CHAPTER 5 Structural

BUILDING STRUCTURE

The building structure is composed of four subsystems:

FOUNDATION	Subsystem
FLOOR	Subsystem
WALL	Subsystem
ROOF	Subsystem

Together these subsystems support their own weight, the weight of fixed loads such as shingles, siding, interior finishes, etc., and portable loads such as furniture and occupants. The structure is designed to support and transfer these loads through the foundation to the subsoil. These loads create forces such as stress, which tends to produce deformation of the construction elements. An element or system may have enough strength to resist the force or it may yield to it and fail.

TYPES OF STRESSES

Shear refers to the action of two forces, not directly opposed, that tend to cause sections of a body to slide over each other.

Tension is a force that tends to pull a body apart.

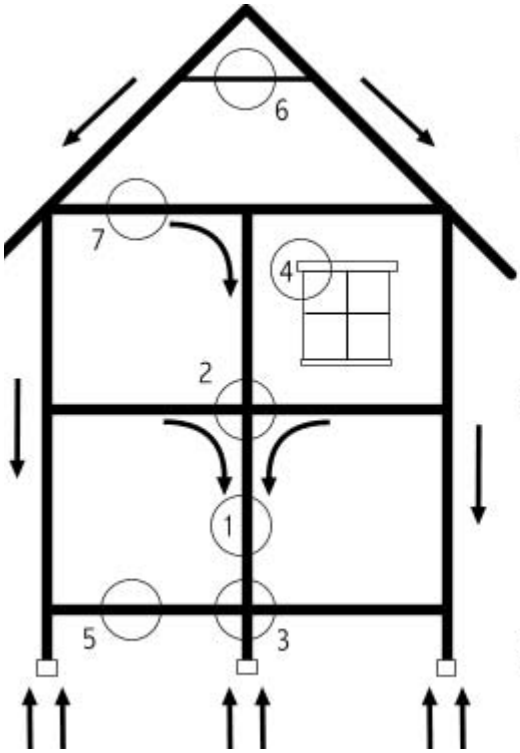
Compression refers to the action of two opposing forces that tend to compress or reduce the size of a body.

Torsion refers to a force created when an element or system is loaded asymmetrically causing twisting or rotation around its length as an axis.

The following diagram illustrates these types of stresses and the way forces act on the elements of wood frame construction. The same forces are also exerted on other building materials.

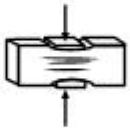
Principles of Load Transfer

Types of loads: Uniform and Concentrated loads



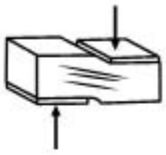
1. Compression Parallel to Grain

2. Compression Perpendicular to Grain



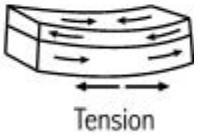
3. Flexure Strength

4. Vertical Shear



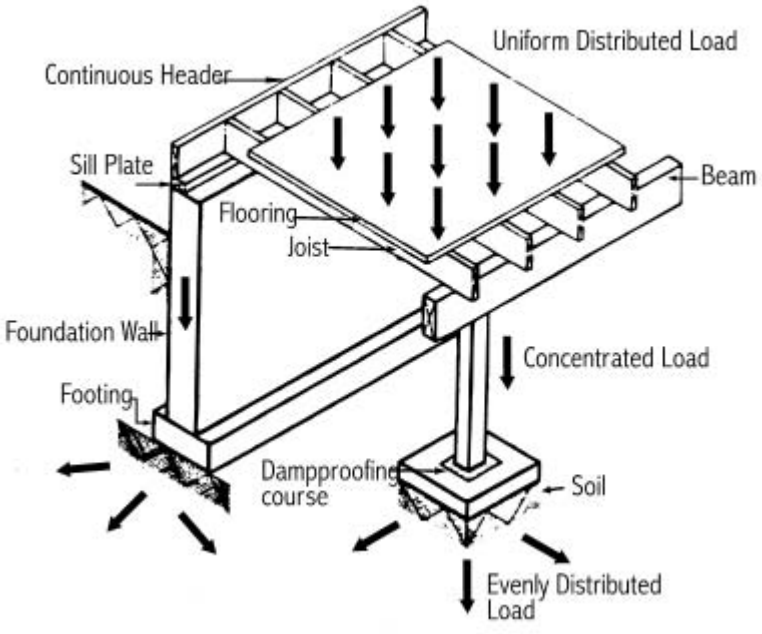
5. Longitudinal Shear

6. Tension Parallel to Grain



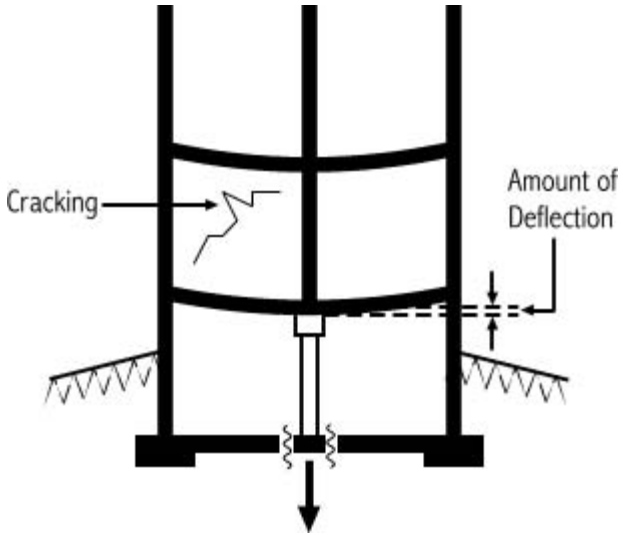
7. Tension Perpendicular to Grain

The load carrying capacity of a beam or joist is called its flexural capacity. This is simply its resistance to bending which is directly related to its dimensional size. The bending or deflection of elements of a structure, especially joists and beams, is significant because excessive bending may cause ceiling finishes to crack or floors to sag.

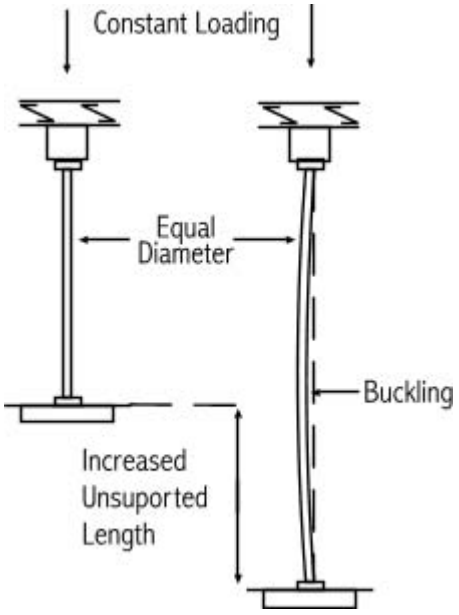


Deflection in a Floor System

The load bearing capacity of columns and walls is a function of unbraced or unsupported length. The compression capacity of a wood column is reduced because buckling may occur before the member fails in compression.



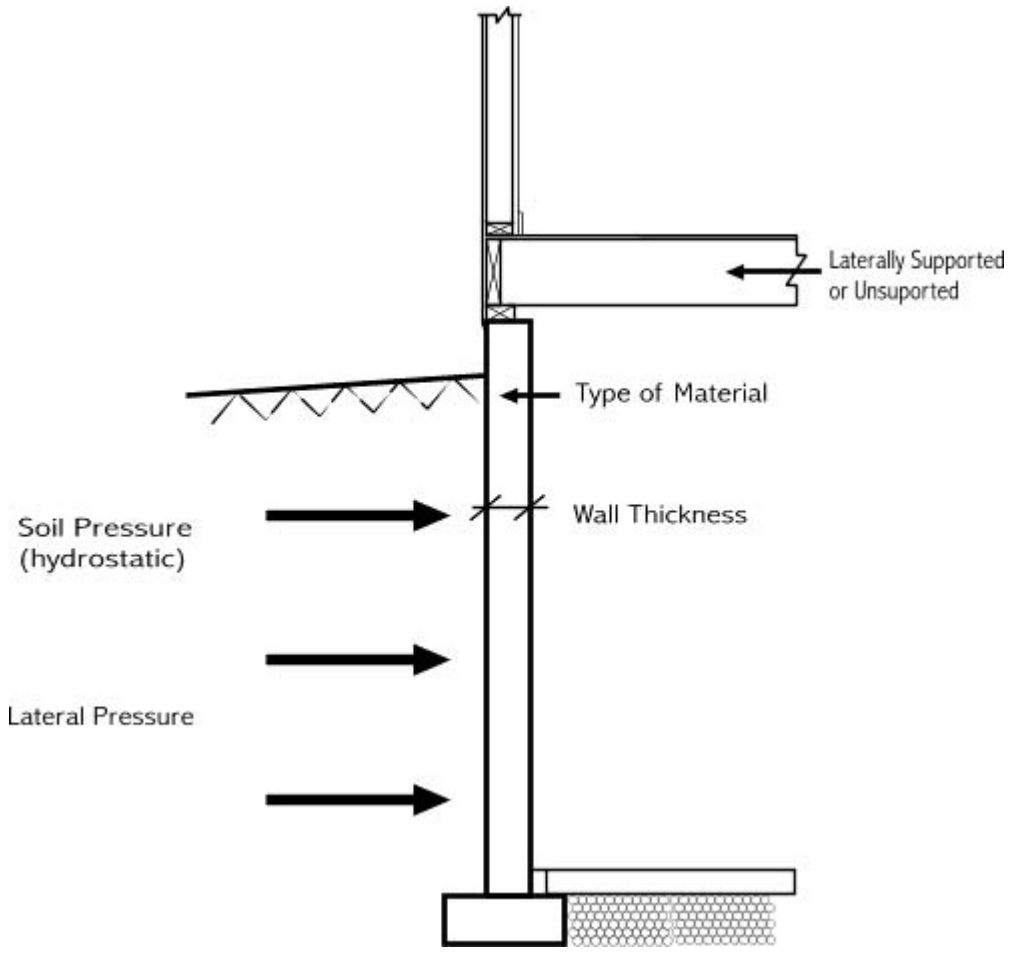
Load carrying Capacity of Columns



The stability of a foundation wall is a function of:

- height of finished grade above basement floor or inside grade
- type of foundation wall (material)
- wall thickness
- whether the foundation wall is laterally supported or unsupported at the top
- the lateral pressures exerted on the foundation wall

Lateral Stability of a Foundation Wall



To ensure public safety and structural soundness in house construction, building codes have laid out a set of minimum requirements.

The standards include pre-determined limitations of building materials and use. Measurements for foundation's wall thickness, footing sizes, span tables for joists and beams, stud size and spacing, and many other useful tables are part of the building code.

FOUNDATION SYSTEMS

A building structure must have an appropriate foundation to support the entire weight of the structure and transfer this load to the subsoil .

Foundation systems used for house construction can be categorized into two basic types - basement and basementless. The type of foundation used is usually determined by the degree of slope of the building site, the subsoil conditions, frost conditions, and whether additional usable living or storage space is desired.

TYPE	ADVANTAGES	DISADVANTAGES
Basementless On-Grade	low excavation cost on level site	must be anchored below frost-level or built to resist frost action
	lower home silhouette	construction difficult on sloped site
	grade level access for wheelchairs possible	extra floor area required for storage and mechanical facilities on main floor
Basementless Crawl Space (Heated or Unheated)	reasonable access for mechanical installation and subsequent repair	must be anchored below frost-level
	warm floor	crawl space must be heated or floor insulated
	low home silhouette	extra floor area required for storage and mechanical facilities
	good choice in permafrost areas.	cost of building and maintaining unusable space

TYPE	ADVANTAGES	DISADVANTAGES
Basement	low cost extra space lower heating costs for same total areas on two levels as opposed to one level most stable foundation provided in non-permafrost areas.	may be excavation problems in certain soils waterproofing problems extra area required for stair well

Movement and irregular settlement of the foundation may occur due to subsoil conditions such as unstable soil, frost action, permafrost, or a high ground water level. The selection of a foundation must take these conditions into account and be designed to eliminate the risk of future problems. Occasionally conditions may dictate that a specially designed foundation by a professional engineer may be required.

The subsoil conditions, street elevations, water and sewer services, and the profile of the building site all have some determining factor on the depth of the foundation.

Surface drainage patterns must also be considered. The top of the foundation should be at least 8” above the adjacent finished grade. The finished grade should be sloped away from the foundation with provisions made to carry any surface water off of the area surrounding the dwelling. This will ensure that wood framing members and wood finish are adequately protected from soil moisture.

Basement Foundation

This type of foundation system has walls which form an enclosure under the building, commonly referred to as a basement.

Basements usually contain storage and mechanical space but may also be used for extra living space. For a completely usable living space, the basement should be planned in conjunction with the main floor plan. This will ensure that adequate and suitable placements of stairs and mechanical facilities are made. Adequate openings (windows) for natural light and ventilation, proper heating, drainage and moisture protection, and ease of interior finishing must all be taken into account in the design and construction stages, even if the area is not planned to be used until a later date. These precautions are relatively inexpensive at the construction stage.

The most commonly used material in the Yukon for basement foundations is preserved wood, although materials such-as-cast in place concrete, concrete block, and precast concrete may also be used.

Footings act as the base of the foundation and transmit the loads to the soil. Footings may be a continuous strip of concrete or wood, or spaced concrete piles or concrete or preserved wood pads. Footings must be placed far enough below ground level to be protected from frost action and must bear directly on undisturbed subsoil, or they must be protected from frost action on undisturbed soil properly compacted gravel, if subject to frost.

The size of wall footings should comply with code requirements. In normal conditions, the size of concrete strip footings is 8” deep and 16” wide. Preserved wood footing plates are sized according to the stud width of the wood foundation wall, usually 2” wider.

Pad footings for interior or exterior posts or columns are centred under the member they are supporting. The size of these footings varies depending on the load they support and the allowable soil pressure. On average stable soil, a common size for a one-storey house is a 32” x 32” x 8” deep concrete pad for each support. Footings for fireplaces or chimneys are commonly of the pad type or, if located on an exterior wall, may be a thickened portion of the wall footing.

On steeply sloping sites, or where unstable soil is encountered in part of the excavation, stepped footings may be required.
Foundation walls carry the weight of the upper structure to the footings and must also resist horizontal pressures caused by soil fill, as well as uplift and side forces caused by wind pressure.

Monolithic concrete walls refers to cast-in-place concrete foundations. Wall thickness may vary depending upon the depth below grade and the lateral support provided by the floor framing system. A common thickness is 8”, while the wall height is usually 8 feet. Window and door opening sizes are limited, and provisions for these openings must be made during construction as future alterations are difficult and expensive.

Preserved Wood Foundation (Permanent Wood Foundations) walls are constructed using similar techniques to above ground wood framing (stud frame wall with plywood sheathing). The wood used below grade is pressure treated with chemical preservatives which make the wood resistant to decay. Special care must be taken to damp proof this type of foundation. A Preserved Wood Foundation should be constructed by competent builders who are familiar with and understand the special requirements to properly erect this type of foundation. Finishing the exterior and interior is convenient as normal finishing techniques for wood frame walls can be used.

Basementless Foundation

Soil, frost, or moisture conditions may dictate a basementless house, or some people may prefer a house with no stairs. With this foundation, it is important to include space on the main floor for mechanical facilities and storage. Basementless foundations can either be a concrete floor slab on grade, a space frame foundation where subsoil conditions are unstable, footing pads with support posts or 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.

Where permafrost conditions are not present, the foundation wall with crawl space is popular and efficient.

If permafrost conditions are present, pads and support posts, or a space frame (interlocking metal framework) is usually used in conjunction with an insulated floor joist system to keep heat away from the soil.

Crawl Space:

A crawl space foundation supports the structure on a perimeter wall. Trenches are dug for the foundation walls and the footings placed at a depth determined by soil conditions and frost penetration. Footings for columns supporting floor beams must also be placed on solid ground. The walls are constructed similar to those in basement foundations, using either monolithic concrete or preserved wood.

An alternative to this method is the use of a grade beam on piles or pads. Sizes, spacings and depth must be calculated for each case and depend on load and soil conditions. Local inspectors can give advice on this type of foundation.

The main floor is framed in the same way as for the basement-type house, but is suspended 12” to 48” over the ground below. Mechanical service access may be required which calls for a minimum height of 24” under all pipes, ducts and joists. As well, regulations require that:

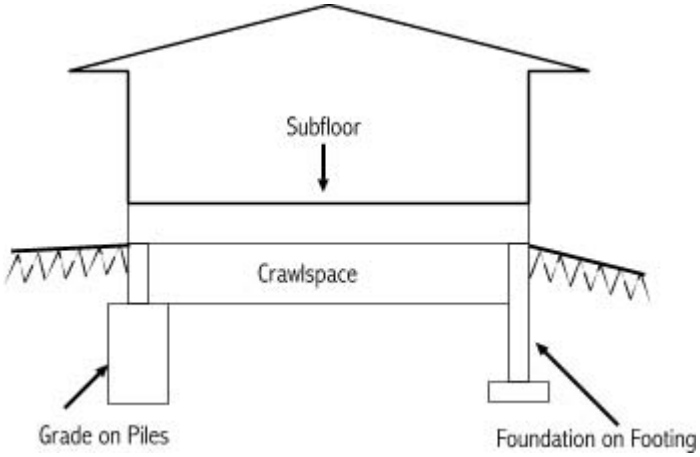
1) crawl spaces be adequately ventilated and/or heated
2) a minimum 20” x 48” access be provided
3) a proper ground cover be installed, and
4) moisture accumulation be prevented.

If the crawl space is unheated, the main floor must be insulated. At times a combination of a lower temperature in the crawl space and slightly insulated house floor are used.

Slab on Grade:

Slab on grade refers to the type of foundation commonly used in car garages (i.e. a concrete floor with a thickened edge placed directly on the ground). The entire slab is reinforced and literally “floats” on the ground surface. Any frost heaving or settling acts on the floor as a whole, shifting it rather than cracking it.

To maintain a stable foundation suitable for housing, the slab must be anchored below the frost line (using either piles or a foundation wall and footing) protected from frost action or be strong enough to resist frost movement or damage. All debris, topsoil and organic matter must be removed and compacted gravel or undisturbed subsoil provided under the slab. The requirement of a water tight membrane between the slab and the gravel base as well as adequate perimeter insulation are very important construction aspects of this foundation system.



Heating ducts, water and sewer service, some electrical wiring and possibly a gas line have to be placed below or into the slab before construction, and subsequent repairs or additions are difficult and costly.

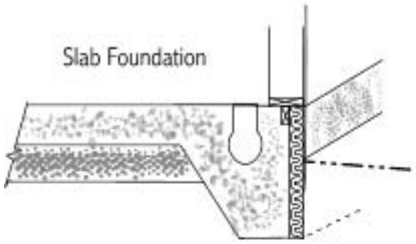
Footing Pads and Support Pads or Space Frame:

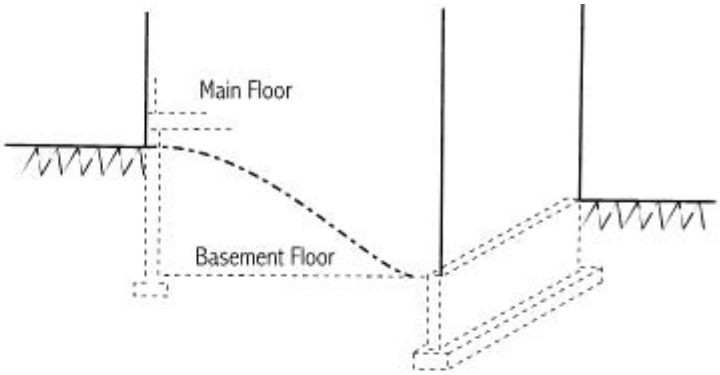
When using these foundation types, a layer of levelled, tamped gravel is installed after the topsoil has been removed and a moisture membrane is laid down. Footing pads (either concrete or preserved wood) are laid down at support points around the perimeter, and at intervals beneath the floor system. These pads then support either short posts or an interlocking metal space frame, which in turn supports the floor structure of the dwelling. If posts are used, they should incorporate some method to re-level the unit from time to time (slip blocks or screw-jacks).

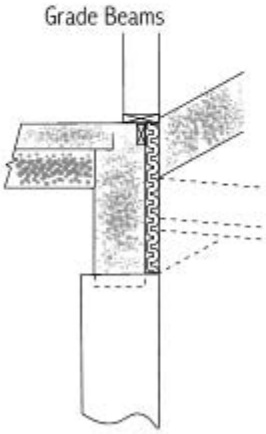
Foundation Dampproofing

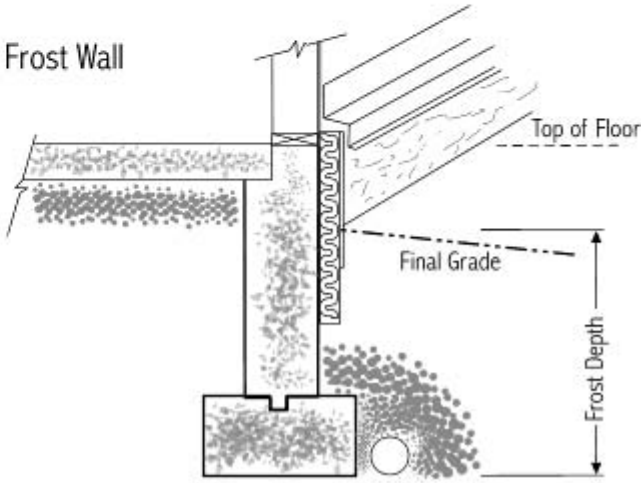
Basement foundation walls below grade must be dampproofed. Also, where a crawl space foundation wall extends into the soil, the foundation walls must be dampproofed.
Concrete walls should be dampproofed with a heavy coat of dampproofing (tar) applied on the outside from the footings to the finish gradeline. Such a coating is usually sufficient to make the wall shed water, as may occur after a rainstorm.

Where insulation is applied to the inner surface of concrete foundation walls, the below grade portions of the insulation and any associated wood strapping must be protected by dampproofing. This dampproofing can take the form of a polyethylene film, a layer of sheathing paper or two coats of bitumen applied to the inner surface of the concrete wall. If the insulation is a type which will not readily absorb water (e.g. expanded polystyrene), no dampproofing is required behind the insulation but associated wood strapping should be protected. Neither the inner nor the outer surface of the above grade portion of the wall should be dampproofed.









Preserved wood foundation walls rest on a gravel drainage bed or concrete footing and may be dampproofed with polyethylene or a non-reactive emulsion over the preserved plywood exterior. A complete set of dampproofing and drainage details are a part of the wood foundation design.

Foundation Drainage

Construction of a water tight basement is difficult and costly on a site where the ground water level is near grade level. Wet sites in low areas, especially where the soil is coarse grained, should be avoided. A basementless foundation may be the most trouble-free foundation to use if no alternate site can be found. The high points on a given site should be favoured over lower areas. A hillside site may require grading on the uphill side to direct run-off around the structure.

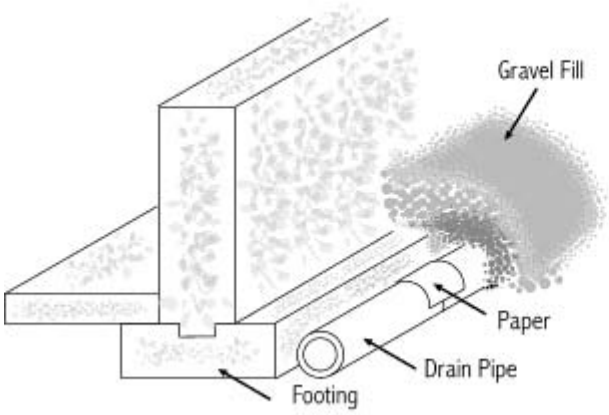
Regardless of the site, there are certain times of the year when the soil around a foundation will be wet. Good drainage practises are important to maintain a dry basement or crawl space. Drainage with regard to foundations can be subdivided into two parts - surface and subsurface.

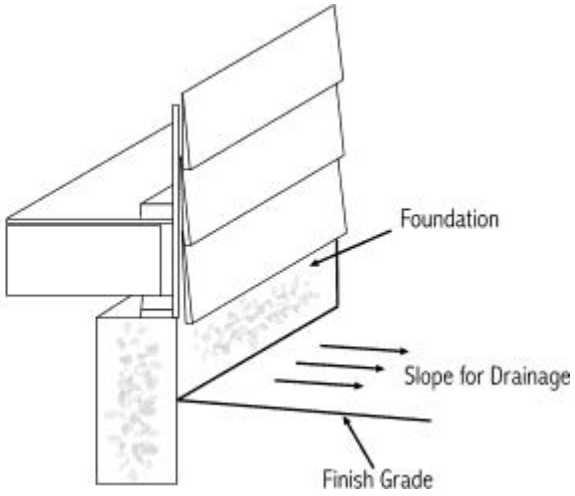
Correct grading to provide surface drainage is an important step if a dry basement is to result. Grading should provide a fall away from the foundation wall of 1/4 to 1 inch per foot for a distance of at least 8 feet. Some settlement will result after back-filling so it is essential that the grade is maintained to provide a slope. Run-off water from eavestrough downspouts should be diverted with extension or splash pads at least 3 feet long.

Subsurface drainage may be required in wet areas to prevent damp basement and floors. Good drainage consists of providing a means of collecting ground water that may accumulate around the foundation and letting it run downhill to a suitable outlet (sump pit, storm sewer, etc.). Weeping tile (either clay sections or perforated plastic) should be laid around the perimeter of the footings, making sure that the top of the tile is below the basement floor level, with a slight slope to the outlet. The top and sides of the tile should be covered with a minimum of six inches of clean 1” washed crushed gravel.
The weeping tile should drain to a sump pit designed to accumulate subsurface drainage and a pump installed to periodically remove the collected water. If the site is sloped sufficiently, gravity will drain the tile to an open drainage ditch downslope from the installation. In any event, the ground water collected should not drain into the sanitary sewer system as this volume of cold water may overload municipal sewage treatment facilities. If you have a septic tank, you definitely do not want to drain ground water into it.

If a preserved wood foundation is used, a gravel bed drainage system may also be used, sometimes in conjunction with perimeter drain tile .

It is almost as easy to build a good foundation as a poor one. In residential construction, foundation failures seldom result from structural loads. It is more often a





case of soil swelling or shrinking, hydrostatic pressure or deteriorating foundation caused by ground water accumulation.

If you are not sure whether your site has subsurface drainage problems, always err on the side of safety and install a drainage system.

FOUNDATION SUMMARY

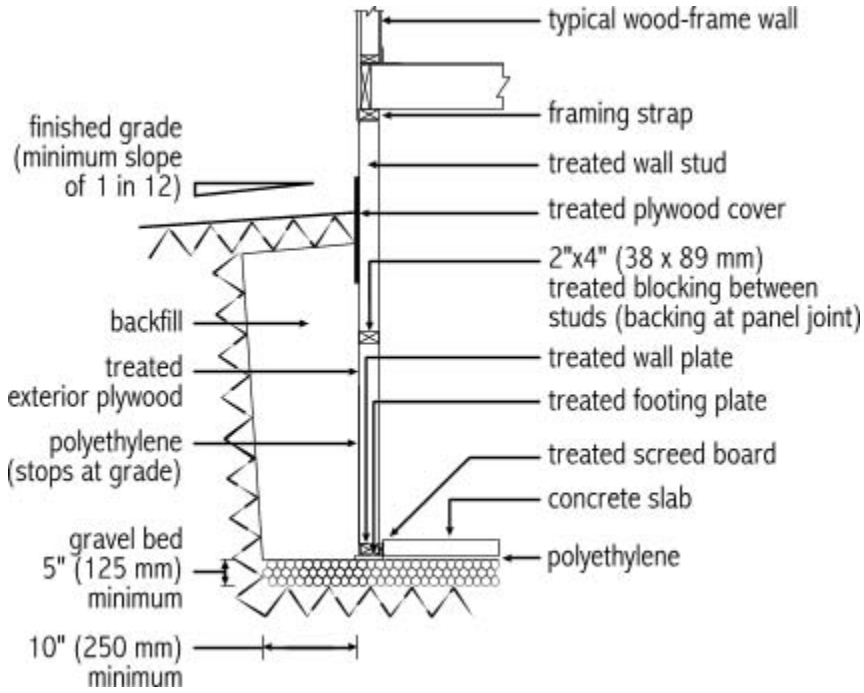
MATERIAL	ADVANTAGES	DISADVANTAGES
Concrete Pile (Cast-in-Place)	low cost ease of construction	can be used only with basementless types
Concrete Strip	can be used for any type of wall material	needs protection when when poured below 4C
Wood Strip	no weather restrictions cheaper than concrete in remote area	can only be used with wood foundation wall proper preparation of gravel base essential
Pressure Treated Wood	ease of mechanical installation interior and exterior finishing convenience prefabrication possibilities no weather problems insulation addition is convenient to interior	careful backfilling techniques required expense of structural design material availability may be limited competent contractors may be scarce
Monolithic Concrete	ease of reinforcing no limitation to unit dimensions reusable form work strongest	high labour cost ready-mix maybe expensive in remote areas size of window openings is limited changes are difficult after construction needs protection when placed below 4 celsius interior finishing difficult
Combination (Concrete/Pony Wall)	larger windows exterior finish	extra reinforcing required in concrete part interior finishing difficulties

Basement Floors

In order to make a basement usable, a floor is required. Even in crawl space foundations, some type of covering is required to make the servicing of mechanical facilities convenient and to maintain a warm, dry atmosphere. This covering is usually sand or gravel over polyethylene.

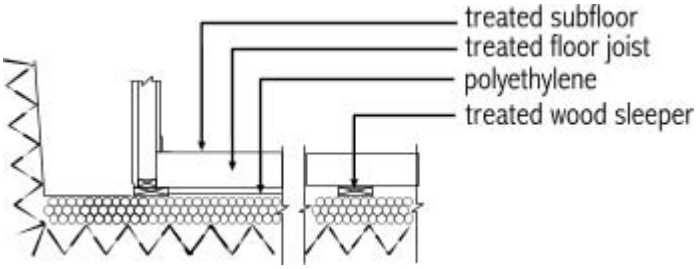
For residential construction the use of concrete is limited to on-ground applications, either as a basement floor or in slab-on-grade applications. Basement floor slabs are usually installed after the roof cover is in place, sewer and water lines installed and the basement floor drain located. Concrete floor slabs should be at least 3” thick and sloped in the area of the floor drain. A 5” layer of coarse granular fill is generally laid under the floor slab to keep moisture away from the underside of the slab. The Building Code also asks that a polyethylene sheet be layed beneath the concrete floor to further isolate the floor from moisture, and to eliminate the passage of soil gases.

Concrete floor slab and wood footings

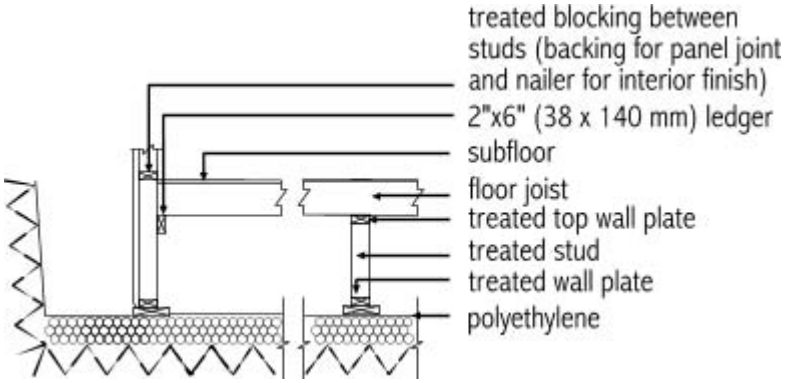


Basement wood floors can be installed by using pressure treated lumber in conjunction with wood foundation walls - on sleepers resting on a gravel bed, or as a suspended floor with a minimum of 12” of air space beneath the lowest part of the floor system.

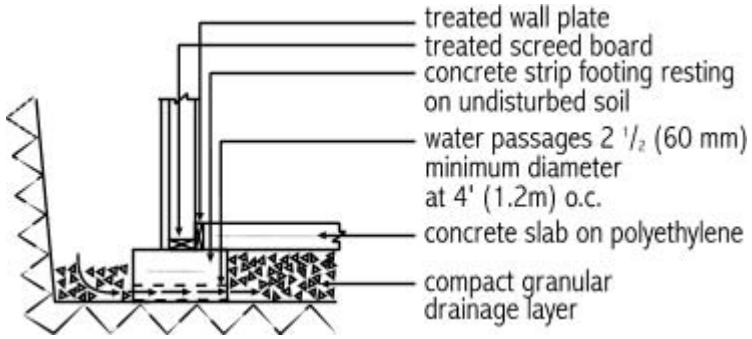
Pressure Treated Wood Sleeper Foundation



Pressure Treated Suspended Wood Foundation



Pressure Treated Wood on Concrete Strip



In full basement construction, the floor acts as an important structural member. It works as a diaphragm holding the walls against side forces which tend to push inward. For this reason, the floor, whether wood or concrete, should be built before backfilling is completed .

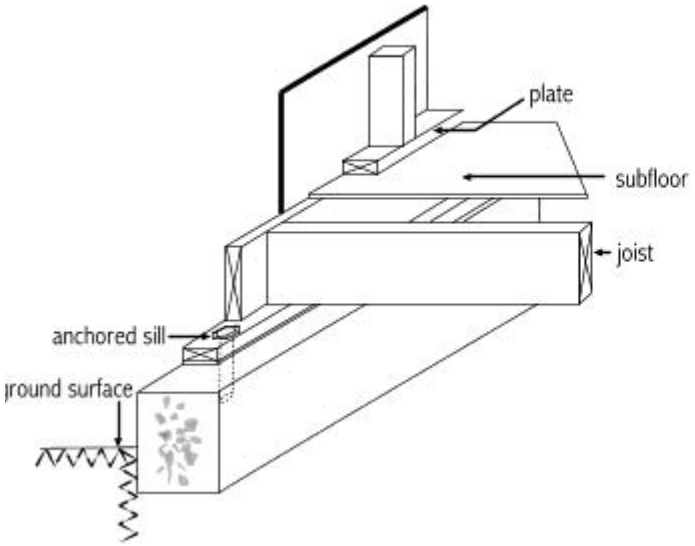
Floors (Wood-Frame)

Platform framing is by far the most common type of residential construction framing used in Canada. The floor framing consists of beams, joists and subfloor from which a platform is constructed. Exterior and interior walls are then erected and supported by this platform .

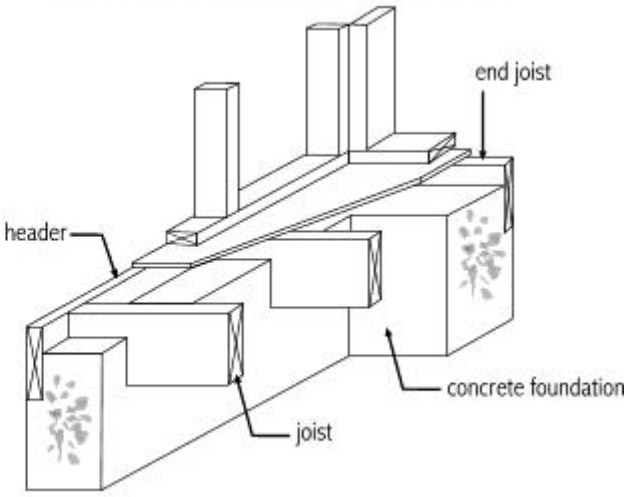
Wood floor joists are generally of 2” nominal thickness and either 6, 8, 10 or 12 inch depth. The size depends upon the loading, length of span, spacing between joists and the species and grade of lumber used. Proper selection of joists should help to limit cracking of ceiling finishes in the basement and to limit vibrations from moving loads. Floor joists spanning distances close to the limitations of the span tables, may, while being structurally adequate, result in a floor that users perceive as “bouncy” or “springy”.

In platform framing, the floor joists may be embedded in the top of the concrete foundation wall or rest on a sill plate which in turn rests on and is anchored to the top of the foundation wall.

Box-sill method used in platform construction



Floor joists imbedded in the top of foundation wall



Floor joists seldom span the entire width of a foundation, making some sort of interior support necessary. Wood or steel columns (posts) are generally used in the basement to support beams, which in turn support the inner ends of the floor joists. Stud walls are sometimes used instead of columns and beams to support the floor joists and centre-bearing partition.

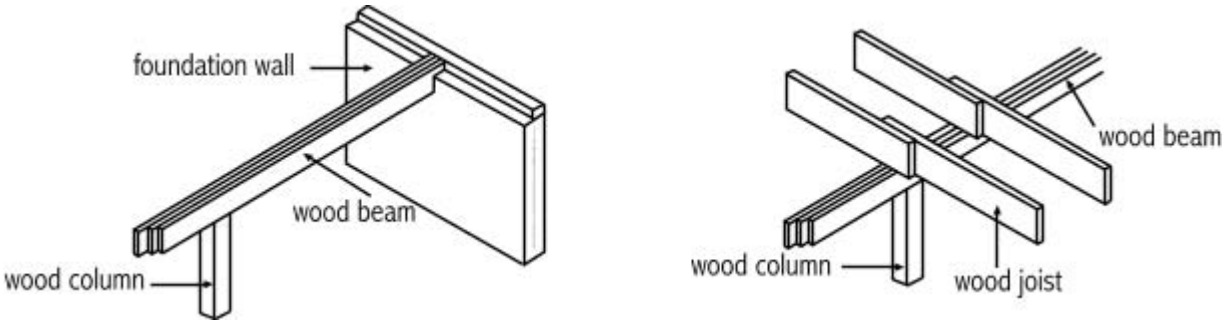
Round, adjustable structural-steel columns (teleposts) fitted with plates at both ends are commonly used. The column rests on a footing pad and is bolted or nailed to a wood beam overhead. Columns may be adjusted to length after installation to compensate for movement in the soil or settling caused by shrinkage in the framing members. Spacing and consequently the number of columns required will depend on the loading and strength of the beam they support.

The most commonly used beam is the built-up beam which is usually made of three or more pieces of 2” lumber set on edge and spiked together from each side. The depth of the lumber depends on the beam span, the loading, the supported joist length, the number of plies and the species and grade. Ends of beams rest in a beam pocket provided in the foundation wall. Steel beams can be substituted, but are not commonly used. Several structural beam materials are available for longer spans, such as Microlam and Glue-lam products.

Built-up-beam span tables and construction methods are included in the National Building Code. They should be checked to ensure the floor system you are using is correct.

The simplest method of beam and joist framing is to have the joists rest on top of the beam, in which case the beam is level with the top of the sill plate. Joists may also be supported by ledger strips securely fastened to each side of the beam with the top of opposing joists lapped and nailed or supplied with a splice connection. Joist hangers or other structural connectors attached to the beam are also acceptable .

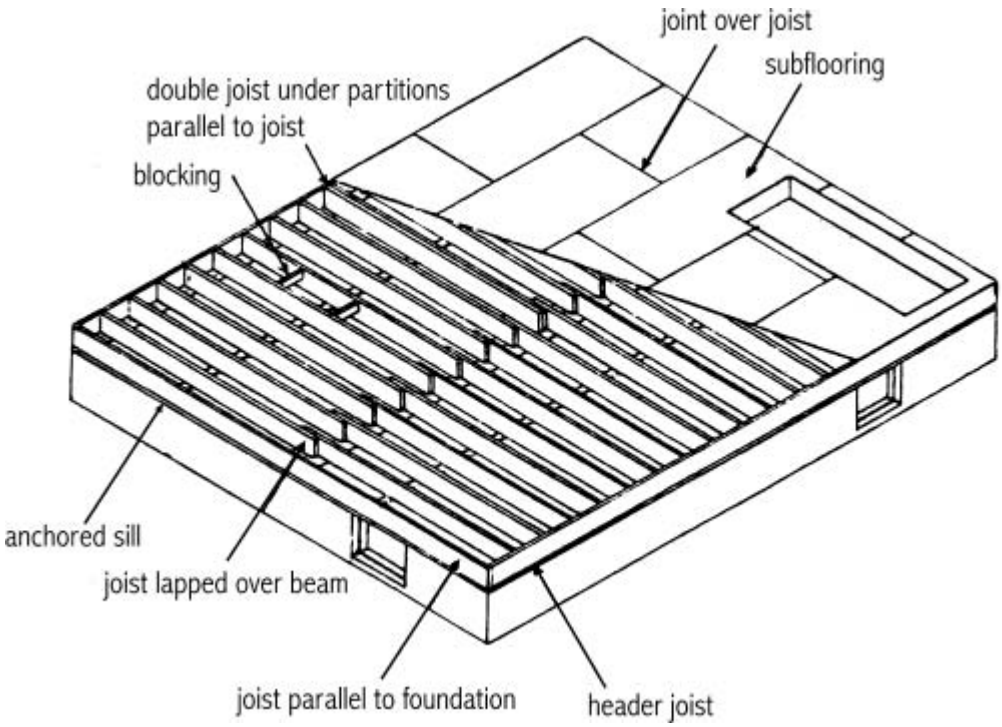
Beam and Joist Framing



Joist spacing of 16” centre-to-centre is most commonly used, although for heavy loads or when space is limited 12” spacing of shallower joists may be substituted. Joists may be kept from twisting by cross-bridging or furring strips fastened to the underside of the joists. 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 should not exceed 1-1/2 times the joist depth unless specifically designed in accordance with accepted engineering practice.

For large openings, such as stairwells or fireplaces, special assembly methods are required. Considerations for loadbearing and non-loadbearing partitions supported on top of the floor system also require special framing.

Floor Framing



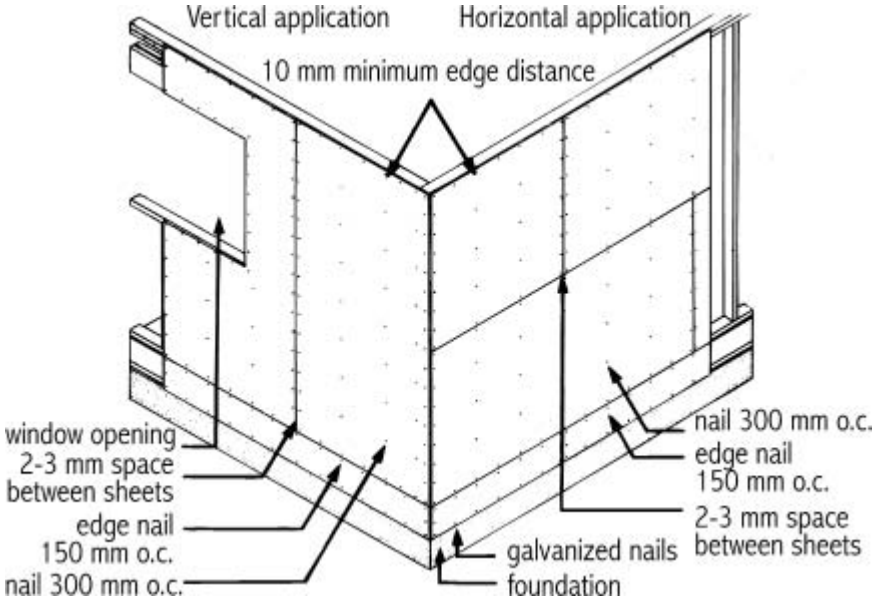
Many different types of floor trusses are available which may be used in place of solid wood joists. Floor trusses are prefabricated structural units that may permit wider unsupported spans than wood joists . Trusses also allow open spaces that may make the installation of plumbing, heating and electrical components less awkward. Floor trusses are manufactured in many different configurations and using a variety of materials. Each truss must be engineer designed and approved, with limitations to its application stated.

because of its simplicity, platform construction is by far the most popular, and recent building techniques have developed almost entirely around the platform method. The chief advantage of this method is that the floor system is assembled independently from the walls. This 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 without the use of heavy lifting equipment. 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.

In platform construction, panel-type wall sheathing is often applied to the assembled exterior wall before it is raised into position.

Wall sheathing is the outside covering used over the wall framework and is nailed directly to the wall framing members. Sheathing provides a nailing base for some types of siding and backing for others. It also braces the structure, although in most cases sufficient bracing is provided by the interior wall surface. Plywood and waferboard are the most commonly used types of sheathing, although fibreboard, particleboard and lumber are also used.

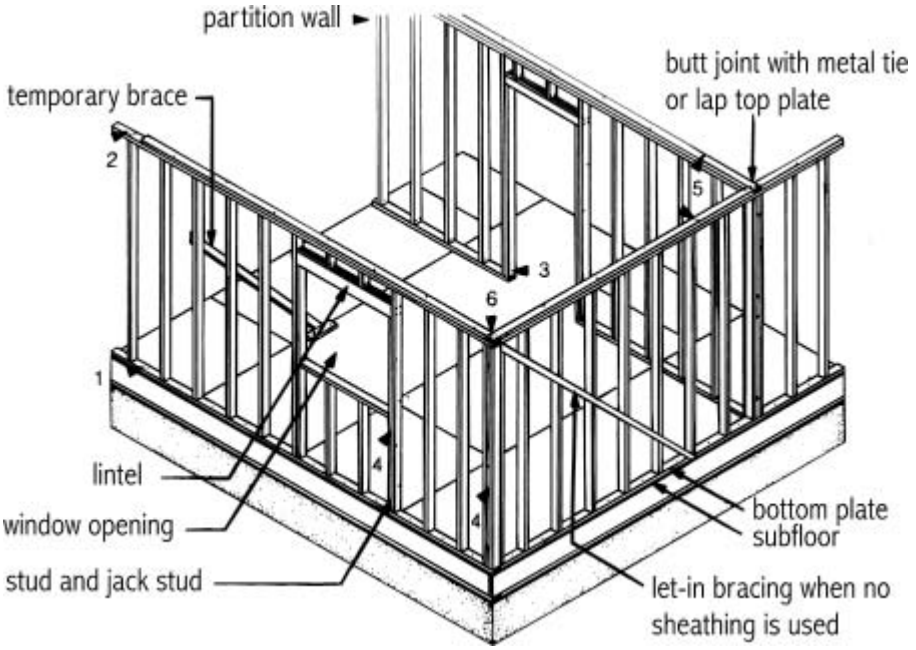
Plywood sheathing should be an exterior type, i.e. laminated with a waterproof adhesive. The minimum thickness should be 5/16”, but 1/2” may be preferable if it is to be used as a nailing base. Panel-type sheathing may be applied vertically or horizontally; horizontal application is the common practise.
Interior partitions supporting floor, ceiling or roof loads are called “loadbearing partitions”; others are called “non-loadbearing”.



The subfloor is the final component of the system. The main purpose of the subfloor is to add rigidity to the structure and provide a base for the application of finished flooring materials. Plywood is the most common material used, although particleboard and oriented strand board, square edge lumber, shiplap or tongue-and-groove lumber are also acceptable. Plywood can be installed rapidly and is often used as a combination subfloor and underlay in carpet areas. In this application, tongue-and-groove plywood is recommended. Floor stiffness can be increased and floor squeaks minimized by applying appropriate glue between the floor joists and the plywood subfloor (not suggested in winter), or fastening the plywood with screws.

WALL SYSTEMS

Wall framing systems include the vertical and horizontal members which form the exterior walls and interior partitions of the structure. These members serve as a nailing base for all covering materials and support the upper floors, ceiling and roof. Studs are the vertical members to which wall sheathing and exterior finish are attached. Exterior studs, those in outside walls, generally consist of 2 x 6" lumber and are commonly spaced at 16" on centre. This spacing may be changed depending on insulation system used. The studs are attached to horizontal top and bottom plates of nominal 2" lumber the same width as the studs. Lintels (headers) 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" lumber on edge separated with spacers to the width of the studs and nailed together to form a single unit. The depth of a lintel is determined by the width of the opening and vertical loads supported.



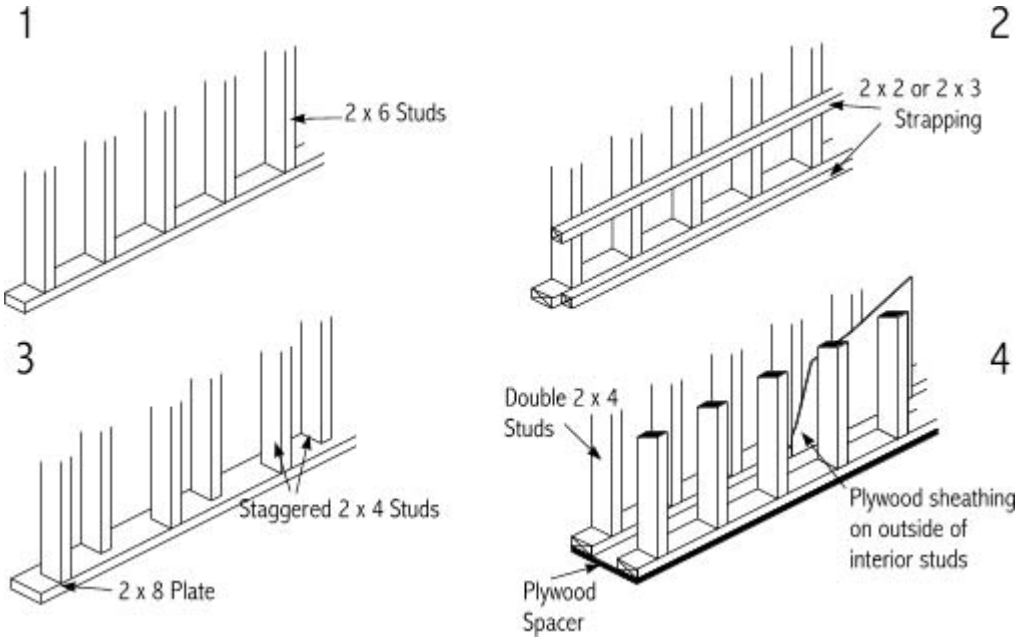
Loadbearing partitions are framed in the same way as exterior walls, usually using 2 x 4” studs spaced at 16” on centre.

Non-loadbearing partitions are similarly built, but since there is no vertical load to be supported, single studs may be used at the door openings. The top of the opening may be bridged with a single piece of 2” lumber the same width as the studs. These members provide a nailing support for wall finish, door frames and trim.

The need to satisfy energy conservation requirements has somewhat altered exterior wall framing techniques in recent years. The main emphasis has been placed on increasing the depth of the stud framing wall cavity in order to accommodate thicker batt insulation. Some of the techniques used in place of the over standard 2 x 4” stick frame are:

1. 2 x 6” stud wall
2. staggered studs
3. double wall
4. stud wall with interior horizontal strapping.

These methods are relatively simple variations of framing methods but special framing details, especially around openings (doors and windows) in exterior walls, require attention. Another aspect to be considered is the amount of floor area that may be lost due to the increased wall thickness.

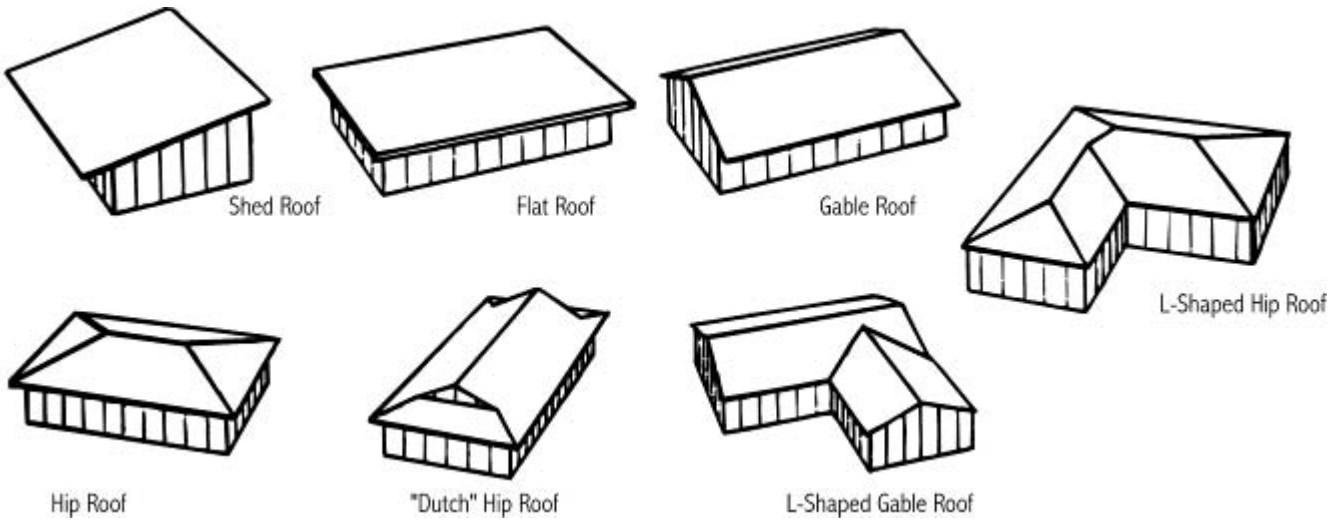


Other spin-offs of stick frame construction are prefabricated modular wall systems or components. These can take the form of pre-built stud wall sections, prefabricated “truss” studs, or even wall sections that arrive already insulated. Each of these systems have advantages and possibly disadvantages which you may want to consider. Manufacturers with new products, materials and construction methods will have pertinent information for you to compare the relative merits of different systems. When checking out these products or systems consider the following points:

- costs: material and labour
- availability
- use limitations
- ease of use
- speed of construction
- energy conservation considerations
- ease of installing electrical, plumbing and heating.

ROOF SYSTEMS

There are two basic types of roof design - flat and pitched, but each type has many variations. The roof, if carefully designed and proportioned, contributes to the distinctive look and style of the house.



The slope of a roof dictates its profile and has a great effect on the overall character and appearance of a house. The so-called flat roof should actually have some slope for drainage. Slope indicates the incline of a roof as a ratio of the vertical rise to the horizontal run.

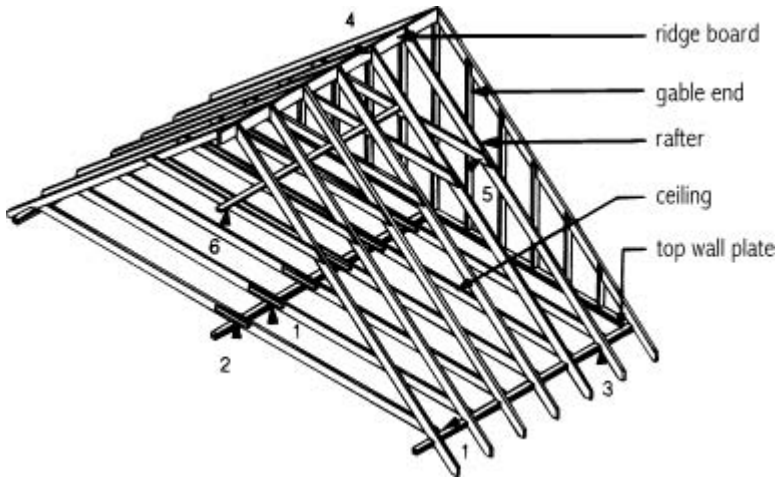
For example: a roof that rises at the rate of 4 inches for each foot of run is designated as having a 4 in 12 slope. A triangular symbol above the roof line in the house plan drawings is used to convey this information.

Two different methods are used in roof construction:

1. stick framed (conventional)
2. roof trusses.

Ceiling joists and rafters are the main framing members of a stick framed roof. The ceiling joists are used to support the ceiling finish and to act as ties between exterior walls and, in some cases, opposing rafters. The rafters create the roof shape and support roof loads as well as providing the base to which roofing materials will be attached. In cases where rafters also serve as ceiling joists, as in flat-roof construction, they are called roof joists and the size is established on the basis of both roof and ceiling loads.

Ceiling joists usually run across the narrow dimensions of the structure. Basic construction of the ceiling framing is similar to floor framing, the main difference being that lighter members are used and header joists are not included around the perimeter. Like floor joists, ceiling joists generally require support by way of an interior bearing partition. In large rooms, the mid-point of the joists may have to be supported by a beam which can be located below the joists or installed flush with the joists using a ledger or joist hangers. Ceiling joists and rafters are generally spaced 16” on centre.



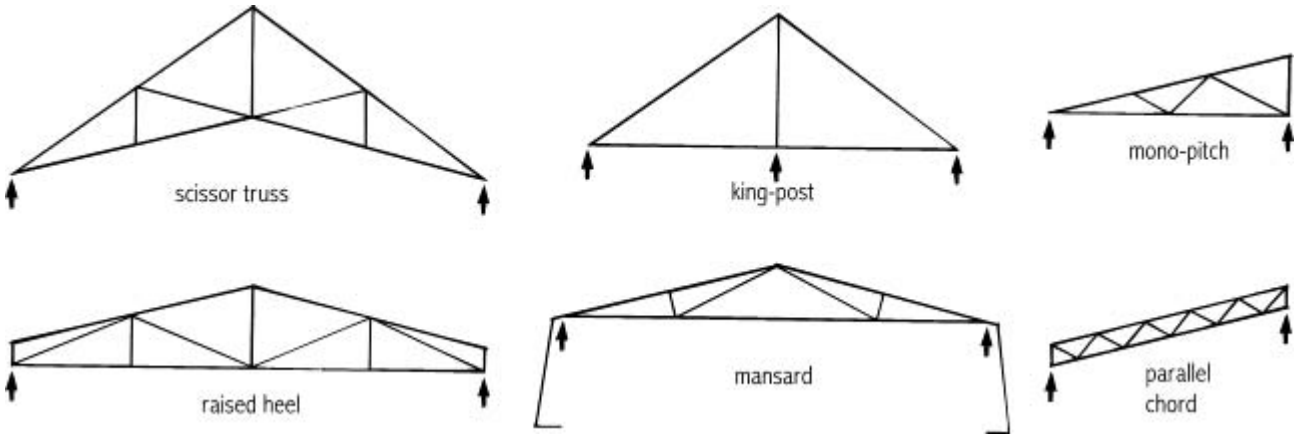
Common rafters are erected in pairs, usually located directly opposite each other, and nailed to a ridge board at the peak of the roof. The lower ends are fastened to the wall top plate but may extend beyond the wall to form an overhang. Many different types of rafters are used for various roof styles, but all perform in basically the same way.

Roof trusses are much more commonly used for roof framing than are rafters and ceiling joists. They can be put in place quickly, so that the house can be rapidly enclosed and protected from weather. In most cases, trusses are designed to span from exterior wall to exterior wall and no intermediate bearing partitions are required. Flexibility of interior planning increases, since no load bearing partitions are required and partitions can be placed without regard to structural requirements.

Roof trusses are frames that carry the roof and ceiling loads and upon which roofing materials and ceiling finishes are applied. 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, however, pressed-on metal connectors with integral teeth are most widely used (gang nail connectors). Trusses are generally spaced 24” on centre and fastened to the top plates of the exterior walls.

A wide variety of roof types and shapes can be framed with trusses. They must be designed in accordance with accepted engineering practice and the design details may need to be approved by a professional engineer. Trusses are normally prefabricated and delivered to the job site ready to install.

Roofs framed with trusses need not be limited to gable types. Hip roofs can be framed through the use of special trusses, or trusses in combination with conventional rafter and joist framing. Scissor trusses, mono trusses, flat trusses and



other special trusses are available for use in just about any application.
Roof sheathing is applied over roofing framing and usually consists of lumber, plywood panels or particleboard panels. Sheathing provides a nailing base for the roof covering and laterally braces the roof framing .

The thickness of plywood or particleboard 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 across the framing should be supported by inserting metal H-clips between the sheets or by blocking nailed securely between the roof framing members.

For a wood-shingle roof or metal roof, the 1x4 roof boards may be used and spaced to accommodate the shingle exposure or properly support the metal roofing. This method permits freer movement of air around the boards and under the shingles, thus reducing the possibility of decay.

If lumber sheathing is used it is usually 1” thick boards. Roof boards must be laid tight together under materials requiring solid and continuous support such as asphalt shingles .