same as for plywood.

Corner Treatment for Siding

The method of finishing siding at the corners may be influenced by the house design. Corner boards may be appropriate to some designs and mitered joints to others.

For lumber siding applied horizontally (Fig. 64) mitered corners are most common but metal corners or corner boards may also be used.

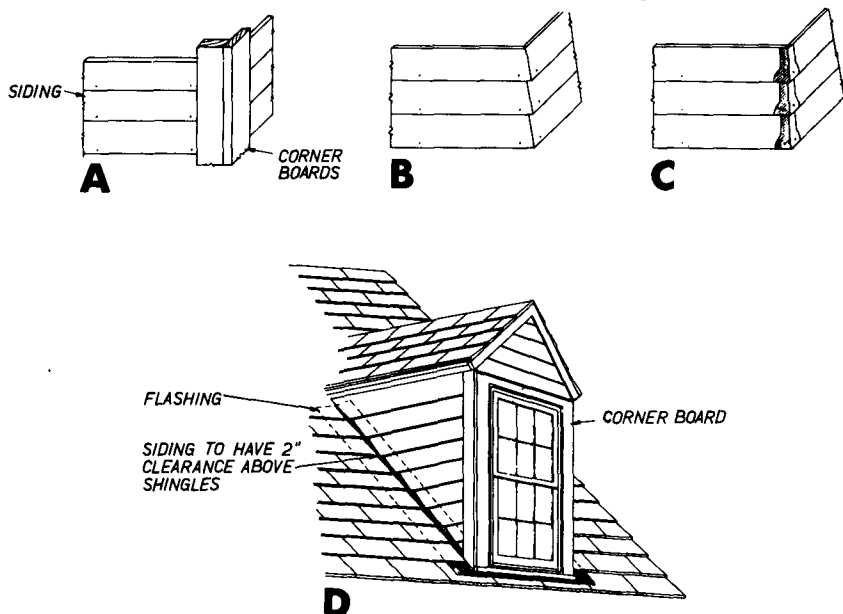


FIGURE 64.—Corner treatment of siding. A, Corner boards; B, mitered corner; C, metal corner; D, siding return on main roof, showing corner boards. Mitered or metal corners can also be used on the return, depending on the design.

Mitered corners (Fig. 64B) must fit tightly and smoothly for the full depth of the miter. To maintain a tight fit at the miter, it is important that the siding be properly seasoned before delivery and be stored at the site so as to be protected from rain. The ends are often set in

caulking compound or putty when the siding is applied. At interior corners the siding is usually butted against a corner strip of nominal 1- or 1½-inch material, depending upon the thickness of the siding.

Metal corners (Fig. 64C), used as a substitute for mitered corners, are made of light-gauge metals such as aluminum or galvanized steel. The application of metal corners takes less skill than is required to make good mitered corners or to fit siding to a corner board.

Corner boards (Fig. 64A) are generally used with drop siding but may be used with other types of siding. The boards are made of 1- or 1¼-inch material, depending on the thickness of the siding. The corner boards are applied against the sheathing, with the siding fitted tightly against the narrow edge of the corner boards. Joints between the siding and corner boards should be filled with caulking compound or putty when the siding is applied.

Plywood, hard-pressed fiberboard and asbestos-cement board are usually lapped at the corners or fitted to a corner board. Lumber siding applied vertically is lapped at the corners.

Wood Shingles and Machine-Grooved Shakes

Wood shingles or machine-grooved shakes are sometimes used for wall covering. A large selection is available, including special wall shingles in lengths of 16-, 18-, and 24 inches, factory-painted or stained.

Shingles are usually separated into three grades. The first grade is composed of clear shingles, all heart, all edge grain. The second grade consists of shingles with clear butts and admits defects in that part of the shingle that will normally be covered in use. The third grade includes those that have defects other than permitted in the second grade and may be used for under-coursing.

Shingles are made in random widths varying in the No. 1 grade from 3 to 14 inches, with only a small proportion of the narrow width permitted in the grade. Shingles of a uniform width, known as dimension shingles, are also obtainable. Widths of 4, 5 or 6 inches, may be specified. Table 12 shows the commonly used exposure and thickness of wood shingles and machine-grooved shakes. Lumber or plywood sheathing should be used under shingles or shakes.

When the single-course application is used, the joints in succeeding courses should be off-set at least 1½-inches and care taken that the joints in any two of three courses do not line up.

To obtain deep shadow lines, shingles can be laid in what is called double-coursing. This may be done by using a lower grade shingle under the shingle exposed to the weather. The exposed shingle butt extends about ½-inch below the butt of the under course. Where double-coursing is used, wider exposure to the weather is possible. Joints in the outer course should be off-set from joints in the under course by at least 1½-inches.

Shingles should be fastened with corrosion-resistant nails, those up to 8 inches wide require only two nails and those more than 8 inches wide require three. Nails should be driven about $\frac{3}{4}$ -inch from the edges and 1 inch above the exposure line for single-course application and 2 inches for double-coursing.

Asbestos-Cement Shingles

Asbestos-cement shingles, which come in various sizes and colors, should be applied in accordance with the manufacturer's directions.

Lumber sheathing or $\frac{3}{8}$ -inch plywood, covered with a layer of sheathing paper, should be used under asbestos-cement shingles. Non-corroding nails are used and nailed carefully so as not to crack the shingles. Vertical joints are flashed with 4-inch wide strips of saturated felt which are normally supplied with the shingles and placed under each joint.

Corner boards may be used as a corner treatment. However, in most cases, the manufacturer will suggest the type of corner treatment best suited for his product. A wide strip of asphalt paper should be applied vertically beneath the shingles at the corners.

Stucco Side-Wall Finish

Stucco generally consists of Portland cement and well-graded sand with hydrated lime added to make the mixture more plastic. Table 11, showing stucco mixes frequently recommended, includes masonry cement which may be substituted for the lime.

Applied in three coats, (two base coats and one finish coat) the stucco is held in place by stucco lath or reinforcing. The finish coat may be left a natural cement colour or colored by the addition of pigments. For what is called a "stone dash finish", mineral chips are partially embedded in the second coat before it has set and no third coat is used in this case.

Stucco reinforcing of self-furring welded or woven mesh is put on horizontally over asphalt sheathing paper, with the joints in the mesh lapped at least 2 inches. External corners are reinforced either by extending the mesh from one side 16 inches around the adjacent corner, or by vertical strips of reinforcing that extend 6 inches on either side of the corner.

Galvanized steel fasteners should be used to hold the mesh in place. Suitable fasteners are 10-gauge nails with $\frac{7}{16}$ -inch heads or 14-gauge staples. Fasteners are spaced 6 inches vertically and 16 inches horizontally or 4 inches vertically and 24 inches horizontally. Other fastening patterns may be used provided there are at least 16 fasteners per square yard of wall surface. Where the sheathing is other than lumber or $\frac{1}{2}$ -inch plywood, the fasteners should penetrate the sheathing and go into the framing member (stud or plate) at least 1 inch.

The first coat of stucco should be forced through the reinforcing, embedding the mesh completely and trowelled to a thickness of not less than ¼-inch measured from the face of the mesh. The surface must then be scored to provide a bonding key for the second coat.

Just before putting on the second coat, the base is dampened to ensure a good bond between the coats. The second coat is applied at least ¼-inch thick and firmly trowelled into the scored surface of the base. For a "stone-dash" finish, mineral chips are picked up in a hand scoop and "dashed" into the fresh mortar of the second base coat. To ensure a good adhesion, this must be done while the mortar is still soft but firm enough to resist sagging.

For finish coats other than stone-dash, the base is dampened to ensure a good bond and the finish applied to a depth of at least ⅛-inch.

In dry, warm weather fresh stucco should be kept dampened to ensure proper curing. In cold weather each coat of stucco should be kept at a temperature of at least 50° F. for 48 hours after application.

Metal Siding

Metal siding is produced in a variety of shapes and patterns. Some simulate the appearance of wood bevel siding and vertical board and batten. Most kinds have factory-finished surfaces in a variety of colors.

Metal siding should be applied to sheathed walls according to the manufacturer's instructions. Aluminum siding should be effectively coated or separated from masonry to avoid deterioration which may be caused by lime in the masonry materials.

Masonry Veneer

Brick or stone veneer is often used for part or all of the wall covering over wood-frame walls. For detailed information on the installation of masonry veneer, see Figure 13.

FRAMING DETAILS FOR PLUMBING, HEATING AND WIRING

One advantage of wood-frame construction is that the space between the framing members in wood-framed walls, floors and roofs provides a safe and economical location to conceal the greater part of the heating, plumbing and electrical distribution systems.

Most of the electrical wiring and many plumbing pipes and heating ducts run parallel to the joists and studs and can easily be concealed in the space between the members. Where it is necessary to run pipes or wires at right angles to the joists and studs, the wood members may be notched or drilled. Within certain limitations, the structural strength of a framing member is not seriously reduced by these notches or holes.

Cutting of Framing Members

Notching of Joists.—Notches made in the top of the joists should be within one-half the joist depth from the edge of the bearing and the depth of the notch no more than one-third of the joist depth (Fig. 65B).

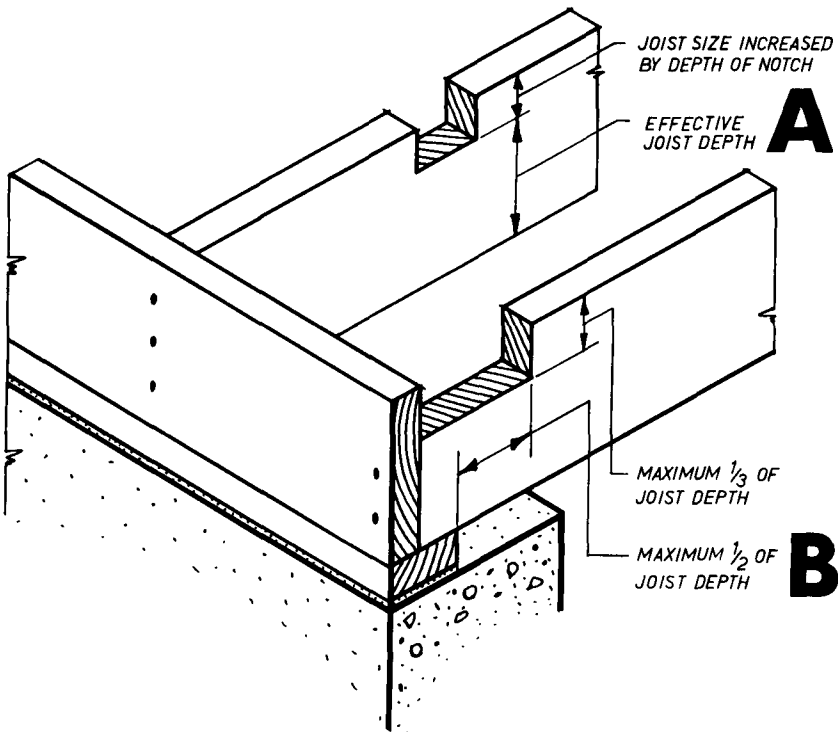


FIGURE 65.—Example of notch limitations. A, Notch located away from support; B, when applied to a $7\frac{1}{2}$ -inch joist the depth of the notch at the support would be $2\frac{1}{2}$ -inches maximum and the length of the notch would not extend more than $3\frac{3}{4}$ -inches from the joist support.

If notches are necessary elsewhere in the span (Fig. 65A), this should be considered when deciding the size of joist to use and the size of joist increased by the depth of the notch. The bottom edge of joists should not be notched since this may cause a joist to split when it deflects under load.

Drilled holes in joists.—Normally holes drilled in joists should not be larger than one-quarter the joist depth or closer than 2 inches to either edge (Fig. 66)

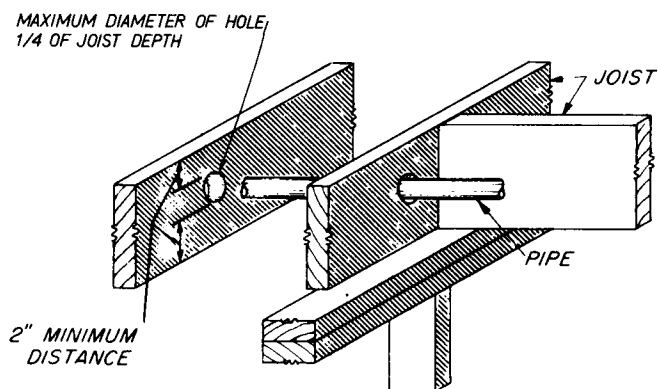


FIGURE 66.—Maximum size of holes drilled in joists.

Notching and Drilling of Studs.—Bearing wall studs that have been notched or drilled to more than one-third of their depth are usually reinforced with 2-inch lumber nailed to the side of the studs and extending about 2 feet on each side of the notch or hole. Similar reinforcing is used when notched, non-bearing wall studs have less than 1½-inches of solid wood remaining.

Notching and Drilling of Top-Plates.—In load-bearing walls, top plates are also reinforced with 2-inch lumber when the solid wood remaining in the plates is less than 2 inches in width. If the required reinforcing must be placed on the face of the plate, sheet metal is normally used so that the wall finish may readily be applied over it.

Framing Details for Plumbing Systems

The installation of the plumbing system usually begins after the walls are framed. This initial work is called “roughing in”. It includes putting in the plumbing drains and all the hot and cold water piping which will be enclosed in the walls and ceilings and under the basement floor (piping in outside walls should be insulated). Since the bathtub must be put in before the wall finish can be applied, the bathtub installation is usually included in “roughing in”. Plumbing fixtures and accessories are not connected until after the installation of the interior finish has been completed. The design and installation of the entire plumbing system is usually regulated by local codes.

If 4-inch cast-iron bell pipe is used for the soil stack and stack vent, it is necessary to use at least 2- by 6-inch studs in the wall which incorporates the stack to accommodate the pipe hubs (Fig. 67A). When 3-inch copper piping is used, the stack wall may be made of 2- by 4-inch

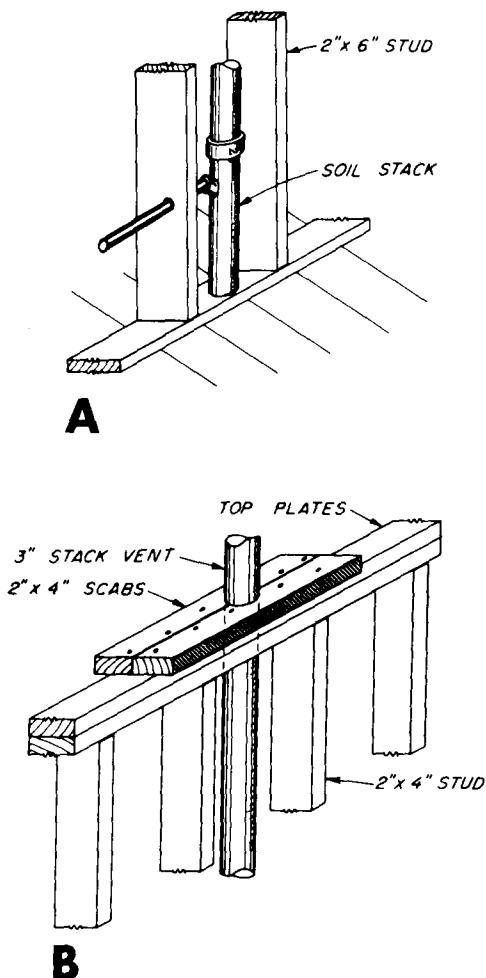


FIGURE 67.—Stack-vent walls. A, 4-inch cast-iron stack in wall; B, 3-inch pipe for stack vent.

material. In both cases, however, the top plates of the wall, in which openings are cut for the vent pipe, will have to be reinforced. Generally, a 2- by 4-inch piece of wood cut in a half circle is used on each side of the top plate (Fig. 67B). This reinforcing should be well nailed to the top plates and should extend over two studs as shown. If the reinforcing members are extended the full length of the wall they can be used as a nailing support for the ceiling finish.

Where soil stacks or large pipes have to run horizontally at right angles to the joists it will be necessary to frame out the joists. To do this, headers are installed between the joists (Fig. 68).

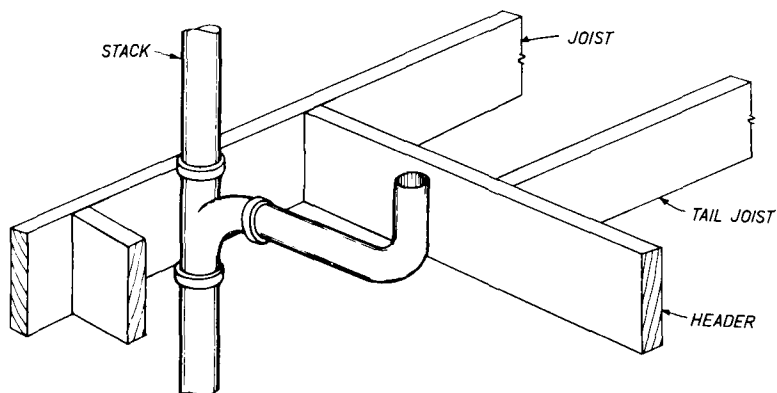


FIGURE 68.—Framing for soil-stack pipes.

Framing Details for Heating Systems

There are many ways to heat a house. Heating systems range from the multi-controlled electric or hot-water heating systems to the relatively simple single space heater. In Canada, natural gas and oil are the most commonly used fuels with electricity increasing in popularity.

Three modern heating systems are: forced-warm air, forced-flow hot water and electric heating.

All types of heating systems may be safely and easily installed in wood-framed houses. Certain clearances, however, must be maintained between parts of the system and combustible material. Installers of heating equipment should be aware of local regulations before starting work.

For a warm air heating system, the ducts for supply and return air are usually located between studs in walls and between joists in floors. When planning the house, locating joists, beams and studs to suit the requirements of the duct system must be considered.

Warm-Air Systems

Normally, wall studs and joists are located so that they do not have to be cut to install heating ducts. When ducts have to pass up through a wall to heat the room above, the top and bottom plates have to be removed at these points. Ducts are then fitted between the studs.

When a partition is supported on doubled floor joists and a heating duct is to go in the partition, the joists are ordinarily spaced apart to allow room for the duct. This eliminates having to cut framing members unnecessarily or to use intricate duct angles.

Return air grilles, usually located on inside walls near floor level, can be connected to a duct or an enclosed stud space. At this point the bottom plate and subfloor is cut to make a passage for the duct or air

space. Blocks are nailed between the joists to support the ends of boards if diagonal sub-flooring has been used. Sometimes, the studs have to be cut to accommodate large return air grilles. Where this occurs a lintel is used to support the studs that have been cut and the opening is framed in the same way as shown in Figure 69. When enclosed, the space between floor joists may be used as a return air duct and other return air ducts connected to the same joist space. Non-combustible material such as metal should be used to line the joist space within 2 feet of the furnace, under floor registers and at the bottom of vertical ducts.

Warm air registers are usually placed in the floor close to the outside walls, preferably under the windows. These registers are fitted with vanes to direct the warm air over a wide area of the outside walls. Where possible, ducts leading to these registers are located between joists with a shaped "boot" connecting the duct and register. Then, only the sub-floor and floor covering have to be cut. Diagonal subflooring must be supported by blocking at this point.

In houses with a crawl space, a warm air furnace can either be put in a special compartment on the floor in the house, hung under the floor or mounted on a concrete base in the crawl space beneath the house. In the first two cases the joists will have to be designed to carry the weight of the furnace.

Hot Water Systems

Where the heating system requires only small pipes for a supply-and-return system, pre-planning of the structural framing layout to accommodate the pipes is not normally necessary.

Baseboard type convectors are usually selected and located under windows along outside walls. In this manner, warm air rising through the convector blankets the outside walls. Virtually no cutting of the studs or joists is required with this type of installation as the baseboard type of convector is positioned on the surface of the wall.

Semi-concealed or recessed radiators or convectors are not common, but where they are used the necessary recesses must be provided during the wall framing operation. A header is used over the top of the opening such as for a window (Fig. 69). The space between the sheathing and wall finish is insulated when the radiator is located on an outside wall. In all cases, the wall finish in a radiator recess should be of non-combustible material. Corner beads are placed over the external corners to protect the wall covering.

Electric Heating Systems

Since it is easy to conceal wiring in walls and floors electric heating systems require little or no planning in the structural framing for their accommodation. As with hot-water and warm-air systems, heating units are usually located along outside walls and air, warmed by the heating

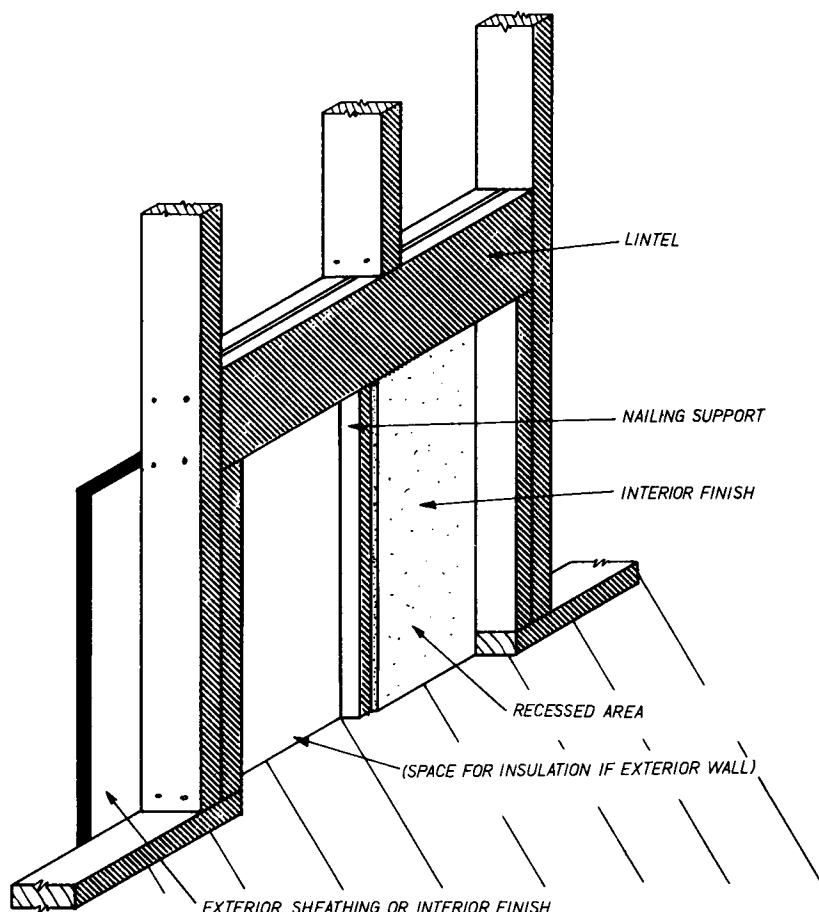


FIGURE 69.—Framing for a convector recess in bearing partition or outside wall. Same framing method should be used for large-return air grilles.

elements, blankets the walls. Because the heating elements are mounted on the surface of the wall there is no need to cut the wall studs. Radiant heating with the heating elements located in the ceiling is also used.

WIRING

House wiring for electrical services is usually started after the house has been closed in, i.e. after the exterior wall sheathing and roof have been completed. This initial phase of wiring, also termed “roughing in”, includes the installation of wiring and the boxes for the switches, lights and receptacles.

“Roughing-in” is done before applying the inside finish and ordinarily before placing the insulation in walls or ceilings. Lighting fixtures, switches, receptacles and cover plates are installed after the interior finish and painting operations.

The design and installation of the entire wiring system is usually regulated by the electrical code which applies in the particular locality.

Box Location

Because the location of switches, receptacles, and outlets is important, the wiring plans should be studied carefully to ensure that everything is included. After the house is finished alterations and additions are expensive.

Switches

Switches are commonly located just inside the door of a room so that they may be easily reached upon opening the door. Switches may service a wall receptacle for a table or a floor lamp as well as the usual ceiling or wall lights.

It is common practice to locate the switch boxes about 4 feet 6 inches above the floor. Switches or outlets at kitchen-counter walls are usually about 8 to 12 inches above the counter.

Multiple-control switches are convenient in many locations so that lights may be controlled from more than one switch. A living-room light could have a switch near the outside-entrance door and another at inner doors leading to the kitchen or to bedroom hallways. In two-storey houses three-way switches should be provided at the bottom and at the top of the stairway to control the stairway lighting. Basement stair lights should be controlled by three-way switches at the head and foot of the stairs particularly if there is a garage or living accommodation in the basement or if there is an outside exit from the basement.

Receptacles

Today's house uses electricity for a multitude of purposes — lamps, radio and television equipment, electric clocks, ventilating fans, small kitchen appliances, electric heaters, garbage-disposal unit, refrigerator, dishwasher, washing machine, powered workshop equipment, etc. Location of outlets for all these should be carefully planned.

The amperage of the electrical service and the number of circuits and receptacles installed should take into account future needs as well as the requirements of local codes.

VAPOR BARRIERS

Most building materials are permeable to water vapor. During cold weather vapor which is generated in the house from cooking, dishwashing, laundering, bathing, and other activities may pass through wall and ceiling materials to condense in the wall or attic space, eventually

damaging exterior paint and interior finish or even causing decay in structural members. To protect against this condensation a material highly resistive to vapor transmission, called a vapor barrier, is used on the warm side of exterior walls, below the roof insulation and where the floor is insulated between the subfloor and finish floor. Papers coated or laminated with bitumen, wax-coated papers, aluminum foil and polyethylene film are used as vapor barriers.

The effectiveness of a vapor barrier depends to a large degree on how carefully it is installed. To ensure a good vapor seal, all joints in the barrier should be lapped at least 1 inch and the joints made over a supporting member such as wall plates, studs, joists, blocking or furring. Staples are used at these joints to hold the barrier in place. When the interior finish is later nailed to the same members, this helps ensure that the vapor barrier joints are pressed together to make a good seal.

The vapor barrier must be carefully cut so that it extends fully over the entire surface area and fits closely around electrical boxes, door and window frames and other openings in the walls or ceiling.

In two-storey houses the vapor barrier covering the insulation in the second-floor joist area (as shown in Figure 71B) is usually held in place by folding back and stapling the edges of the barrier to the surrounding surfaces.

Joints between an insulated ceiling and wall are made by extending the ceiling barrier down over the wall plates so as to lap the vapor barrier on the walls.

While every precaution must be taken to ensure a good seal, some vapor leakage may occur. Since condensation of vapor in the wall space can cause damage, it is important to allow vapor to escape readily from the wall space to the outside by using materials of relatively low vapor resistance on the outside of the wall. For example, sheathing paper should be waterproof but not highly vapor resistant.

INSULATION

All materials used in walls, roofs and floors of dwellings as well as the enclosed air spaces offer some resistance to the transfer of heat from the warm side to the cold side. However, materials well suited to serve as sheathing or as wall finish may have little resistance to heat transfer. The addition of material high in resistance to heat transfer, namely insulation, reduces heat loss through the walls, ceilings and floors and thereby improves interior comfort and reduces fuel consumption. The cost of insulation will, in a relatively short time, be recovered in fuel savings.

Since the thermal properties of most building materials are known, the rate of heat flow or coefficient of transmission for most combina-

tions of construction materials can be calculated. This coefficient of transmission, or U-value, represents the amount of heat expressed in British thermal units transmitted in 1 hour through 1-square foot of surface per 1°F. difference in temperature between air on the warm side and the air on the cold side. The insulating value (U-value) will vary with different types of construction, with the materials used and with different types and thicknesses of insulation. By comparing the U-values, different combinations of materials and insulation can be evaluated on a basis of overall heat loss, fuel cost and cost of installation.

Air spaces add to the total resistance of a wall section to heat transmission, but an air space is not as effective as the same space filled with insulating material.

Commercial insulation is manufactured in a variety of forms and types, each having advantages for specific uses but none of which is best for all applications. The various types can be grouped into three classes: (1) batt-type, (2) loose-fill and (3) rigid.

Batt-Type Insulation.—Batt-type insulation generally comes in rolls or strips of convenient length and in widths to fit standard stud and joist spacing. Obtainable in thicknesses of 2, 3, 4 and 6 inches it is usually made of mineral wool with a vapor barrier paper on one side. The barrier extends about 2-inches beyond each side of the batt so that it will lap when fastened to the framing members. Batts may also be obtained without an attached vapor barrier and this type, often called "friction fit", does not require fastening.

Batt-type insulation 2 or 3 inches thick (or the equivalent) is generally used in walls and 3 inches in ceilings. For electrically heated houses 4 inches in the walls and 6 inches in the ceilings is usually provided. This amount of insulation should ensure a comfortable house in most parts of Canada.

Loose-Fill Insulation.—Loose-fill insulation may either be granular or composed of small, detached clusters of fiber made of mineral wool. It may be poured or blown into open spaces and used over level ceilings below unheated attics. Because of the difficulty in ensuring uniform distribution of this material over the full height of the wall it is not recommended in new wall construction. However, because of the difficulty of insulating with other material, it is sometimes used in walls of existing houses which were not insulated originally.

Rigid Insulation.—Rigid insulation can be made from wood or vegetable fibers, expanded polystyrene, polyurethane, mineral wool or cork formed into panels of various thicknesses and sizes. When used for flat or flat-pitched roofs, this type of insulation is placed on top of the roof sheathing. It is also used around concrete floor slabs that are built on grade (Fig. 14 and 15), but in this case only insulation which will not deteriorate in the presence of ground moisture should be used.

Where to Insulate

To reduce heat loss during cold weather, all walls, ceilings, roofs and floors that separate heated spaces from unheated spaces or the exterior should be insulated. Figure 70 shows some of the areas where insulation is required.

In colder climates the crawl space in basementless houses is usually heated and insulation is not required in the floor (Fig. 70A). How-

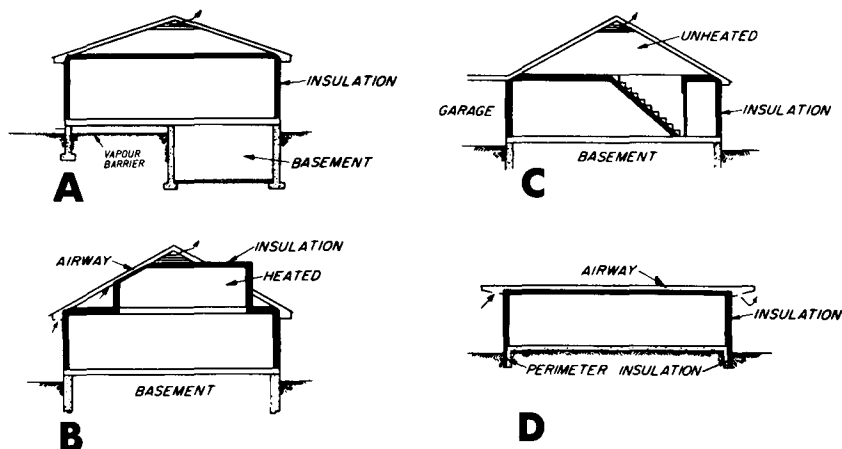


FIGURE 70.—Placement of insulation. A, In walls and ceiling; B, in 1½-storey house; C, at door and stairwell to unfinished attic; D, in flat roof and around perimeter of concrete slab on ground.

ever, in milder climates the crawl space is sometimes left unheated and then insulation is placed between the floor joists close to the subfloor. Batt-type insulation is generally used for this purpose. The batts should be well supported by strapping and a galvanized mesh or by a rigid board (Fig. 74).

In one-and-a-half storey houses with finished space on the second floor, insulation should be placed along all surfaces adjacent to unheated areas (Fig. 70B), including the ceiling beneath the attic space at the eaves, dwarf walls and dormers. If the second floor is to be left unheated, the stairway leading to the attic space as well as the first floor ceiling must be insulated (Fig. 70C). The door leading to the unheated attic should be weather-stripped to prevent heat loss.

When insulation is placed between the roof joists in flat or low-pitch roofs (Fig. 70D) or the sloping ceiling of a one-and-a-half storey house (Fig. 70B) sufficient space must be allowed above the insulation for ventilation between the joists.

Other places requiring insulation include:

1) spaces between window or door frames and the rough openings as well as under the sill (Fig. 71A)

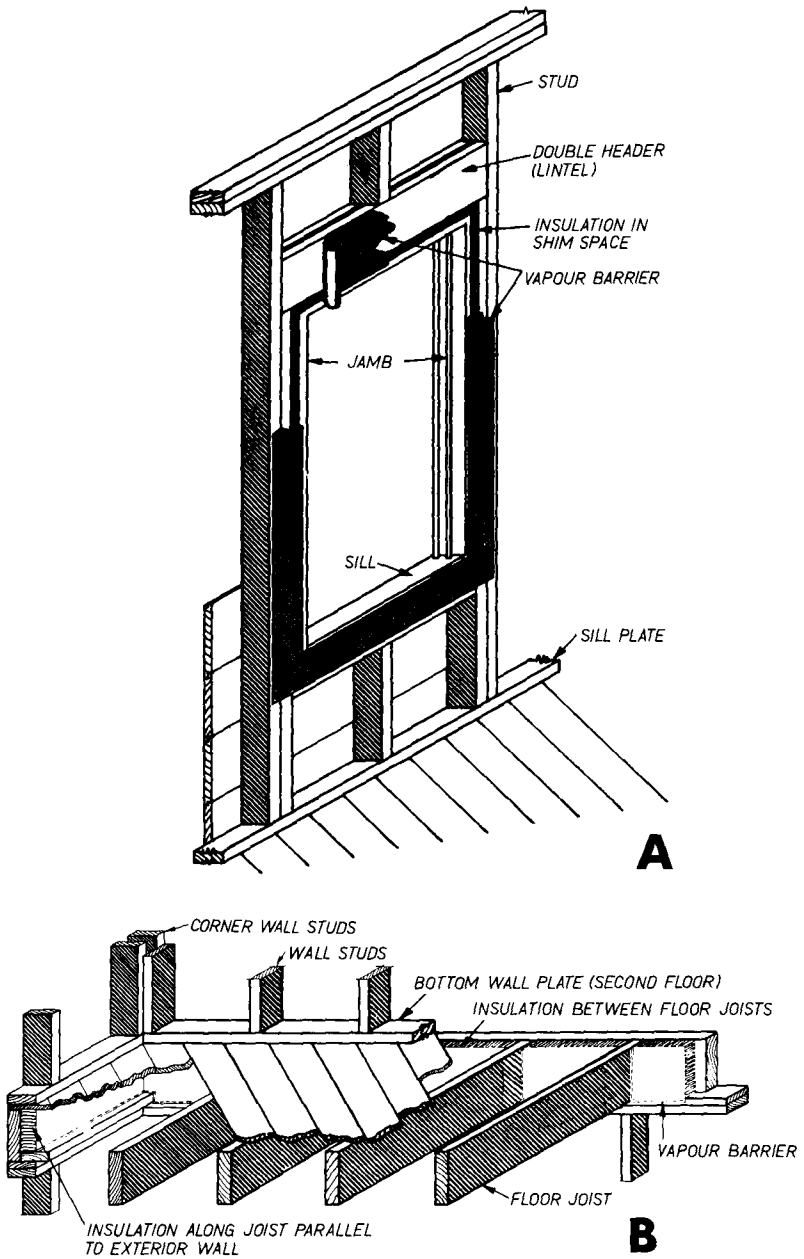


FIGURE 71.—Important small areas requiring insulation. A, Around openings; B, joist space in outside wall.

2) the small spaces between studs at wall corners and intersections (Figs. 31, 32 and 33) — these areas may have to be insulated before application of the exterior sheathing

3) in two-storey houses, around the perimeter between first floor ceiling and second floor (Fig. 71B)

4) areas behind switch and receptacle boxes on outside walls

5) around the perimeter of concrete slab floors on grade (Figs. 14 and 15).

Insulation will also keep a house cooler during hot weather. Surfaces exposed to the sun may be more than 50°F warmer than surfaces on the shady side. Insulation in roofs and walls will retard heat flow into the house and help keep it cooler for a longer period than without insulation.

How to Insulate

Batt-type insulation which is long enough to cover the stud or joist space in one piece may be installed so that the vapor-barrier covering on the batt can be used both as a fastener for the batt and as the main part of the vapor barrier for the walls and ceiling (Fig. 72A). The tabs on adjoining batts are lapped at least 1-inch on the face of the studs or joists. The ends of vapor-barrier covering are also extended over the bottom and top plates and both the side tabs and ends are stapled to the framing members. Strips of vapor barrier are then fastened over door and window lintels, along the bottom and top plates and over other framing members such as doubled studs, which have not been fully covered by the vapor barrier on the batts.

Vapor-barrier covered batts which are not long enough to cover the stud or joist space in one piece (i.e. 4-foot batts), may be placed with the end joints in the vapor barrier lapped over blocking, fitted between the framing member. Alternatively, the batts may be installed by using the covering as a means of fastening the batt only and a separate vapor barrier used to cover the entire wall or ceiling (Fig. 72B and C). Large sheets of polyethylene, the full height of the wall, are often used for this purpose. It is particularly effective since there are few joints.

Self-supporting or friction-fit batts with no vapor barrier attached are held in place by fitting them tightly between the studs. To eliminate the possibility of continuous air travel around the batts from the warm side to the cold side, they should also be tightly fitted to the bottom and top plates. As a further precaution against air circulation, the batts are closely fitted against the outside sheathing thus eliminating the cold air space. A separate vapor barrier is always required with this type of insulation and is applied as shown in Figure 72B.

Loose-fill insulation is poured or blown onto the flat surface of the ceiling. A vapor barrier must be attached to the bottom of the ceiling joists and the ceiling finish installed before the insulation is placed.

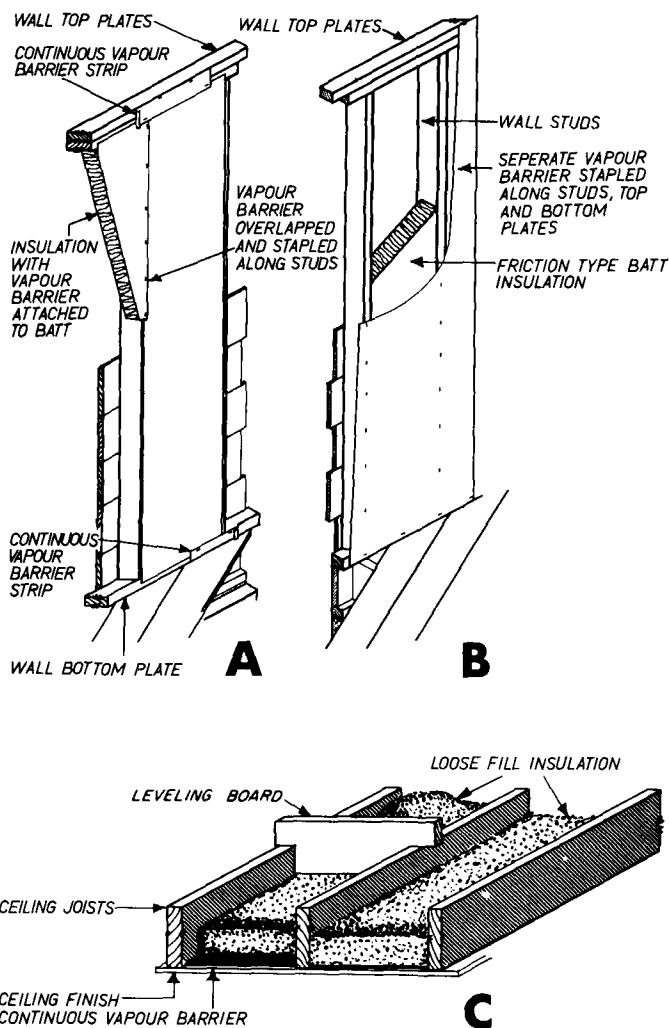


FIGURE 72.—Application of insulation. A, Batt-type insulation with integral vapor barrier; B, batt-type insulation with separate vapor barrier; C, fill type insulation with separate vapor barrier attached to bottom edge of ceiling joists.

Using a leveling board as shown in Figure 72C the insulation is spread to an even and constant thickness.

VENTILATION

Even where vapor barriers are used, some moisture will leak around pipes and other openings and some through the vapor barrier itself. If vapor is allowed to accumulate in attic spaces and under flat roofs

it is likely to condense in some cold spot during cold weather in sufficient quantity to cause damage. Since most types of roof coverings are highly resistant to vapor transmission, the most practical way of removing vapor which enters the roof space is by ventilation.

During cold weather, heat loss through the ceiling insulation combined with exposure to sun may provide enough heat to melt the snow on the roof. But the snow at the eaves may not melt. Water from the melting snow can then freeze and form ice dams at the gutter and roof overhang. This may cause water to back up at the eaves, penetrate through the roof and get into the walls and ceilings. Similar dams may form in roof valleys. A well-insulated ceiling and adequate ventilation will keep attic temperatures low and help prevent snow on the roof from melting.

A common method of providing ventilation is to install louvered openings or continuous screened slots in the eaves of gable and hip roofs (Fig. 73A). Air movement through such openings depends pri-

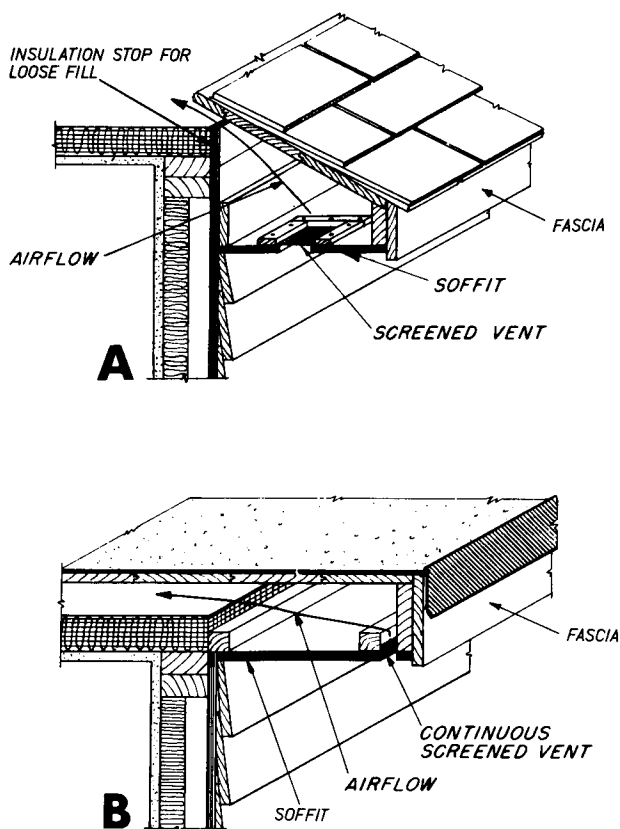


FIGURE 73.—Roof ventilators. A, Soffit vent; B, continuous-screened vent.

marily on wind. Additional openings near the ridge in both types of roofs will provide additional ventilation.

Continuous strip ventilators or a screened slot are normally used for ventilating flat roofs where the insulation is placed between the roof joists at the ceiling level (Fig. 73B). This will ensure every joist space being properly vented. Where the insulation is installed over the roof sheathing the area between the roof joists must not of course be ventilated.

Crawl spaces under the house or porch need to be ventilated during warm weather to remove moisture vapor rising from the soil through the vapor barrier. Otherwise, the vapor might condense on the wood below the floor and facilitate decay.

Size of Ventilators

The recommended minimum net area of ventilators for attic or roof spaces is one square foot for each 300 square feet of insulated ceiling area. For example, a ceiling area of 1,000 square feet requires ventilators totalling at least $3\frac{1}{3}$ -square feet in net area. The area provided should be increased to allow for restrictions such as louvers, wire cloth or screens. Corrosion-resistant metal or plastic materials should be used to screen ventilator openings.

Where there are rooms in the attic with sloping ceilings under the roof, the insulation should follow the ceiling slope, leaving a space of about $1\frac{1}{2}$ -inches between the roof boards and insulation for air movement (Fig. 70B). This is also important where insulation is installed between joists in flat roofs (Fig. 73B). Solid blocking should not be used for bridging between the roof joists if it prevents air circulation. Ventilating holes should be drilled in roof-framing members which would otherwise interrupt the flow of air (Fig. 38).

Crawl-Space Ventilation and Soil Cover

Unless it serves as a plenum for the heating system the crawl space below the floor of a basementless house should be ventilated through the outside walls. The net ventilating area should be at least $1/500$ of the crawl-space floor area. Where the crawl space serves as a plenum the heating outlets in the floor will serve as ventilators as well.

Ventilators in outside walls should be screened and equipped with tight-fitting doors to prevent air leakage in winter when the crawl space is heated (Fig. 74).

Outside wall or floor ventilators are not usually necessary in a partial crawl space having one side open to the basement as shown in Figure 70A. The crawl space will be adequately ventilated through the open side into the basement, without any special provision being made.

The ground surface in all crawl spaces should be covered with a vapor barrier as described on page 14.

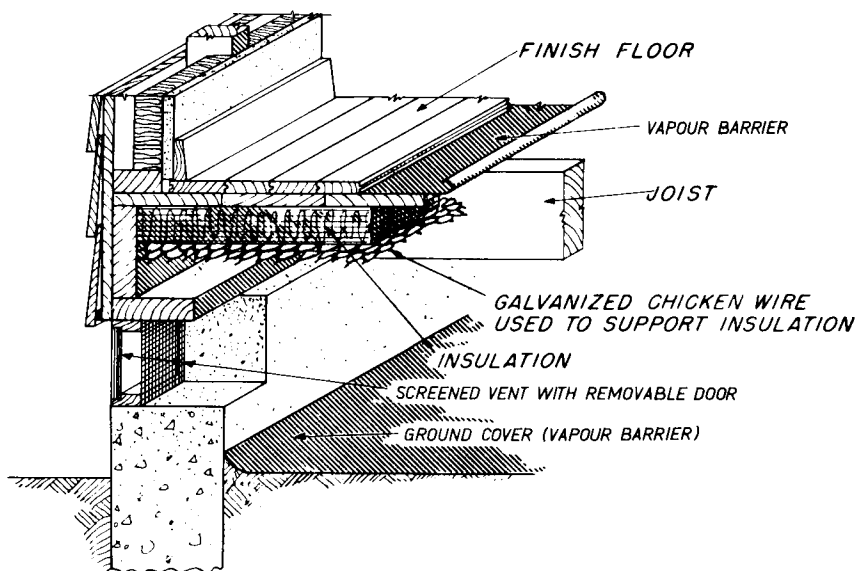


FIGURE 74.—Crawl-space ventilator and vapor-barrier ground cover.

INTERIOR WALL AND CEILING FINISH

Interior finish describes any material used to cover the interior wall and ceiling framing. The two principal types of interior finish are plaster and dry-wall.

Though plaster is still widely used in construction, the use of dry-wall material in wood-frame houses has been steadily increasing in recent years. While dry-wall generally requires better alignment of studs and joists to ensure well finished walls and ceilings, it does not hold up work by other trades as does plaster while it is drying. The choice of one type of finish over the other is very much a matter of personal preference.

A plaster finish requires a base. Wood lath at one time was the base most commonly used, but sheet or board materials have now eliminated its use. Metal lath is used for special purposes.

Of the many types of dry-wall finish, the type most widely used is gypsum board applied in sheets 4 feet wide. Insulating board in a wide variety of sizes and shapes is available for both wall and ceiling coverings. Plywood, V-beaded boards, and other forms of wood are also used.

Plaster Base and Finish

A plaster finish requires some type of base upon which it can be spread and the base must provide a good bond or key for the plaster.

One of the popular types of plaster base, which may be used on walls or ceilings, is gypsum board lath. It is manufactured in sheets 16- by 48-inches and has a gypsum core faced with paper. For stud or joist spacing of 16 inches on center, $\frac{3}{8}$ -inch thick sheets are used. For 24 inch on center spacing, $\frac{1}{2}$ -inch thickness is required. This material can be obtained with perforations which, by improving the bond with the plaster, lengthens the time the plaster will remain intact if exposed to fire.

Gypsum lath should be applied horizontally with joints staggered as shown in Figure 75A. End joints are made over the center of studs or joists and should be nailed with 13-gauge gypsum-lathing nails $1\frac{1}{4}$ -inches long and with a large flat head. Lath 16 inches wide should be fastened with 4 nails on supports up to 16 inches on center and 5 nails for supports at 24 inches on center. The lath is nailed at each wall stud or ceiling joist.

Since slight shrinkage in the corner-framing members may pull the joint apart the lath is not nailed at inside corners. Cornerites, which reinforce the plaster, supply the necessary support for both lath and plaster at this point. Lath joints should not be made on the jamb studs above or below openings, as slight movement between the lintel or plate and the framing may lead to plaster cracks.

Insulating fiberboard lath may also be used as a plaster base, but its use is not common. It is usually supplied in sheets 18- by 48-inches. Fiberboard lath is applied much the same as gypsum lath. Normally $7\frac{1}{16}$ -inch lath is used where the nailing supports are 16 inches on center on walls and 12 inches on center on ceilings. One-inch lath may be supported at 16 inches on center for both walls and ceilings. Nails used to fasten fiberboard lath should not be less than 13-gauge with large heads, spaced not more than $4\frac{1}{2}$ -inches on the supports and long enough to penetrate $\frac{5}{8}$ -inch into the support. Fiberboard lath provides added insulation when used on walls or ceilings adjoining exterior and unheated areas.

Expanded-metal lath consists of sheet metal, slit and expanded to form many small openings which provide a key for the plaster. This lath, treated with rust-inhibitive coating after manufacture, should be applied in the weight per square yard recommended for the applicable stud and joist spacing. Metal lath is usually provided in sheets 17- by 96-inches in size.

Expanded-metal lath and plaster is sometimes used as a base for ceramic tile (Fig. 75B). The first or scratch coat should be Portland-cement plaster, of $\frac{3}{8}$ -inch minimum thickness and integrally waterproofed, and must be scratched (roughened) thoroughly. The scratch coat should be dry before the tile is applied. Where this method is used on an outside wall, the vapor barrier should be protected from damage during lathing and plastering operations by a number 15 asphalt-saturated sheathing paper. The paper is applied shingle style under the metal lath and stapled to the face of the stud.

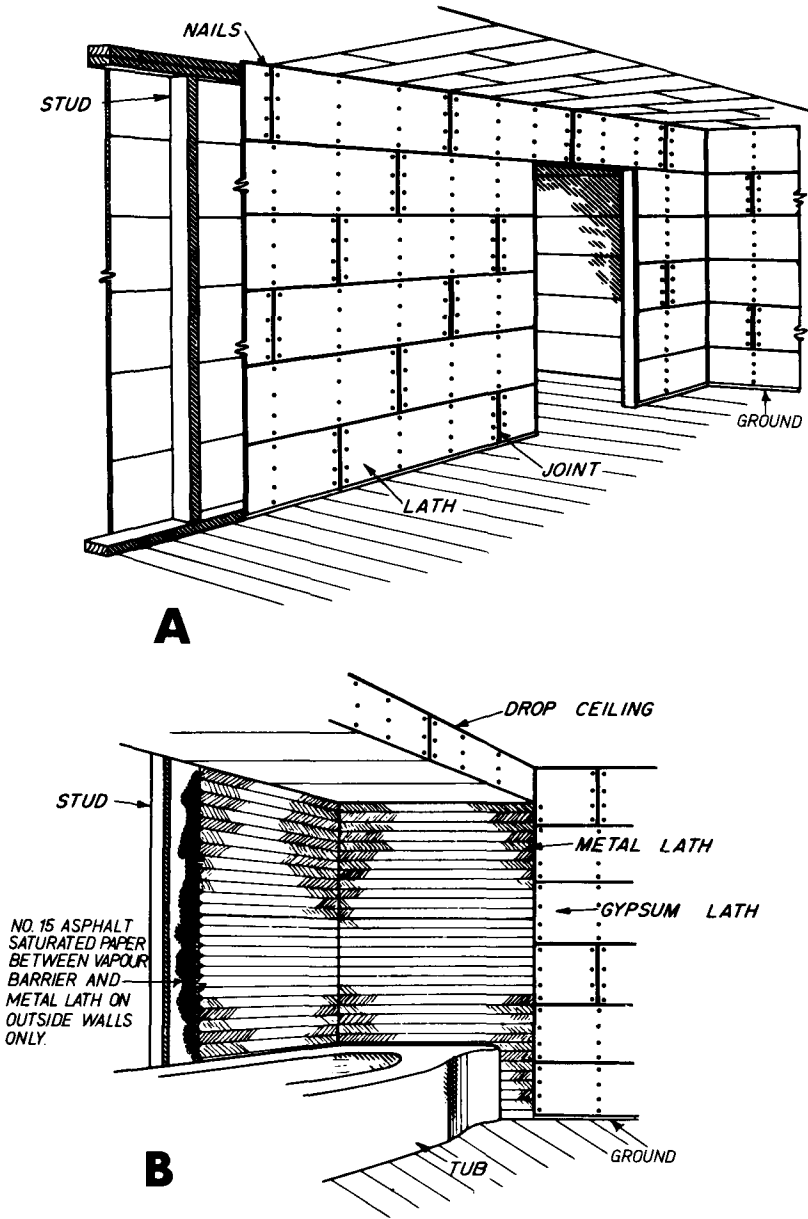


FIGURE 75.—Application of plaster base. A, Gypsum lath; B, metal lath.

Because some drying will take place in wood-framing members after the house is completed, some shrinkage can be expected which, in turn, may cause plaster cracks to develop around openings. To minimize this cracking, strips of expanded-metal lath should be used at window and door openings (Fig. 76A). A strip 6- by 18-inches, placed diagonally across each corner will prove effective. The metal lath should be tacked lightly in place.

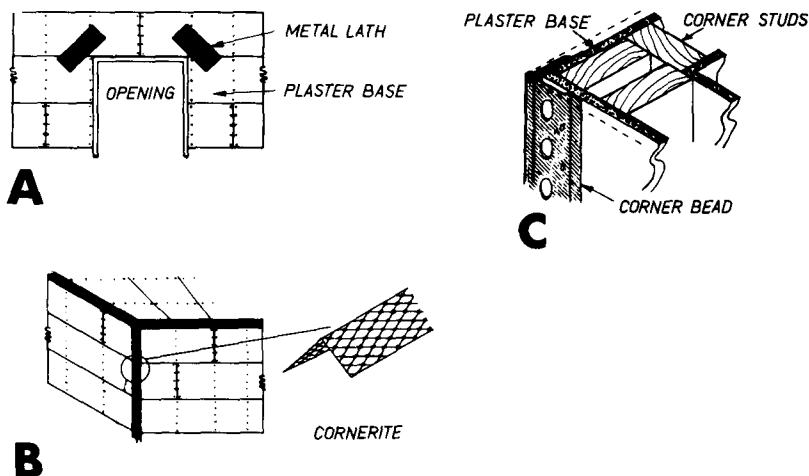


FIGURE 76.—Reinforcement of plaster. A, At openings; B, at inside corners; C, at exterior corners.

Inside corners at the juncture of walls and ceilings and of two walls should be reinforced with cornerites of metal lath or wire fabric (Fig. 76B). The minimum width of cornerites should be 4 inches, or 2 inches on each side of the internal corner. Cornerites should also be tacked lightly in place.

Corner beads (Fig. 76C) of expanded-metal lath or of perforated metal should be installed on all exterior corners. The bead acts as a leveling edge when walls are plastered and reinforces the corner against damage.

Plaster grounds are strips of wood which are attached to the framing before the plastering operation begins. They are used around window and door openings and along the floor line to serve as a leveling surface for the plaster (Fig. 77). The plaster grounds along the floor line always remain in place to serve as a nailing base for the baseboard. The plaster grounds around openings may either remain in place, to be used for the same purpose, or be removed after plastering is completed. Grounds which will remain in place (Fig. 77A & B) are the same thickness as the lath plus plaster and are nailed securely before lath is installed.

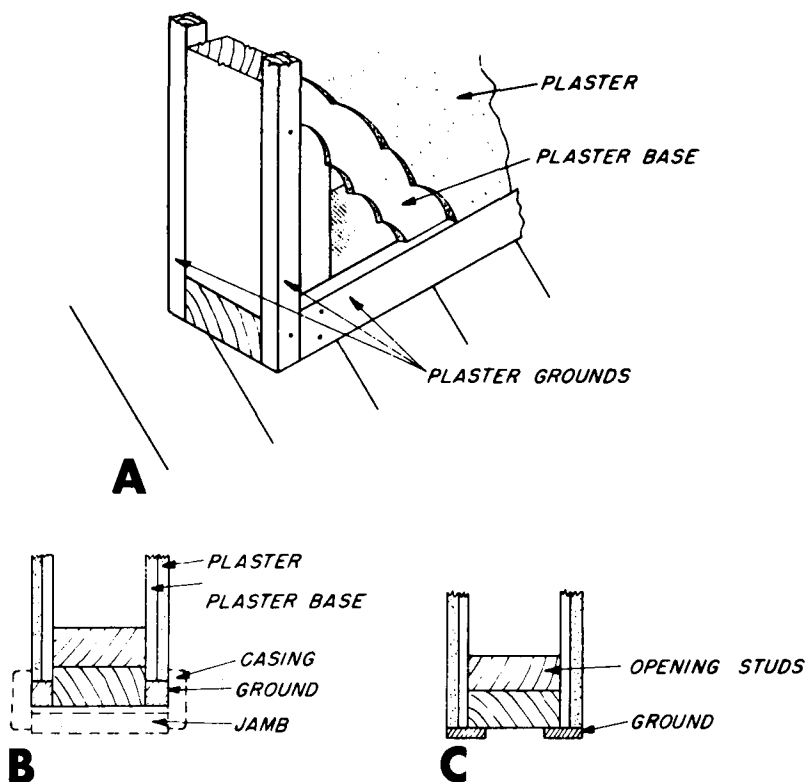


FIGURE 77.—Plaster grounds. A and B, Types of grounds left in place; C, temporary grounds usually removed after plastering.

When temporary grounds are used around openings, they are nailed to the face of the openings (Fig. 77C) after the lath is installed. They are spaced to conform to the width of the door jambs, usually $5\frac{1}{8}$ -inch, to ensure a good casing fit when trim is installed. These temporary grounds are removed after the plaster is dry.

Plaster for interior finish is usually a mixtue of sand, gypsum plaster and water although vermiculite or perlite aggregate may also be used. It is applied in two or three coats depending on the type of base used, but the total plaster thickness should not be less than $\frac{3}{8}$ -inches in either case.

For a three-coat application, the first coat, also called the scratch coat, is made of 1 part gypsum plaster and 2 parts of sand by weight. While still soft, it is scratched to ensure a good bond for the second

coat. The second coat, called the brown or leveling coat, is made of 1 part gypsum plaster and 3 parts of sand. The finish coat, sometimes called the "putty-coat", usually consists of 1 part gypsum plaster to 3 parts of lime by volume. It is applied in a thin layer after the brown coat has set and is trowelled to a smooth hard finish.

A two-coat application may be used with gypsum lath. In this case, the scratch and brown coats are combined by allowing the scratch coat to set only long enough to prevent it from sagging when the brown coat is applied. Since the scratch and brown coats go on in a single operation, the plaster mix is the same for both — 1 part gypsum plaster to $2\frac{1}{2}$ parts of sand by weight. The surface is levelled during the application of this coat. After the scratch and brown coats have set, the finish coat is applied.

Plaster should not be applied at a temperature below 50°F and this minimum temperature should be maintained for at least 96 hours, and above freezing thereafter. For this reason, if plaster is to be applied in cold weather the house should be closed in and the heating system in operation. It is also important to ensure adequate ventilation to carry off the excess moisture which is released as the plaster dries out.

Dry-Wall Finish

Dry-wall finish describes any finish that requires little or no water for application. This includes plywood, fiberboard and other finishes that are applied in dry form as well as gypsum board which requires a water-based joint cement.

Thin sheet materials such as plywood or gypsum board require that studs and ceiling joists be well aligned. A "strongback" (Fig. 78B) can sometimes be used to level and align the ceiling joists. Attached to the top of the ceiling joists, this L-shaped member helps prevent the joists from twisting or warping.

Gypsum board is a sheet material composed of a gypsum filler between two layers of paper. Sheets are 4 feet wide and are supplied in various lengths up to 12 feet. The edges along the length of the sheet are tapered on one face to receive joint cement and tape. Although gypsum board may be used in $\frac{3}{8}$ -inch thickness on support spacings up to 16 inches on center, $\frac{1}{2}$ -inch board is more commonly used for its extra strength. Where supports are spaced at 24 inches on center, the minimum thickness which should be used is $\frac{1}{2}$ -inch.

Nails used to fasten gypsum board should be annular grooved with 13-gauge shanks and $\frac{7}{32}$ -inch diameter heads. The nails should be long enough to penetrate the support $\frac{3}{4}$ -inch. By using special hammers, the nail heads can be set slightly below the surface without damaging the paper. A slight dimple is thus formed in the face of the board

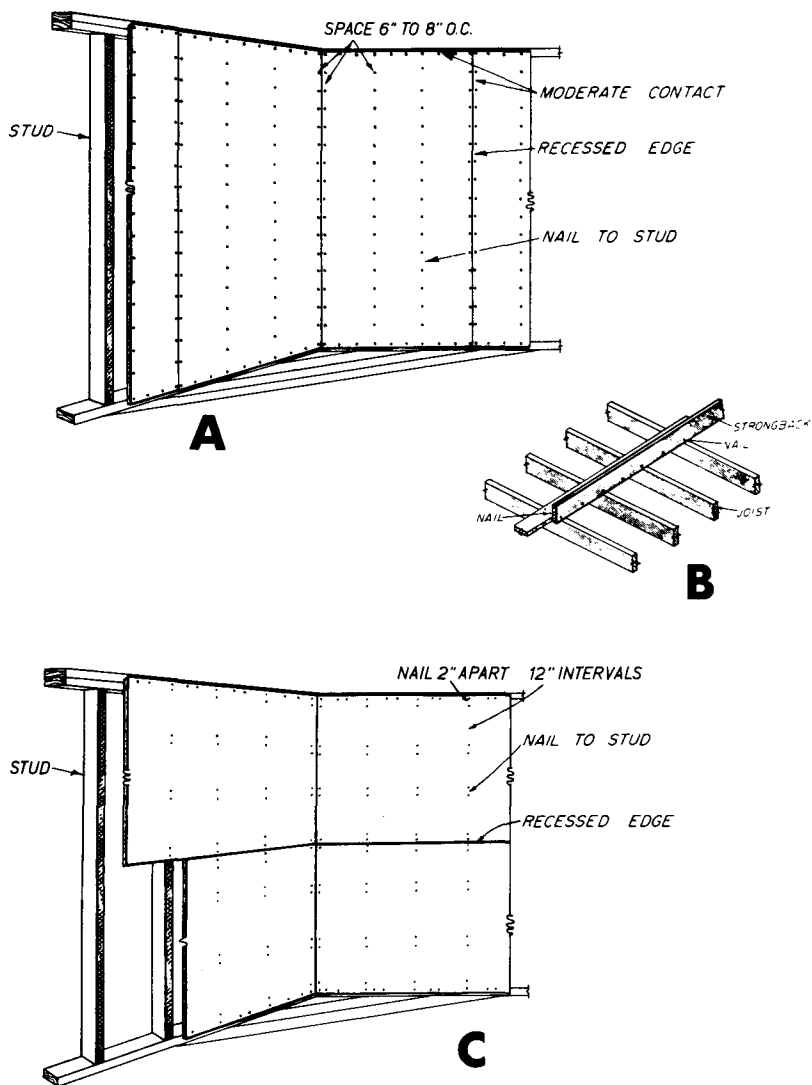


FIGURE 78.—Application of dry-wall finish. A, Vertical application of gypsum board showing single nailing method; B, strongback; C, horizontal application of gypsum board showing double nailing method.

(Fig. 79A). The nails at the recessed edge of the sheet may be driven with the heads flush since they will be covered with tape and joint cement.

Gypsum board may be "double-nailed", i.e. nails are driven in pairs about two inches apart at intervals of 12 inches along the supports

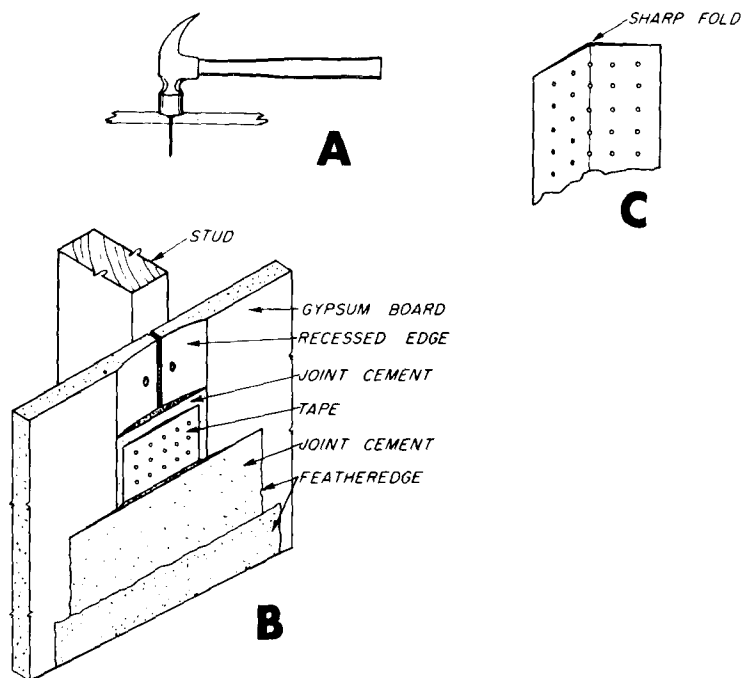


FIGURE 79.—Finishing of gypsum board. A, Nail set with crowned hammer; B, cementing and taping of joint; C, taping at inside corners.

(Fig. 78C) or the nails may be driven in a single pattern, spaced 5- to 7-inches along the supports on ceilings and 6- to 8-inches on the walls (Fig. 78A). The former method is more commonly used as “nail-popping” is less likely to occur.

With special power-operated screwdrivers, screws can be used to fasten gypsum board. Screws are usually spaced 12 inches on center at both the edge and intermediate supports. This distance can be increased to 16 inches on walls when the supports are not more than 16 inches on center. The screws should be long enough to penetrate the support at least $\frac{3}{8}$ -inch.

Gypsum wall board is usually applied in single sheets directly on the framing members. On ceilings, the board is generally applied with the long dimension at right angles to the joists. On walls it is more common to apply the sheets horizontally rather than vertically as it reduces the amount of nailing and the length of the joints. Horizontal joints at 4 feet above the floor are below eye level making them less conspicuous. Since the ends of the sheets are not recessed, end joints are weaker than side joints and should therefore be made over supports.

Gypsum board may also be applied in double layers, using sheets $\frac{3}{8}$ -inch thick. The first layer is applied vertically and nailed to the

supports. The finish sheets are then cemented on horizontally. Joint cement is applied to the back of the second layer before it is put into place. To hold the sheets while the adhesive is setting, double-headed nails are used as temporary fastenings. For ceilings, temporary shoring or bracing is often needed as well. When the adhesive has set, the shoring and nails are removed, the nail holes filled and the joints taped and finished.

Another method of applying gypsum board is to nail strips of gypsum board 6 inches wide along the length of the framing members. The finish course is then cemented on over these strips in the same way as described for the double-layer system.

Joint cement is supplied in powder form and is mixed with water to a soft putty consistency. It may be applied with hand tools but mechanical applicators are now commonly used for both taping and cementing.

Before the joints are taped all loose paper must be removed and the joints cleaned. All joints wider than $\frac{1}{8}$ -inch are then filled with joint cement and allowed to dry. External corners are protected with corrosion-resistant corner beads or wood moldings and at interior corners the tape is folded as shown in Figure 79C.

The first layer of joint cement is applied in a band 5 inches wide along the joint. The tape is applied and pressed into the fresh cement with a trowel or wide blade putty knife, care being taken to remove the excess cement and smooth the tape and feather the cement band to zero thickness at its outer edges (Fig. 79B).

After the first layer has set, a second layer is applied in a band 8 inches wide on recessed joints and 10 inches wide where the edges of the board are not recessed. Once again, the edges are feathered.

A third layer is applied and feathered to a band 10- to 12-inches wide on recessed joints and 16 inches on joints that are not recessed. Special care should be taken with this final layer so that the joint surface is smooth and it does not form a noticeable bulge in the walls. When the third layer has set, the feathered edges should be sanded lightly with fine sand paper, care being taken to avoid damaging the paper surface of the gypsum board.

Nail heads and indentations in the center of the board are filled with two layers of joint cement.

Plywood is usually installed vertically in panels or in strips. The minimum thickness should be $\frac{3}{16}$ -inch for support at 16 inch centers and $\frac{3}{8}$ -inch for 24 inch centers. Panels or strips are nailed on all edges with $1\frac{1}{2}$ -inch casing or finishing nails, spaced 6 inches along the edges and 12 inches at intermediate supports. Panels are available unfinished, or with a factory-applied finish. Joints may have a V-edge or a molding may be used to cover the joints. For a panelled effect, plywood may be installed in strips, with a $\frac{3}{4}$ -inch space between strips and supported on a backing course nailed to the framing members.

Hard-pressed fiberboard finish is also supplied in panels and is usually installed vertically. Thin sheets $\frac{1}{8}$ -inch thick need continuous backing. Sheets may be nailed directly to the studs provided $\frac{1}{4}$ -inch thick sheets are used for supports up to 16 inch centers and $\frac{3}{8}$ -inch sheets on supports up to 24 inch centers. Hardpressed fiberboard should be supported on all edges and nailed as recommended for plywood. Both finished and unfinished panels are available.

Insulating fiberboard is not often used but is available unfinished or with a factory-applied finish. Usually panels are put on vertically with a batten covering the joints. Thickness should not be less than $\frac{7}{16}$ -inch when used on supports up to 16 inches on center. The edges of the panels should be supported and nailed at 4-inch intervals and 8 inches along intermediate supports.

Insulating fiberboard is also supplied in tile form and used principally on ceilings. Tile size may vary from 12- by 12-inches to 16- by 32-inches. The tile is tongue-and-grooved and is supported by concealed nails, clips or staples.

FLOOR COVERINGS

Any material used as the final wearing surface on a floor is called "finish flooring". Of the many such materials on the market each has specific advantages for a particular use. Two essential properties of any kind of finish flooring are durability and ease of cleaning.

Hardwoods such as birch, maple, beech and oak are used in a variety of widths and thicknesses as strip flooring; some species are also available in parquet form. Vertical grain strips of soft woods such as fir or hemlock are sometimes used. Other materials suitable for finish flooring include resilient flooring in tile or sheet form, terrazzo and ceramic tile; since these materials are not adversely affected by moisture they may be used in any location within the house. Carpet, of course, may also be used as a finish flooring.

Wood-Strip Flooring

Wood-strip flooring is manufactured in various widths and thicknesses and is available in several grades. The strips come in random lengths in separate bundles, the number of short pieces depending on the grade chosen. One edge of each strip has a tongue and the other a groove with the ends similarly matched. The thickness of wood-strip flooring required for various support conditions is shown in Table 13.

Wood flooring is generally hollow-backed, and the top face is slightly wider than the bottom so that when the strips are driven together the upper edges touch but the lower edges are slightly apart. The tongue must fit snugly; a loose fit may cause the floor to squeak.

The flooring should not be laid until plastering and other interior wall and ceiling finish is completed. All windows and exterior doors

should also be in place. This precaution prevents damage to the wood flooring either through wetting or other construction activities.

Strip flooring presents a better appearance when laid lengthwise in a rectangular room. Lumber sub-flooring is usually laid diagonally under wood-strip flooring so that the strips can be laid either parallel or at right angles to the joists. Where it is necessary to place the wood strips parallel to the lumber sub-flooring an underlay as described on page 105 should be used to provide a level base for the narrow strips.

Hardwood flooring should not be brought into the house until the basement floor slab has been placed and plastering is completed. Moisture given off during these operations can be absorbed by the flooring and make the wood swell. Then after being put into place the wood strips will shrink and open the joints. The flooring should be stored in the warmest and driest place available in the house until it is installed.

Various types of nails including annular and spiral-grooved types, are used for nailing the flooring. Minimum nail lengths and nail spacing are listed in Table 14.

To nail the wood strips in place many workmen use a mallet-driven nailing tool which drives the nail in the proper location, at the correct angle, and sets the head to the proper depth. Others drive the nails using a carpenter's hammer.

Figure 80B shows the method of nailing the first strip of flooring with the nail driven straight down through the board at the grooved edge. The nails should be driven into the subfloor or joist and near enough to the edge so that the base or shoe molding will cover the nailheads. The first strip of flooring should also be nailed through the tongue.

Succeeding strips of flooring can be fastened (using a carpenter's hammer) by driving nails into each strip at a 45-degree angle at the spot where the tongue adjoins the shoulder (Fig. 80C). Nails should not be driven home with the hammer as the wood may be struck and easily damaged (Fig. 80D). Instead, to finish the driving, a nail set positioned as shown in Figure 80D is used. To avoid splitting, it is sometimes necessary to pre-drill the nailholes through the tongue. For all courses of flooring after the first, the pieces should be selected by length so that the butt joints are well separated from those in the previous course (Fig. 80A). By using a piece of scrap flooring as a driving block, each board can be driven up tightly against the previous course with no danger of damaging the wood with the hammer.

Wood Tile Flooring

Flooring manufacturers have developed a wide variety of special patterns of flooring, which are sometimes called floor tile and sometimes referred to as parquet flooring. One type is a block 9 inches square, available in various thicknesses and made up of several individual strips of flooring, with two edges tongued and the opposing

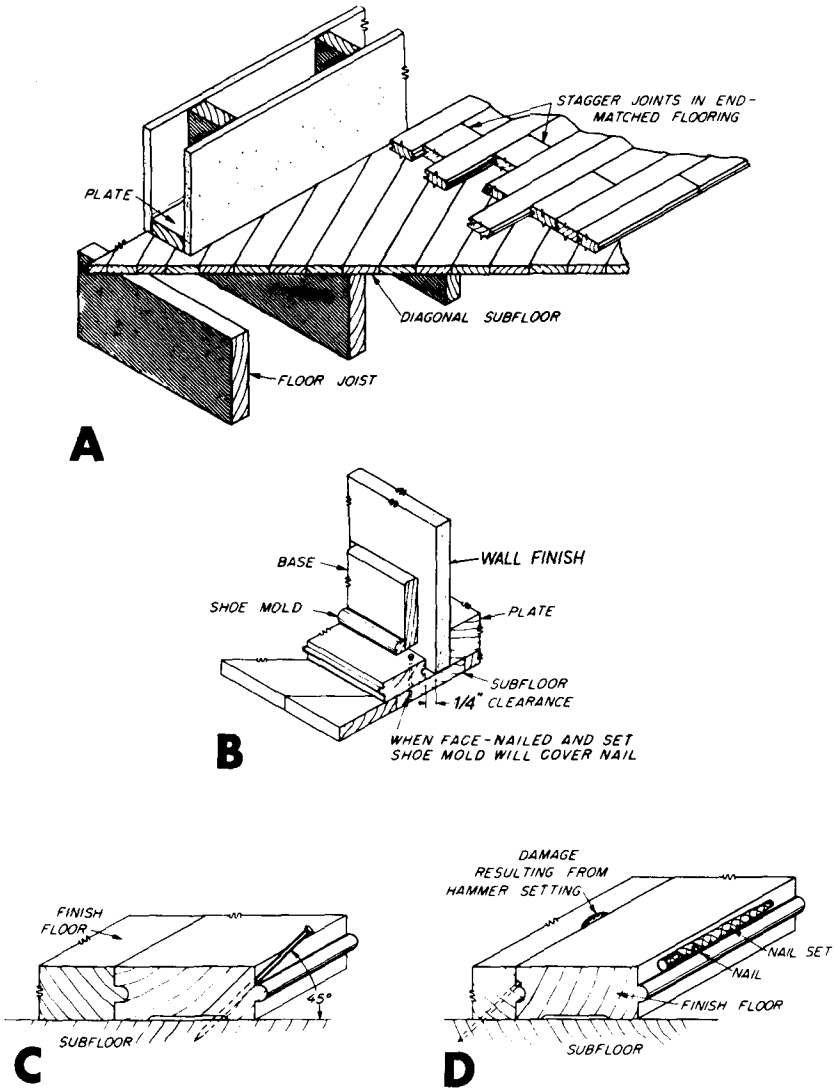


FIGURE 80.—Application of strip flooring. A, General application; B, laying first strip; C, nailing method; D, suggested method for setting nails.

edges grooved. In laying, the direction of the strips is alternated to create a checkerboard effect. Each manufacturer provides specific directions for laying his own type of tile and these directions should be followed carefully.

Underlay for Resilient Flooring

When the subfloor is not a combination type as described on page 29, an underlay should be installed under resilient flooring or carpet.

Plywood panels $\frac{1}{4}$ -inch thick are commonly used although wood particle board and hard-pressed fiberboard in the same thickness are also used. The panels are attached to the subfloor with annular grooved nails spaced 6 inches apart along the edges and at 8 inches on center both ways over the rest of the panel. Nails should be at least $\frac{3}{4}$ -inch long for $\frac{1}{4}$ -inch thick panels and $\frac{7}{8}$ -inch long for $\frac{5}{16}$ -inch panels. Staples may also be used (see Table 30).

Joints between panels and any defects in their surface should be filled with a non-shrinking filler compound that will bond to the underlay. The filler should be sanded smooth after it has set.

Installation of Resilient Floor Covering

Resilient flooring is usually installed after other trades have finished their work. The more common types of resilient floor covering used are linoleum, asphalt tile, vinyl asbestos, cork, solid vinyl, vinyl faced and rubber. Most types are available in both tile and sheet form. The thickness used should not be less than shown in Table 15. Resilient flooring is cemented to the underlay with a special adhesive. Water-proof adhesives are preferable to the non-waterproof types especially in kitchens, bathrooms, entrance ways and laundry rooms. Both tile and sheet material should be installed in accordance with the manufacturer's recommendations. Immediately after the flooring is laid it should be rolled in both directions, the surface cleaned and then sealed with the type of floor wax recommended for the material used.

Resilient flooring for concrete slabs supported on the ground must be of a type recommended by the manufacturer for this particular use. In general the flooring material should be selected from the following types: asphalt, vinyl asbestos, solid vinyl and rubber. A water-proof adhesive should be used in their application.

Carpeting

Carpet is sometimes used as a floor covering in rooms other than kitchens, laundry rooms or other areas where water damage or staining is likely to occur. As in the case of resilient flooring, carpet should be installed over panel-type subfloor or an underlay. In addition, felt or sponge rubber should be used under the carpet.

Ceramic Tile

Ceramic tile can be obtained in different colours and with glazed or unglazed surface. Since this tile has a hard impervious surface it is often used as a floor covering in bathrooms and vestibules as well as for fireplace hearths.

Ceramic tile may be installed on a concrete slab floor, applied to a mortar base supported on the subfloor, or attached by a special adhesive to panel type underlay such as plywood or hard-pressed fiber-board.

When a mortar base is used, an asphalt sheathing paper is placed over the subfloor. The base should be at least $1\frac{1}{4}$ -inches thick, reinforced with wire mesh. The mortar may consist of 1 part Portland cement, $\frac{1}{4}$ -part lime and 4 to 6 parts coarse sand. The tiles are pressed into the fresh mortar. To ensure a good bond between the joint material and base, the joints between the tiles should be filled the same day the tile is installed. To provide sufficient depth for the mortar bed, it is often desirable to drop the wood subfloor between the joists so that the finish floor will be level with floors in adjoining rooms (Fig. 81).

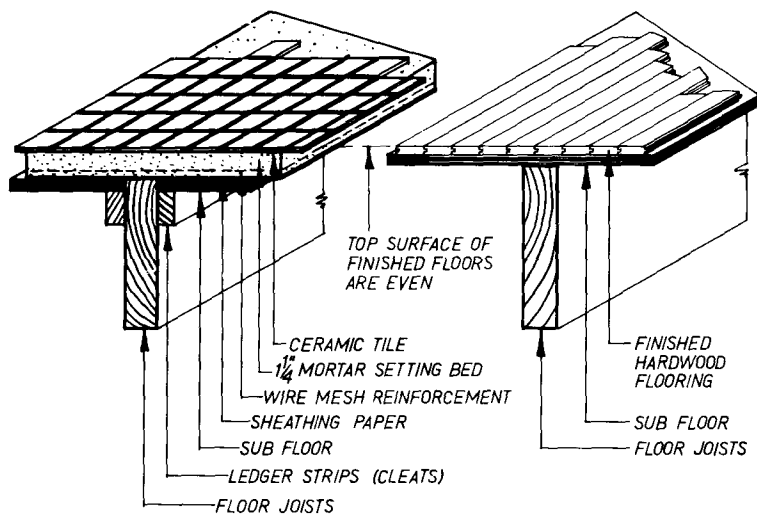


FIGURE 81.—Installation of ceramic tile floor on mortar base.

Where the tops of the joists have to be cut out for this purpose the span of the joists should be calculated on the basis of the reduced depth.

When an adhesive is used to fasten the tiles to an underlay or concrete floor, the base must be smooth and free from surface irregularities. The adhesive is applied to both the tile and the base and each tile pressed firmly in place. After the adhesive is well set the joints between the tiles are filled with the material recommended by the tile manufacturer for this purpose.

INTERIOR DOORS, FRAMES AND TRIM

Interior doors, door frames and interior trim are usually installed after hardwood flooring is in place, but before it is sanded and before

the resilient flooring is laid. Kitchen cabinets and other millwork are usually installed at the same time. The decorative treatment for interior doors and trim may be paint or a natural finish using stain, filler and varnish or other selected materials. The finish selected for the woodwork in various rooms may determine the type or species of wood to be used.

Wood trim should be smooth, clean, sound stock suitable for finishing. Some of the commonly used species are pine, fir and basswood. Moisture content of the wood trim at the time of installation should not be more than 12 percent.

Doors, Frames and Trim

Door frames are made up of two sidejamb and a headjamb, together with separate moldings called doorstops. Stock jambs are made of nominal 1-inch material and in widths to suit the thickness of the finished wall. Sidejamb are often dadoed at the mill, with doorstops and headjamb cut to size (Fig. 82). Frames may also be rabbeted to

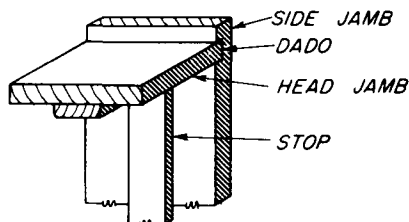


FIGURE 82.—Interior door frame showing typical connection between side and head jamb.

form the stop, in which case the thickness of the frame is usually increased to $1\frac{1}{4}$ -inches. If frames are unassembled when delivered, they should be securely nailed together at each corner.

Casing is the framing or edging trim used around door openings. Many standard patterns in various widths and thicknesses are obtainable from stock. Those with molded forms require miter joints.

There are two general types of interior doors, flush and panel. The standard thickness for interior doors is $1\frac{3}{8}$ -inches and they may be obtained in various widths and heights.

The flush door is made up with facings of plywood or other sheet material glued to a light framework. For natural or varnished finish the face plies are selected for quality and color, but for painted finish the face plies may be the less expensive or non-select grades.

The panel door consists of solid stiles and rails with panel fillers of various materials.

Special doors are also obtainable with various kinds of closing hardware. Sliding doors and folding doors are popular for clothes closets. Sliding doors made of single sheets of plywood should be used

in small sizes only since larger sheets will have a greater tendency to warp.

Doors should be hinged so that they open in the direction of natural entry. Doors should also swing against a blank wall wherever possible and not be obstructed by other swinging doors.

Interior doors are usually 2 feet 6 inches wide and 6 feet 6 inches high. These sizes will generally allow easy passage of furniture.

Setting the interior door frame is done by means of wedges that are used between the sidejamb and rough-opening studs (Fig. 83). Shingles

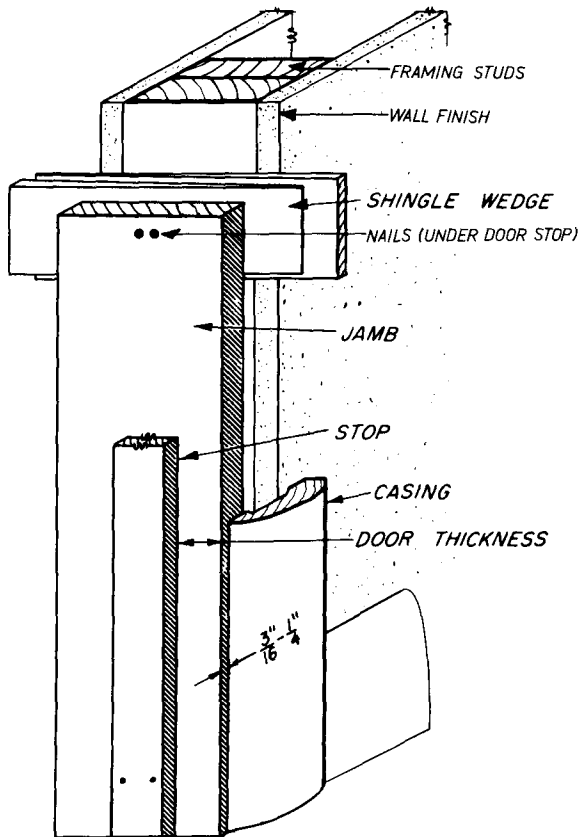


FIGURE 83.—Door frame and trim showing frame blind-nailed under door-stop.

may be used for this purpose. Jambs are set plumb and square, wedges are fitted snugly and the jambs are then securely nailed to the studs through the wedges. After nailing, the wedges are sawed flush with the face of the wall. Nails should be driven in pairs as shown in Figure 83.

Casings are nailed to both the framing studs and the jambs with casing or finishing nails. Nails should be spaced about 16 inches apart and the heads countersunk and filled. The casing is placed $\frac{3}{16}$ - to $\frac{1}{4}$ -inch from the inner edge of the jamb.

Stops are usually $\frac{3}{8}$ - by $1\frac{1}{4}$ -inches and are nailed to the jamb with finishing or casing nails after the door is hung.

Casing joints at the head of the frame are usually mitered. Careful cutting and fitting is required to ensure a tight joint. Mitered joints are sometimes glued because a glued joint is less likely to open when slight shrinkage occurs.

Standard clearances and the location of door hardware are shown in Figure 84. The clearances may vary slightly, but those shown are

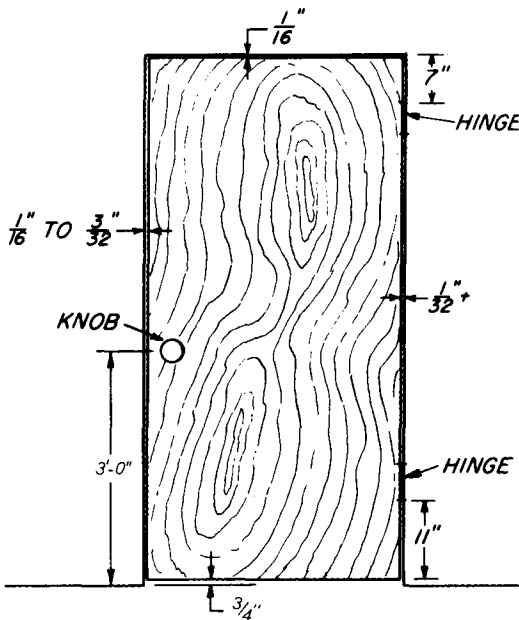


FIGURE 84.—Suggested door clearances and location of hardware.

widely used. Hinges are shown as 7 inches from the top and 11 inches from the bottom, but these distances may also vary slightly, especially in panel doors. Where three hinges are used the center one is spaced midway between the top and bottom hinges. Standard knob height is 34 to 38 inches from the floor, and locks or latches should be installed accordingly.

Clearance around the door should be $\frac{1}{16}$ - to $\frac{3}{32}$ -inch on the latch side and $\frac{1}{32}$ -inch on the hinge side. A clearance of $\frac{1}{16}$ -inch at the top and $\frac{3}{4}$ -inch at the bottom is usual but if the door is to open over heavy carpeting, the bottom clearance may have to be greater.

Some manufacturers supply prefitted doorjamb and doors, with the hinge slots routed ready for installation. Also on the market are sheet-metal door frames with formed stops and casing. Hinge slots and strike plates are integral with these units.

Installation of Door Hardware

Hinges should be of the proper size for the door they support. For $1\frac{3}{8}$ -inch thick interior doors, two 3- by 3-inch butt hinges are used. The door is first fitted to the framed opening to ensure it has the proper clearances then it is removed and the hinges are fitted to it. The door edge is routed to take the two half hinges. The edge of each hinge should be at least $\frac{1}{8}$ -inch back from the face of the door. When

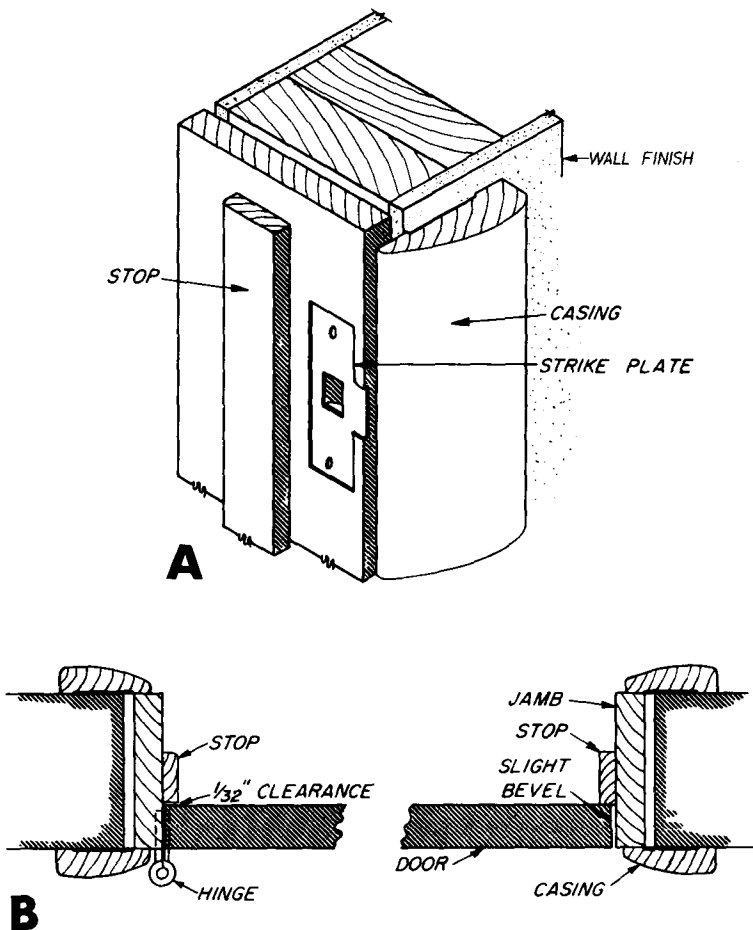


FIGURE 85.—Installation of A, typical strike plate and B, stops.

the hinge halves are screwed in place they must be flush with the surface and square.

The door is now placed in the opening and blocked up at the bottom to provide the proper clearance. The door jamb is marked at the hinge locations, and routed to take the other two hinge halves which are then fastened in place. The door may now be placed in the opening, and the hinge pins inserted.

There are several types of door locks which vary both in cost and in method of installation. Lock sets are supplied with installation instructions that should be followed.

The location of the latch is marked on the door jamb and the strike plate located in this way. The marked outline is routed out to take the striker plate and the recess to take the latch is also routed out (Fig. 85A). The strike plate is then fixed in place and should be flush with or slightly below the face of the door jamb. When the door is latched the face of the door should be flush with the edge of the jamb.

Doorstops may have been set temporarily during the installation of the hardware, but now is the time to nail them permanently in place. The stop at the jamb on the latch side is nailed first (Fig. 85B) and should be set up tight against the door face when the door is latched. The stop on the hinge side is nailed next and should be given a $\frac{1}{32}$ -inch clearance from the door face to prevent scraping as the door is opened. Finally the headjamb stop is nailed in place. Casing or finishing nails should be used and heads counter-sunk and filled. When door and trim are painted, some of the clearances allowed will be taken up.

Window-Trim Installation

Casing for window trim is usually the same pattern as that selected for the doors. The casing is applied using casing or finishing nails on all four sides of the window except where a stool is used. In this instance the casing terminates on top of the stool and an apron is added as a finish member below the stool.

Base Moldings

Base molding serves as a finish between the walls and floor. It may vary in size and form but must be of sufficient thickness at the bottom to cover the flooring joint and high enough to cover the plaster-ground if plaster is used. A two-piece base molding consists of a baseboard fitted with a shoe mold at the bottom (Fig. 86A). A one-piece base is milled with a thickened edge at the bottom to cover the flooring joint (Fig. 86B).

When a two-piece base is used the baseboard is nailed through to the wall plate and studs, high enough so that the lower edge clears the finish floor. The shoe mold is later nailed to the subfloor using a long thin nail driven at an angle which holds the shoe mold tightly against both the baseboard and the finish floor. A one-piece base

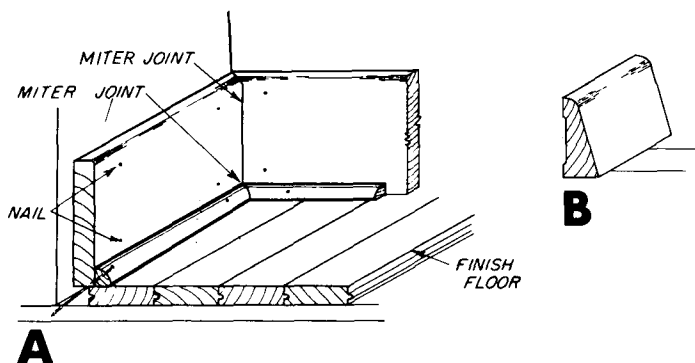


FIGURE 86.—Base molding. A, Two-piece; B, one piece.

is fitted tightly to the finish floor and nailed to the wall plate or studs. The one-piece base or the shoe mold where a two-piece base is used are installed after the resilient floor has been laid or after hardwood flooring has been sanded.

Joints at interior corners may either be mitered or butted and coped. Butted and coped corners are made by butting the first piece of trim against the corner and scribing the end of the corresponding piece to the molded face of the first piece. Exterior corners are mitered. All nails used should be casing or finishing nails with heads countersunk and filled.

Millwork

Kitchen cabinets, shelving, mantels, and other items of millwork are installed at the same time as the interior trim. This work is ordinarily carried out before the hardwood floors are sanded or the resilient flooring laid.

Cabinets and similar units may be either built in place or shop-built.

As in the case of interior trim, which is also classed as millwork, the cabinets, shelving and other items can be made from various species of wood.

Factory-made cabinets of steel or other materials are also available and can be obtained in various sizes.

Kitchen Cabinets

The kitchen deserves special attention, since it is the area where the housewife spends a large part of her time. An efficient arrangement of kitchen cabinets, refrigerator, sink and range reduces work and saves steps.

Base units of kitchen cabinets are approximately 36 inches high with the counter top 22 to 24 inches deep. Various combinations of drawers

and doors may be included in the base. Some cabinet arrangements include a corner cabinet equipped with revolving shelves. The counter top and back-splash (added along the wall above the counter top) are faced with plastic laminate or other impervious covering.

To provide work space, wall units are set about 16 inches above the counter. This distance should be increased to at least 24 inches for wall units over the range. The shelves, which can be adjustable, are usually 11 to 12 inches deep. The ceiling may be dropped over the cabinets as shown in Figure 87.

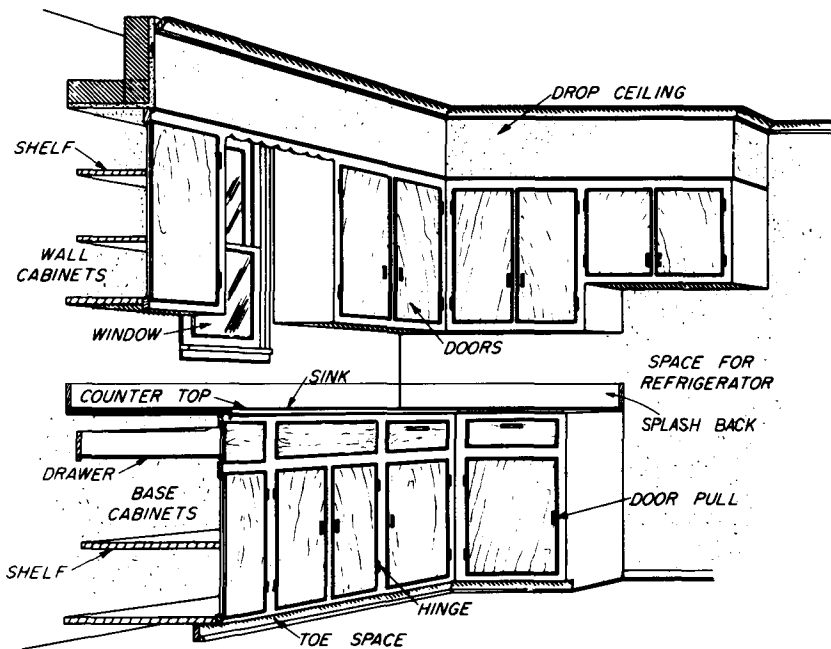


FIGURE 87.—An arrangement of kitchen cabinets.

Closets

Linen closets are commonly of two types; (a) those with standard doors and cased openings with shelving installed on the interior (Fig. 88A); and (b) built-in closets with doors and drawers (Fig. 88B). Many variations are possible.

Clothes closets are commonly provided with a standard interior door and with shelves, closet rods or metal track (Fig. 88C).

Built-in wardrobes may also be used. While this type of unit costs more than a standard opening, the inclusion of dressers and chests of drawers eliminates the need for much of the bedroom furniture (Fig. 88C).

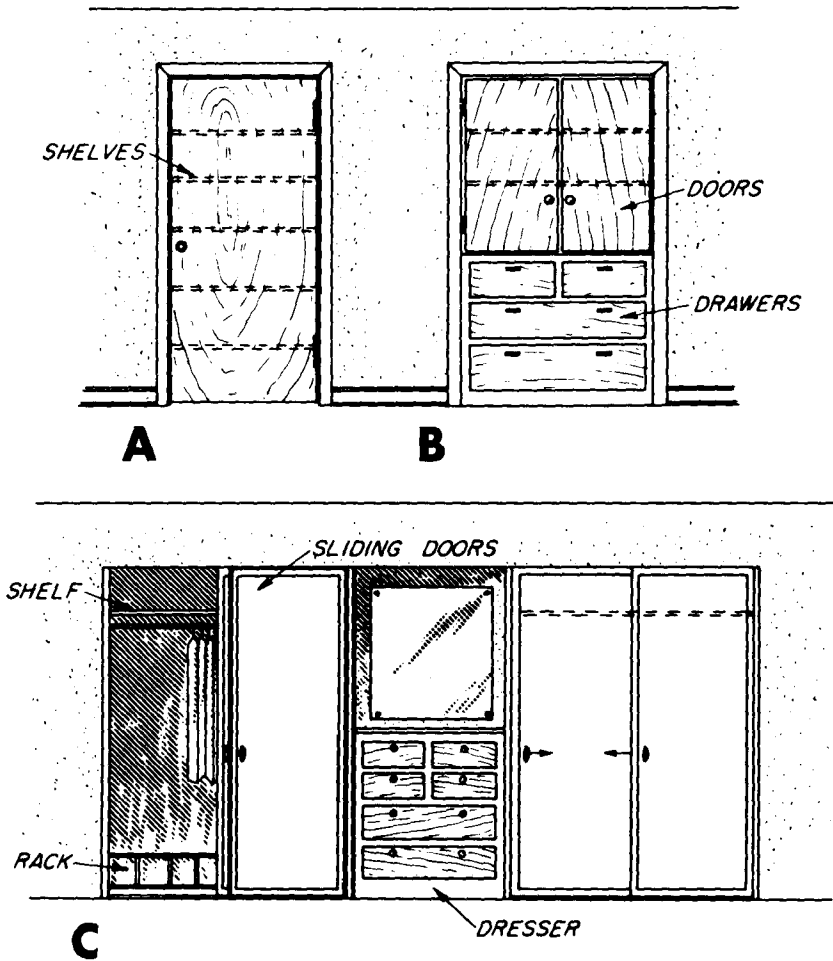


FIGURE 88.—Storage closets. A, With shelves; B, with shelves and drawers; C, wardrobe.

Sliding doors in pairs or other multiple combinations are often used on clothes closets. They are hung on a track with rollers fastened to the doors. Folding doors, consisting of narrow wood or metal panels or accordion-type doors consisting of a metal frame covered with a vinyl fabric, are also used.

STAIRS

Stairways should be so designed, arranged and installed to afford safety, adequate headroom and space for the passage of furniture. In

general, there are two types of stairs in a house, those between finished areas usually referred to as "main stairs" and those which lead to areas used only for storage, laundry and heating equipment, such as unfinished basement or attic stairs. The main stairs are designed to provide ease and comfort and are often made a feature of design, while other stairs are usually somewhat steeper and narrower and are built of less expensive materials. Stairs should be at least 3 feet wide measured face to face of wall.

Stairs may be built in place, or may be built as units in the shop and set in place.

Stairways may have a straight, continuous run without an intermediate landing or they may consist of two or more runs with changes in direction. In the best and safest practice a landing is introduced at any change in direction, but the turn may be made with radiating risers called winders. The length or width of any landing should not be less than the width of the stairs.

The diagrams shown in Figure 89 are for non-winder stairways. If winders are necessary, because of cramped space, not more than one set of winders should be used in the stairway and each winder tread should form an angle of 30 degrees, so that three treads would be necessary for a 90-degree turn.

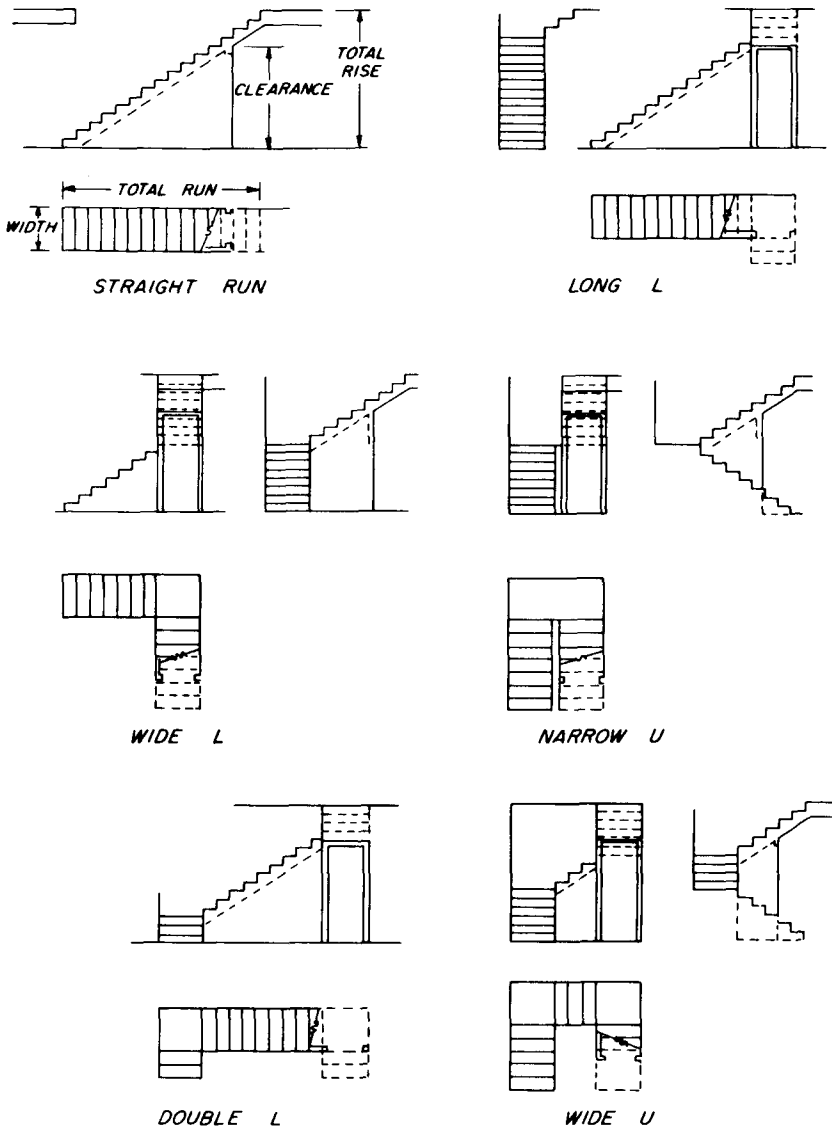
Terms

The terms generally used in stair design (and shown in Figs. 89-92) are defined as follows:

Balusters	—	the vertical members supporting the handrail on open stairs,
Stringer	—	member supporting the treads and risers,
Landing	—	a flat platform incorporated in a stairway,
Newel	—	the main post of the railing at the start of the stairs and the stiffening posts at changes of direction and landings,
Nosing	—	projection of tread beyond face of riser,
Run	—	the net width of a step measured from riser to riser,
Rise	—	the vertical height of a step,
Tread	—	horizontal face of a step,
Riser	—	the vertical board under the tread,
Winders	—	radiating or wedge-shaped treads at turns of stairs.

Ratio of Rise to Run

The relation between the height of the rise and the width of the run, should conform to well-established rules. Experience has shown



TYPES OF STAIRS

FIGURE 89.—Types of nonwinder stairs.

that a rise of 7- to 7½-inches with a run of about 10 inches combines both comfort and safety, and these dimensions are commonly used for main stairs. Unfinished basement stairs may be steeper than the main

stairs, but the height of the rise rarely exceeds $8\frac{1}{2}$ -inches. As the height of the rise is increased, the width of the run must be decreased for comfort. A good rule is that the run multiplied by the rise should be between 70 and 75. Treads rarely are less than $9\frac{1}{2}$ -inches nor more than 12 inches wide.

Although the dimensions recommended above may be considered desirable, space does not always permit their use, in which case the following limitations should be observed:

- Main stairs — maximum rise 8 inches, minimum run $8\frac{1}{2}$ -inches, minimum tread width $9\frac{1}{2}$ -inches.
- Other stairs — maximum rise 9 inches, minimum run 8 inches, minimum tread width 9 inches.

Design of Stairway

Once the location and the width of a stairway and landing, if any, have been determined, the next thing to do is to fix the height of the rise and the width of the run. A suitable height of rise is chosen, and the exact distance between the finish floors of the two storeys under consideration is divided by the height of the rise. If the answer is an even number, the number of risers is thereby determined. It usually happens, however, that the result is uneven, in which case the storey height is divided by the next higher or lower whole number and this will give the actual height of the rise. The width of the run is then established by dividing the number of treads into the total run of the stairs.

The headroom is the vertical distance from a line drawn through the outer edge of each nosing to the underside of the ceiling above (Fig. 90). The minimum headroom should be 6 feet 4 inches.

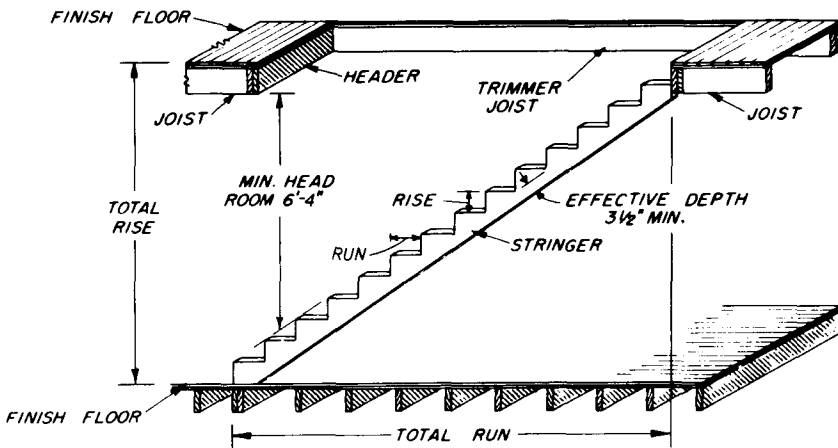


FIGURE 90.—Stairway design.

Stringers

The treads and risers are supported on stringers which must always be solidly supported and fixed in place, level and true. The stringers may be cut-out (Fig. 92B and C) or ploughed (Fig. 91A and C) to fit the outline of the treads and risers.

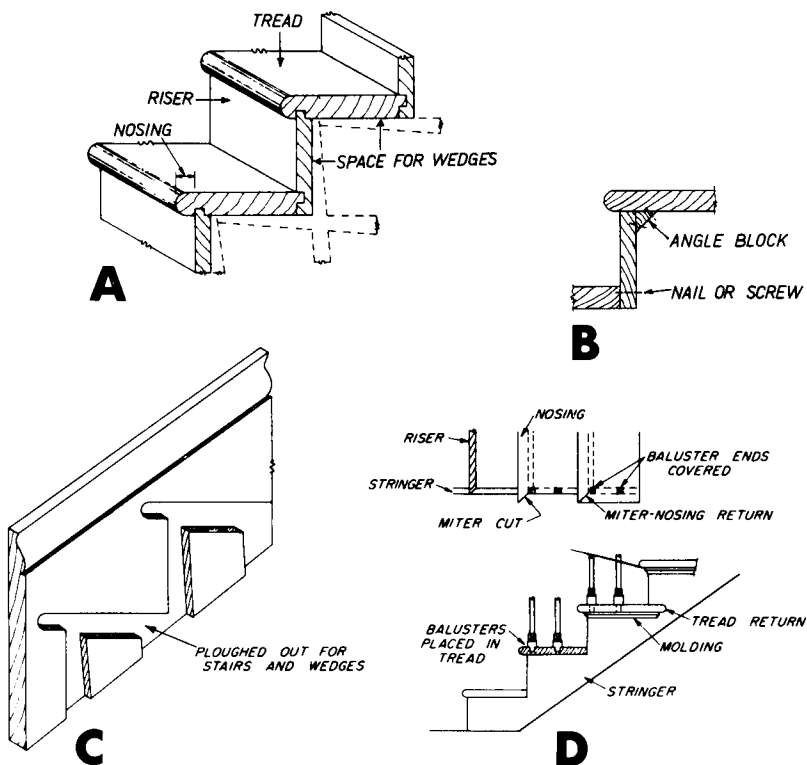


FIGURE 91.—Parts of stairs. A, Risers and treads tongued and grooved together; B, risers and treads connected with angle blocks; C, housed stringers; D, other parts.

Stringers should not be less than $1\frac{1}{4}$ -inches thick when they are supported along their length or $1\frac{3}{8}$ -inches when supported only at the top and bottom. The overall depth should be at least $9\frac{1}{2}$ -inches and when the stringer is cut out to fit the treads and risers, the portion remaining should not be less than $3\frac{1}{2}$ -inches deep. A third stringer should be used when the width of the stairs is more than 3 feet. Treads should be at least $1\frac{3}{8}$ -inches thick when used with open risers. This thickness can be reduced to 1 inch where the stringers are not more

than 2 feet 6 inches apart or where the tread is supported by a closed riser attached to the treads.

The wall stringer may be ploughed out to the exact profile of the tread and riser with sufficient space at the back to take wedges (Fig. 91C). The top of the riser may be connected to the bottom of the tread by angle-blocks glued to both surfaces, screws being added to reinforce the joint. The bottom of the riser is attached to the back of the tread with screws (Fig. 91B). Another method is to tongue the top of the riser into the front of the tread and the back of the tread into the bottom of the next riser (Fig. 91A). The wall stringer is nailed to the wall, the nails being located behind the treads and risers. The treads and risers are fitted together and forced into the wall-stringer nosing, where they are set tight by driving and glueing wood wedges behind them. The wall stringer thus shows above the profiles of the tread and risers as a finish against the wall and is often made continuous with the baseboard of the upper and lower floors.

If the outside stringer is an open stringer, it may be cut out to fit the risers and treads. The edges of the risers are mitered with the corresponding edges of the stringer, and the nosing of the tread may be returned upon its outside edge along the face of the stringer (Fig. 91D).

Newels and Handrails

All stairways should have a handrail from floor to floor. For closed stairways the rail is attached to the wall with suitable metal brackets. The rail should be set 2 feet 6 inches above the tread at the nosing. Handrails and balusters are used for open stairs and around open landings with the handrails ending against newel posts.

Basement Stairs

Ploughed stringers (Fig. 92A) are probably the most widely used supports for treads on basement stairs, but the tread may be supported on cut-out stringers (Fig. 92B). Another method sometimes used is cut-out stringers nailed to a finish member as shown in Figure 92C.

Exterior Steps and Stoops

Proportioning of risers and treads in laying out porch steps or approaches to terraces should be as carefully considered as in the design of interior stairways. The riser-to-tread ratio should not exceed those for main stairs referred to previously. Outside steps and stoops need good support. If they are supported independently, their foundation should extend below the frost penetration line and be carried down to undisturbed ground. Outside steps and stoops leading to entrances usually consist of precast units or concrete cast in place.

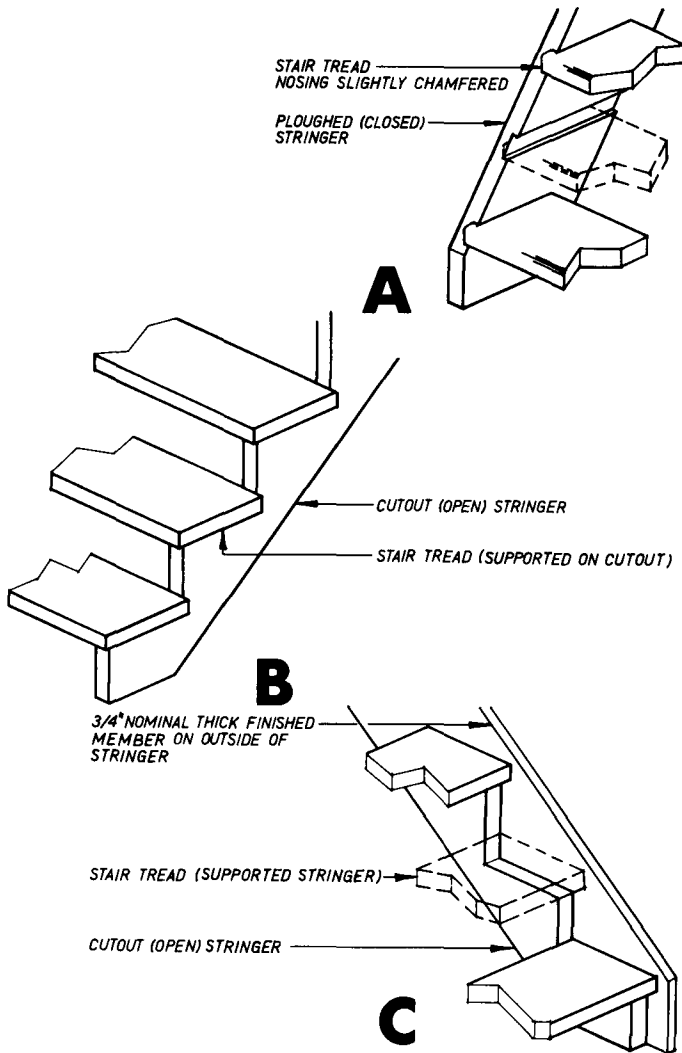


FIGURE 92.—Basement stairs. A, Ploughed stringers; B, cutout stringers; C, cutout stringers with finish member nailed to the outside of the stringer.

FLASHING

Flashing is provided where necessary to prevent the entry of water through joints between materials. Proper installation of flashing is important, as is the selection of the most suitable materials for each specific location.

The minimum recommended weights and types of materials for flashing are as follows:

Exposed flashing—4-lb sheet lead, 28-gauge galvanized copper-bearing sheet metal, 14-ounce copper, 11-ounce zinc, or 0.019-inch thick aluminum.

Concealed flashing—4-lb lead, 28-gauge galvanized copper-bearing sheet steel, 14-ounce copper, 11-ounce zinc, 45-lb roll roofing, 6-mil polyethylene and 2-ounce copper or aluminum laminated to felt or kraft paper.

Aluminum flashing should be separated from masonry or concrete or coated with an impervious membrane.

Flashing should be used at the junction of roofs and walls, roofs and chimneys, over window and door openings, in roof valleys and at other critical areas.

A typical example of construction requiring flashing is at the intersection of two types of materials, as shown in Figure 93. The stucco

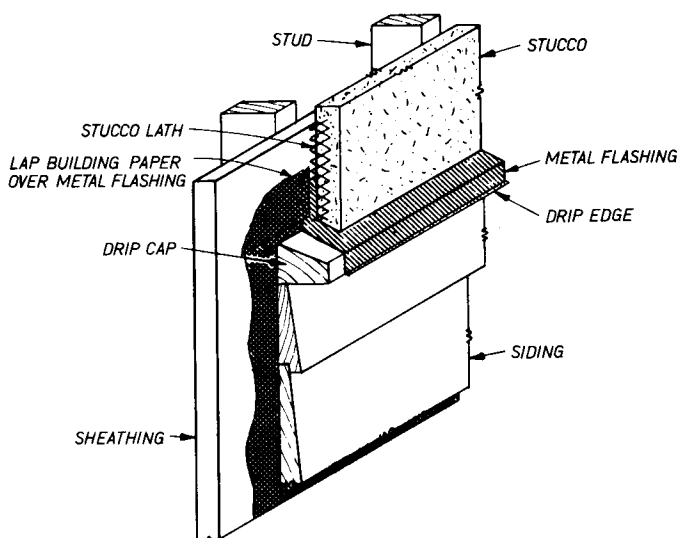


FIGURE 93.—Typical flashing between two different materials.

is separated from the wood siding below by a wood drip cap. To prevent the water from entering the wall, formed flashing is installed over the drip cap so as to form a drip at the outside edge. The flashing should extend at least 4 inches above this drip cap and under the sheathing paper. This type of flashing is also used over the heads of windows and doors unless they are well protected by a roof overhang. Where the vertical distance between the top of the trim and the outer lower edge of the overhang is less than one-quarter of its horizontal projection, flashing should always be used. The heads and sills of

openings in masonry-veneered wood-frame walls should be flashed. Head flashing should extend from the front edge of the lintel, up and over the lintel and on up under the sheathing paper. Where a jointed masonry sill is used the flashing should extend from the outer edge under the masonry sill up to the underside of the wood sill.

Flashing should also be used at the junction of roof surfaces and walls. If built-up roofing is used, a cant strip should be provided to avoid a right-angle bend in the membrane which is more liable to be punctured. The built-up roofing is carried at least 6 inches up the wall of the house over the cant strip and sheathing. The sheathing paper is then lapped 4 inches over the edge of the roofing. When the siding is placed on the wall, a clearance of at least 2 inches should be allowed between the siding and the roof to keep the siding well clear of drainage water.

Where stack-vents penetrate the roof they should be flashed to prevent moisture entry, and sheet lead is generally used for this purpose.

Flashing should be used where two roof-lines intersect to form a valley. Depending on the shingling method used valleys are referred to as open or closed. Open valleys usually are flashed with one layer of sheet metal at least 24 inches wide, or with two layers of roll roofing. When roll roofing is used, the bottom layer may be 55-lb smooth surface or 90-lb mineral surface material (mineral surface down), at least 18 inches wide. This layer is centered on the valley and fastened along the edges with nails spaced 16 to 18 inches apart. A 4-inch band of cement is then applied along the edges of the bottom layer and a 36-inch wide strip of 90-lb mineral surface roll roofing is placed over the first layer. The top layer is fastened along the edges with only enough nails to hold it in place until the shingles are applied. The roof shingles are stopped on a line 4 to 6 inches from the center of the valley, this distance usually being greater at the eaves than at the ridge.

Closed valleys are flashed with one layer of sheet metal or 55-lb roll roofing 24 inches wide. Each course of asphalt shingles is continued across the valley ensuring that shingle nails are not placed within 3 inches of the valley centerline at the ridge or 5 inches at the eaves. Where rigid shingles are used they are cut to fit the center line of the valley but these should not be used with the closed valley method on roofs that slope less than 10 in 12.

Flashing squares (sometimes called "step-flashing" or "shingle flashing") may be used at the intersections of shingled roofs with walls or chimneys. This type of flashing is installed at the time the shingles are applied, with one square being used at each course and being bent up along the wall under the sheathing paper (Fig. 94A). The siding will cover the flashing along the wall except for the clearance allowed. These squares should be large enough to give a good lap at the roof and wall line and the head lap should be no less than 3 inches. On roof slopes behind a chimney, the flashing should extend both up the

roof slope and up the chimney to a point equal in height to the counter flashing on the chimney, but in any case not less than $1\frac{1}{2}$ times the shingle exposure.

Counter-flashing is used at the intersection of a roof with a masonry wall or chimney. This counter-flashing should extend at least 6 inches up the side of the chimney or masonry veneer and be embedded at least 1 inch into the mortar joint. The counter-flashing is fitted tightly against the masonry and lapped over the shingle flashing at least 4 inches. Counter-flashing is applied to all sides of the chimney.

If the upper side of a chimney is more than 30 inches wide, a cricket or saddle should be installed (Fig. 94B). These are often made of sheet

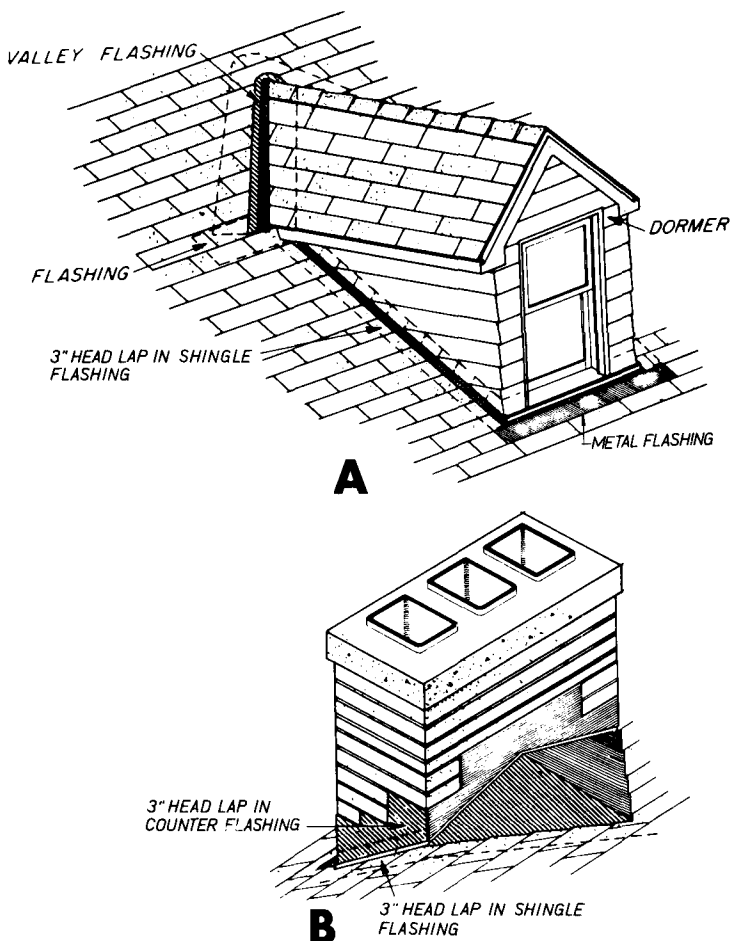


FIGURE 94.—A, Open valley and shingle flashing at side wall; B, cricket flashing used with chimney that is more than 30 inches wide.

metal and should be placed over a wood-framing support constructed during roof-framing operations. The saddle should be suitably flashed at the roof and counter-flashed at the chimney. Open joints and laps should be soldered or sealed, or a locked joint used.

GUTTERS AND DOWNSPOUTS

Formed metal gutters commonly used for eaves-troughing are available in lengths of 10 to 12 feet. The outside edge is stiffened by shaping it to form an Ogee pattern. Fittings such as inside and outside corners, downspout connectors and elbows are available in sizes and angles to suit installation requirements. Plastic materials are also used for gutters and downspouts.

Gutters are installed after the exterior finish is in place. They are mounted on the fascia board as close as possible to the shingle overhang, with a slight slope towards the downspouts. Gutters are fastened with 6-inch corrosion-resistant spikes spaced about 30 inches apart. A sheet metal spacer tube is used between the interior surfaces of the gutter and the spike is driven through the gutter and spacer into the fascia board and rafter header. Joints in the gutter are soldered or otherwise sealed.

Downspouts may be rectangular or round and those made from metal are usually corrugated for added strength. The corrugated patterns are also less likely to burst when plugged with ice. Goosenecks, made up from elbows and short sections of downspout piping, are used to bring the downspout in line with the wall.

Downspouts are fastened to the wall by means of straps or hooks. At least two hooks or straps should be used with each 10-foot length of downspout.

Where the downspouts are not connected to a storm sewer, an elbow with an extension, or a splash block, is used to direct the water away from the foundation wall to avoid erosion. The final grading of the lot should be such as to ensure positive drainage away from the building and off the lot.

GARAGES AND CARPORTS

Garages can be classified as attached, detached or built-in and the type used is sometimes determined by the nature and size of the lot. Where space is not a limitation, the attached garage has many points in its favor. It is warmer during cold weather and, when equipped with a connecting door to the house, provides covered protection between car and house. Detached garages are usually located at the rear of the house.

Built-in garages with living accommodation over the garage area are sometimes used in two-storey houses. A built-in garage may also be incorporated in the basement where reasonable access from the street can be provided.

It is a mistake to make the garage too small for convenient use. Cars vary in size, but the garage should be long and wide enough to take any model and still leave space to walk all around the car. This requires a minimum of 20 feet between the inside face of front and rear walls. If a work bench or storage space is to be put on the rear wall, the length of the garage must be increased accordingly. A width of 10 feet of clear space should be a minimum, but 11 feet or more is better so that doors on either side of the car can be opened freely. A two-car garage should be at least 18 feet wide. Since garage space is valuable for storage of garden tools, bicycles, screens, storm sash, and other articles, additional space should be considered for this purpose.

Foundations for garages are usually concrete or masonry. The minimum depth below grade should not be less than shown in Table 3. The foundation wall should not be less than 6 inches thick and should extend at least 6 inches above grade. Other suitable types of foundations include concrete slab on ground or post and beam. Mud sills, which should only be used with detached garages, are made from durable wood such as cedar or other species pressure-treated with a preservative. Foundations for attached garages should generally be the same as those used to support the house.

Sill plates are anchored to the foundation wall or slab with anchor bolts spaced about 8 feet apart and with at least 2 bolts in each sill piece. Extra anchors may be required at the sides of the main door. The framing and exterior finish of the side walls and roof are done in the same way as for the house.

If fill is required below the floor a granular material is preferable and should be well compacted, to avoid settlement after the floor is laid. The floor is usually concrete, which should not be less than 3 inches thick where a base is used or 5 inches thick without a base. The floor usually slopes towards the entrance unless a floor drain is installed.

Interior finish is largely a matter of choice; the studs may be left exposed or covered. When the garage is to be heated, insulation and a vapor barrier should be included and covered with a wall finish to protect them from damage. The door between the garage and house should have a fire rating of at least 20 minutes (a 1¾-inch solid core wood door meets this rating) and be fitted with weather stripping and a self-closing device to prevent gas and exhaust fumes from entering the house.

There are many types of doors for garages, each with different advantages. The two most commonly used are the swing-up door (Fig. 95B) and the sectional overhead doors (Fig. 95C). Hinged doors (Fig. 95A) are sometimes used. The one-piece swing-up door operates on a pivot principle with the track mounted on the ceiling and rollers located at the center and top of the door. Counterbalance-springs are mounted on the door, one at each side, to make operation easier. The sectional overhead door has rollers at each section fitted into a track up each side of the door and along the ceiling.

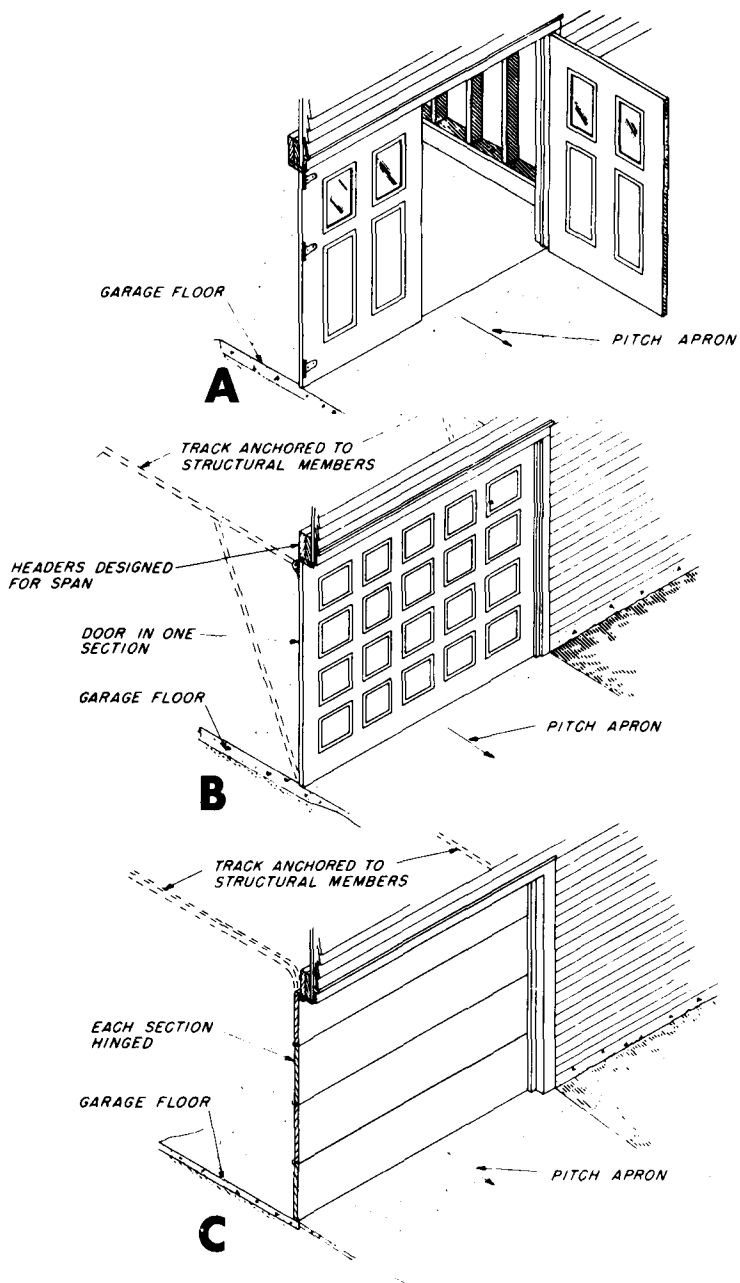


FIGURE 95.—Types of garage doors. A, Hinged; B, overhead swing; C, overhead sectional.

Carports are generally attached to the house with all or most of the other three sides open. Carport roofs are usually supported by posts located on top of concrete piers. Piers should be at least 8- by 8-inches in size. Round piers formed in paper cylinders available for this purpose are often used. The base of the pier should be sufficiently large to ensure that the safe bearing pressure for the soil is not exceeded and far enough below grade to prevent frost heaving. Piers should extend at least 6 inches above the ground to protect the posts from ground moisture, where wood posts are used. Posts must be securely anchored to both piers and roof framing to resist wind uplift.

CHIMNEYS AND FIREPLACES

Chimneys and fireplaces are usually of masonry construction supported on a suitable foundation. Light-weight, factory-built chimneys and fireplaces requiring no foundation may also be used. A chimney must be capable of producing sufficient draft to maintain the fire and carry off the products of combustion.

Since an ordinary fireplace has a very low heating efficiency its chief value is decorative. Its efficiency can be increased, however, by use of a factory-made metal unit incorporated in the fireplace structure. In addition to direct heat from the fire the room is also heated by air circulating through the unit. Both the chimney and the fireplace must be carefully built to be free of fire hazards.

Chimneys

Masonry chimneys should be built on a concrete footing, properly proportioned to support the load. Since a chimney may contain more than one flue the minimum dimensions depend on the number of flues and their arrangement and size.

The flue is a vertical shaft through which smoke and gases are carried to open air. A single flue may serve one or more appliances, for example, a furnace and water heater. In this case both connections to the flue should be made within the same storey and the connections should be located one above the other to ensure a good draft. A fireplace should always have its own separate flue. The size of the flue depends on the size of the flue pipes connected to it, and the type of fuel used.

The wall thickness of a masonry chimney should not be less than 3½-inches of solid masonry units. The lining usually consists of rectangular glazed clay pipe in sections, which are about 2 feet long and installed when the surrounding masonry is being placed. Care should be taken to set the linings close and flush on top of each other. If more than one flue is used in a chimney they should be separated from each other by at least 3½-inches of solid masonry (Fig. 96). The linings usually start about 8 inches below the flue pipe connection and extend 2 to 4 inches above the chimney cap.

Most factory-built chimneys are fabricated in sections and connected during installation. They are comparatively light in weight and can be supported by special anchors that are attached to the floor joists when

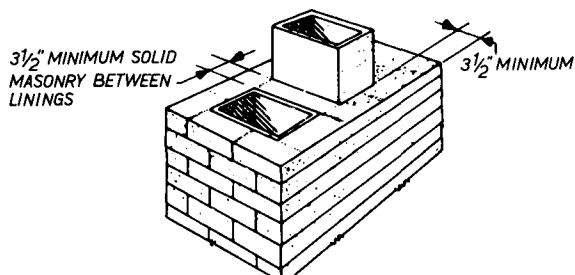


FIGURE 96.—Installation of flue linings.

the chimney is erected. Two precautions to be observed in the use of a factory-built chimney are:

- (a) Make sure the model has been tested and approved by the Underwriters' Laboratory, and
- (b) Installed in strict accordance with both the manufacturer's instructions and the Underwriters' conditions of approval.

The chimney should be carried high enough above the roof to avoid downdrafts caused by wind turbulence. The height should never be less than 3 feet above the highest point where the chimney intersects the roof and should extend at least 2 feet above the ridge or any other obstruction within 10 feet of the chimney (Fig. 97).

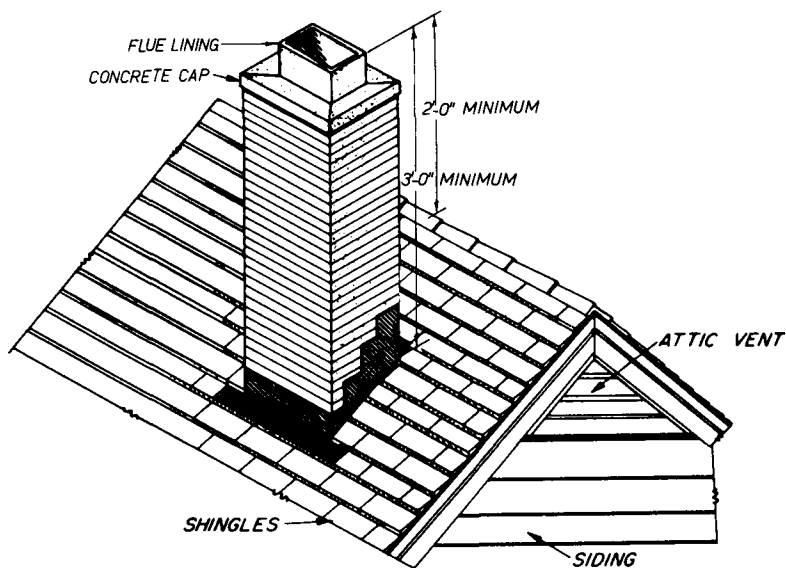


FIGURE 97.—Chimney height above ridge.

The top of masonry chimneys should be capped to keep water out of the masonry joints. Concrete is generally used for this purpose. The top of the cap should be sloped away from the flue lining and extend beyond the chimney wall at least 1 inch to form a drip edge.

A metal cleanout opening and door should be provided near the bottom of the flue so that soot can easily be removed from the chimney.

Chimneys may be used to vent gas-burning equipment; alternatively the equipment may be vented through special gas vents approved for this purpose.

Fireplaces

A fireplace that draws properly can be assured by applying proper principles of design. The fireplace flue should be lined. Its size depends on the size of the fireplace opening. One rule commonly used is to take one-tenth of the area of the fireplace opening to find the minimum size of the flue; however, the outside dimension of the flue liner should never be less than nominal 8- by 12-inches. The names and locations of the various parts of a fireplace are illustrated in Figure 98.

Other design principles commonly used in the construction of a fireplace with a single face are:

- The front of the fireplace should be wider than the back and the upper part of the back should tilt forward to meet the throat, thus helping to throw heat into the room instead of up the chimney.

- The back, which should rise one-half the height of the opening before sloping forward, is usually about two-thirds of the opening in width.

- A smoke shelf, to reduce back drafts, is formed by projecting the throat forward as much as possible. The throat should be as wide and shallow as possible but in total area it must equal the area of the flue. Thus the narrowing of the throat will cause a quick suction into the flue.

- The sides of the fireplace above the throat are drawn together to form the flue, which usually starts over the centre of the width of the fireplace; this slope, however, should not exceed 45° to the vertical.

The lining of the fire box must be built with materials having a high resistance to heat. A steel liner designed for this purpose or 2 inches of fire brick meet this requirement. When fire brick is used it should be laid with fire-clay mortar or high-temperature cement.

If a 2-inch fire brick liner is used, the back and sides of the fireplace should be at least 7½-inches thick for walls built of solid masonry and 12 inches thick when hollow masonry or stone is used. Hollow masonry units should be laid up in two wythes with joints staggered between wythes. These wall thicknesses are exclusive of the 2-inch liner. However, if 3½-inch fire brick liner is used the thickness of the

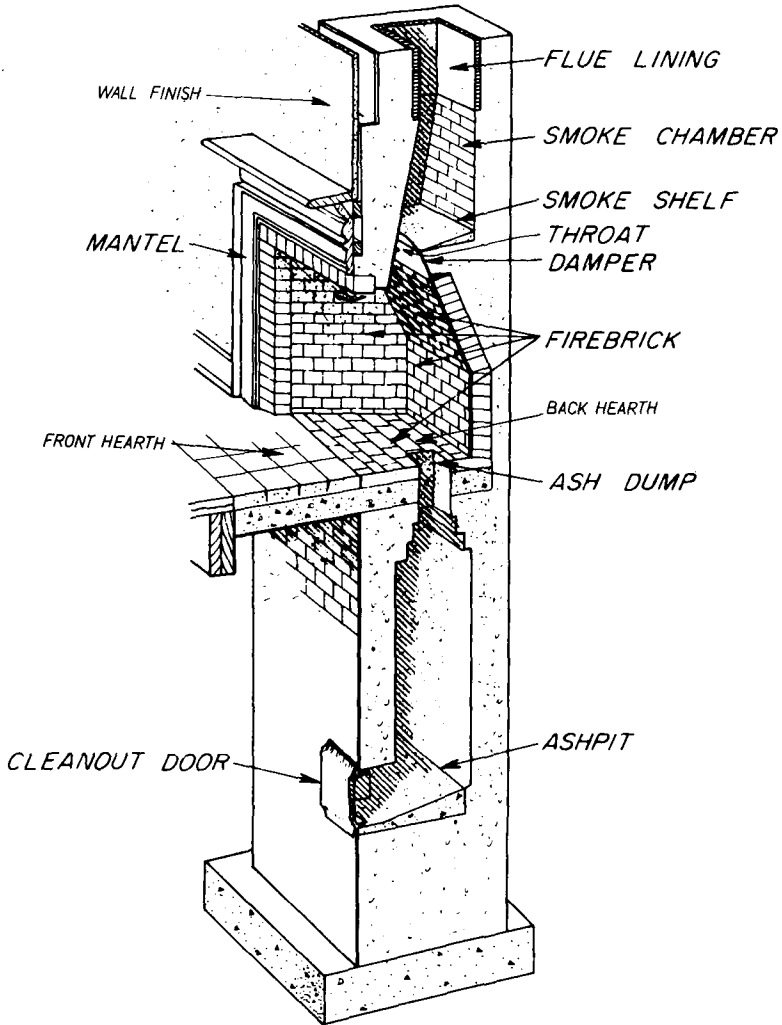


FIGURE 98.—Terms used in fireplace construction.

liner may be included in the required thicknesses mentioned above. Where a steel fireplace liner with an air circulating chamber surrounding the firebox is used, the back and side may be solid masonry units $3\frac{1}{2}$ -inch thick or $7\frac{1}{2}$ inch hollow units.

The damper is a large valve set in the throat of the fireplace which can be adjusted from the outside to regulate the draft. Many types of damper units are available. By choosing one with a correctly pro-

portioned throat passage the risk of failure in the function of the completed fireplace is reduced.

The hearth may be set even with the floor, or raised above the floor level. It consists of two parts: the front or finish hearth and the back hearth under the fire. Because the back hearth must withstand more heat it is usually built of fire brick. The front hearth is simply a precaution against flying sparks and is usually built of 4-inch reinforced concrete capped with ceramic tile. The front hearth should extend at least 16 inches in front of the fireplace opening and 8 inches on each side.

At the back of the fireplace it is customary to have an ash dump through which ashes can be dropped into an ash pit. A cleanout door to the ash pit is provided in the basement for periodic removal of ashes.

If a factory-built fireplace is used, the same precautions should be observed as indicated on page 128 for the use of factory-built chimneys.

SURFACE DRAINAGE, DRIVEWAYS AND WALKS

For a successful landscape plan it is necessary to assess the needs for surface drainage, driveways and walks. Driveways and walks should be made of materials in character with the house and yard.

Surface Drainage

A surface drainage pattern should be established which will drain the entire lot to direct water away from the house. Driveways and walks should be set low enough to avoid interference with the drainage pattern. If a well is used to supply water for the house, all surface drainage must be directed away from the well to avoid contamination of water supply.

Driveways

A safe driveway should not slope too steeply to the street and should be graded so that water will not accumulate on the surface. The drainage slope, which may be across the driveway or along its length, should be not less than 2 inches in 10 feet.

The commonly used materials for driveways are concrete, asphalt and crushed stone. A full-width driveway is preferable although a satisfactory driveway may be made of two ribbons at least 2 feet wide, spaced about 5 feet apart center-to-center. While the ribbon type is more economical than full-width pavement, it is limited to straight runs and is not suitable for use on curves.

The full-width driveway is easier to drive over and a virtual necessity where curves or turnout areas are required. In addition, by increasing its width, the full-width driveway may also serve as a walkway. A driveway should be at least 8 feet wide, increased to 10 feet when it serves as a walkway.

In the construction of driveways, the area to be paved should be graded to a uniform smooth surface and be well compacted. All soft material, as well as loose rocks or boulders must be removed to a depth

of several inches and the holes filled and well tamped with hard material. If the ground has recently been filled it should be well compacted as any settlement in the subsoil is likely to cause cracking in the finished driveway. A well-compacted base of gravel or crushed stone, at least 4 inches thick, is necessary if the driveway is to be surfaced with asphalt. Asphalt is usually 1½-inches thick. Concrete 5 inches thick may be used without a base but this thickness can be reduced to 3 inches when put down over a 5-inch base.

Contraction joints should be included in concrete pavement and these are usually spaced about 10 feet apart. These joints minimize irregular cracks resulting from shrinkage of concrete during the curing process and from the expansion and contraction that occur with changes in temperature. A contraction joint usually takes the form of a complete separation between adjoining concrete slabs across the full width of the driveway and to the full depth of concrete. Sometimes the separation only extends an inch or so below the surface to create a weak plane at which contraction cracks will occur. In addition expansion joints of tarred felt or prepared joint material are usually placed where the driveway butts the street curb.

Walkways

Concrete formed in place or precast slabs are commonly used for walkways. Other types of material such as asphalt, clay or concrete brick, fine gravel or crushed stone may also be used.

Walkways should be built on a well-compacted base, with a slight slope to drain the water off the surface. A base course is not normally used under concrete walks, but must be used under asphalt surfaces. Concrete walks should be at least 4 inches thick and asphalt 1½-inches. Contraction joints are included in concrete walks for the same reason as described for driveways. These joints are usually spaced apart about one-and-a-half times the walkway width. Precast slabs are generally laid in a leveling bed of sand.

PROTECTION AGAINST DECAY AND TERMITES

Wood used under conditions where it will always be dry or even where it is subject to short periods of intermittent wetting followed by rapid redrying will not decay. However, all wood and wood products as used in construction are subject to decay if allowed to remain wet for long periods. Most of the wood used in a house is not subject to this condition provided suitable precautions are taken. Protection is accomplished by methods of design and construction, by use of suitable materials, and in some cases by treating the materials.

The building site should be well drained and untreated wood should not come in contact with the soil. Foundation walls should extend at least 6 inches above the ground and where wood siding is used it should be kept at least 8 inches from the ground. The ground level in a crawl space should be at least 12 inches below joists and beams.

Surfaces like steps, porches, door and window sills should be sloped to promote run-off of water. Flashing should be used over doors and windows and other projections (see Flashing Page 121) where water is likely to seep into the structure. The use of roofs with considerable overhang gives added protection to the siding and other parts of the house. Similarly covered entrance-ways protect the doors.

Exterior wood steps, rails and porch floors exposed to rain and snow have a high decay hazard. Where pressure-treated wood is not readily obtainable for these purposes the application of a preservative by dipping or soaking is recommended. The wood should be cut to final dimensions, and then dipped or soaked in the preservative solution. It is important to protect the end grain of wood at the joints since this area absorbs water easily. The ends and joints in siding may be treated during erection or filled later to prevent the entry of water (see Page 71). A good quality compound should be used around window frames, door frames, siding that comes in contact with masonry veneer, under door sills that are not fully protected from rain and at other similar locations to prevent the entry of water into the structure.

If a vapor barrier is not used on the ground surface, crawl spaces are apt to become very humid and expose the framing members to conditions that are conducive to decay. The vapor barrier which prevents moisture in the ground from entering the space should be installed as described on Page 14 and the crawl space should also be ventilated (see Ventilation Page 92). When the space is heated, the ventilator covers should be removed during summer, so that any water vapor which escapes through the joints in the vapor barrier will be carried to the outdoors.

Water vapor is also given off during cooking, washing and other household activities. This vapor can pass through walls and ceilings and condense on sheathing, studs, and rafters to cause decay. A vapor barrier is needed on the warm side of the walls and ceilings to prevent passage of the vapor into these areas (see Vapor Barriers Page 84). The attic space above the ceilings, and the roof space above insulation in flat roofs should be ventilated (see Page 92). This ensures that any vapor which passes through joints in the barrier is carried to the outside.

Wood is subject to attack by termites. In regions where termites are known to occur precautions should be taken to safeguard the structure against damage. The best time to provide protection is during the planning and construction of the house. Local building codes which outline necessary methods of protection should be followed in this respect.

PAINTING

The primary purpose of exterior painting is to protect surfaces from the weather and to enhance appearance.

As well as for appearance, interior surfaces are painted to protect them from damage by moisture which is more prevalent in the kitchen, bathroom and laundry room. Painted surfaces are also easier to clean.

There is a wide variety of paints, stains and other coatings available for exterior and interior use. Good quality materials should be selected and applied in accordance with the manufacturers' recommendations. Since the cost of the materials is nearly always a small proportion of the total cost of painting it is false economy to use poor quality materials.

Surfaces to be painted should be clean and free from substances which will interfere with the adhesion of the paint. After the prime coat is applied, nail holes, cracks and other defects should be filled with putty or a suitable filler. Painting should not be carried out in temperatures below 40°F. The surface to be painted should be dry.

Clear coatings that provide a protective film over the surface of wood are adversely affected by direct sunlight and have a short life expectancy, perhaps one or two years, on surfaces exposed to the sun's rays. Direct sunlight causes the film to disintegrate and fall off in patches leaving parts of the wood exposed. Since the parts of the film that remain are hard and brittle, preparation of the surface for re-coating becomes difficult. Colored stains soak into the wood leaving no visible film on the surface and protect all sides of the house much longer — perhaps four years or more. Re-coating is also much easier as it can be done with a minor amount of surface preparation. Good quality house paint properly applied will usually last for four or five years.

PROTECTION AND CARE OF MATERIALS ON THE BUILDING SITE

The protection of building materials on the site when they arrive, and their storage before use is very important. If materials are stored without protection in inclement weather, damage may be caused that could be reflected in wastage of material and troublesome maintenance.

As far as possible material should be delivered to the site just before it is to be used. This is especially true of exterior window and door frames and exterior trim materials. Interior finishing materials currently required may be stored in the house once the roof is on.

In the normal staging of construction the framing lumber and sheathing materials are delivered to the job after the foundation is complete. Structural and framing materials in place before the house is enclosed may be subject to wetting during rain storms, but the wetting is mostly on the exposed surfaces and can dry out quickly in subsequent dry weather without causing damage.

Lumber stored in close piles, however, may soak up and retain water and drying out will be very slow. This condition should be avoided as it may lead to stain and decay. Piles of lumber should be placed on skids raised off the ground and covered with sheets of waterproof material to shed water.

After the framing is started the roof shingles may be delivered. Asphalt shingles should be stored so that bundles can lie flat without

bending. Curved or buckled shingles will result in a roof which is not attractive.

Window and door frames are usually the next items to be installed after the roofing. If the frames are delivered before they can be installed they should be sheltered until they are used. Put them under cover. Good frames are costly items and exposure to the weather may nullify their good construction. This is especially true where the frames are delivered with window sash installed.

Insulation, interior wall and ceiling finish, wood siding and similar items can easily be stored in the house. Heavy materials such as gypsum wall board or lath should be distributed over the floor area so as not to overload the floor joists. Heavy loads, concentrated in one spot for any appreciable time, may cause permanent deflection in the floor joists.

Hardwood flooring, interior trim and millwork should not be stored in the house until after plastering and the basement floor have been completed and allowed to dry. The moisture given off during these operations may cause the kiln-dried material to swell resulting in excessive shrinkage after the materials are installed.

MAINTENANCE

A house that is built well, with adequate attention to construction details and the use of suitable materials as explained in the body of this publication, will need far less maintenance than a house that is not well built. The maxim "It's not the first cost, it's the up-keep" certainly applies to a house that requires more maintenance than its well-constructed neighbor.

Sound construction methods and suitable materials in the initial construction will greatly reduce the cost of maintenance but will not result in a "maintenance-free" house and some maintenance can be expected even during the first year of occupancy.

In a newly-built house it is quite common, for example, for the interior wall finish to develop some minor cracks and for some of the doors to stick. These flaws usually show up during or after the first heating season when the wood frame members may shrink slightly due to changes in moisture content or after the bearing members have settled to their final position under loading.

Quite frequently the backfill material around the house foundation will settle, which can cause the surface water to pond against the basement or foundation wall. This can be corrected by filling any settled areas up to their proper level as and when required.

The prudent home owner develops a well-planned program of care and maintenance which he continues throughout the years. Just as maintenance costs are greatly reduced by adequate attention to the methods and materials used in construction, it is equally true that a continuing program of maintenance will further reduce the cost of up-keep, enhance the value of the property and greatly increase the useful life of the home.

APPENDIX

TABLE 1
CONCRETE MIXES (BY VOLUME)

Concrete Strength	Cement (part)	Sand (parts)	Coarse Aggregate
2000 psi	1	2	4 parts up to 2 in. in size
	1	—	6 parts pit run gravel
2500 psi	1	2	3½ parts up to 1½ in. in size
	1	—	5½ parts pit run gravel

TABLE 2
MINIMUM THICKNESS OF FOUNDATION WALLS

Type of Foundation Wall	Wall Thickness (in.)	Maximum Height of Finish Grade Above Basement Floor or Inside Grade	
		Foundation Wall Laterally Unsupported At the Top (1) to (4) ft.—in.	Foundation Wall Laterally Supported At the Top (1) to (4) ft.—in.
Solid concrete	6	2 — 6	5 — 0
	8	4 — 0	7 — 0
	10	4 — 6	7 — 6
	12	5 — 0	7 — 6
Unit masonry	6	2 — 0	2 — 0
	8	3 — 0	4 — 0
	10	4 — 0	6 — 0
	12	4 — 6	7 — 0

NOTES TO TABLE 2

- (1) Foundation walls are considered laterally supported at the top if the floor joists are embedded in the top of the foundation walls or if the floor system is anchored to the top of the foundation walls with anchor bolts, in which case the joists may run either parallel or perpendicular to the foundation wall.
- (2) When a foundation wall contains an opening more than 4 ft. in length or openings in more than 25 per cent of its length (3), that portion of the wall beneath such openings shall be considered laterally unsupported unless the wall around the opening is reinforced to withstand the earth pressure.
- (3) When the length of solid wall between windows is less than the average length of the windows, the combined length of such windows shall be considered as a single opening.
- (4) When solid masonry walls are supported, the foundation wall is considered to be laterally supported by the first floor on top of the foundation wall.

TABLE 3
MINIMUM DEPTHS OF FOUNDATIONS

Type of Soil	Foundations Containing Heated Basements, Cellars, or Crawl Space		Foundation Containing No Heated Space	
	Good Soil Drainage to at Least the Depth of Frost Penetration	Poor Soil Drainage	Good Soil Drainage to at Least the Depth of Frost Penetration	Poor Soil Drainage
Rock	No limit	No limit	No limit	No limit
Coarse grained soils	No limit	No limit	No limit	Below the depth of frost penetration
Silt	No limit	No limit	Below the depth of frost penetration	Below the depth of frost penetration
Clay or soils not clearly defined	4 ft.	4 ft.	4 ft. but not less than the depth of frost penetration	4 ft. but not less than the depth of frost penetration

TABLE 4
MORTAR MIX PROPORTIONS (BY VOLUME)

Permissible Use of Mortar	Portland Cement	Masonry Cement (Type H)	Lime	Aggregate
All locations (1)	$\frac{1}{2}$ to 1	1	—	Not less than $2\frac{1}{4}$ and not more than 3 times the sum of the volumes of the cement and lime
All locations, (1) except: foundation walls and piers	1	1	$\frac{1}{4}$ to $\frac{1}{2}$	
All locations, except load bearing walls of hollow units	1	—	$\frac{1}{2}$ to $1\frac{1}{4}$	
All non load bearing partitions and all load bearing walls of solid units except foundation walls.	—	—	$1\frac{1}{4}$ to $2\frac{1}{2}$	
			$2\frac{1}{4}$ to 4	
			1	

NOTE TO TABLE 4

(1) Must not be used for sand-lime brick or concrete brick.

TABLE 5
MINIMUM THICKNESS OF SUBFLOORING

Maximum Joist Spacing (in.)	Minimum Plywood Thickness (in.)	Minimum Particle Board Thickness (in.)
16 20 24	$\frac{1}{2}$ $\frac{5}{8}$ (1) $\frac{3}{4}$ (1)	$\frac{5}{8}$ $\frac{3}{4}$ (1) 1 (1)

NOTE TO TABLE 5

- (1) Plywood may be $\frac{1}{2}$ in. thick and particle board $\frac{5}{8}$ in. thick if the finish flooring consists of matched wood strip flooring at least $\frac{3}{4}$ in. thick laid at right angles to the joist.

TABLE 6
SIZE AND SPACING OF STUDS

Type of Wall	Supported Loads Including Dead Loads	Minimum Stud Size (in.)	Maximum Stud Spacing (in.)	Maximum Unsupported Height (ft.)
Interior Partitions	Limited attic storage or no load	2 by 3 (1) or 2 by 4 (2)	24	10 12
	Full attic storage, or roof-load, or limited attic storage plus one floor.	2 by 4	24	12
	Full attic storage plus one floor, or roof load plus one floor, or limited attic storage plus two floors	2 by 4	16	12
	Full attic storage plus two floors, or roof load plus two floors	2 by 4 3 by 4 2 by 6	12 16 16	12 12 14
Exterior Walls	Roof, with or without attic storage	2 by 4	24	10
	Roof, with or without attic storage plus one floor	2 by 4	16	10
	Roof, with or without attic storage plus two floors	2 by 4 3 by 4 2 by 6	12 16 16	10 10 12

NOTES TO TABLE 6

- (1) Must be 16 in. o.c. if partition contains a swing type door.
 (2) When the partition supports no load, 2 in. by 4 in. studs may be placed parallel to walls that do not contain swing type doors provided they are spaced not more than 16 in. o.c. and are not more than 8 ft. high.

TABLE 7

SPANS FOR VARIOUS DEPTHS OF LINTELS MADE FROM NOMINAL 4-IN. THICK LUMBER OR TWO THICKNESSES OF NOMINAL 2-IN. LUMBER INSTALLED ON EDGE

Location of Lintels	Supported Loads Including Dead Loads and Ceiling	Nominal Depth of Lintels (in.)	Maximum Allowable Spans (ft. — in.)
Interior Partitions or Walls	Limited attic storage	4	4 — 0
		6	6 — 0
		8	8 — 0
		10	10 — 0
		12	12 — 6
	Full attic storage, or roof load, or limited attic storage plus one floor	4	2 — 0
		6	3 — 0
		8	4 — 0
		10	5 — 0
		12	6 — 0
	Full attic storage plus one floor, or roof load plus one floor, or limited attic storage plus two floors	4	—
		6	2 — 6
		8	3 — 0
		10	4 — 0
		12	5 — 0
	Full attic storage plus two floors, or roof load plus two floors	4	—
		6	2 — 0
		8	3 — 0
		10	3 — 6
		12	4 — 0
Exterior Walls	Roof, with or without attic storage	4	4 — 0
		6	6 — 0
		8	8 — 0
		10	10 — 0
		12	12 — 0
	Roof, with or without attic storage plus one floor	4	2 — 0
		6	5 — 0
		8	7 — 0
		10	8 — 0
		12	9 — 0
	Roof with or without attic storage plus two floors	4	2 — 0
		6	4 — 0
		8	6 — 0
		10	7 — 0
		12	8 — 0

TABLE 8

MINIMUM THICKNESS OF ROOF SHEATHING

Joist or Rafter Spacing (in.)	Minimum Plywood Thickness (in.)		Minimum Particle Board Thickness (in.) Edges Supported
	Edges Supported	Edges Unsupported	
12	5/16	5/16	3/8
16	5/16	3/8	3/8
20	3/8	1/2	7/16
24	3/8	1/2	7/16
32	1/2	—	—
36	5/8	—	—
40	3/4	—	—
48	7/8	—	—

TABLE 9

MAXIMUM EXPOSURE OF WOOD SHINGLES — ROOFS

Roof Slope	Maximum Shingle Exposure (in.)		
	16-in. Shingles	18-in. Shingles	24-in. Shingles
4/12 or less	3¾	4¼	5¾
Over 4/12	5	5½	7½

TABLE 10
MATERIAL COMBINATIONS FOR BUILT-UP ROOFS

Type of Roof	Amount of Bitumen per 100 sq. ft. of Roof Surface (1)		Minimum Amount of Aggregate Surfacing per 100 sq. ft. of Roof Surface	Number of Plies of Dry Sheathing, Roofing Felts and Mineral Surface Cap Sheet				
	Mopping Coats Between Plies	Flood Coat		Wood Board or Plywood Deck			Other than Wood Board or Plywood Deck (3)	
				Dry Sheathing	Roofing Felts	Wide Selvage Asphalt Roofing	Roofing Felts	Wide Selvage Asphalt Roofing
Asphalt and Aggregate	20 lb.	60 lb.	400 lb. gravel or crushed rock or 300 lb. slag on level roof; 300 lb. gravel or crush- ed rock or 225 lb. slag on 3/12 slope. Proportional weights for intermediate roof slopes	1	4 (5)	—	3 (6)	—
Coal Tar Pitch and Aggregate	25 lb.	75 lb.		1	4 (5)	—	3 (6)	—
Glass Felt and Aggregate	25 lb.	60 lb.		—	3 (7)	—	2 (8)	—
Asphalt Smooth Surface	20 lb.	25 lb.	—	1	4 (5)	—	3 (6)	—
Glass Felt Smooth Surface	20 lb.	20 lb.	—	—	3 (8)	—	3 (8)	—
Asphalt and Wide Selvage Asphalt Roofing (2)	20 lb.	None	—	1	2	2	2	2
Cold Process Roofing	1.5 gal. Cold Process Cement	4 gal. Cold Process Top Coating	—	—	2 (4)	—	—	—

NOTES TO TABLE 10

- (1) The quantities of bitumen may be 10 per cent less than those in the table at application but must average out to not less than the stipulated weight over the entire roof.
- (2) 19 in. wide selvage asphalt roofing surfaced with mineral granules.
- (3) Includes poured and precast concrete and insulated decks.
- (4) Cold process felt is used.
- (5) 2 layers laid dry over the sheathing and 2 layers mopped with bitumen.
- (6) All layers mopped with bitumen.
- (7) 1 combination felt laid dry and 2 layers of glass felts mopped with bitumen.
- (8) All layers of glass felt mopped with bitumen.

TABLE 11
STUCCO MIXES (BY VOLUME)

Portland Cement	Masonry Cement Type II	Lime	Aggregate
1 1	— 1	$\frac{1}{4}$ to 1 —	$3\frac{1}{4}$ to 4 parts per part of cementitious material

TABLE 12
EXPOSURE AND THICKNESS OF WOOD SHINGLES AND MACHINE GROOVED SHAKES — WALLS

Shake or Shingle Length (in.)	Maximum Exposure		Minimum Butt Thickness (in.)
	Single Coursing (in.)	Double Coursing (in.)	
16	$7\frac{1}{2}$	12	$\frac{2}{5}$
18	$8\frac{1}{2}$	14	$\frac{9}{20}$
24	$11\frac{1}{2}$	16	$\frac{1}{2}$

TABLE 13
DIMENSIONS FOR WOOD STRIP FLOORING

Type of Flooring	Maximum Joist Spacing (in.)	Minimum Flooring Thickness	
		With Subfloor (in.)	No Subfloor (in.)
Matched Hardwood (interior use only)	16 24	$\frac{3}{4}$ $\frac{5}{8}$	$\frac{3}{4}$ 1-5/16
Matched Softwood (interior or exterior use)	16 24	$\frac{3}{4}$ $\frac{5}{8}$	$\frac{3}{4}$ 1-5/16
Square Edge Softwood (exterior use only)	16 24	— —	1-1/16 $1\frac{1}{8}$
Column 1	2	3	4

TABLE 14
NAILING OF WOOD STRIP FLOORING

Finish Floor Thickness (in.)	Minimum Length of Flooring Nails (in.)	Maximum Spacing of Flooring Nails (in.)
$\frac{3}{8}$	$1\frac{1}{2}$	8
$\frac{1}{2}$	2	12
$\frac{25}{32}$	$2\frac{1}{4}$	16
1-1/16	$2\frac{1}{2}$	16
1-5/16	$2\frac{3}{4}$	24
$1\frac{1}{8}$	$3\frac{1}{4}$	24

TABLE 15
SPECIFICATIONS AND THICKNESS OF RESILIENT FLOORING

Type	Specification	Minimum Thickness (in.)
Asphalt	CSA A100-1962	0.125
Linoleum	CSA A146-1958	0.098
Vinyl Asbestos	CSA A126-1955	0.080
Rubber	CSA A145-1959	0.080
Vinyl	FS-L-F 00450	0.080

TABLE 16
FLOOR LOADS

Use of Floor Area	Minimum Design Load, lb/sq. ft.
Living spaces other than bedrooms	40
Bedrooms	30
Entrance halls, corridors, exits and stairs, and all other non-living spaces	40
Attics accessible by a stairway	30
Attics not accessible by a stairway	10

TABLE 17
CEILING JOISTS — ATTIC NOT ACCESSIBLE BY A STAIRWAY

Species	Grade	Nominal Size (2) Inches	LIVE LOAD 10 lb. per sq. ft.															
			Plastered ceiling (1)								Other than plastered ceiling							
			Joist spacing								Joist spacing							
			12 in.		16 in.		20 in.		24 in.		12 in.		16 in.		20 in.		24 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir, Western Larch	Construction	2 x 4	11	6	10	1	9	0	8	2	11	7	10	1	9	0	8	2
		2 x 6	17	6	15	11	14	8	13	11	20	0	18	2	16	11	15	11
		2 x 8	23	10	21	8	20	1	18	11	27	4	24	10	23	0	21	7
		2 x 10	29	9	27	1	25	1	23	7	34	1	31	0	28	9	27	0
	Standard	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	17	6	15	11	14	8	13	11	20	0	18	2	16	5	15	0
		2 x 8	23	10	21	8	20	1	18	11	27	4	24	10	22	5	20	6
		2 x 10	29	9	27	1	25	1	23	7	34	1	31	0	28	0	25	7
	Utility	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 6		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
2 x 8	21	6	18	7	16	8	15	2	21	6	18	7	16	8	15	2		
2 x 10	29	0	25	7	22	6	20	6	29	0	25	7	22	6	20	6		
Pacific Coast Hemlock	Construction	2 x 4	10	8	9	2	8	4	7	7	10	8	9	2	8	4	7	7
		2 x 6	17	1	15	6	14	5	13	7	19	7	17	10	16	6	15	6
		2 x 8	23	4	21	2	19	8	18	6	26	8	24	4	22	6	21	2
		2 x 10	29	1	26	6	24	7	32	1	33	5	30	5	28	1	26	6
	Standard	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	17	1	15	6	14	5	13	7	19	7	17	10	16	5	15	0
		2 x 8	23	4	21	2	19	8	18	6	26	8	24	4	22	5	20	6
		2 x 10	29	1	26	6	24	7	32	1	33	5	30	5	28	0	25	7
	Utility	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 6		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
2 x 8	19	10	17	2	15	5	14	0	19	10	17	2	15	5	14	0		
2 x 10	26	8	23	7	20	10	18	11	26	8	23	7	20	10	18	11		
Spruce, all western species Lodgepole Pine, Pon- derosa Pine	Construction	2 x 4	9	7	8	4	7	5	6	10	9	7	8	4	7	5	6	10
		2 x 6	15	5	14	0	12	7	11	6	16	2	14	1	12	7	11	6
		2 x 8	21	0	19	1	17	8	16	8	24	1	21	11	19	11	18	2
		2 x 10	26	3	23	11	22	1	20	11	30	1	27	5	24	11	22	9
	Standard	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	12	7	10	11	9	8	8	11	12	7	10	11	9	8	8	11
		2 x 8	20	2	17	6	15	7	14	4	20	2	17	6	15	7	14	4
		2 x 10	26	3	23	0	20	4	18	7	26	4	23	0	20	4	18	7
	Utility	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 6		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
2 x 8	17	10	15	5	13	10	12	7	17	10	15	5	13	10	12	7		
2 x 10	24	0	21	2	18	7	17	0	24	0	21	2	18	7	17	0		
Western Red Cedar Western White Pine (3)	Construction	2 x 4	9	0	7	10	7	0	6	5	9	0	7	10	7	0	6	5
		2 x 6	14	11	13	7	12	7	11	6	16	4	14	1	12	7	11	6
		2 x 8	20	5	18	6	17	2	16	2	23	4	20	11	18	8	17	1
		2 x 10	25	6	23	1	21	6	20	3	29	1	26	1	23	5	21	5
	Standard	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	12	11	11	2	10	0	9	2	12	11	11	2	10	0	9	2
		2 x 8	19	0	16	6	14	8	13	6	19	0	16	6	14	8	13	6
		2 x 10	24	8	21	7	19	1	17	7	24	8	21	7	19	1	17	7
	Utility	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 6		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
2 x 8	16	8	14	11	12	11	11	10	16	8	14	11	12	11	11	10		
2 x 10	22	6	19	6	17	5	15	11	22	6	19	6	17	5	15	11		
Pacific Coast Yellow Cedar	Construction	2 x 4	10	4	9	0	8	0	7	4	10	4	9	0	8	0	7	4
		2 x 6	15	11	14	5	13	5	12	7	18	2	16	2	14	5	13	2
		2 x 8	21	7	19	8	18	4	17	2	24	10	22	6	20	1	18	4
		2 x 10	27	0	24	7	22	11	21	6	31	0	28	1	26	1	24	5
	Standard	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	14	10	12	10	11	5	10	5	14	10	12	10	11	5	10	5
		2 x 8	21	7	18	10	16	10	15	4	21	8	18	10	16	10	15	4
		2 x 10	27	0	24	7	21	10	19	11	28	2	24	8	21	10	19	11
	Utility	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 6		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
2 x 8	19	2	16	7	14	11	13	7	19	2	16	7	14	11	13	7		
2 x 10	25	11	22	10	20	1	18	5	25	11	22	10	20	1	18	5		

Continued next page

TABLE 17 (Continued)
CEILING JOISTS — ATTIC NOT ACCESSIBLE BY A STAIRWAY

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 4	9	7	8	4	7	5	6	10	9	7	8	4	7	5	6	10
		2 x 6	15	5	14	0	13	0	12	2	17	8	16	0	14	7	13	4
		2 x 8	21	0	19	1	17	8	16	8	24	1	21	11	19	11	18	2
	No. 2 (Standard)	2 x 10	26	3	23	11	22	1	20	11	30	1	27	5	24	11	22	9
		2 x 4	8	6	7	4	6	6	6	0	8	6	7	4	6	6	6	0
		2 x 6	15	5	14	0	12	7	11	6	16	4	14	1	12	7	11	6
Jack Pine	No. 1 (Construc- tion)	2 x 8	21	0	19	1	17	8	16	8	24	1	20	11	18	8	17	1
		2 x 10	26	3	23	11	22	1	20	11	30	1	26	5	23	7	21	7
	No. 2 (Standard)	2 x 4	10	4	9	0	8	0	7	4	10	4	9	0	8	0	7	4
		2 x 6	15	11	14	5	13	5	12	7	18	2	16	6	15	4	14	4
		2 x 8	21	7	19	8	18	4	17	2	24	10	22	6	20	11	19	6
		2 x 10	27	0	24	7	22	11	21	6	31	0	28	1	26	1	24	5
White Pine Red Pine	No. 1	2 x 4	9	10	8	11	8	4	7	10	11	4	10	2	9	2	8	5
		2 x 6	14	11	13	7	12	7	11	11	17	1	15	4	13	8	12	6
		2 x 8	20	5	18	6	17	2	16	2	23	4	20	11	18	8	17	1
		2 x 10	25	6	23	1	21	6	20	3	29	1	26	1	23	5	21	5
	Merchant- able and No. 2	2 x 4	9	10	8	11	8	2	7	6	10	6	9	1	8	2	7	6
		2 x 6	14	11	13	7	12	7	11	6	16	4	14	1	12	7	11	6
		2 x 8	20	5	18	6	17	2	16	0	22	8	19	7	17	7	16	0
		2 x 10	25	6	23	1	21	6	20	2	28	8	24	8	22	2	20	2
	No. 1 Dimension	2 x 4	9	0	7	10	7	0	6	5	9	0	7	10	7	0	6	5
		2 x 6	14	11	13	4	11	11	10	10	15	4	13	4	11	11	10	10
		2 x 8	20	5	18	6	16	10	15	4	21	8	18	10	16	10	15	4
		2 x 10	25	6	23	1	21	6	20	3	28	10	24	11	22	4	20	4
	No. 2 Dimension (4)	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	11	10	10	2	9	2	8	5	11	10	10	2	9	2	8	5
		2 x 8	16	8	14	6	12	11	11	10	16	8	14	6	12	11	11	10
		2 x 10	22	6	19	7	17	5	15	11	22	6	19	7	17	5	15	11
Poplar	No. 1 (Construc- tion)	2 x 4	9	0	7	10	7	0	6	5	9	0	7	10	7	0	6	5
		2 x 6	14	11	13	7	12	7	11	11	17	1	15	4	13	8	12	6
		2 x 8	20	5	18	6	17	2	16	2	23	4	20	11	18	8	17	1
		2 x 10	25	6	23	1	21	6	20	3	29	1	26	1	23	5	21	5
	No. 2 (Standard)	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	14	11	13	4	11	11	10	11	15	4	13	4	11	11	10	11
		2 x 8	20	5	18	6	17	2	16	0	22	8	19	7	17	7	16	0
		2 x 10	25	6	23	1	21	6	20	2	28	8	24	8	22	2	20	2

NOTES TO TABLE 17

- (1) Includes gypsum board.
- (2) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (3) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:
 Construction Grade 6 per cent
 Standard Grade 8 per cent
- (4) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:
 2 x 6, 2 x 8 10 per cent
 2 x 10 15 per cent

TABLE 18
FLOOR JOISTS — LIVING QUARTERS

Species	Grade	Nominal Size (1)	LIVE LOAD 40 lb. per sq. ft.							
			All ceilings							
			Joist spacing							
		Inches	12 in.		16 in.		20 in.		24 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir, Western Larch	Construc- tion (dense and non-dense)	2 x 6	11	0	10	0	9	4	8	8
		2 x 8	15	0	13	7	12	8	11	11
		2 x 10	19	0	17	4	16	0	15	1
		2 x 12	23	0	20	11	19	5	18	4
	Standard	2 x 6	11	0	10	0	9	4	8	6
		2 x 8	15	0	13	7	12	8	11	7
		2 x 10	19	0	17	4	16	0	14	8
		2 x 12	23	0	20	11	19	5	17	10
	Utility	2 x 6	—	—	—	—	—	—	—	—
		2 x 8	12	2	10	6	9	5	8	7
		2 x 10	16	8	14	6	13	0	11	10
		2 x 12	19	8	17	0	15	2	13	11
Pacific Coast Hemlock	Construc- tion	2 x 6	10	10	9	10	9	1	8	7
		2 x 8	14	8	13	4	12	5	11	8
		2 x 10	18	7	16	11	15	8	14	10
		2 x 12	22	6	20	6	19	0	17	11
	Standard	2 x 6	10	10	9	10	9	1	8	6
		2 x 8	14	8	13	4	12	5	11	7
		2 x 10	18	7	16	11	15	8	14	8
		2 x 12	22	6	20	6	19	0	17	10
	Utility	2 x 6	—	—	—	—	—	—	—	—
		2 x 8	11	2	9	8	8	8	7	11
		2 x 10	15	5	13	5	11	11	10	11
		2 x 12	18	0	15	7	14	0	12	8
Spruce, all western species Lodgepole Pine, Pon- derosa Pine	Construc- tion	2 x 6	9	2	8	0	7	1	6	6
		2 x 8	13	4	12	0	11	2	10	4
		2 x 10	16	10	15	2	14	2	13	0
		2 x 12	20	4	18	6	17	1	15	10
	Standard	2 x 6	7	1	6	2	5	6	5	1
		2 x 8	11	5	9	11	8	10	8	1
		2 x 10	15	0	13	0	11	7	10	7
		2 x 12	19	4	16	8	15	0	13	7
	Utility	2 x 6	—	—	—	—	—	—	—	—
		2 x 8	10	1	8	8	7	10	7	1
		2 x 10	13	6	12	0	10	8	9	6
		2 x 12	16	2	14	0	12	7	11	6
Western Red Cedar Western White Pine (2)	Construc- tion	2 x 6	9	2	8	0	7	2	6	6
		2 x 8	12	10	11	8	10	7	9	8
		2 x 10	16	4	14	10	13	5	12	3
		2 x 12	19	8	17	11	16	2	14	10
	Standard	2 x 6	7	4	6	4	5	8	5	3
		2 x 8	10	10	9	4	8	4	7	7
		2 x 10	14	1	12	2	10	11	10	0
		2 x 12	18	2	15	8	14	1	12	10
	Utility	2 x 6	—	—	—	—	—	—	—	—
		2 x 8	9	6	8	2	7	4	6	8
		2 x 10	13	0	11	4	10	1	9	3
		2 x 12	15	4	13	2	11	10	10	10
Pacific Coast Yellow Cedar	Construc- tion	2 x 6	10	0	9	1	8	2	7	6
		2 x 8	13	7	12	5	11	6	10	10
		2 x 10	17	4	15	8	14	7	13	8
		2 x 12	20	11	19	0	17	7	16	7
	Standard	2 x 6	8	5	7	2	6	6	5	11
		2 x 8	12	4	10	7	9	6	8	8
		2 x 10	16	1	14	0	12	6	11	5
		2 x 12	20	8	18	0	16	1	14	8
	Utility	2 x 6	—	—	—	—	—	—	—	—
		2 x 8	10	11	9	5	8	5	7	8
		2 x 10	14	11	12	11	11	6	10	6
		2 x 12	17	6	15	1	13	6	12	5

Continued next page

TABLE 18 (Continued)
FLOOR JOISTS — LIVING QUARTERS

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construction)	2 x 6	9 8	8 10	8 2	7 6	
		2 x 8	13 4	12 0	11 2	10 4	
		2 x 10	16 10	15 2	14 2	13 0	
	No. 2 (Standard)	2 x 12	20 4	18 6	17 1	16 1	
		2 x 6	9 2	8 0	7 1	6 6	
		2 x 8	13 4	11 10	10 7	9 8	
Jack Pine	No. 1 (Construction)	2 x 10	16 10	15 2	13 7	12 5	
		2 x 12	20 4	18 6	17 1	16 1	
	No. 2 (Standard)	2 x 6	9 11	8 7	7 8	7 0	
		2 x 8	13 7	12 5	11 5	10 5	
		2 x 10	17 4	15 8	14 7	13 4	
		2 x 12	20 11	19 0	17 7	16 7	
White Pine Red Pine	No. 1	2 x 6	9 5	8 7	7 10	7 1	
		2 x 8	12 10	11 8	10 7	9 8	
		2 x 10	16 4	14 10	13 5	12 2	
		2 x 12	19 8	17 11	16 7	15 7	
	Merchant- able and No. 2	2 x 6	9 2	8 0	7 2	6 6	
		2 x 8	12 10	11 1	9 11	9 1	
		2 x 10	16 4	14 2	12 8	11 7	
		2 x 12	19 8	17 11	16 7	15 6	
	No. 1 Dimension	2 x 6	8 8	7 6	6 8	6 1	
		2 x 8	12 4	10 7	9 6	8 8	
		2 x 10	16 4	14 2	12 8	11 7	
		2 x 12	19 8	17 11	16 2	14 10	
	No. 2 Dimension (3)	2 x 6	6 8	5 10	5 2	4 8	
		2 x 8	9 6	8 2	7 4	6 8	
		2 x 10	13 0	11 4	10 1	9 2	
		2 x 12	16 6	14 4	12 10	11 8	
Poplar	No. 1 (Construction)	2 x 6	9 5	8 7	7 10	7 1	
		2 x 8	12 10	11 8	10 7	9 8	
		2 x 10	16 4	14 10	13 5	12 2	
		2 x 12	19 8	17 11	16 7	15 7	
	No. 2 (Standard)	2 x 6	8 8	7 6	6 8	6 1	
		2 x 8	12 10	11 1	9 11	9 1	
		2 x 10	16 4	14 2	12 8	11 7	
		2 x 12	19 8	17 11	16 7	15 6	

NOTES TO TABLE 18

- (1) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (2) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:

Construction Grade	6 per cent
Standard Grade	8 per cent
- (3) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:

2 x 6, 2 x 8	10 per cent
2 x 10, 2 x 12	15 per cent

TABLE 19
CEILING JOISTS — ATTIC ACCESSIBLE BY A STAIRWAY AND
FLOOR JOISTS IN BEDROOMS

Species	Grade	Nominal Size (2) inches	LIVE LOAD 30 lb. per sq. ft.											
			Plastered ceiling (1)								Other than plastered ceiling			
			Joist spacing								Joist spacing			
			12 in.		16 in.		20 in.		24 in.		12 in.		16 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir, Western Larch	Construc- tion	2 x 6	12	1	11	0	10	2	9	7	13	11	12	7
		2 x 8	16	6	15	0	13	11	13	1	18	11	17	2
		2 x 10	20	11	19	0	17	8	16	7	23	11	21	10
		2 x 12	25	4	23	0	21	5	20	1	29	0	26	4
	Standard	2 x 6	12	1	11	0	10	2	9	7	13	7	11	10
		2 x 8	16	6	15	0	13	11	13	1	18	6	16	1
		2 x 10	20	11	19	0	17	8	16	7	23	6	20	4
		2 x 12	25	4	23	0	21	5	20	1	28	5	24	7
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	13	10	11	11	10	8	9	9	13	10	11	11
		2 x 10	19	0	16	5	14	8	13	5	19	0	16	5
		2 x 12	22	4	19	4	17	2	15	8	22	4	19	4
Pacific Coast Hemlock	Construc- tion	2 x 6	11	11	10	10	10	0	9	5	13	7	12	4
		2 x 8	16	2	14	8	13	7	12	10	18	6	16	10
		2 x 10	20	6	18	7	17	4	16	4	23	5	21	4
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	10
	Standard	2 x 6	11	11	10	10	10	0	9	5	13	7	11	10
		2 x 8	16	2	14	8	13	7	12	10	18	6	16	1
		2 x 10	20	6	18	7	17	4	16	4	23	5	20	4
		2 x 12	24	10	22	6	20	11	19	8	28	5	24	7
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	12	8	11	0	9	10	9	0	12	8	11	0
		2 x 10	17	6	15	1	13	6	12	4	17	6	15	1
		2 x 12	20	5	17	8	15	10	14	5	20	5	17	8
Spruce, all Western species Lodgepole Pine, Ponderosa Pine	Construc- tion	2 x 6	10	5	9	0	8	1	7	5	10	5	9	0
		2 x 8	14	7	13	2	12	4	11	7	16	6	14	4
		2 x 10	18	6	16	10	15	7	14	8	20	10	18	0
		2 x 12	22	5	20	4	18	11	17	8	25	2	21	11
	Standard	2 x 6	8	1	7	0	6	2	5	8	8	1	7	0
		2 x 8	12	11	11	2	10	0	9	2	12	11	11	2
		2 x 10	17	0	14	8	13	1	12	0	17	0	14	8
		2 x 12	21	11	18	11	16	11	15	6	21	11	18	11
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	11	5	9	11	8	10	8	1	11	5	9	11
		2 x 10	15	8	13	7	12	2	11	1	15	8	13	7
		2 x 12	18	4	15	11	14	2	13	0	18	4	15	11
Western Red Cedar, Western White Pine (3)	Construc- tion	2 x 6	10	5	9	1	8	1	7	5	10	6	9	1
		2 x 8	14	1	12	10	11	11	10	11	15	6	13	5
		2 x 10	17	11	16	4	15	1	13	11	19	7	17	0
		2 x 12	21	8	19	8	18	4	16	10	23	8	20	7
	Standard	2 x 6	8	4	7	2	6	5	5	10	8	4	7	2
		2 x 8	12	2	10	7	9	5	8	7	12	2	10	7
		2 x 10	16	0	13	10	12	5	11	4	16	0	13	10
		2 x 12	20	7	17	10	15	11	14	6	20	7	17	10
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	10	8	9	4	8	4	7	7	10	8	9	4
		2 x 10	14	8	12	10	11	5	10	5	14	8	12	10
		2 x 12	17	4	15	0	13	5	12	2	17	4	15	0
Pacific Coast Yellow Cedar	Construc- tion	2 x 6	11	0	10	0	9	4	8	6	12	0	10	4
		2 x 8	15	0	13	7	12	8	11	11	16	7	14	5
		2 x 10	19	0	17	4	16	0	15	1	21	10	19	5
		2 x 12	23	0	20	11	19	5	18	4	26	4	23	6
	Standard	2 x 6	9	6	8	2	7	4	6	8	9	6	8	2
		2 x 8	13	11	12	0	10	8	9	10	13	11	12	0
		2 x 10	18	4	15	10	14	2	12	11	18	4	15	10
		2 x 12	23	0	20	4	18	2	16	7	23	6	20	4
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	12	4	10	7	9	6	8	8	12	4	10	7
		2 x 10	16	11	14	7	13	1	11	11	16	11	14	7
		2 x 12	19	10	17	1	15	4	14	0	19	10	17	1

Continued next page

TABLE 19 (Continued)
CEILING JOISTS — ATTIC ACCESSIBLE BY A STAIRWAY AND
FLOOR JOISTS IN BEDROOMS

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 6	10	8	9	8	9	0	8	6	12	1	10	6	9	4	8	6
		2 x 8	14	7	13	2	12	4	11	7	16	6	14	4	12	8	11	7
		2 x 10	18	6	16	10	15	7	14	8	20	10	18	0	16	1	14	8
	No. 2 (Standard)	2 x 12	22	5	20	4	18	11	17	8	25	7	23	4	21	0	19	2
		2 x 6	10	6	9	1	8	1	7	5	10	6	9	1	8	1	7	5
		2 x 8	14	7	13	2	12	0	10	11	15	6	13	5	12	0	10	11
Jack Pine	No. 1 (Construc- tion)	2 x 10	18	6	16	10	15	4	14	0	19	10	17	2	15	4	14	0
		2 x 12	22	5	20	4	18	11	17	8	25	7	22	10	20	5	18	7
	No. 2 (Standard)	2 x 6	11	0	10	0	9	4	8	8	12	7	11	2	10	0	9	2
		2 x 8	15	0	13	7	12	8	11	11	17	2	15	4	13	8	12	6
		2 x 10	19	0	17	4	16	0	15	1	21	10	19	5	17	4	15	10
		2 x 12	23	0	20	11	19	5	18	4	26	4	23	11	22	2	20	7
White Pine Red Pine	No. 1	2 x 6	10	5	9	5	8	8	8	0	11	4	9	10	8	10	8	0
		2 x 8	14	1	12	10	11	11	10	11	15	6	13	5	12	0	10	11
		2 x 10	17	11	16	4	15	1	13	11	19	7	17	0	15	2	13	11
		2 x 12	21	8	19	8	18	4	17	2	24	10	22	1	19	8	18	0
	Merchant- able and No. 2	2 x 6	10	5	9	1	8	1	7	5	10	6	9	1	8	1	7	5
		2 x 8	14	1	12	7	11	2	10	4	14	6	12	7	11	2	10	4
		2 x 10	17	11	16	1	14	5	13	2	18	7	16	1	14	5	13	2
		2 x 12	21	8	19	8	18	4	17	2	24	8	21	5	19	2	17	6
	No. 1 Dimension	2 x 6	9	10	8	6	7	7	6	11	9	10	8	6	7	7	6	11
		2 x 8	13	11	12	0	10	8	9	10	13	11	12	0	10	8	9	10
		2 x 10	17	11	16	1	14	5	13	2	18	7	16	1	14	5	13	2
		2 x 12	21	8	19	8	18	4	16	10	23	8	20	7	18	5	16	10
	No. 2 Dimension (4)	2 x 6	7	7	6	7	5	11	5	4	7	7	6	7	5	11	5	4
		2 x 8	10	8	9	4	8	4	7	7	10	8	9	4	8	4	7	7
		2 x 10	14	8	12	10	11	5	10	5	14	8	12	10	11	5	10	5
		2 x 12	18	8	16	2	14	6	13	2	18	8	16	2	14	6	13	2
Poplar	No. 1 (Construc- tion)	2 x 6	10	5	9	5	8	8	8	0	11	4	9	10	8	10	8	0
		2 x 8	14	1	12	10	11	11	10	11	15	6	13	5	12	0	10	11
		2 x 10	17	11	16	4	15	1	13	11	19	7	17	0	15	2	13	11
	No. 2 (Standard)	2 x 12	21	8	19	8	18	4	17	2	24	10	22	1	19	8	18	0
		2 x 6	9	10	8	6	7	7	6	11	9	10	8	6	7	7	6	11
		2 x 8	14	1	12	7	11	2	10	4	14	6	12	7	11	2	10	4
Poplar	No. 2 (Standard)	2 x 10	17	11	16	1	14	5	13	2	18	7	16	1	14	5	13	2
		2 x 12	21	8	19	8	18	4	17	2	24	8	21	5	19	2	17	6

NOTES TO TABLE 19

- (1) Includes gypsum board.
- (2) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (3) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:
 Construction Grade 6 per cent
 Standard Grade 8 per cent
- (4) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:
 2 x 6, 2 x 8 10 per cent
 2 x 10, 2 x 12 15 per cent

TABLE 20
ROOF JOISTS — SUPPORTING CEILING — 50 lb./sq. ft. Live Load

Species	Grade	Nominal Size (2) inches	LIVE LOAD 50 lb. per sq. ft.															
			Plastered ceiling (1)								Other than plastered ceiling							
			Joist spacing								Joist spacing							
			12 in.		16 in.		20 in.		24 in.		12 in.		16 in.		20 in.		24 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir, Western Larch	Construc- tion (dense and non-dense)	2 x 6	10	2	9	4	8	7	8	1	11	8	10	7	9	11	9	4
		2 x 8	13	11	12	8	11	10	11	1	15	11	14	6	13	6	12	8
		2 x 10	17	8	16	0	14	11	14	0	20	2	18	5	17	0	16	0
		2 x 12	21	2	19	2	17	11	16	10	24	2	22	1	20	5	19	2
	Standard	2 x 6	10	2	9	4	8	7	8	1	11	8	10	2	9	1	8	4
		2 x 8	13	11	12	8	11	10	11	1	15	11	13	11	12	5	11	4
		2 x 10	17	8	16	0	14	11	14	0	20	2	17	7	15	8	14	5
		2 x 12	21	2	19	2	17	11	16	10	24	2	21	1	18	10	17	4
	Utility	2 x 6	11	11	10	4	9	2	8	5	11	11	10	4	9	2	8	5
		2 x 8	16	5	14	2	12	8	11	7	16	5	14	2	12	8	11	7
		2 x 10	19	1	16	6	14	10	13	6	19	1	16	6	14	10	13	6
		2 x 12																
Pacific Coast Hemlock	Construc- tion	2 x 6	10	0	9	1	8	5	7	11	11	5	10	5	9	8	9	1
		2 x 8	13	7	12	5	11	6	10	10	15	7	14	2	13	2	12	5
		2 x 10	17	4	15	8	14	7	13	8	19	10	18	0	16	8	15	8
		2 x 12	20	10	19	0	17	6	16	5	23	10	21	7	20	0	18	10
	Standard	2 x 6	10	0	9	1	8	5	7	11	11	5	10	2	9	1	8	4
		2 x 8	13	7	12	5	11	6	10	10	15	7	13	11	12	5	11	4
		2 x 10	17	4	15	8	14	7	13	8	19	10	17	7	15	8	14	5
		2 x 12	20	10	19	0	17	6	16	5	23	10	21	1	18	10	17	4
	Utility	2 x 6	11	0	9	6	8	6	7	10	11	0	9	6	8	6	7	10
		2 x 8	15	1	13	1	11	8	10	8	15	1	13	1	11	8	10	8
		2 x 10	17	7	15	2	13	7	12	6	17	7	15	2	13	7	12	6
		2 x 12																
Spruce, all western species Lodgepole Pine, Ponderosa Pine	Construc- tion	2 x 6	9	0	7	10	6	11	6	5	9	0	7	10	6	11	6	5
		2 x 8	12	4	11	2	10	5	9	10	14	1	12	4	11	0	10	1
		2 x 10	15	7	14	2	13	1	12	5	17	10	15	7	14	0	12	8
		2 x 12	18	8	17	0	15	8	14	11	21	5	18	8	16	10	15	2
	Standard	2 x 6	7	0	6	1	5	5	5	0	7	0	6	1	5	5	5	0
		2 x 8	11	2	9	8	8	7	7	11	11	2	9	8	8	7	7	11
		2 x 10	14	8	12	8	11	5	10	5	14	8	12	8	11	5	10	5
		2 x 12	18	8	16	2	14	6	13	2	18	8	16	2	14	6	13	2
	Utility	2 x 6	9	11	8	6	7	7	7	0	9	11	8	6	7	7	7	0
		2 x 8	13	7	11	10	10	6	9	7	13	7	11	10	10	6	9	7
		2 x 10	15	10	13	8	12	2	11	2	15	10	13	8	12	2	11	2
		2 x 12																
Western Red Cedar Western White Pine (3)	Construc- tion	2 x 6	8	8	7	10	7	0	6	5	9	0	7	10	7	0	6	5
		2 x 8	11	11	10	10	10	0	9	6	13	5	11	7	10	5	9	6
		2 x 10	15	1	13	8	12	8	12	0	17	0	14	8	13	1	12	0
		2 x 12	18	1	16	5	15	2	14	5	20	5	17	7	15	8	14	5
	Standard	2 x 6	7	2	6	2	5	7	5	1	7	2	6	2	5	7	5	1
		2 x 8	10	6	9	1	8	2	7	5	10	6	9	1	8	2	7	5
		2 x 10	13	10	12	0	10	8	9	10	13	10	12	0	10	8	9	10
		2 x 12	17	7	15	4	13	7	12	6	17	7	15	4	13	7	12	6
	Utility	2 x 6	9	4	8	0	7	2	6	6	9	4	8	0	7	2	6	6
		2 x 8	11	0	11	0	9	11	9	0	12	8	11	0	9	11	9	0
		2 x 10	12	8	12	10	11	6	10	6	14	10	12	10	11	6	10	6
		2 x 12																
Pacific Coast Yellow Cedar	Construc- tion	2 x 6	9	4	8	5	7	10	7	4	10	4	9	0	8	0	7	4
		2 x 8	12	8	11	6	10	8	10	0	14	5	12	5	11	1	10	2
		2 x 10	16	0	14	7	13	6	12	8	18	5	16	8	15	0	13	8
		2 x 12	19	2	17	7	16	2	15	2	22	1	20	0	18	0	16	5
	Standard	2 x 6	8	2	7	1	6	4	5	10	8	2	7	1	6	4	5	10
		2 x 8	12	0	10	5	9	4	8	6	12	0	10	5	9	4	8	6
		2 x 10	15	10	13	8	12	2	11	2	15	10	13	8	12	2	11	2
		2 x 12	19	2	17	5	15	6	14	2	20	1	17	5	15	6	14	2
	Utility	2 x 6	10	7	9	2	8	2	7	6	10	7	9	2	8	2	7	6
		2 x 8	14	7	12	7	11	4	10	4	14	7	12	7	11	4	10	4
		2 x 10	17	0	14	8	13	2	12	0	17	0	14	8	13	2	12	0
		2 x 12																

Continued next page

TABLE 20 (Continued)
ROOF JOISTS — SUPPORTING CEILING — 50 lb./sq. ft. Live Load

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 6	9 0	8 2	7 7	7 2	10 4	9 0	8 1	7 5
		2 x 8	12 4	11 2	10 5	9 10	14 1	12 4	11 0	10 1
		2 x 10	15 7	14 2	13 1	12 5	17 10	15 7	14 0	12 8
	No. 2 (Standard)	2 x 6	9 0	7 10	7 0	6 5	9 0	7 10	7 0	6 5
		2 x 8	12 4	11 2	10 5	9 6	13 5	11 7	10 5	9 6
		2 x 10	15 7	14 2	13 1	12 1	17 1	14 10	13 4	12 1
Jack Pine	No. 1 (Construc- tion)	2 x 6	9 4	8 5	7 10	7 5	10 7	9 8	8 8	7 11
		2 x 8	12 8	11 6	10 8	10 0	14 6	13 2	11 10	10 10
		2 x 10	16 0	14 7	13 6	12 8	18 5	16 8	15 0	13 8
	No. 2 (Standard)	2 x 6	9 4	8 5	7 6	6 11	9 8	8 5	7 6	6 1
		2 x 8	12 8	11 6	10 8	10 0	14 5	12 5	11 1	10 2
		2 x 10	16 0	14 7	13 6	12 8	18 5	15 11	14 2	13 0
White Pine Red Pine	No. 1	2 x 6	8 8	7 11	7 5	6 11	9 10	8 6	7 7	6 11
		2 x 8	11 11	10 10	10 0	9 6	13 5	11 7	10 5	9 6
		2 x 10	15 1	13 8	12 8	12 0	17 0	14 8	13 1	12 0
		2 x 12	18 1	16 5	15 2	14 5	20 10	18 10	16 10	15 5
	Merchant- able and No. 2	2 x 6	8 8	7 10	7 0	6 5	9 0	7 10	7 0	6 5
		2 x 8	11 11	10 10	9 8	8 11	12 7	10 11	9 8	8 11
		2 x 10	15 1	13 8	12 6	11 5	16 1	13 11	12 6	11 5
		2 x 12	18 1	16 5	15 2	14 5	20 10	18 4	16 6	15 0
	No. 1 Dimension	2 x 6	8 6	7 5	6 7	6 0	8 6	7 5	6 7	6 0
		2 x 8	11 11	10 5	9 4	8 6	12 0	10 5	9 4	8 6
		2 x 10	15 1	13 8	12 6	11 5	16 1	13 11	12 6	11 5
		2 x 12	18 1	16 5	15 2	14 5	20 4	17 6	15 9	14 5
	No. 2 Dimension (4)	2 x 6	6 7	5 8	5 1	4 7	6 7	5 8	5 1	4 7
		2 x 8	9 4	8 0	7 2	6 6	9 4	8 0	7 2	6 6
		2 x 10	12 8	11 0	9 11	9 0	12 8	11 0	9 11	9 0
		2 x 12	15 10	13 8	12 5	11 2	15 10	13 8	12 5	11 2
Poplar	No. 1 (Construc- tion)	2 x 6	8 8	7 11	7 5	6 11	9 10	8 6	7 7	6 11
		2 x 8	11 11	10 10	10 0	9 6	13 5	11 7	10 5	9 6
		2 x 10	15 1	13 8	12 8	12 0	17 0	14 8	13 1	12 0
		2 x 12	18 1	16 5	15 2	14 5	20 10	18 10	16 10	15 5
	No. 2 (Standard)	2 x 6	8 6	7 5	6 7	6 0	8 6	7 5	6 7	6 0
		2 x 8	11 11	10 10	9 8	8 11	12 6	10 11	9 8	8 11

NOTES TO TABLE 20

- (1) Includes gypsum board.
- (2) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (3) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:
 Construction Grade 6 per cent
 Standard Grade 8 per cent
- (4) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:
 2 x 6, 2 x 8 10 per cent
 2 x 10, 2 x 12 15 per cent

TABLE 21
ROOF JOISTS — SUPPORTING CEILING — 40 lb./sq. ft. Live Load

Species	Grade	Nominal Size (2)	LIVE LOAD 40 lb. per sq. ft.															
			Plastered ceiling (1)								Other than plastered ceiling							
			Joist spacing								Joist spacing							
			12 in.		16 in.		20 in.		24 in.		12 in.		16 in.		20 in.		24 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir, Western Larch	Construc- tion (dense and non-dense)	2 x 6	11	0	10	0	9	4	8	8	12	7	11	5	10	7	10	0
		2 x 8	15	0	13	7	12	8	11	11	17	2	15	7	14	6	13	4
		2 x 10	19	0	17	4	16	0	15	1	21	10	19	10	16	5	17	4
		2 x 12	23	0	20	11	19	5	18	4	26	2	23	10	22	1	20	10
	Standard	2 x 6	11	0	10	0	9	4	8	8	12	7	11	2	10	0	9	1
		2 x 8	15	0	13	7	12	8	11	11	17	2	15	2	13	7	12	5
		2 x 10	19	0	17	4	16	0	15	1	21	10	19	4	17	2	15	8
		2 x 12	23	0	20	11	19	5	18	4	26	2	23	2	20	7	18	10
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 8		13	1	11	4	10	1	9	2	13	1	11	4	10	1	9	2	
2 x 10		18	0	15	6	13	11	12	8	18	0	15	6	13	11	12	8	
2 x 12		21	0	18	0	16	2	14	10	21	0	18	0	16	2	14	10	
Pacific Coast Hemlock	Construc- tion	2 x 6	10	10	9	10	9	1	8	7	12	4	11	2	10	5	9	10
		2 x 8	14	8	13	4	12	5	11	8	16	10	15	4	14	2	13	4
		2 x 10	18	7	16	11	15	8	14	10	21	4	19	5	18	0	16	11
		2 x 12	22	6	20	6	19	0	17	11	25	7	23	4	21	7	20	4
	Standard	2 x 6	10	10	9	10	9	1	8	7	12	4	11	2	10	0	9	1
		2 x 8	14	8	13	4	12	5	11	8	16	10	15	2	13	7	12	5
		2 x 10	18	7	16	11	15	8	14	10	21	4	19	4	17	2	15	8
		2 x 12	22	6	20	6	19	0	17	11	25	7	23	2	20	7	18	10
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 8		12	0	10	5	9	4	8	6	12	0	10	5	9	4	8	6	
2 x 10		16	6	14	4	12	10	11	8	16	6	14	4	12	10	11	8	
2 x 12		19	2	16	7	14	11	13	7	19	2	16	7	14	11	13	7	
Spruce, all western species Lodgepole Pine, Pon- derosa Pine	Construc- tion	2 x 6	9	8	8	6	7	7	6	11	9	11	8	6	7	7	6	11
		2 x 8	13	4	12	0	11	2	10	6	15	2	13	6	12	1	11	0
		2 x 10	16	10	15	2	14	2	13	4	19	2	17	1	15	4	14	0
		2 x 12	20	4	18	6	17	1	16	1	23	0	20	6	18	5	16	10
	Standard	2 x 6	7	7	6	7	5	11	5	5	7	7	6	7	5	11	5	5
		2 x 8	12	2	10	7	9	6	8	7	12	2	10	7	9	6	8	7
		2 x 10	16	1	13	11	12	6	11	5	16	1	13	11	12	6	11	5
		2 x 12	20	4	17	8	15	11	14	6	20	6	17	8	15	11	14	6
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 8		10	10	9	5	8	5	7	7	10	10	9	5	8	5	7	7	
2 x 10		14	11	12	11	11	6	10	6	14	11	12	11	11	6	10	6	
2 x 12		17	4	15	0	13	5	12	2	17	4	15	0	13	5	12	2	
Western Red Cedar Western White Pine (3)	Construc- tion	2 x 6	9	5	8	7	7	8	7	0	9	11	8	7	7	8	7	0
		2 x 8	12	10	11	8	10	10	10	2	14	8	12	8	11	5	10	5
		2 x 10	16	4	14	10	13	8	12	11	18	7	16	1	14	5	13	1
		2 x 12	19	8	17	11	16	7	15	7	22	4	19	4	17	4	15	8
	Standard	2 x 6	7	11	6	10	6	1	5	7	7	11	6	10	6	1	5	7
		2 x 8	11	6	10	0	8	11	8	2	11	6	10	0	8	11	8	2
		2 x 10	15	1	13	1	11	8	10	8	15	1	13	1	11	8	10	8
		2 x 12	19	2	16	8	14	11	13	7	19	2	16	8	14	11	13	7
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 8		10	1	8	10	7	11	7	2	10	1	8	10	7	11	7	2	
2 x 10		14	0	12	1	10	10	9	11	14	0	12	1	10	10	9	11	
2 x 12		16	4	14	1	12	7	11	6	16	4	14	1	12	7	11	6	
Pacific Coast Yellow Cedar	Construc- tion	2 x 6	10	0	9	1	8	5	7	11	11	4	9	10	8	10	8	0
		2 x 8	13	7	12	5	11	6	10	10	15	7	13	7	12	2	11	1
		2 x 10	17	4	15	8	14	7	13	8	19	10	18	0	16	5	15	0
		2 x 12	20	11	19	0	17	7	16	7	23	10	21	7	19	8	18	0
	Standard	2 x 6	9	0	7	10	6	11	6	4	9	0	7	10	6	11	6	4
		2 x 8	13	1	11	5	10	2	9	4	13	1	11	5	10	2	9	4
		2 x 10	17	4	15	0	13	5	12	2	17	4	15	0	13	5	12	2
		2 x 12	20	11	19	0	17	0	15	6	22	0	19	1	17	0	15	6
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2 x 8		11	7	10	1	9	0	8	2	11	7	10	1	9	0	8	2	
2 x 10		16	0	13	10	12	5	11	4	16	0	13	10	12	5	11	4	
2 x 12		18	7	16	1	14	5	13	2	18	7	16	1	14	5	13	2	

Continued next page

TABLE 21 (Continued)
ROOF JOISTS — SUPPORTING CEILING — 40 lb./sq. ft. Live Load

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 6	9	8	8	10	8	2	7	8	11	1	9	11	8	11	8	1
		2 x 8	13	4	12	0	11	2	10	6	15	2	13	6	12	1	11	0
		2 x 10	16	10	15	2	14	2	13	4	19	2	17	1	15	4	14	0
		2 x 12	20	4	18	6	17	1	16	1	23	0	21	0	19	5	18	0
	No. 2 (Standard)	2 x 6	9	8	8	7	7	8	7	0	9	11	8	7	7	8	7	0
		2 x 8	13	4	12	0	11	2	10	5	14	8	12	8	11	5	10	5
2 x 10		16	10	15	2	14	2	13	4	18	10	16	4	14	6	13	4	
2 x 12		20	4	18	6	17	1	16	1	23	0	21	0	19	5	17	7	
Jack Pine	No. 1 (Construc- tion)	2 x 6	10	0	9	1	8	5	7	11	11	5	10	5	9	6	8	8
		2 x 8	13	7	12	5	11	6	10	10	15	7	14	2	13	0	11	10
		2 x 10	17	4	15	8	14	7	13	8	19	10	18	0	16	5	15	0
		2 x 12	20	11	19	0	17	7	16	7	23	10	21	7	20	0	18	10
	No. 2 (Standard)	2 x 6	10	0	9	1	8	2	7	6	10	7	9	2	8	2	7	6
		2 x 8	13	7	12	5	11	6	10	10	15	7	13	7	12	2	11	1
2 x 10		17	4	15	8	14	7	13	8	19	10	17	5	15	7	14	2	
2 x 12		20	11	19	0	17	7	16	7	23	10	21	7	20	0	18	8	
White Pine Red Pine	No. 1	2 x 6	9	5	8	7	7	11	7	6	10	8	9	4	8	4	7	7
		2 x 8	12	10	11	8	10	10	10	2	14	8	12	8	11	5	10	5
		2 x 10	16	4	14	10	13	8	12	11	18	7	16	1	14	5	13	1
		2 x 12	19	8	17	11	16	7	15	7	22	4	20	4	18	6	16	10
	Merchant- able and No. 2	2 x 6	9	5	8	7	7	8	7	0	9	11	8	7	7	8	7	0
		2 x 8	12	10	11	8	10	8	9	8	13	10	11	11	10	7	9	8
		2 x 10	16	4	14	10	13	8	12	6	17	7	15	4	13	8	12	6
		2 x 12	19	8	17	11	16	7	15	7	22	4	20	2	18	1	16	6
	No. 1 Dimension	2 x 6	9	4	8	1	7	2	6	7	9	4	8	1	7	2	6	7
		2 x 8	12	10	11	5	10	2	9	4	13	1	11	5	10	2	9	4
		2 x 10	16	4	14	10	13	8	12	6	17	7	15	4	13	8	12	6
		2 x 12	19	8	17	11	16	7	15	7	22	2	19	4	17	4	15	9
	No. 2 Dimension (4)	2 x 6	7	2	6	2	5	7	5	1	7	2	6	2	5	7	5	1
		2 x 8	10	1	8	10	7	11	7	2	10	1	8	10	7	11	7	2
		2 x 10	14	0	12	1	10	10	9	11	14	0	12	1	10	10	9	11
		2 x 12	17	6	15	1	13	6	12	5	17	6	15	1	13	6	12	5
Poplar	No. 1 (Construc- tion)	2 x 6	9	5	8	7	7	11	7	6	10	8	9	4	8	4	7	7
		2 x 8	12	10	11	8	10	10	10	2	14	8	12	8	11	5	10	5
		2 x 10	16	4	14	10	13	8	12	11	18	7	16	1	14	5	13	1
		2 x 12	19	8	17	11	16	7	15	7	22	4	20	4	18	6	16	10
	No. 2 (Standard)	2 x 6	9	4	8	1	7	2	6	7	9	4	8	1	7	2	6	7
		2 x 8	12	10	11	8	10	8	9	8	13	8	11	11	10	8	9	8
2 x 10		16	4	14	10	13	8	12	6	17	7	15	4	13	8	12	6	
2 x 12		19	8	17	11	16	7	15	7	22	4	20	2	18	1	16	6	

TABLE 22
ROOF JOISTS — SUPPORTING CEILING — 30 lb./sq. ft. Live Load

Species	Grade	Nominal Size (2) inches	LIVE LOAD 30 lb. per sq. ft.															
			Plastered ceiling (1)								Other than plastered ceiling							
			Joist spacing								Joist spacing							
			12 in.		16 in.		20 in.		24 in.		12 in.		16 in.		20 in.		24 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir, Western Larch	Construc- tion (dense and non-dense)	2 x 6	12	1	11	0	10	2	9	7	13	11	12	7	11	8	11	0
		2 x 8	16	6	15	0	13	11	13	1	18	11	17	2	15	11	15	0
		2 x 10	20	11	19	0	17	8	16	7	23	11	21	10	20	2	19	0
		2 x 12	25	4	23	0	21	5	20	1	29	0	26	4	24	6	23	0
	Standard	2 x 6	12	1	11	0	10	2	9	7	13	11	12	6	11	2	10	2
		2 x 8	16	6	15	0	13	11	13	1	18	11	17	0	15	2	13	11
		2 x 10	20	11	19	0	17	8	16	7	23	11	21	6	19	4	17	7
		2 x 12	25	4	23	0	21	5	20	1	29	0	25	10	23	2	21	1
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	14	7	12	7	11	4	10	4	14	7	12	7	11	4	10	4
		2 x 10	20	1	17	5	15	6	14	2	20	1	17	5	15	6	14	2
		2 x 12	23	5	20	4	18	0	16	6	23	5	20	4	18	0	16	6
Pacific Coast Hemlock	Construc- tion	2 x 6	11	11	10	10	10	0	9	5	13	7	12	4	11	5	10	10
		2 x 8	16	2	14	8	13	7	12	10	18	6	16	10	15	7	14	8
		2 x 10	20	6	18	7	17	4	16	4	23	5	21	4	19	10	18	7
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	10	23	11	22	6
	Standard	2 x 6	11	11	10	10	10	0	9	5	13	7	12	4	11	2	10	2
		2 x 8	16	2	14	8	13	7	12	10	18	6	16	10	15	2	13	11
		2 x 10	20	6	18	7	17	4	16	4	23	5	21	4	19	4	17	7
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	10	23	2	21	1
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	13	5	11	7	10	5	9	6	13	5	11	7	10	5	9	6
		2 x 10	18	6	16	0	14	4	13	1	18	6	16	0	14	4	13	1
		2 x 12	21	6	18	7	16	7	15	2	21	6	18	7	16	7	15	2
Spruce, all western species Lodgepole Pine, Ponderosa Pine	Construc- tion	2 x 6	10	8	9	7	8	6	7	10	11	0	9	7	8	6	7	10
		2 x 8	14	7	13	2	12	4	11	7	16	8	15	1	13	6	12	4
		2 x 10	18	6	16	10	15	7	14	8	21	1	19	1	17	1	15	7
		2 x 12	22	5	20	4	18	11	17	8	25	7	22	11	20	6	18	8
	Standard	2 x 6	8	6	7	5	6	7	6	1	8	6	7	5	6	7	6	1
		2 x 8	13	8	11	10	10	7	9	8	13	8	11	10	10	7	9	8
		2 x 10	18	0	15	7	13	11	12	8	18	0	15	7	13	11	12	8
		2 x 12	22	5	19	10	17	8	16	2	22	11	19	10	17	8	16	2
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	12	1	10	5	9	5	8	6	12	1	10	5	9	5	8	6
		2 x 10	16	7	14	5	12	11	11	10	16	7	14	5	12	11	11	10
		2 x 12	19	4	16	10	15	0	13	8	19	4	16	10	15	0	13	8
Western Red Cedar Western White Pine (3)	Construc- tion	2 x 6	10	5	9	5	8	7	7	10	11	1	9	7	8	7	7	10
		2 x 8	14	1	12	10	11	11	11	2	16	2	14	2	12	8	11	7
		2 x 10	17	11	16	4	15	1	14	2	20	6	18	0	16	1	14	8
		2 x 12	21	8	19	8	18	4	17	2	24	10	21	7	19	4	17	7
	Standard	2 x 6	8	10	7	7	6	10	6	2	8	10	7	7	6	10	6	2
		2 x 8	12	11	11	2	10	0	9	1	12	11	11	2	10	0	9	1
		2 x 10	16	11	14	7	13	1	12	0	16	11	14	7	13	1	12	0
		2 x 12	21	6	18	7	16	8	15	4	21	6	18	7	16	8	15	4
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	11	4	9	10	8	10	8	0	11	4	9	10	8	10	8	0
		2 x 10	15	7	13	6	12	1	11	0	15	7	13	6	12	1	11	0
		2 x 12	18	2	15	8	14	1	12	10	18	2	15	8	14	1	12	10
Pacific Coast Yellow Cedar	Construc- tion	2 x 6	11	0	10	0	9	4	8	8	12	7	11	0	9	10	9	0
		2 x 8	15	0	13	7	12	8	11	11	17	2	15	2	13	7	12	5
		2 x 10	19	0	17	4	16	0	15	1	21	10	19	10	18	5	16	10
		2 x 12	23	0	20	11	19	5	18	4	26	4	23	11	22	1	20	2
	Standard	2 x 6	10	0	8	8	7	10	7	1	10	0	8	8	7	10	7	1
		2 x 8	14	8	12	8	11	5	10	5	14	8	12	8	11	5	10	5
		2 x 10	19	0	16	10	15	0	13	8	19	5	16	10	15	0	13	8
		2 x 12	23	0	20	11	19	1	17	5	24	8	21	5	19	1	17	5
	Utility	2 x 6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 8	13	0	11	4	10	1	9	2	13	0	11	4	10	1	9	2
		2 x 10	17	11	15	6	13	10	12	7	17	11	15	6	13	10	12	7
		2 x 12	20	10	18	0	16	1	14	8	20	10	18	0	16	1	14	8

Continued next page

TABLE 22 (Continued)
ROOF JOISTS — SUPPORTING CEILING — 30 lb./sq. ft. Live Load

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 6	10	8	9	8	9	0	8	6	12	2	11	1	9	11	9	0
		2 x 8	14	7	13	2	13	4	11	7	16	8	15	1	13	6	13	4
		2 x 10	18	6	16	10	15	7	14	8	21	1	19	1	17	1	15	7
	No. 2 (Standard)	2 x 12	22	5	20	4	18	11	17	8	25	7	23	4	21	7	20	0
		2 x 6	10	8	9	7	8	7	7	10	11	1	9	7	8	7	7	10
		2 x 8	14	7	13	2	12	4	11	7	16	5	14	2	12	8	11	7
Jack Pine	No. 1 (Construc- tion)	2 x 10	18	6	16	10	15	7	14	8	21	0	18	2	16	4	14	10
		2 x 12	22	5	20	4	18	11	17	8	25	7	23	4	21	6	19	6
		2 x 6	11	0	10	0	9	2	8	5	11	11	10	4	9	2	8	5
	No. 2 (Standard)	2 x 8	15	0	13	7	12	8	11	11	17	2	15	7	14	6	13	2
		2 x 10	19	0	17	4	16	0	15	1	21	10	19	6	17	5	15	11
		2 x 12	23	0	20	11	19	5	18	4	26	4	23	11	22	2	20	11
White Pine Red Pine	No. 1	2 x 6	10	5	9	5	8	8	8	2	11	11	10	5	9	4	8	6
		2 x 8	14	1	12	10	11	11	11	2	16	2	14	2	12	8	11	7
		2 x 10	17	11	16	4	15	1	14	2	20	6	18	0	16	1	14	8
	Merchant- able and No. 2	2 x 12	21	8	19	8	18	4	17	2	24	10	22	6	20	8	18	11
		2 x 6	10	5	9	5	8	7	7	10	11	1	9	7	8	7	7	10
		2 x 8	14	1	12	10	11	11	10	11	15	5	13	4	11	11	10	11
	No. 1 Dimension	2 x 10	17	11	16	4	15	1	13	11	19	8	17	1	15	4	13	11
		2 x 12	21	8	19	8	18	4	17	2	24	10	22	6	20	2	18	4
		2 x 6	10	5	9	0	8	1	7	5	10	5	9	0	8	1	7	5
	No. 2 Dimension (4)	2 x 8	14	1	12	8	11	5	10	5	14	8	12	8	11	5	10	5
		2 x 10	17	11	16	4	15	1	13	11	19	8	17	1	15	4	13	11
		2 x 12	21	8	19	8	18	4	17	2	24	10	21	6	19	4	17	6
Poplar	No. 1 (Construc- tion)	2 x 6	10	5	9	5	8	8	8	2	11	11	10	5	9	4	8	6
		2 x 8	14	1	12	10	11	11	11	2	16	2	14	2	12	8	11	7
		2 x 10	17	11	16	4	15	1	14	2	20	6	18	0	16	1	14	8
	No. 2 (Standard)	2 x 12	21	8	19	8	18	4	17	2	24	10	22	6	20	8	18	11
		2 x 6	10	5	9	0	8	1	7	5	10	5	9	0	8	1	7	5
		2 x 8	14	1	12	10	11	11	10	11	15	5	13	4	11	11	10	11

NOTES TO TABLE 22

- (1) Includes gypsum board.
- (2) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (3) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:
 Construction Grade 6 per cent
 Standard Grade 8 per cent
- (4) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:
 2 x 6, 2 x 8 10 per cent
 2 x 10, 2 x 12 15 per cent

TABLE 23
ROOF JOISTS — SUPPORTING CEILING — 20 lb./sq. ft. Live Load

Species	Grade	Nominal Size (2) inches	LIVE LOAD 20 lb. per sq. ft.											
			Plastered ceiling (1)						Other than plastered ceiling					
			Joist spacing				Joist spacing				Joist spacing			
			12 in.		16 in.		20 in.		24 in.		12 in.		16 in.	
			ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Douglas Fir Western Larch	Construction (dense and non-dense)	2 x 6	13	10	12	7	11	8	11	0	15	11	14	5
		2 x 8	18	11	17	2	15	11	15	0	21	8	19	8
		2 x 10	23	11	21	9	20	2	19	0	27	5	24	11
		2 x 12	29	0	26	4	24	6	23	0	33	2	30	2
	Standard	2 x 6	13	10	12	7	11	8	11	0	15	11	14	5
		2 x 8	18	11	17	2	15	11	15	0	21	8	19	8
		2 x 10	23	11	21	9	20	2	19	0	27	5	24	10
		2 x 12	29	0	26	4	24	6	23	0	33	2	20	1
	Utility	2 x 6	16	10	14	7	13	1	11	11	16	10	14	7
		2 x 8	23	2	20	1	17	11	16	5	23	2	20	1
		2 x 10	27	3	23	7	21	1	19	3	27	3	23	7
		2 x 12	—	—	—	—	—	—	—	—	—	—	—	—
Pacific Coast Hemlock	Construction	2 x 6	13	7	12	4	11	5	10	9	15	6	14	1
		2 x 8	18	6	16	10	15	7	14	8	21	2	19	3
		2 x 10	23	5	21	4	19	9	18	7	26	10	24	5
		2 x 12	28	5	25	9	23	11	22	6	32	6	29	6
	Standard	2 x 6	13	7	12	4	11	5	10	9	15	6	14	1
		2 x 8	18	6	16	10	15	7	14	8	21	2	19	3
		2 x 10	23	5	21	4	19	9	18	7	26	10	24	5
		2 x 12	28	5	25	9	23	11	22	6	32	6	29	6
	Utility	2 x 6	15	6	13	5	12	0	11	0	15	6	13	5
		2 x 8	21	4	18	6	16	6	15	1	21	4	18	6
		2 x 10	24	11	21	7	19	4	17	8	24	11	21	7
		2 x 12	—	—	—	—	—	—	—	—	—	—	—	—
Spruce, all western species Lodgepole Pine Ponderosa Pine	Construction	2 x 6	12	3	11	0	9	10	9	0	12	9	11	0
		2 x 8	16	8	15	2	14	1	13	3	19	1	17	4
		2 x 10	21	2	19	2	17	10	16	9	24	2	22	0
		2 x 12	25	7	23	3	21	7	20	4	29	4	26	7
	Standard	2 x 6	9	11	8	7	7	8	7	0	9	11	8	7
		2 x 8	15	9	13	8	12	3	11	2	15	9	13	8
		2 x 10	20	9	17	11	16	1	14	8	20	9	17	11
		2 x 12	25	7	23	2	20	8	18	11	26	9	23	2
	Utility	2 x 6	13	11	12	1	10	10	9	10	13	11	12	1
		2 x 8	19	2	16	7	14	10	13	7	19	2	16	7
		2 x 10	22	5	19	5	17	5	15	10	22	5	19	5
		2 x 12	—	—	—	—	—	—	—	—	—	—	—	—
Western Red Cedar Western White Pine (3)	Construction	2 x 6	11	10	10	9	9	11	9	1	12	9	11	1
		2 x 8	16	2	14	8	13	8	12	10	18	6	16	5
		2 x 10	20	6	18	7	17	3	16	3	23	5	20	9
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	2
	Standard	2 x 6	10	1	8	9	7	10	7	2	10	1	8	9
		2 x 8	14	11	12	11	11	6	10	6	14	11	12	11
		2 x 10	19	6	16	11	15	1	13	10	19	6	16	11
		2 x 12	24	10	21	9	19	6	17	9	25	2	21	9
	Utility	2 x 6	13	1	11	4	10	2	9	3	13	1	11	4
		2 x 8	18	0	15	7	13	11	12	9	18	0	15	7
		2 x 10	21	2	18	4	16	5	15	0	21	2	18	4
		2 x 12	—	—	—	—	—	—	—	—	—	—	—	—
Pacific Coast Yellow Cedar	Construction	2 x 6	12	7	11	5	10	8	10	0	14	5	12	8
		2 x 8	17	2	15	7	14	6	13	8	19	8	17	7
		2 x 10	21	9	19	9	18	4	17	3	24	11	22	8
		2 x 12	26	4	23	11	22	3	20	11	30	2	27	5
	Standard	2 x 6	11	7	10	0	9	0	8	2	11	7	10	0
		2 x 8	17	0	14	8	13	2	12	0	17	0	14	8
		2 x 10	21	9	19	4	17	4	15	10	22	4	19	4
		2 x 12	26	4	23	11	22	3	20	10	28	8	24	10
	Utility	2 x 6	15	0	13	0	11	8	10	7	15	0	13	0
		2 x 8	20	7	17	10	16	0	14	7	20	7	17	10
		2 x 10	24	2	21	0	18	9	17	1	24	2	21	0
		2 x 12	—	—	—	—	—	—	—	—	—	—	—	—

Continued next page

TABLE 23 (Continued)
ROOF JOISTS — SUPPORTING CEILING — 20 lb./sq. ft. Live Load

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construction)	2 x 6	12	3	11	1	10	4	9	9	14	0	12	9	11	5	10	5
		2 x 8	16	8	15	2	14	1	13	3	19	1	17	4	15	7	14	3
		2 x 10	21	2	19	2	17	10	16	9	24	2	22	0	19	9	18	0
		2 x 12	25	7	23	3	21	7	20	4	29	4	26	7	24	9	23	3
	No. 2 (Standard)	2 x 6	12	3	11	1	9	11	9	0	12	9	11	1	9	11	9	0
		2 x 8	16	8	15	2	14	1	13	3	18	11	16	5	14	8	13	5
		2 x 10	21	2	19	2	17	10	16	9	24	2	21	0	18	9	17	2
		2 x 12	25	7	23	3	21	7	20	4	29	4	26	7	24	9	22	9
Jack Pine	No. 1 (Construction)	2 x 6	12	7	11	5	10	8	10	0	14	5	13	1	12	2	11	2
		2 x 8	17	2	15	7	14	6	13	8	19	8	17	10	16	7	15	3
		2 x 10	21	9	19	9	18	4	17	3	24	11	22	8	21	0	19	4
		2 x 12	26	4	23	11	22	3	20	11	30	2	27	5	25	5	23	11
	No. 2 (Standard)	2 x 6	12	7	11	5	10	8	9	8	13	9	11	11	10	8	9	8
		2 x 8	17	2	15	7	14	6	13	8	19	8	17	7	15	9	14	4
		2 x 10	21	9	19	9	18	4	17	3	24	11	22	6	21	0	18	4
		2 x 12	26	4	23	11	22	3	20	11	30	2	27	5	25	5	23	11
White Pine Red Pine	No. 1	2 x 6	11	10	10	9	10	0	9	5	13	7	12	0	10	9	9	10
		2 x 8	16	2	14	8	13	8	12	10	18	6	16	5	14	8	13	5
		2 x 10	20	6	18	7	17	3	16	3	23	5	20	9	18	7	16	11
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	9	23	11	22	0
	Merchant- able and No. 2	2 x 6	11	10	10	9	9	11	9	0	12	9	11	1	9	11	9	0
		2 x 8	16	2	14	8	13	8	12	7	17	9	15	4	13	9	12	7
		2 x 10	20	6	18	7	17	3	16	1	22	9	19	9	17	8	16	1
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	9	23	5	21	5
	No. 1 Dimension	2 x 6	11	10	10	5	9	4	8	6	12	0	10	5	9	4	8	0
		2 x 8	16	2	14	8	13	2	12	0	17	0	14	8	13	2	12	0
		2 x 10	20	6	18	7	17	3	16	1	22	9	19	9	17	8	16	1
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	2	22	6	20	6
	No. 2 Dimension (4)	2 x 6	9	3	8	0	7	2	6	7	9	3	8	0	7	2	6	7
		2 x 8	13	1	11	4	10	2	9	3	13	1	11	4	10	2	9	3
		2 x 10	18	0	15	7	13	11	12	9	18	0	15	7	13	11	12	9
		2 x 12	22	10	19	9	17	8	16	2	22	10	19	9	17	8	16	2
Poplar	No. 1 (Construction)	2 x 6	11	10	10	9	10	0	9	5	13	7	12	0	10	9	9	10
		2 x 8	16	2	14	8	13	8	12	10	18	6	16	5	14	8	13	5
		2 x 10	20	6	18	7	17	3	16	3	23	5	20	9	18	7	16	11
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	9	23	11	22	0
	No. 2 (Standard)	2 x 6	11	10	10	5	9	4	8	6	12	0	10	5	9	4	8	6
		2 x 8	16	2	14	8	13	8	12	7	17	9	15	4	13	9	12	7
		2 x 10	20	6	18	7	17	3	16	1	22	9	19	9	17	8	16	1
		2 x 12	24	10	22	6	20	11	19	8	28	5	25	9	23	5	21	5

NOTES TO TABLE 23

- (1) Includes gypsum board.
- (2) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (3) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:

Construction Grade	6 per cent
Standard Grade	8 per cent
- (4) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:

2 x 6, 2 x 8	10 per cent
2 x 10, 2 x 12	15 per cent

TABLE 24
RAFTERS — NOT SUPPORTING CEILING — 50 and 40 lb./sq. ft. Live Load

Species	Grade	Nominal Size (1) inches	LIVE LOAD 50 lb. per sq. ft.				LIVE LOAD 40 lb. per sq. ft.			
			Rafter spacing				Rafter spacing			
			12 in.	16 in.	20 in.	24 in.	12 in.	16 in.	20 in.	24 in.
			ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Douglas Fir, Western Larch	Construc- tion	2 x 4	6 8	5 10	5 1	4 8	7 4	6 5	5 8	5 2
		2 x 6	12 11	11 8	10 6	9 7	13 11	12 7	11 7	10 7
		2 x 8	17 7	16 0	14 5	13 1	18 11	17 2	15 10	14 6
		2 x 10	22 2	20 2	18 2	16 7	24 0	21 10	20 1	18 4
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	12 2	10 6	9 5	8 7	13 5	11 7	10 5	9 6
		2 x 8	16 7	14 5	12 10	11 8	18 4	15 11	14 2	12 11
		2 x 10	21 0	18 2	16 4	14 11	23 2	20 1	18 0	16 5
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	12 4	10 8	9 7	8 8	13 7	11 10	10 6	9 7
		2 x 10	17 0	14 8	13 1	12 0	18 8	16 2	14 6	13 2
Pacific Coast Hemlock	Construc- tion	2 x 4	6 1	5 4	4 8	4 4	6 10	5 11	5 2	4 10
		2 x 6	12 7	11 5	10 6	9 7	13 7	12 4	11 5	10 7
		2 x 8	17 2	15 7	14 5	13 1	18 6	16 10	15 7	14 6
		2 x 10	21 10	19 10	18 2	16 7	23 5	21 4	19 10	18 4
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	12 2	10 6	9 5	8 7	13 5	11 7	10 5	9 6
		2 x 8	16 7	14 5	12 10	11 8	18 4	15 11	14 2	12 11
		2 x 10	21 0	18 2	16 4	14 11	23 2	20 1	18 0	16 5
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	11 5	9 10	8 10	8 0	12 6	10 11	9 8	8 11
		2 x 10	15 7	13 6	12 1	11 0	17 2	14 11	13 5	12 2
Spruce, all western species Lodgepole Pine, Ponderosa Pine	Construc- tion	2 x 4	5 6	4 10	4 4	3 11	6 1	5 2	4 8	4 4
		2 x 6	9 4	8 1	7 2	6 7	10 4	8 11	8 0	7 2
		2 x 8	14 8	12 10	11 5	10 5	16 2	14 1	12 7	11 6
		2 x 10	18 8	16 1	14 5	13 2	20 7	17 10	15 11	14 7
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	7 2	6 2	5 7	5 1	8 0	6 11	6 2	5 7
		2 x 8	11 7	10 0	9 0	8 2	12 10	11 0	9 11	9 0
		2 x 10	15 2	13 2	11 10	10 5	16 10	14 6	13 0	11 11
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	10 2	8 10	7 11	7 2	11 4	9 10	8 8	8 0
		2 x 10	14 0	12 2	10 11	9 11	15 6	13 5	12 0	11 0
Western Red Cedar Western White Pine (2)	Construc- tion	2 x 4	5 2	4 6	4 0	3 8	5 8	4 11	4 5	4 0
		2 x 6	9 5	8 1	7 2	6 7	10 4	8 11	8 0	7 4
		2 x 8	13 10	12 0	10 8	9 10	15 4	13 2	11 10	10 10
		2 x 10	17 6	15 2	13 7	12 5	19 5	16 10	15 0	13 8
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	7 5	6 5	5 10	5 2	8 2	7 1	6 4	5 10
		2 x 8	10 11	9 5	8 5	7 8	12 0	10 5	9 4	8 6
		2 x 10	14 4	12 5	11 1	10 1	15 10	13 8	12 2	11 1
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	9 7	8 4	7 5	6 10	10 7	9 2	8 2	7 6
		2 x 10	13 2	11 5	10 2	9 4	14 7	12 7	11 4	10 4
Pacific Coast Yellow Cedar	Construc- tion	2 x 4	5 11	5 1	4 7	4 2	6 6	5 8	5 1	4 7
		2 x 6	10 8	9 4	8 4	7 7	11 10	10 2	9 1	8 4
		2 x 8	14 11	12 11	11 7	10 6	16 5	14 2	12 8	11 7
		2 x 10	20 0	17 5	15 6	14 2	21 10	19 1	17 1	15 7
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	8 6	7 4	6 7	6 0	9 4	8 1	7 2	6 7
		2 x 8	12 5	10 10	9 7	8 2	13 8	11 11	10 7	9 8
		2 x 10	16 4	14 2	12 8	11 7	18 0	15 7	14 0	12 10
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	11 0	9 6	8 6	7 10	12 1	10 6	9 5	8 7
		2 x 10	15 1	13 1	11 8	10 8	16 7	14 5	12 11	11 10

Continued next page

TABLE 24 (Continued)
RAFTERS — NOT SUPPORTING CEILING — 50 and 40 lb./sq. ft. Live Load

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 4	5	6	4	10	4	4	3	11	6	1	5	2	4	8	4	4
		2 x 6	10	10	9	5	8	5	7	7	11	11	10	4	9	2	8	5
		2 x 8	14	8	12	10	11	5	10	5	16	2	14	1	12	7	11	6
		2 x 10	18	8	16	2	14	5	13	2	20	7	17	10	15	11	14	7
	No. 2	2 x 4	4	10	4	3	3	9	3	5	5	5	4	7	4	2	3	9
		2 x 6	9	5	8	1	7	2	6	7	10	4	8	11	8	0	7	4
		2 x 8	13	11	12	0	10	8	9	10	15	4	13	2	11	10	10	10
		2 x 10	17	8	15	5	13	8	12	6	19	7	16	11	15	2	13	10
Jack Pine	No. 1 (Construc- tion)	2 x 4	5	11	5	1	4	7	4	2	6	6	5	8	5	1	4	7
		2 x 6	11	7	10	0	9	0	8	2	12	7	11	1	9	11	9	0
		2 x 8	15	10	13	8	12	4	11	2	17	2	15	1	13	6	12	4
		2 x 10	20	0	17	5	15	6	14	2	21	10	19	1	17	1	15	7
	No. 2 (Standard)	2 x 4	5	2	4	6	4	1	3	8	5	9	5	0	4	6	4	1
		2 x 6	10	0	8	8	7	10	7	1	11	1	9	7	8	7	7	10
		2 x 8	14	11	12	11	11	6	10	6	16	5	14	2	12	8	11	7
		2 x 10	19	0	16	6	14	8	13	5	21	0	18	2	16	2	14	10
White Pine Red Pine	No. 1	2 x 4	6	10	5	11	5	4	4	10	7	6	6	6	5	10	5	4
		2 x 6	10	2	8	10	7	11	7	2	11	2	9	8	8	8	7	11
		2 x 8	13	10	12	0	10	8	9	10	15	4	13	2	11	10	10	10
		2 x 10	17	6	15	2	13	7	12	5	19	5	16	10	15	0	13	5
	Merchant- able and No. 2	2 x 4	6	1	5	2	4	8	4	4	6	8	5	10	5	2	4	8
		2 x 6	9	5	8	1	7	2	6	7	10	4	8	11	8	0	7	4
		2 x 8	13	0	11	3	10	1	9	2	14	4	12	5	11	1	10	1
		2 x 10	16	8	14	5	12	11	11	10	18	5	15	11	14	2	13	0
	No. 1 Dimension	2 x 4	5	2	4	6	4	0	3	8	5	8	4	11	4	5	4	0
		2 x 6	8	10	7	7	6	10	6	2	9	8	8	5	7	6	6	11
		2 x 8	12	5	10	10	9	7	8	10	13	8	11	11	10	7	9	8
		2 x 10	16	8	14	5	12	11	11	10	18	5	15	11	14	2	13	0
	No. 2 Dimension (3)	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	6	10	5	11	5	4	4	10	7	6	6	6	5	10	5	4
		2 x 8	9	7	8	4	7	5	6	10	10	7	9	2	8	2	7	6
		2 x 10	13	2	11	5	10	2	9	4	14	7	12	7	11	4	10	4
Poplar	No. 1 (Construc- tion)	2 x 4	5	2	4	6	4	0	3	8	5	8	4	11	4	5	4	0
		2 x 6	10	2	8	10	7	11	7	2	11	2	9	8	8	8	7	11
		2 x 8	13	10	12	0	10	8	9	10	15	4	13	2	11	10	10	10
		2 x 10	17	6	15	2	13	7	12	5	19	5	16	10	15	0	13	8
	No. 2 (Standard)	2 x 4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		2 x 6	8	10	7	7	6	10	6	2	9	8	8	5	7	6	6	11
		2 x 8	13	0	11	2	10	1	9	2	14	4	12	5	11	1	10	1
		2 x 10	16	8	14	5	12	11	11	10	18	5	15	11	14	2	13	0

NOTES TO TABLE 24

- (1) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (2) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:
- | | |
|--------------------|------------|
| Construction Grade | 6 per cent |
| Standard Grade | 8 per cent |
- (3) When graded by Eastern Pine Grading Committee Rules, spans may be increased as follows:
- | | |
|--------------|-------------|
| 2 x 6, 2 x 8 | 10 per cent |
| 2 x 10 | 15 per cent |

TABLE 25
RAFTERS — NOT SUPPORTING CEILING — 30 and 20 lb./sq. ft. Live Load

Species	Grade	Nominal Size (1) inches	LIVE LOAD 30 lb. per sq. ft.				LIVE LOAD 20 lb. per sq. ft.			
			Rafter spacing				Rafter spacing			
			12 in.	16 in.	20 in.	24 in.	12 in.	16 in.	20 in.	24 in.
			ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Douglas Fir, Western Larch	Construction	2 x 4	8 4	7 2	6 5	5 11	9 9	8 5	7 7	6 11
		2 x 6	15 4	13 11	12 11	12 0	17 6	15 11	14 9	13 10
		2 x 8	20 10	18 11	17 7	16 5	23 10	21 8	20 1	15 11
		2 x 10	26 5	24 0	22 2	20 8	30 2	27 5	25 5	23 11
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	15 2	13 1	11 10	10 8	17 6	15 6	13 10	12 7
		2 x 8	20 8	17 11	16 0	14 7	23 10	21 1	18 10	17 3
		2 x 10	26 2	22 8	20 4	18 6	30 2	26 8	23 11	21 10
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	15 5	13 4	11 11	10 11	18 11	15 8	14 0	12 10
		2 x 10	21 2	18 4	16 5	15 0	24 11	21 7	19 3	17 7
Pacific Coast Hemlock	Construction	2 x 4	7 7	6 7	5 11	5 5	9 0	9 9	7 0	6 4
		2 x 6	14 11	13 7	12 7	11 11	17 1	15 6	14 5	13 7
		2 x 8	20 5	18 6	17 2	16 2	23 4	21 2	19 8	18 6
		2 x 10	25 10	23 5	21 10	20 6	29 6	26 10	24 11	23 5
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	14 11	13 1	11 10	10 8	17 1	15 6	13 10	12 7
		2 x 8	20 5	17 11	16 0	14 7	23 4	21 1	18 10	17 3
		2 x 10	25 10	22 8	20 4	18 6	29 6	26 8	23 11	21 10
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	14 2	12 4	11 0	10 0	16 8	14 5	12 11	11 10
		2 x 10	19 6	16 11	15 1	13 10	22 11	19 10	17 9	16 3
Spruce, all western species Lodgepole Pine, Ponderosa Pine	Construction	2 x 4	6 11	5 11	5 4	4 10	8 1	7 0	6 3	5 8
		2 x 6	11 7	10 0	9 0	8 4	13 8	11 10	10 8	9 8
		2 x 8	18 5	15 11	14 2	13 0	21 0	18 9	16 9	15 3
		2 x 10	23 4	20 1	18 0	16 5	26 8	23 8	21 2	19 4
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	9 0	7 10	7 0	6 4	10 8	9 3	8 3	7 6
		2 x 8	14 5	12 6	11 2	10 2	16 11	14 8	13 2	12 0
		2 x 10	19 0	16 5	14 8	13 5	22 4	19 4	17 3	15 9
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	12 8	11 0	9 11	9 0	15 0	13 0	11 7	10 7
		2 x 10	17 6	15 2	13 7	12 5	20 7	17 10	16 0	14 7
Western Red Cedar Western White Pine (2)	Construction	2 x 4	6 6	5 7	5 0	4 7	7 7	6 7	5 11	5 4
		2 x 6	11 8	10 1	9 0	8 2	13 9	11 11	10 8	9 9
		2 x 8	17 4	15 0	13 5	12 2	20 4	17 7	15 9	14 4
		2 x 10	21 11	19 0	17 0	15 6	25 9	22 4	19 11	18 2
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	9 2	8 0	7 2	6 6	10 10	9 4	8 4	7 7
		2 x 8	13 7	11 10	10 6	9 7	16 0	13 10	12 5	11 4
		2 x 10	17 10	15 5	13 10	12 7	21 0	18 2	16 3	14 10
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	11 11	10 5	9 4	8 5	14 1	12 2	10 11	9 11
		2 x 10	16 5	14 2	12 8	11 7	19 4	16 9	15 0	13 8
Pacific Coast Yellow Cedar	Construction	2 x 4	7 5	6 5	5 8	5 2	8 8	7 6	6 9	6 2
		2 x 6	13 4	11 7	10 4	9 5	15 9	13 7	12 2	11 1
		2 x 8	18 6	16 1	14 5	13 1	21 8	18 11	16 11	15 5
		2 x 10	24 0	21 7	19 5	17 8	27 5	24 11	22 9	20 10
	Standard	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	10 7	9 1	8 2	7 6	12 5	10 10	9 7	8 10
		2 x 8	15 6	13 5	12 0	11 0	18 3	15 9	14 1	12 11
		2 x 10	20 5	17 8	15 10	14 5	24 0	20 9	18 7	17 0
	Utility	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	—	—	—	—	—	—	—	—
		2 x 8	13 8	11 11	10 7	9 8	16 2	14 0	12 6	11 5
		2 x 10	18 10	16 4	14 7	13 4	22 2	19 2	17 2	15 8

Continued next page

TABLE 25 (Continued)

RAFTERS — NOT SUPPORTING CEILING — 30 and 20 lb./sq. ft. Live Load

Eastern Spruce Balsam Fir Eastern Hemlock	No. 1 (Construc- tion)	2 x 4	6 11	5 11	5 4	4 10	8 1	7 0	6 3	5 8
		2 x 6	13 6	11 8	10 5	9 6	15 5	13 9	12 3	11 2
		2 x 8	18 6	15 11	14 2	13 0	21 0	18 9	16 9	15 1
		2 x 10	23 4	20 1	18 0	16 5	26 8	23 8	21 2	19 4
	No. 2 (Standard)	2 x 4	6 1	5 2	4 8	4 3	7 2	6 2	5 6	5 0
		2 x 6	11 8	10 1	9 0	8 2	13 9	11 11	10 8	9 8
		2 x 8	17 4	15 0	13 5	12 2	20 4	17 7	15 9	14 4
		2 x 10	22 1	19 2	17 1	15 7	26 0	22 6	20 2	18 5
Jack Pine	No. 1 (Construc- tion)	2 x 4	7 5	6 5	5 8	5 2	8 8	7 6	6 9	6 2
		2 x 6	13 11	12 6	11 2	10 2	15 11	14 5	13 2	12 0
		2 x 8	18 11	17 1	15 4	13 11	21 8	19 8	18 0	16 5
		2 x 10	24 0	21 7	19 5	17 8	27 5	24 11	22 9	20 10
	No. 2 (Standard)	2 x 4	6 6	5 8	5 0	4 7	7 8	6 7	5 11	5 5
		2 x 6	12 6	10 10	9 8	8 11	14 9	12 9	11 5	10 5
		2 x 8	18 6	16 1	14 5	13 1	21 8	18 11	16 11	15 5
		2 x 10	23 8	20 6	18 5	16 10	27 5	24 2	21 7	19 9
White Pine Red Pine	No. 1	2 x 4	8 6	7 4	6 7	6 0	9 10	8 8	7 9	7 1
		2 x 6	12 8	11 0	9 10	9 0	14 11	12 11	11 7	10 6
		2 x 8	17 4	15 0	13 5	12 2	20 4	17 7	15 9	14 4
		2 x 10	21 11	19 0	17 0	15 6	25 9	22 4	19 11	18 2
	Merchant- able and No. 2	2 x 4	7 6	6 6	5 10	5 4	8 10	7 8	6 10	6 3
		2 x 6	11 8	10 1	9 0	8 2	13 9	11 11	10 8	9 8
		2 x 8	16 2	14 0	12 6	11 6	19 1	16 6	14 9	13 6
		2 x 10	20 10	18 0	16 1	14 8	24 5	21 2	18 11	17 4
	No. 1 Dimension	2 x 4	6 6	5 7	5 0	4 7	7 7	6 7	5 11	5 4
		2 x 6	11 0	9 6	8 6	7 10	12 11	11 2	10 0	9 2
		2 x 8	15 6	13 5	12 0	11 0	18 3	15 9	14 1	12 11
		2 x 10	20 10	18 0	16 1	14 8	24 5	21 2	18 11	17 4
	No. 2 Dimension (3)	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	8 6	7 4	6 7	6 0	9 11	8 7	7 8	7 0
		2 x 8	11 11	10 4	9 4	8 5	14 1	12 2	10 11	9 11
		2 x 10	16 5	14 2	12 8	11 7	19 4	16 9	15 0	13 8
Poplar	No. 1 (Construc- tion)	2 x 4	6 6	5 7	5 0	4 7	7 7	6 7	5 11	5 4
		2 x 6	12 8	11 0	9 10	9 0	14 11	12 11	11 7	10 6
		2 x 8	17 4	15 0	13 5	12 2	20 4	17 7	15 9	14 4
		2 x 10	21 11	19 0	17 0	15 6	25 9	22 4	19 11	18 2
	No. 2 (Standard)	2 x 4	—	—	—	—	—	—	—	—
		2 x 6	11 0	9 6	8 6	7 10	12 11	11 2	10 0	9 2
		2 x 8	16 2	14 0	12 6	11 6	19 1	16 6	14 9	13 6
		2 x 10	20 10	18 0	16 1	14 8	24 5	21 2	18 11	17 4

NOTES TO TABLE 25

- (1) Spans for sizes not listed in the tables (2 x 5, 2 x 7, etc.) may be estimated with sufficient accuracy by straight line interpolation.
- (2) When either of these species is graded by Western Pine Association Rules, reduce the spans of 2 x 6 members as follows:
- | | |
|--------------------|-------------|
| Construction Grade | 6 per cent |
| Standard Grade | 8 per cent |
| 2 x 6, 2 x 8 | 10 per cent |
| 2 x 10 | 15 per cent |

TABLE 26
MAXIMUM SPANS FOR BUILT UP WOOD BEAMS
IN BASEMENTS, CELLARS AND CRAWL SPACES⁽¹⁾
TWO STOREY HOUSES⁽⁴⁾

Species	Grade	Supported Joist Length (2) (3)	Size of built up beam, inches (5) (6)					
			3-2 x 8	4-2 x 8	3-2 x 10	4-2 x 10	3-2 x 12	4-2 x 12
		ft.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Douglas Fir Western Larch Pacific Coast Hemlock	Construction	8	9 6	10 11	12 0	13 10	14 6	16 9
		10	8 6	9 9	10 9	12 5	13 0	15 0
		12	7 8	8 11	9 8	11 4	11 8	13 8
		14	6 9	8 3	8 6	10 6	10 4	12 8
		16	6 0	7 7	7 8	9 8	9 3	11 8
	Standard	8	8 6	9 9	10 9	12 5	13 0	15 0
		10	7 5	8 9	9 4	11 1	11 4	13 5
		12	6 4	8 0	8 1	10 1	9 9	12 3
		14	5 8	7 1	7 2	9 0	8 8	10 10
		16	5 1	6 4	6 5	8 0	7 9	9 9
Pacific Coast Yellow Cedar Eastern Larch Jack Pine	No. 1 (Construction)	8	7 11	9 4	10 0	11 10	12 1	14 4
		10	6 7	8 4	8 4	10 6	10 1	12 9
		12	5 8	7 2	7 2	9 0	8 8	10 11
		14	5 0	6 3	6 4	8 0	7 9	9 8
		16	4 7	5 8	5 9	7 2	7 0	8 8
	No. 2 (Standard)	8	6 4	7 4	8 4	9 8	10 9	12 5
		10	5 8	6 7	7 6	8 8	9 7	11 1
		12	5 2	6 0	6 10	7 11	8 8	10 1
		14	4 10	5 6	6 4	7 4	7 9	9 4
		16	4 6	5 2	5 9	6 10	7 0	8 8
Fir (Amabilis and Grandis) Balsam Fir Eastern Hemlock Pine (Lodgepole and Ponderosa) Spruce (all species)	No. 1 (Construction)	8	7 6	8 8	9 6	11 0	11 6	13 4
		10	6 3	7 9	7 11	9 10	9 7	11 11
		12	5 5	6 10	6 10	8 8	8 4	10 5
		14	4 10	6 0	6 1	7 8	7 5	9 3
		16	4 4	5 5	5 6	6 10	6 8	8 4
	No. 2 (Standard)	8	5 11	6 10	7 9	9 0	10 0	11 6
		10	5 3	6 1	6 11	8 0	8 11	10 4
		12	4 10	5 7	6 4	7 4	8 2	9 5
		14	4 6	5 2	5 10	6 9	7 5	8 9
		16	4 2	4 10	5 6	6 4	6 8	8 2
Western Red Cedar Red Pine Pine (Eastern and Western White) Poplar (Aspen, Largetooth Aspen, and Balsam Poplar)	No. 1 (Construction) (No. 1 Dimension)	8	6 4	7 4	8 6	9 10	10 6	12 6
		10	5 8	6 7	7 3	8 9	8 9	11 0
		12	5 0	6 0	6 3	7 10	7 7	9 6
		14	4 5	5 6	5 7	7 0	6 10	8 5
		16	4 0	4 11	5 1	6 3	6 2	7 7
	No. 2 (Standard) (No. 2 Dimension)	8	4 11	5 8	6 9	7 9	8 6	9 10
		10	4 4	5 1	6 0	6 11	7 8	8 10
		12	4 0	4 7	5 6	6 4	7 0	8 1
		14	3 8	4 3	5 1	5 11	6 5	7 5
		16	3 6	4 0	4 9	5 6	6 0	7 0

NOTES TO TABLE 26

- (1) These tables provide maximum allowable spans for main beams or girders which are built up from nominal 2 in. members in the species, sizes and grades indicated. Allowable spans for solid wood beams, glued-laminated wood beams or built up beams in sizes or grades other than shown, shall be determined from standard engineering formulae.
- (2) Supported joist length means $\frac{1}{2}$ the sum of the joist spans on both sides of the beam.
- (3) For supported joist lengths intermediate between those shown in the tables, straight line interpolation may be used in determining the maximum beam span.
- (4) Beams for $1\frac{1}{2}$ storey houses shall be taken from the table for 2 storey houses.
- (5) The 2 in. members shall be laid on edge and fastened together with a double row of common nails not less than $3\frac{1}{2}$ in. in length. Nails shall be spaced not more than 18 in. apart in each row with the end nails placed 4 in. to 6 in. from the end of each piece.
- (6) Where built up wood beams are employed over a single span, the length of each individual piece used to fabricate the beam shall equal the length of the beam.

TABLE 27
MAXIMUM SPANS FOR BUILT UP WOOD BEAMS
IN BASEMENTS, CELLARS AND CRAWL SPACES⁽¹⁾
ONE STOREY HOUSES⁽⁴⁾

Species	Grade	Supported Joist Length (2) (3)	Size of built up beam, inches (5) (6)					
			3-2 x 8	4-2 x 8	3-2 x 10	4-2 x 10	3-2 x 12	4-2 x 12
			ft. ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Douglas Fir Western Larch Pacific Coast Hemlock	Construction	8	12 6	14 6	15 11	18 4	19 3	22 2
		10	11 3	12 11	14 2	16 5	17 2	19 10
		12	10 3	11 10	13 0	15 0	15 8	18 1
		14	9 6	10 11	12 0	13 10	14 6	16 9
		16	8 10	10 3	11 3	13 0	13 7	15 8
	Standard	8	11 3	12 11	14 2	16 5	17 2	19 10
		10	10 0	11 7	12 8	14 8	15 5	17 9
		12	9 2	10 7	11 7	13 5	14 0	16 2
		14	8 6	9 9	10 9	12 5	13 0	15 0
		16	7 11	9 2	10 0	11 7	12 2	14 0
Pacific Coast Yellow Cedar Eastern Larch Jack Pine	No. 1 (Construction)	8	10 8	12 4	13 6	15 8	16 5	18 11
		10	9 7	11 0	12 1	14 0	14 8	16 11
		12	8 9	10 1	11 1	12 9	13 5	15 5
		14	7 11	9 4	10 10	11 10	12 1	14 4
		16	7 0	8 9	8 11	11 1	10 9	13 5
	No. 2 (Standard)	8	8 5	9 8	11 1	12 9	14 2	16 5
		10	7 6	8 8	9 11	11 5	12 8	14 8
		12	6 10	7 11	9 0	10 5	11 7	13 5
		14	6 4	7 4	8 4	9 8	10 9	12 5
		16	5 11	6 10	7 10	9 0	10 0	11 7
Fir (Amabilis & Grandis) Balsam Fir Eastern Hemlock Pine (Lodgepole and Ponderosa) Spruce (all species)	No. 1 (Construction)	8	9 11	11 6	12 7	14 7	15 3	17 7
		10	8 11	10 3	11 3	13 0	13 8	15 9
		12	8 1	9 5	10 3	11 11	12 6	14 5
		14	7 6	8 8	9 6	11 0	11 6	13 4
		16	6 9	8 1	8 6	10 3	10 4	12 6
	No. 2 (Standard)	8	7 10	9 0	10 3	11 10	13 3	15 3
		10	7 0	8 1	9 2	10 7	11 10	13 8
		12	6 4	7 4	8 5	9 8	10 9	12 6
		14	5 11	6 10	7 9	9 0	10 0	11 6
		16	5 6	6 4	7 3	8 5	9 4	10 9
Western Red Cedar Red Pine Pine (Eastern and Western White) Poplar (Aspen, Largetooth Aspen, and Balsam Poplar)	No. 1 (Construction) (No. 1 Dimension)	8	8 5	9 8	11 3	13 0	14 4	16 7
		10	7 6	8 8	10 1	11 8	12 10	14 10
		12	6 10	7 11	9 2	10 7	11 9	13 6
		14	6 4	7 4	8 6	9 10	10 6	12 6
		16	5 11	6 10	7 9	9 2	9 5	11 9
	No. 2 (Standard) (No. 2 Dimension)	8	6 6	7 6	8 11	10 3	11 4	13 1
		10	5 9	6 8	8 0	9 2	10 1	11 8
		12	5 3	6 1	7 3	8 5	9 3	10 8
		14	4 11	5 8	6 9	7 9	8 6	9 10
		16	4 7	5 3	6 4	7 3	8 0	9 3

NOTES TO TABLE 27

- (1) These tables provide maximum allowable spans for main beams or girders which are built up from nominal 2 in. members in the species, sizes and grades indicated. Allowable spans for solid wood beams, glued-laminated wood beams or built up beams in sizes or grades other than shown, shall be determined from standard engineering formulae.
- (2) Supported joist length means $\frac{1}{2}$ the sum of the joist spans on both sides of the beam.
- (3) For supported joist lengths intermediate between those shown in the tables, straight line interpolation may be used in determining the maximum beam span.
- (4) Beams for $1\frac{1}{2}$ storey houses shall be taken from the table for 2 storey houses.
- (5) The 2 in. members shall be laid on edge and fastened together with a double row of common nails not less than $3\frac{1}{2}$ in. in length. Nails shall be spaced not more than 18 in. apart in each row with the end nails placed 4 in. to 6 in. from the end of each piece.
- (6) Where built up wood beams are employed over a single span, the length of each individual piece used to fabricate the beam shall equal the length of the beam.

TABLE 28
MAXIMUM SPANS FOR STEEL BEAMS IN BASEMENTS,
CELLARS AND CRAWL SPACES (1) (3) (4)

No. of Storeys	Minimum Depth (in.)	Minimum Weight/Foot (lb.)	Width (2) of Floor to be Supported				
			8 ft.	10 ft.	12 ft.	14 ft.	16 ft.
1	4	7.7	10	9	8.5	8	7.5
	5	10.0	12.5	11.5	11	10.5	10
	6	12.5	15	14	13	12.5	12
	7	15.3	18	17	16	15	14.5
	8	18.4	21	19.5	18.5	17.5	16.5
1½ or 2	4	7.7	8	7.5	7	6.5	6
	5	10.0	10.5	9.5	8.5	8	7.5
	6	12.5	12.5	11.5	10.5	9.5	9
	7	15.3	15	14	13	12	11
	8	18.4	17.5	16	15	14	13

NOTES TO TABLE 28

- (1) A beam may be considered to be laterally supported if wood joists bear on its top flange at intervals of 24 in. or less over its entire length and if all the load being applied to this beam is transmitted through the joists and if 1-in. by 2-in. wood strips in contact with the top flange are nailed on both sides of the beam to the bottom of the joists supported. Other additional methods of positive lateral support are acceptable.
- (2) Supported joist length means ½ the sum of the joist spans on both sides of the beam.
- (3) For supported joist lengths intermediate between those shown in the tables, straight line interpolation may be used in determining the maximum beam span.
- (4) This table provides maximum spans for main steel beams or girders, of the sizes and weights indicated. Allowable spans for steel beam in sizes, weights or shapes other than shown, shall be determined from standard engineering formulae.

TABLE 29 NAILING TABLE

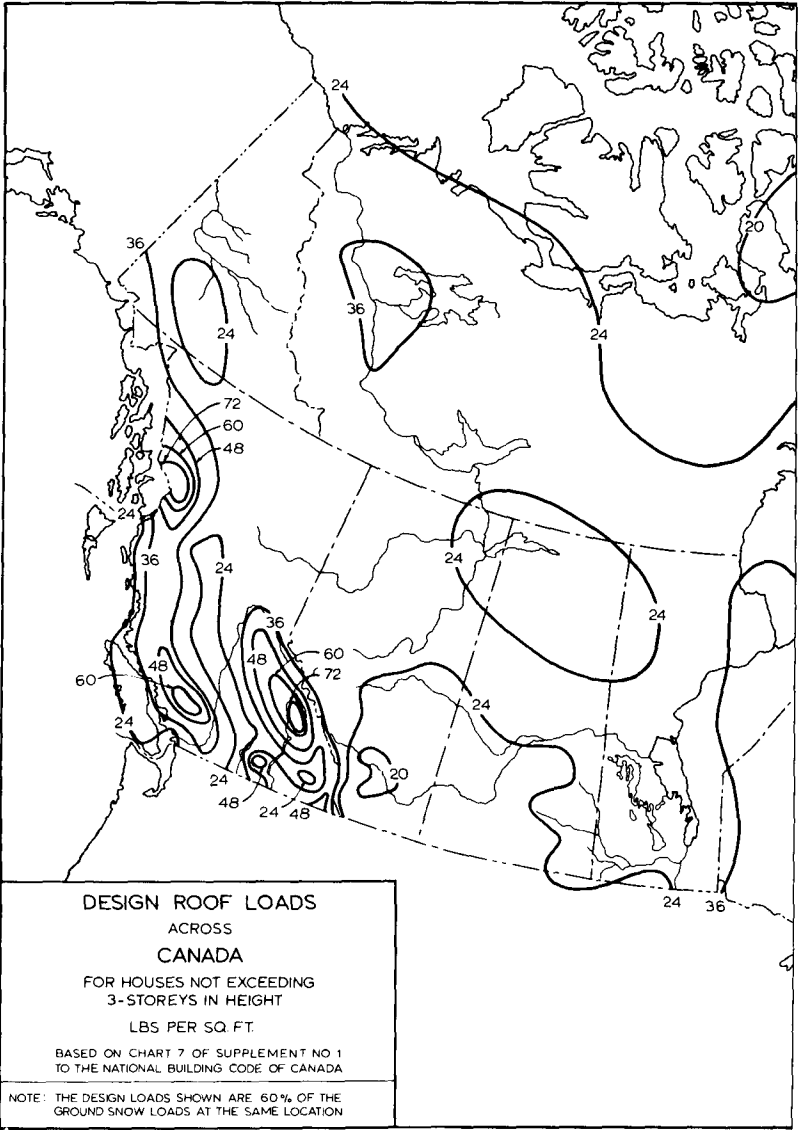
Construction Detail	Minimum Length of Nails (in.)	Minimum Number or Maximum Spacing of Nails
Floor Joist to plate — toe nail	3¼	2
Woods or metal strapping to underside of floor joists	2½	2
Cross bridging to joists	2¼	2 each end
Doubled header or trimmer joists	3¼	12 in. o.c.
Floor joist to stud (balloon construction)	3¼	2
Ledger strip to wood beam	3¼	2 per joist
Joist splice to joist	3¼	2 each end
Tail joist to adjacent header joist (end nailed) around openings	3¼	5
	4	3
Each header joist to adjacent trimmer joist (end nailed) around openings	3¼	5
	4	3
Stud to wall plate (each end) toe nail	2½	4
or end nail	3¼	2
Doubled studs at openings, or studs at partition or wall intersections and corners	3¼	30 in. o.c.
Doubled top wall plates	3¼	24 in. o.c.
Bottom wal' plate or sole plate to joists or blocking (exterior walls)	3¼	16 in. o.c.
Interior partitions to framing or subflooring	3¼	24 in. o.c.
Horizontal member over openings in non load bearing partitions — each end	3¼	2
Ceiling joist to plate — toe nail, each end	3¼	2
Roof rafter or roof joist to plate — toe nail	3¼	3
Rafter plate to each ceiling joist	4	2
Rafter to joist (with ridge supported)	3¼	3
Rafter to joist (with ridge unsupported)	See note 1 to table	

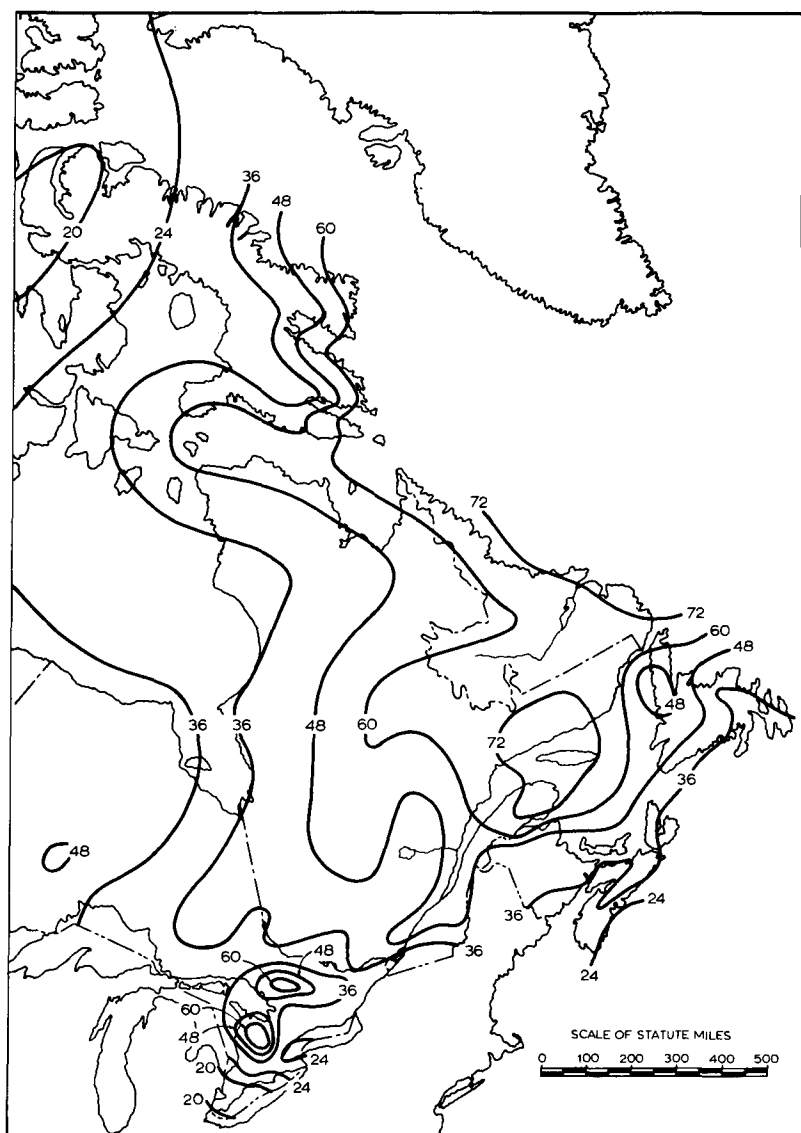
Continued next page

TABLE 30 — STAPLING TABLE

-
- (A) $\frac{3}{8}$ in. T & G Hardwood Flooring
18 gauge, $1\frac{1}{8}$ in. long, $\frac{3}{16}$ in. crown.
- (B) Asphalt Shingles to Wood Decks —
16 gauge, $\frac{3}{8}$ in. long, $\frac{7}{16}$ in. crown.
Corrosion resistant.
 $\frac{1}{3}$ more staples than the number of nails required.
16 gauge, $\frac{3}{4}$ in. long, 1 in. crown.
Corrosion resistant.
Equivalent to number of nails required.
- (C) Cedar Shingles to Wood Decks —
16 gauge, $1\frac{1}{8}$ in. long, $\frac{3}{8}$ in. crown.
Corrosion resistant.
- (D) Gypsum Plaster Lath, $\frac{3}{8}$ in. thick —
16 gauge, 1 in. long, $\frac{3}{4}$ in. crown.
Gypsum Plaster Lath, $\frac{1}{2}$ in. thick —
16 gauge, $1\frac{1}{8}$ in. long, $\frac{3}{4}$ in. crown.
- (E) $\frac{5}{16}$ in. and $\frac{3}{8}$ in. Plywood Wall Sheathing —
16 gauge, $1\frac{1}{2}$ in. long, $\frac{3}{8}$ in. crown.
- (F) $\frac{3}{8}$ in. Plywood Roof Sheathing —
16 gauge, $1\frac{1}{2}$ in. long, $\frac{3}{8}$ in. crown.
- (G) $\frac{7}{16}$ in. and $\frac{1}{2}$ in. Fibreboard Wall Sheathing —
16 gauge, $1\frac{1}{2}$ in. long, $\frac{3}{8}$ in. crown.
- (H) $\frac{5}{16}$ in. Plywood, $\frac{3}{16}$ in. and $\frac{1}{4}$ in. Hardboard Underlayment —
18 gauge, $\frac{3}{8}$ in. long, $\frac{5}{16}$ crown.
 $\frac{3}{8}$ in. Plywood Underlayment —
16 gauge, $1\frac{1}{8}$ in. long, $\frac{3}{8}$ in. crown.
- (I) Metal Plaster Lath —
14 gauge, $1\frac{1}{2}$ in. long, $\frac{3}{4}$ in. crown.
-

DESIGN ROOFLoads**Across Canada**





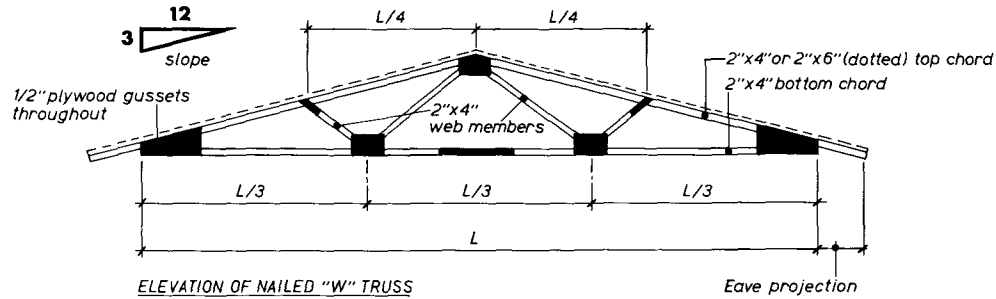
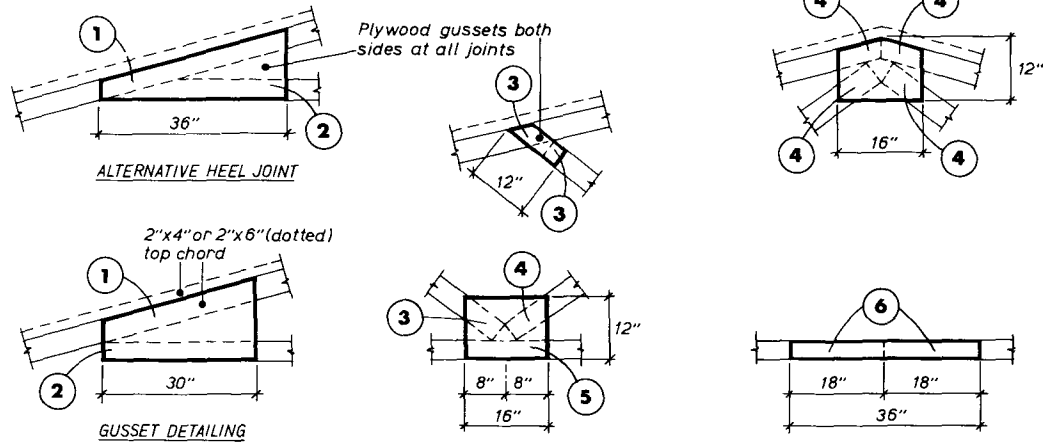
TRUSS DESIGNS

Prepared Jointly By

Division of Building Research—NRC

**The Forest Products Laboratory, Ottawa, of the
Department of Forestry and Rural Development**

Central Mortgage and Housing Corporation



1-66

NAILED "W" TRUSS DESIGN: 1/66

SLOPE: 3/12 only

SPANS: 16'-4" to 28'-4"

GUSSETS: 1/2" plywood

Nailing Schedule:

Roof Snow Load	Slope	Span "L"		Joint Location					
		ft.	in.	1	2	3	4	5	6
22.5 (2x4 top chord)	3/12	16	4	17	17	4	6	6	12
		18	4	20	18	4	6	6	13
		20	4	22	21	4	7	7	14
		22	4	24	24	4	8	8	16
		24	4	26	26	4	9	9	17
		26	4	29	28	5	9	9	19
		28	4	31	30	5	9	9	20
30 (2x4 top chord)	3/12	16	4	21	21	4	7	7	14
		18	4	24	23	4	7	7	16
		20	4	27	26	5	8	8	17
		22	4	29	29	5	9	9	19
		24	4	32	31	5	10	10	21
		26	4	35	34	6	11	11	23
		28	4	37	36	6	11	11	24
22.5 (2x6 top chord)	3/12	16	4	13	13	3	5	5	9
		18	4	15	14	3	5	5	10
		20	4	16	16	3	5	5	11
		22	4	18	18	3	6	6	12
		24	4	20	19	3	6	6	13
		26	4	21	21	4	7	7	14
		28	4	22	22	4	7	7	15
30 (2x6 top chord)	3/12	16	4	16	16	3	5	5	11
		18	4	18	17	3	5	5	12
		20	4	20	19	4	6	6	13
		22	4	22	22	4	7	7	14
		24	4	24	23	4	8	8	16
		26	4	26	25	5	8	8	17
		28	4	27	27	5	8	8	18
37.5 (2x6 top chord)	3/12	16	4	18	18	4	6	6	12
		18	4	21	20	4	6	6	14
		20	4	24	23	5	7	7	15
		22	4	26	25	5	8	8	17
		24	4	28	27	5	9	9	18
		26	4	30	30	6	10	10	20
		28	4	32	32	6	10	10	21

Notes:

LUMBER:

—Construction Grade Spruce or equivalent.

NAILS:

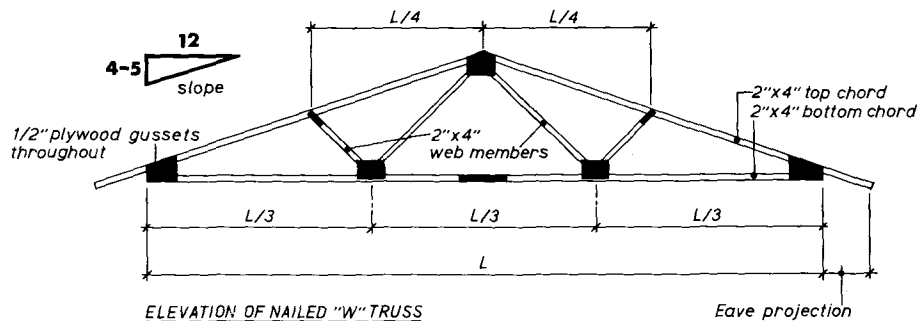
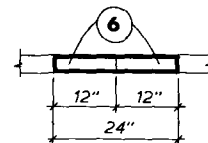
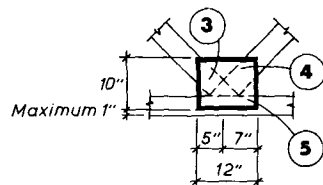
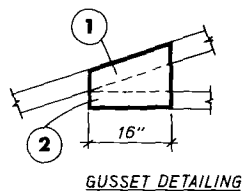
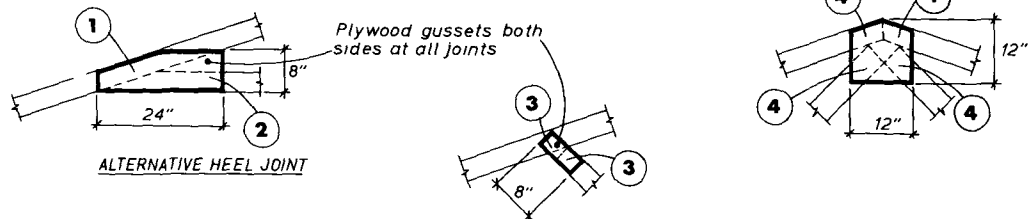
- All nails to be 3" common steel wire.
- All rows of nails to be staggered in direction of grain to keep splitting to a minimum.
- Nails may be clinched or unclinchd.
- Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

- 1/2" sheathing grade Douglas Fir throughout.
- Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

GENERAL:

- To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.
- Trusses with spans different than those listed may be used provided the nailing is not less than that shown for the next larger span.



2-66

NAILED "W" TRUSS DESIGN: 2/66**SLOPES: 4/12 and 5/12****SPANS: 16'-4" to 28'-4"****GUSSETS: 1/2" plywood****Nailing Schedule:**

Roof Snow Load	Slope	Span "L"		Joint Location					
		ft.	in.	1	2	3	4	5	6
22.5	4/12	16	4	9	8	2	3	3	5
		18	4	10	9	2	3	4	6
		20	4	11	10	2	3	4	7
		22	4	12	11	2	4	4	7
		24	4	13	12	3	4	5	8
		26	4	14	13	3	4	5	9
		28	4	15	14	3	4	5	9
22.5	5/12	16	4	7	7	2	2	3	5
		18	4	8	7	2	3	3	5
		20	4	9	8	2	3	4	6
		22	4	10	9	2	3	4	6
		24	4	10	10	2	3	4	7
		26	4	11	10	3	4	5	7
		28	4	12	11	3	4	5	8
30	4/12	16	4	12	11	2	4	4	7
		18	4	13	12	3	4	5	8
		20	4	15	13	3	4	5	9
		22	4	16	14	3	5	6	10
		24	4	17	16	4	5	6	11
		26	4	19	17	4	6	7	11
		28	4	20	18	4	6	7	12
30	5/12	16	4	10	9	2	3	4	6
		18	4	11	10	3	4	4	7
		20	4	12	11	3	4	5	8
		22	4	13	12	3	4	5	8
		24	4	14	13	3	4	6	9
		26	4	15	14	4	5	6	10
		28	4	16	15	4	5	6	10
37.5	4/12	16	4	17	16	3	5	6	11
		18	4	19	18	4	5	7	12
		20	4	21	20	4	6	7	13
		22	4	23	21	4	7	8	14
		24	4	25	23	5	7	9	16
		26	4	27	25	5	8	10	17
		28	4	29	27	5	8	10	18
37.5	5/12	16	4	14	13	3	4	5	9
		18	4	16	14	4	5	6	10
		20	4	17	16	4	5	7	11
		22	4	19	17	4	6	7	12
		24	4	20	19	4	6	8	13
		26	4	22	20	5	7	9	14
		28	4	24	22	5	7	9	15

Notes:**LUMBER:**

—Construction grade spruce or equivalent.

NAILS:

—All nails to be 3" common steel wire.

—All rows of nails to be staggered in direction of grain to keep splitting to a minimum.

—Nails may be clinched or unclinchd.

—Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

—1/2" sheathing grade Douglas Fir throughout.

—Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

GENERAL:

—To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.

—Trusses with spans different than those listed may be used provided the nailing is not less than that shown for the next larger span.

NAILED "W" TRUSS DESIGN: 3/66**SLOPES: 4/12 and 5/12****SPANS: 16'-4" to 28'-4"****GUSSETS: 1/2" plywood****Nailing Schedule:**

Root Snow Load	Slope	Span "L"		Joint Location				
		ft.	in.	1	2	3	4	5
22.5	4/12	16	4	9	8	5	5	5
		18	4	10	9	5	6	6
		20	4	11	10	5	7	7
		22	4	12	11	5	7	7
		24	4	13	12	5	8	8
		26	4	14	13	5	9	9
		28	4	15	14	5	9	9
22.5	5/12	16	4	7	7	5	5	5
		18	4	8	7	5	6	5
		20	4	9	8	5	6	6
		22	4	10	9	5	7	6
		24	4	10	10	5	8	7
		26	4	11	10	5	8	7
		28	4	12	11	5	9	8
30	4/12	16	4	12	11	5	7	7
		18	4	13	12	5	8	8
		20	4	15	13	5	9	9
		22	4	16	14	5	10	10
		24	4	17	16	5	11	11
		26	4	19	17	5	11	11
		28	4	20	18	5	12	12
30	5/12	16	4	10	9	5	7	6
		18	4	11	10	5	8	7
		20	4	12	11	5	8	8
		22	4	13	12	5	9	8
		24	4	14	13	5	10	9
		26	4	15	14	5	11	10
		28	4	16	15	5	12	10
37.5	4/12	16	4	17	16	5	11	11
		18	4	19	18	5	12	12
		20	4	21	20	5	13	13
		22	4	23	21	5	14	14
		24	4	25	23	5	16	16
		26	4	27	25	5	17	17
		28	4	29	27	5	18	18
37.5	5/12	16	4	14	13	5	10	9
		18	4	16	14	5	11	10
		20	4	17	16	5	12	11
		22	4	19	17	5	14	12
		24	4	20	19	5	15	13
		26	4	22	20	5	16	14
		28	4	24	22	5	17	15

Notes:**LUMBER:**

—Construction grade Spruce or equivalent.

NAILS:

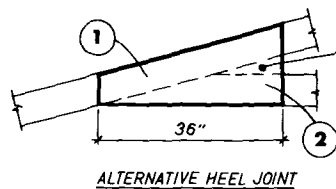
- All nails to be 3" common steel wire except as otherwise shown.
- All rows of nails to be staggered in direction of grain to keep splitting to a minimum.
- Nails may be clinched or unclinched.
- Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

- 1/2" sheathing grade Douglas Fir throughout.
- Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

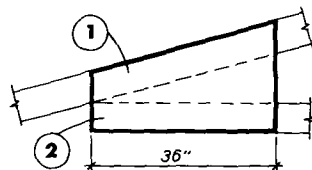
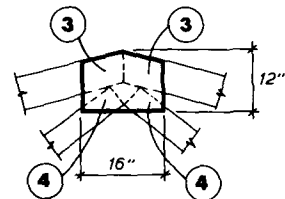
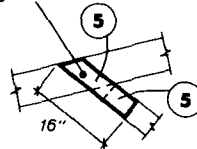
GENERAL:

- To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.
- Trusses with spans different than those listed may be used provided the nailing is not less than that shown for the next larger span.
- 1" x 6" diagonal may be used when the number of nails in 4 is 12 or less.

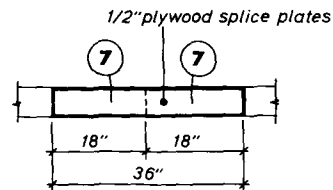
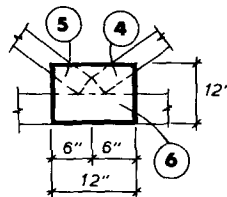


ALTERNATIVE HEEL JOINT

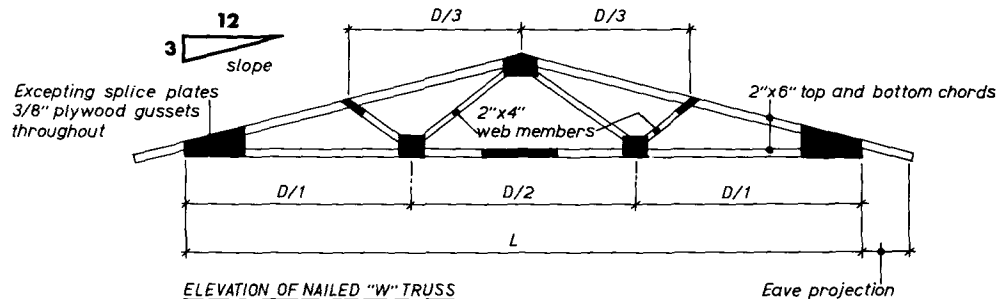
Plywood gussets both sides at all joints



GUSSET DETAILING



1/2" plywood splice plates



ELEVATION OF NAILED "W" TRUSS

Eave projection

4-66

NAILED "W" TRUSS DESIGN: 4/66

SLOPE: 3/12 only

SPANS: 30'-4" and 32'-4"

GUSSETS: $\frac{3}{8}$ "- $\frac{1}{2}$ " plywood

Nailing Schedule:

Roof Snow Load	Slope	Span "L"		Joint Location							
		ft.	in.	1	2	3	4	5	6	7	
22.5	3/12	30	4	24	23	6	6	4	7	16	
		32	4	26	25	6	6	5	8	17	
30	3/12	30	4	30	29	7	7	6	9	20	
		32	4	32	31	7	7	6	10	21	
37.5	3/12	30	4	35	34	8	8	7	11	24	
		32	4	37	36	8	8	7	11	25	

Dimension Schedule:

Span		L-30'-4"	L-32'-4"
Dimensions	D/1	11'-0"	11'-9"
	D/2	8'-4"	8'-10"
	D/3	6'-9"	7'-2"

Notes:

LUMBER:

—Construction grade Spruce or equivalent.

NAILS:

—All nails to be 3" common steel wire.

—All rows of nails to be staggered and clinched perpendicular to direction of plywood face.

—Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

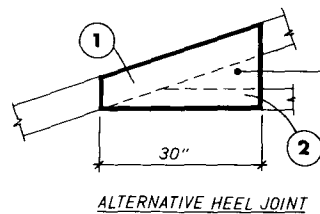
— $\frac{1}{2}$ " sheathing grade Douglas Fir at centre splice bottom chord, all other locations to be $\frac{3}{8}$ " thick plywood of the same grade.

—Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

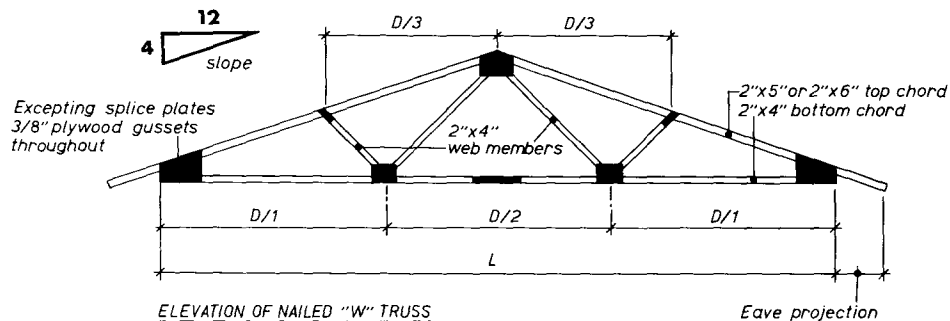
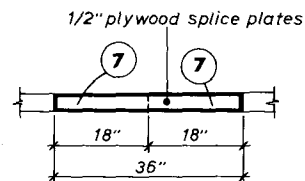
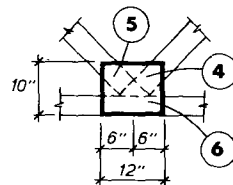
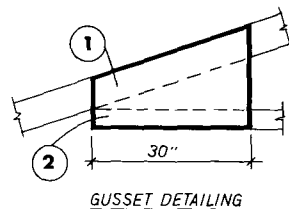
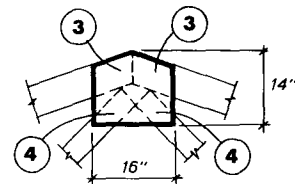
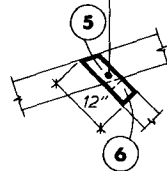
GENERAL:

—To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.

—Trusses with spans between those listed may be used provided the nailing is not less than that shown for the larger span.



Plywood gussets both sides at all joints



5-66

NAILED "W" TRUSS DESIGN: 5/66

SLOPE: 4/12 only

SPANS: 30'-4" to 32'-4"

GUSSETS: $\frac{3}{8}$ "- $\frac{1}{2}$ " plywood

Nailing Schedule:

Roof Snow Load	Slope	Span "L"		Joint Location						
		ft.	in.	1	2	3	4	5	6	7
22.5	4/12	30	4	15	14	4	4	3	5	10
		32	4	16	15	4	4	3	5	11
30	4/12	30	4	18	17	5	5	4	6	12
		32	4	20	19	5	5	4	6	13
37.5	4/12	30	4	22	21	6	6	5	7	15
		32	4	23	22	6	6	5	7	16

Dimension Schedule:

Span		L-30'-4"	L-32'- 4"
Dimensions	D/1	11'-0"	11'- 9"
	D/2	8'-4"	8'-10"
	D/3	6'-9"	7'- 2"

Notes:

LUMBER:

—Construction grade Spruce or equivalent.

NAILS:

—All nails to be 3" common steel wire.

—All rows of nails to be staggered and clinched perpendicular to direction of plywood face.

—Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

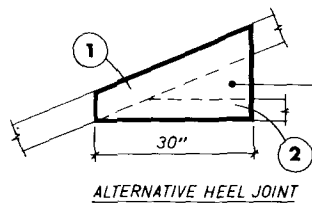
— $\frac{1}{2}$ " sheathing grade Douglas Fir at centre splice bottom chord, all other locations to be $\frac{3}{8}$ " thick plywood of the same grade.

—Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

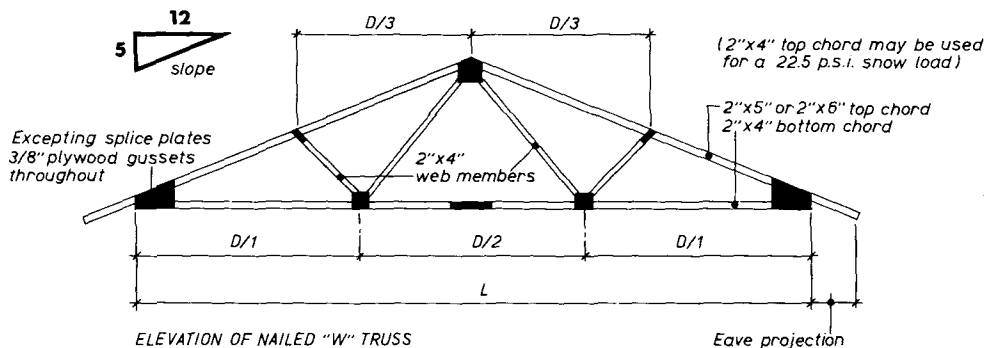
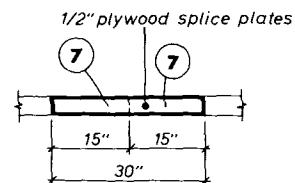
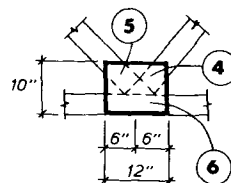
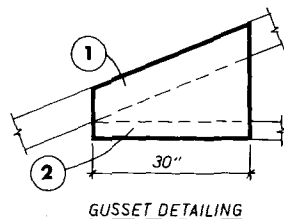
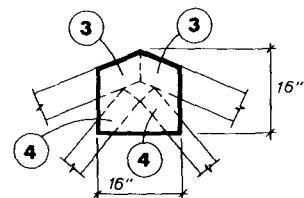
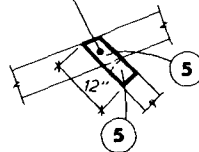
GENERAL:

—To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.

—Trusses with spans between those listed may be used provided the nailing is not less than that shown for the larger span.



Plywood gussets both sides at all joints



6-66

NAILED "W" TRUSS DESIGN: 6/66

SLOPE: 5/12 only

SPANS: 30'-4" to 32'-4"

GUSSETS: $\frac{3}{8}$ "- $\frac{1}{2}$ " plywood

Nailing Schedule:

Roof Snow Load	Slope	Span "L"		Joint Location						
		ft.	in.	1	2	3	4	5	6	7
22.5	5/12	30	4	12	12	4	4	3	4	8
		32	4	13	12	4	4	3	4	8
30	5/12	30	4	15	14	5	5	4	5	10
		32	4	16	15	5	5	4	5	11
37.5	5/12	30	4	18	17	5	5	4	5	12
		32	4	19	18	6	6	5	6	13

Dimension Schedule:

Span		L-30'- 4"	L-32'-4"
Dimensions	D/1	10'-10"	11'-7"
	D/2	8'- 8"	9'-2"
	D/3	6'- 9"	7'-2"

Notes:

LUMBER:

—Construction grade Spruce or equivalent.

NAILS:

—All nails to be 3" common steel wire.

—All rows of nails to be staggered and clinched perpendicular to direction or plywood face.

—Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

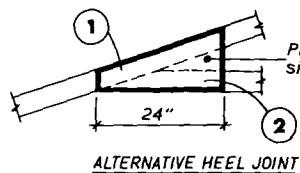
— $\frac{1}{2}$ " sheathing grade Douglas Fir at centre splice bottom chord, all other locations to be $\frac{3}{8}$ " thick plywood of the same grade.

—Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

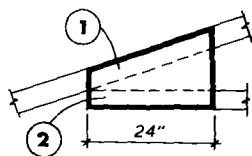
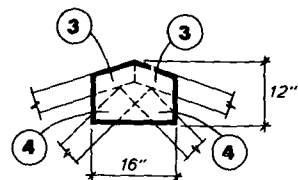
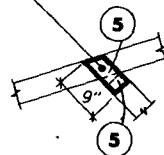
GENERAL:

—To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.

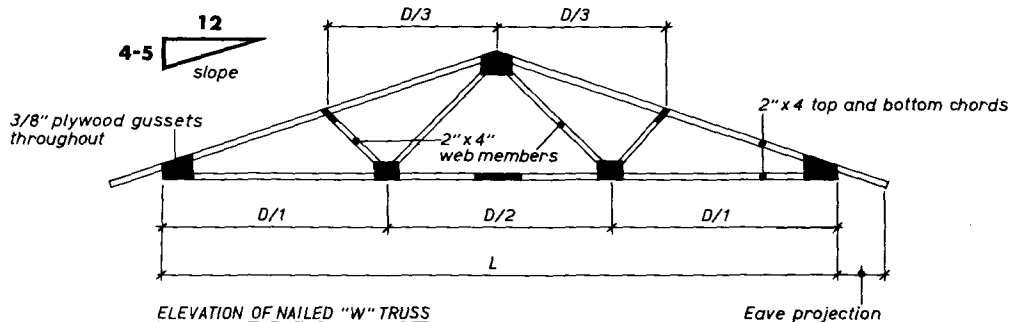
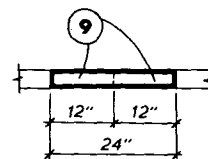
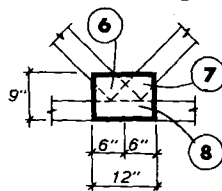
—Trusses with spans between those listed may be used provided the nailing is not less than that shown for the larger span.



Plywood gussets both sides at all joints



GUSSET DETAILING



ELEVATION OF NAILED "W" TRUSS

Eave projection

7-66

NAILED "W" TRUSS DESIGN: 7/66

SLOPES: 4/12 and 5/12

SPANS: 24'-4", 26'-4" and 28'-4"

GUSSETS: $\frac{3}{8}$ " plywood

Nailing Schedule:

Roof Snow Load	Slope	Span "L"		Joint Location								
		ft.	in.	1	2	3	4	5	6	7	8	9
22.5	5/12	24	4	10	10	3	3	2	2	3	4	7
		26	4	11	11	4	4	3	3	4	4	7
		28	4	12	11	4	4	3	3	4	4	8
30	5/12	24	4	13	12	4	4	3	3	4	4	8
		26	4	14	13	4	4	3	3	4	5	9
		28	4	15	14	5	5	3	3	5	5	9
37.5	5/12	24	4	15	14	5	5	4	4	5	5	10
		26	4	16	15	5	5	4	4	5	5	10
		28	4	18	16	5	5	4	4	5	6	11
22.5	4/12	24	4	13	12	3	3	3	3	3	4	9
		26	4	14	13	3	3	3	3	3	4	10
		28	4	15	14	4	4	3	3	4	5	10
30	4/12	24	4	16	15	4	4	3	3	4	5	11
		26	4	17	16	4	4	3	3	4	5	12
		28	4	18	17	4	4	4	4	4	6	13
37.5	4/12	24	4	18	18	4	4	4	4	4	6	13
		26	4	20	19	5	5	4	4	5	6	14
		28	4	21	20	5	5	4	4	5	7	15

Dimension Schedule:

Span		L-24'-4"	L-26'- 4"	L-28'-4"
Dimensions	D/1	8'-2"	8'-10"	9'-6"
	D/2	8'-0"	8'- 8"	9'-4"
	D/3	6'-0"	6'- 6"	7'-0"

Notes:

LUMBER:

—Construction grade Spruce or equivalent.

NAILS:

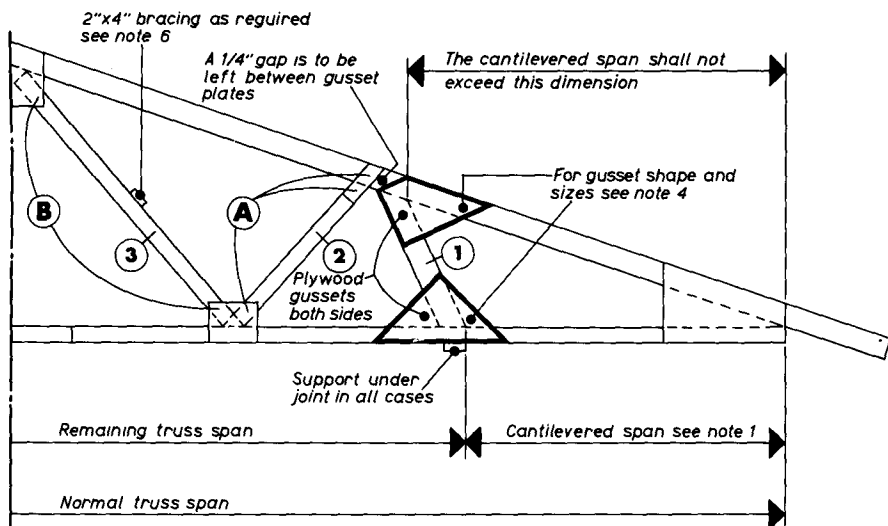
- All nails to be 3" common steel wire.
- All rows of nails to be staggered and clinched perpendicular to direction of plywood face.
- Solid blocking to be used under gusset plates during nailing.

PLYWOOD:

- $\frac{3}{8}$ " sheathing grade Douglas Fir throughout.
- Grain direction of plywood faces to be parallel to bottom chord excepting plates joining web to top chord at quarter points.

GENERAL:

- To ensure maximum stiffness, the upper chords must be in good bearing contact at peak.
- Trusses with spans between those listed may be used provided the nailing is not less than that shown for the larger span.



PART ELEVATION OF TYPICAL TRUSS SHOWING CANTILEVER DETAIL

8-66**CANTILEVER DESIGN: 8/66****Method of Reinforcing Cantilevered Nailed "W" Trusses with Plywood Gussets****Reinforcing Requirements:**

1. The Cantilevered span is not to exceed 6'-8" for trusses with 2" x 6" or 2" x 5" top chords, or 5'-4" for trusses with 2" x 4" top chords.
2. The additional web member (member 1) should be of the same lumber size as the top chord.
3. Gusset plates and nailing required for additional member (member 1) should be equivalent to those at the heel joint.
4. The shape and size of gusset plates should be chosen with regard to the space limitations and required nailing area for individual designs.
5. Number of nails at connections for member 2 (joint A) to be increased to that used for member 3 (joint B).
6. For trusses having roof slopes of 5/12 and greater lateral bracing should be provided for member 3. (Lateral bracing can be achieved by tying together the mid-points of members 3 of the cantilevered trusses used, with a 2" x 4" extending to at least two normally supported trusses).

General Notes:

If desired, both ends can be Cantilevered, providing the above procedure is followed for each end.

The Cantilever detail may be used for most truss designs when web members are nominal 2" or thicker.

The Cantilever detail shall not be used with truss design 3/66.

GLOSSARY

- Aggregate* — Coarse material, such as gravel, broken stone or sand, with which cement and water are mixed to form concrete. Crushed stone is usually designated as coarse aggregate and sand as fine aggregate.
- Airway* — The space left between roof insulation and roof decking to allow free movement of air.
- Anchor Bolt* — A steel bolt used to secure a structural member against uplift. It is usually deformed at one end to ensure a good grip in the concrete or masonry in which it is embedded.
- Angle Iron* — An L-shaped steel section frequently used to support masonry over a window or door opening.
- Apron* — A plain or molded finish piece below the stool of a window, installed to cover the rough edge of the wall finish. Also an extension of the concrete floor of a garage or other structure beyond the face of the building.
- Asbestos Cement* — A fire-resisting weather-proof building material, made from Portland Cement and asbestos. It is manufactured in various forms such as plain sheets, corrugated sheets, shingles, pipes etc.
- Attic or Roof Space* — The space between the top floor ceiling and roof and between a dwarf partition and sloping roof.
- Back Fill* — The material used to re-fill an excavation around the outside of a foundation wall or pipe trench.
- Balloon Framing* — A method of wood-frame construction in which the studs extend in one piece from the foundation sill to the top plate supporting the roof.
- Baseboard* — A molded board placed against the wall around a room next to the floor to conceal the joint between the floor and wall finish.
- Base Course* — In masonry the first or bottom course of brick or masonry blocks.
- Batten* — A narrow strip of wood used to cover joints between boards or panels.
- Batter Board* — Boards set at right angles to each other at each corner of an excavation, used to indicate the level and alignment of the foundation wall.
- Bay Window* — Window which projects outside the main line of a building.
- Beam* — A horizontal structural member usually wood, steel or concrete used to support vertical loads.
- Beam Pocket* — A notch formed at the top of a foundation wall to receive and support the end of a beam.
- Bearing* — The part of a joist, rafter, truss or beam which actually rests on its support and the area of the support on which it rests.
- Bearing Wall* — A wall that supports any vertical load in addition to its own weight.
- Bed* — In masonry, the horizontal layer of mortar on which each course of masonry is laid. Generally any horizontal surface which has been prepared to receive the element(s) it will support.
- Bevel* — The sloping surface formed when two surfaces meet at an angle which is not a right angle.
- Bevel Siding* — Boards tapered to a thin edge and used as exterior wall covering.
- Blind-Nailing* — Nailing in such a way that the nailheads are not finally visible on the face of the work.

- Bond** — In masonry, the pattern in which bricks or blocks are laid to tie the individual units together so that the entire wall they comprise will tend to act as a complete unit.
- Bottom Plate** — The lower horizontal member of a wood-frame wall nailed to the bottom of the wall studs and to the floor framing members.
- Breaking Joints** — The manner of laying masonry units so as to avoid vertical joints in adjacent courses from lining up. Also the distribution of joints in boards, flooring, lath, and panels so no two adjacent end-joints are directly in line.
- Brick Veneer** — A facing of brick tied to a wood-frame or masonry wall, serving as a wall covering only and carrying no structural loads.
- Bridging (Cross)** — Small wood or metal members that are inserted in a diagonal position between adjacent floor or roof joists.
- Built-up Roof** — A roof covering composed of three or more layers of roofing felt or fiberglass saturated with coal tar or asphalt. The top is finished with crushed stone, gravel or a cap sheet. Generally used on flat or low-pitched roofs.
- Butt-Joint** — Any joint made by fastening two members together without overlapping.
- Cant Strip** — A wedge or triangular-shaped piece of lumber generally installed in the deck of a flat roof around the perimeter or at the junction of the roof and an adjoining wall.
- Casing** — A form of molded trim used around window and door openings.
- Ceramic Tiles** — Vitreous clay tile used for a surface finish.
- Chimney Flue** — A passage housed in a chimney through which smoke and gases are carried from a fuel burning appliance, fireplace or incinerator to the exterior.
- Collar Brace** — A horizontal piece of lumber used to provide intermediate support for opposite roof rafters, usually located in the middle third of the rafters. Also called collar beam or collar tie.
- Common Rafter** — One of a series of rafters extending from the top of an exterior wall to the ridge of a roof.
- Corner Bead** — In plastering, a metal strip placed on external corners before plastering to protect, align and reinforce them. In gypsum board finish, a strip of metal or wood fixed to external corners to protect them from damage.
- Corner Boards** — A built-up wood member installed vertically on the external corners of a house or other frame structure against which the ends of the siding are butted.
- Cornerite** — Metal lath cut into strips and bent to a right angle. Used in internal angles of plastered walls and ceilings as reinforcing.
- Counterflashing** — A flashing applied above another flashing to shed water over the top of the under flashing and to allow some differential movement without damage to the flashing.
- Course** — A continuous layer of bricks or masonry units in buildings; the term is also applicable to shingles.
- Crawl Space** — A shallow space between the lowest floor of a house and the ground beneath.
- Cricket** — A small roof structure at the junction of a chimney and a roof to divert rain water around the chimney.
- Curing (of Concrete)** — The maintenance of proper temperature and moisture conditions to promote the continued chemical reaction which takes place between the water and the cement.

Dado — A rectangular groove in a board or plank. In interior decoration, a special type of wall treatment.

Damp-Proof Course — A damp-proof material placed just above the ground level in a brick or stone wall to prevent ground moisture from seeping up through the structure.

Damp-Proofing — The process of coating the outside of a foundation wall with a special preparation to resist passage of moisture through the wall. Material used to resist the passage of moisture through concrete floor slabs and from masonry to wood.

Double Glazing — Two panes of glass in a door or window, with an air space between the panes. They may be sealed hermetically as a single unit or each pane may be installed separately in the door or window sash.

Drywall Finish — Interior wall and ceiling finish other than plaster — e.g. gypsum board, plywood, fiberboard panels etc.

Dwarf Wall — A framed wall of less than normal full height.

Eave — The lower part of a roof which projects beyond the face of the walls.

Eave Soffit — The under surface of the eave.

Eave Trough — A trough fixed to an eave to collect and carry away the run-off from the roof. Also called a gutter.

Edge Grain — Lumber that is sawn along the radius of the annual rings or at an angle less than 45 degrees to the radius is edge-grained; this term is synonymous with quarter-sawn.

End Grain — The face of a piece of lumber which is exposed when the fibers are cut transversely.

End Matched — Having tongued and grooved ends.

Expanded Metal — A metal network formed by stamping or cutting sheet-metal and stretching it to form open meshes. It is used as reinforcing in concrete construction and as lath for plastering and stucco.

Expansion Joint — A joint in a concrete or masonry structure designed to permit expansion without damage to the structure.

Face Nailing — Fastening a member by driving nails through it at right angles to its exposed surface.

Fascia-Board — A finish member around the face of eaves and roof projections.

Feathering — Reducing gradually to a very thin edge.

Fire Clay — A clay of high heat-resisting qualities used to make fire brick and the mortar in which fire brick is laid.

Fire Stop — A complete obstruction placed across a concealed air space in a wall, floor or roof to retard or prevent the spread of flame and hot gases.

Flange — A projecting edge, rib or rim; the top and bottom of I-beams and channels are called flanges.

Flashing — Sheet metal or other material used in roof and wall construction to shed water.

Flooring — Material used in the construction of floors. The surface material is known as finish flooring while the base material is called sub-flooring.

Flue — See chimney flue.

Flue Lining — The material (usually tile pipe in 2-foot lengths) which lines the flue to protect the chimney walls from hot gases.

Footing — The widened section, usually concrete, at the base or bottom of a foundation wall, pier, or column.

Foundation — The lower portion, usually concrete or masonry and including the footings, which transfers the weight of and loads on a building to the ground.

Furring — Strips of wood applied to a wall or other surface as nailing support for the finish material, or to give the wall an appearance of greater thickness.

Gable — The upper triangular-shaped portion of the end wall of a house.

Gable End — The entire end wall of a house having a gable roof.

Gauge — A standard for measuring e.g. diameter of nails or wire and thickness of metal sheets, etc.

Grade (Lumber) — To separate lumber into different established classifications depending upon its suitability for different uses. A classification of lumber.

Grade — The surface slope. The level of the ground surface around the foundation wall. To modify the ground surface by cut and fill.

Grade Line — A pre-determined line indicating the proposed elevation of the ground surface around a building.

Grounds — Strips of wood that are attached to walls before plastering along the floor line and around windows, doors and other openings as a plaster stop and thickness guide.

Grout — A thin mixture of cement mortar and additional water.

Header (Framing) — A wood member at right angles to a series of joists or rafters at which the joists or rafters terminate. When used at openings in the floor or roof system the header supports the joist or rafters and acts as a beam.

Hearth — The floor of the fireplace and immediately in front.

Hip — The sloping ridge of a roof formed by two intersecting roof slopes.

Hip-Rafter — The rafter which forms the hip of a roof.

I-Beam — A steel beam with a cross section resembling the letter "I".

Insulation — Material used to resist heat transmission through walls, floors and roofs.

Interior Finish — The covering used on interior walls and ceilings.

Jack Rafter — A short rafter that spans from the wallplate to a hip rafter or from a valley rafter to the roof ridge.

Jamb — The side post or lining of a doorway, window, or other opening.

Joint Cement — A powder which is mixed with water and applied to the joints between sheets of gypsum-wallboard.

Joist — One of a series of horizontal wood members, usually 2-inch nominal thickness, used to support a floor, ceiling or roof.

Joist Hanger — A steel section shaped like a stirrup, bent so it can be fastened to a beam to provide end support for joists, headers etc.

Kerf — The groove formed in wood by a saw cut.

Lath — A building element made of wood, metal, gypsum, or fiberboard fastened to the frame of a building to serve as a plaster base.

Ledger Strip — A strip of lumber fastened along the bottom of the side of a beam on which joists rest.

Lintel — A horizontal structural member (beam) that supports the load over an opening such as a door or window.

Lookout Rafters — Short wood members cantilevered over a wall to support an overhanging portion of a roof.

- Louver** — A slatted opening for ventilation in which the slats are so placed to exclude rain, sunlight, or vision.
- Mesh** — Expanded metal or woven wire used as a reinforcement for concrete, plaster or stucco.
- Metal Lath** — Expanded metal or woven wire used to provide a base for plaster or stucco.
- Mineral Wool** — A material used for insulating buildings, produced by sending a blast of steam through molten slag or rock; common types now in use include rock wool, glass wool and slag wool.
- Miter Joint** — A joint formed by cutting and butting two pieces of board on a line bisecting the angle of their junction.
- Mortar** — A substance produced from prescribed proportions of cementing agents, aggregates and water which gradually sets hard after mixing.
- Mortar Bed** — Layer of mortar on which any structural member, masonry unit or tile is bedded.
- Mudsill** — Timber placed directly on the ground as a foundation for a structure.
- Newel** — A post to which the end of a stair railing or balustrade is fastened. Also, any post to which a railing or balustrade is fastened.
- Non-bearing Partition** — A wall which separates space into rooms, but supports no vertical load except its own weight.
- Nosing** — The rounded and projecting edge of a stair tread, window sill etc.
- On Center** — A term used to define the point from which measurements are taken — from the center of one member to the center of the adjacent member as in the spacing of studs, joists or nails. Also center to center.
- O.G. or Ogee** — A molding with a profile in the form of a letter S; having the outline of a reversed curve.
- Panel** — A large, thick board or sheet of lumber, plywood, or other material. A thin board with all its edges inserted in a groove of a surrounding frame of thick material. A portion of a flat surface recessed or sunk below the surrounding area, distinctly set off by molding or some other decorative device. Also, a section of floor, wall, ceiling, or roof, usually prefabricated and of large size, handled as a single unit in the operations of assembly and erection.
- Parapet Wall** — That part of an exterior, party or firewall extending above the roof line; a wall which serves as a guard at the edge of a balcony or roof.
- Parging** — A coat of plaster or cement mortar applied to masonry or concrete walls.
- Pier** — A column of masonry, usually rectangular in horizontal cross section, used to support other structural members.
- Pilaster** — A pier forming an integral part of a wall and partially projecting from the wall face.
- Pitch** — Also "slope". Inclination to the horizontal plane.
- Pitched Roof** — A roof which has one or more surfaces sloping at angles greater than necessary for drainage.
- Plain Concrete** — Un-reinforced concrete.
- Plough** — To cut a groove.
- Plumb** — Vertical. To make vertical.
- Plumbing** — The pipes, fixtures and other apparatus for the water supply and the removal of water-borne wastes.

Rabbet — A groove cut in the surface along the edge of a board, plank, or other timber. The recess in a brick jamb which receives a window frame. Also the recess in a door frame to receive the door.

Radiant Heating — A method of heating, usually consisting of coils or pipes, or electric heating elements placed in the floor, wall, or ceiling.

Rafter — One of the series of structural members of a roof usually of 2-inch nominal thickness designed to support roof loads, but not ceiling finish.

Receptacle (Electric) — A wall-mounted electrical outlet.

Ribbon — A narrow board let into studs to support joists.

Ridge Board — A horizontal member usually $\frac{3}{4}$ -inch thick at the upper end of the rafters, to which these rafters are nailed.

Ridge Beam — A horizontal structural member usually 2 inches thick, supporting the upper ends of rafters.

Scratch Coat — The first coat of plaster, which is scratched to form a bond for the second coat.

Scribing — Fitting woodwork to an irregular surface.

Sealer — A liquid applied directly over uncoated wood for the purpose of sealing the surface.

Shake — A shingle split (not sawn) from a block of wood and used for roofing and siding.

Sheathing Paper — Paper treated with tar or asphalt used under exterior wall cladding as protection against the passage of water or air.

Shed Roof — A sloping roof having its surface in one plane.

Shoe Mold — For interior finish, a molding strip placed against the baseboard at the floor; also called base shoe, or carpet strip.

Siding — In wood-frame construction, the material other than masonry or stucco used as an exterior wall covering.

Sill — The horizontal member forming the bottom of an opening such as a door or window.

Sill Plate — A structural member anchored to the top of a foundation wall, upon which the floor joists rest.

Smoke Pipe — A pipe conveying products of combustion from a solid or liquid fuel-fired appliance to a chimney flue.

Soffit — The underside of elements of a building, such as staircases, roof overhangs, beams etc.

Span — The horizontal distance between supports for beams, joists, rafters etc.

Splash Block — A small masonry block laid with the top close to the ground surface to receive roof drainage and divert it away from the building.

Stair Landing — A platform between flights of stairs.

Step Flashing — Rectangular or square pieces of flashing used at the junction of shingled roof and walls. Also called shingle flashing.

Stool — The flat, narrow shelf forming the top member of the interior trim at the bottom of a window.

Stoop — A low platform with or without steps, outside the entrance door of a house.

Storm Door — An extra outside door for protection against inclement weather.

Strike Plate — The part of a door lock set which is fastened to the jamb.

- Strut* — A structural member which is designed to resist longitudinal compressive stress such as members supporting a ridge beam or rafters; a short column.
- Stud* — One of a series of wood structural members (usually 2-inch nominal thickness) used as supporting elements in walls and partitions. (Plural: Studs or studding).
- Subfloor* — Boards or sheet material laid on joists under a finish floor.
- Taping* — In dry-wall construction the masking of joints between sheets by means of paper tape which is smoothed over with joint cement.
- Three-way Switch* — A switch used in house wiring when a light (or lights) is controlled from two places. A three-way switch must be used at each location.
- Threshold* — A strip of wood, metal, or other material beveled on each edge and used at the junction of two different floor finishes under doors, or on top of the door sill at exterior doors.
- Toenailing* — Nailing at an angle to the first member so as to ensure penetration into a second member.
- Tongue and Groove Lumber* — Any lumber, such as boards or planks, machined in such a manner that there is a groove on one edge and a corresponding tongue on the other.
- Top Plate* — In building, the horizontal member nailed to the top of the partition or wall studs.
- Tread* — The horizontal part of a step.
- Trimmer* — A beam or joist alongside an opening and into which a header is framed.
- Valley* — The internal angle formed by the junction of two sloping sides of a roof.
- Valley Rafters* — Rafters which are located at the center of roof valleys to support the jack rafters.
- Vapor Barrier* — Material used to retard the passage of water vapor or moisture.
- Wall Plates* — In wood-frame construction, the horizontal members attached to the ends of the studs. Also called top or bottom plates, depending on their location.
- Water Table* — The level below which the ground is saturated with water.
- Weather Stripping* — Strips of felt, rubber, metal or other material, fixed along the edges of doors or windows to keep out drafts and reduce heat loss.
- Weephole* — A small hole, as at the bottom of a retaining wall or masonry veneer, to drain water to the exposed face.
- Wythe* — A continuous vertical section of a masonry wall having a thickness of one masonry unit.

INDEX

- Anchor bolts 12; 17; 125
- Asphalt shingles 55; 56; 57; 58
- Attic ventilation 90; 91 92; 133
- Balloon-frame construction 36; 37
- Basement floors 61
- Brick veneer 13
- Built-up roofs 60
- Caulking 71; 73; 133
- Ceiling framing 38; 39
- Ceramic-tile floor 105
- Chimney:
 - flue installation 127; 128
 - flashing 122
 - flue installation 127 128
 - framing 54
 - height above ridge 128
 - masonry 127
 - prefabricated 128
- Closets 113
- Collar braces 42; 46
- Columns:
 - steel 18
 - wood 19
- Concrete-slab floors:
 - construction 15
 - duct work for heating 18
 - finish floors 105
 - insulation 18
 - vapor barriers 17
- Corner bead:
 - gypsum board 101
 - plaster reinforcement 96
- Corner intersections, details 33
- Cornerities, plaster reinforcement 96
- Drain Tile 10; 11
- Driveways 131; 132
- Drywall finish 98; 99; 100; 101
- Excavation 3
- Exterior steps and stoops 119
- Exterior trim 61
- Finish flooring 102; 103; 104; 105; 106
- Fireplaces 129; 130; 131
- Flashing:
 - at chimneys 123
 - materials 121
 - over openings 121; 122
 - roof and wall intersections 60; 61; 122
- Flat roofs 39; 40
- Floor framing:
 - beams 18; 19
 - columns 19
 - drilling and notching 78
 - headers 26
 - joists 25
 - trimmers 26
- Flooring:
 - Wod strip 102
- Floor joists:
 - (see floor framing)
- Floor slabs
 - (see concrete-slab floors)
- Flue lining 127; 128; 129
- Footings 5; 6
- Formwork 8
- Foundation walls:
 - concrete 8
 - concrete block 9
- Crawl space
 - soil cover 14; 92
 - Ventilation 92
- Cricket flashing 123
- Dampproofing:
 - basement floor 61
 - foundation walls 8; 10
- Doors:
 - clearance 110
 - exterior 67; 68
 - frames 67; 107
 - hardware 110
 - installation 109
 - interior 107; 108
- Downspouts 125
- Kitchen cabinets 112; 113
- Ledger strips 20; 21
- Linen closet 113
- Lintels 30; 31
- Louvres 91; 92
- Masonry veneer 13

- Painting 133
- Parging foundation walls 10
- Parquet floors 103; 104
- Pilasters 9
- Pitched roofs:
 - gable 41; 42
 - hip 42; 44; 47
- Plaster base 93; 94; 95; 96
- Plumbing:
 - framing 79; 80
- Garages 124; 125
- Heating systems, framing for 81; 82
- Hip roofs 42; 44; 47
- Installation:
 - batt-type 86; 89
 - coefficient of heat transmission 85; 86
 - for concrete slabs 18; 86
 - for door and window areas 87; 88
 - how to insulate 89
 - loose fill 89; 90
 - rigid 86
 - where needed 87; 88
- Interior finish:
 - dry-wall 98; 99; 100; 101
 - plaster 93; 94; 96
- Interior trim 106; 107; 111; 112
- Jack rafters 42; 47
- Termites 133
- Trim:
 - exterior 61
 - interior 106; 107; 111; 112
- Trusses, lightweight roof 48; 49
- Valley:
 - flashing 122
 - framing 44; 47
- Vapor barriers:
 - application 84; 85
 - in concrete-slab floor 15; 17; 18
 - ground cover in crawl space 14; 133
 - on batt type insulation 86
 - separate vapor barriers 89
- Ventilation:
 - attic 90; 91; 92; 133
 - crawl spaces 92; 133
 - flat roofs 92
 - pitched roofs 91; 92
- Ventilators:
 - location 91; 92
 - types 92
- Rafters—
 - common 44; 45
 - hip 42; 44; 47
 - jack 42; 47
 - overhanging roof 40; 61; 63
 - valley 44; 47
- Resilient flooring 105
- Ridge beam 46
- Ridge insulation 86
- Roof framing 38
- Sheathing paper 51
- Sheathing—
 - roofs 52; 53; 54
 - walls 49; 50; 51
- Shingles—
 - asbestos-cement 76
 - asphalt 55; 56; 57; 58
 - wood 58; 59; 60; 75; 76
- Siding 70
- Stairs—
 - basement 119
 - definition of parts 115
 - exterior 119
 - interior 115; 116; 117; 118
- Storm sash 67
- Stringers 118
- Stucco 76; 77
- Subfloor 28; 29
- Wall Framing—
 - corners 33
 - intersections 33
 - lintels 30; 31
 - load-bearing partitions 31
 - non-load-bearing partitions 32
 - studs 32
 - top plates 31
- Weep holes 13
- Windows—
 - frames 67
 - installation 67
 - lintels 30; 31
 - trim 67; 111
 - weather stripping 68
- Window wells 11; 12
- Wiring electrical 83; 84



CANADIAN WOOD-FRAME HOUSE CONSTRUCTION

CENTRAL
MORTGAGE
AND HOUSING
CORPORATION