Contents

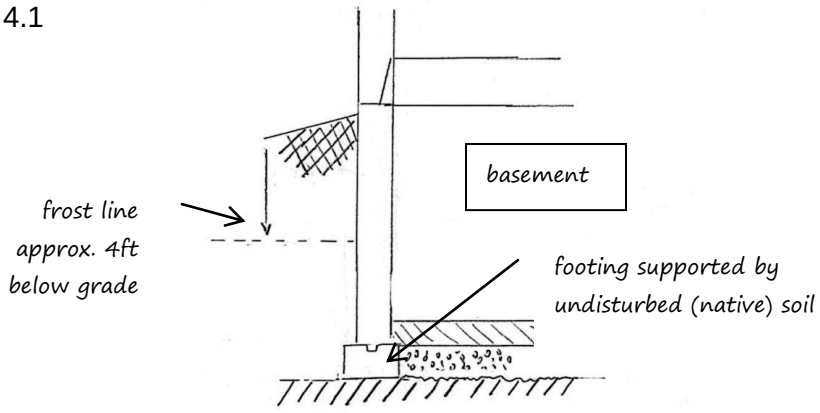
4 Structure

4.1 Description

4.1.1 Foundation Configuration

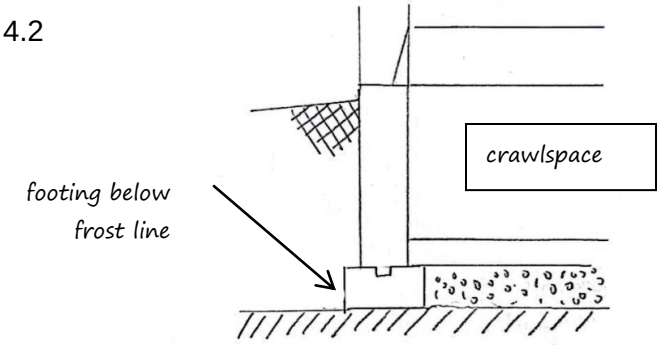
Basement: When a home is built in an area where there is a risk of the ground freezing the footings must be installed below the frost line. In the past builders merely provided a shallow basement (crawlspace) that was not utilized except perhaps for storage. In time it became more feasible to excavate lower and provide a usable basement.

Fig. 4.1



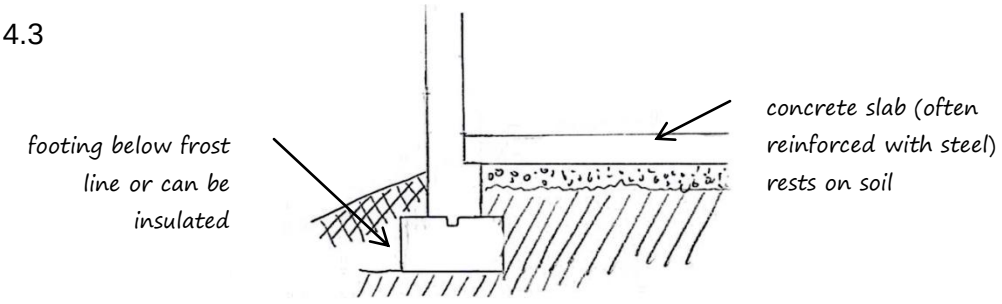
Crawl Space: As mentioned above a crawlspace is a shallow basement below grade though it can also be considered a crawlspace when built above grade.

Fig. 4.2



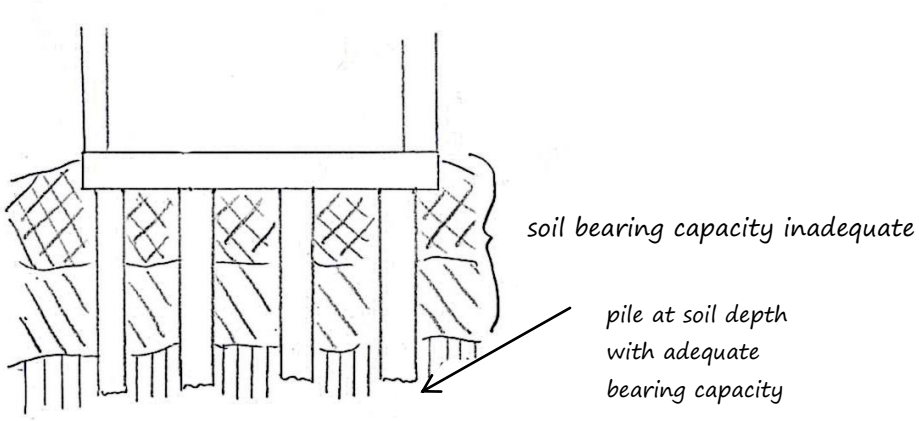
Slab-on-grade: This is type of configuration is almost always built in areas where temperatures do not normally drop below freezing. It is essentially a poured concrete slab that rests directly on the ground and is supported by shallow footings around the perimeter (or under the slab depending on the size of slab).

Fig. 4.3



Piers/Piles: Some buildings are supported by piers. This is typically done because the undisturbed bearing soil is too deep for a regular excavation.

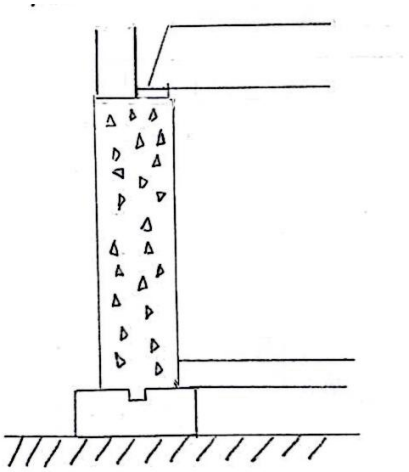
Fig. 4.4



4.1.2 Foundation Materials

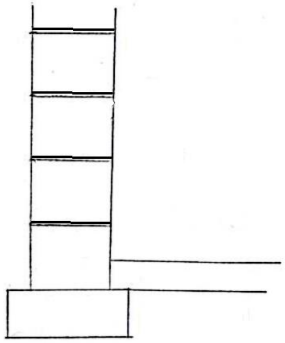
Poured Concrete: Generally this is the most common type of foundation material especially for modern homes. Wood forms are set up with reinforced steel then filled with concrete.

Fig. 4.5



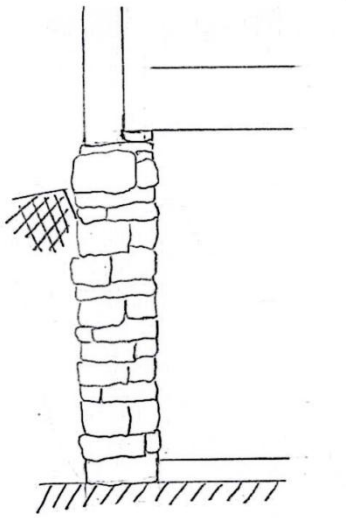
Masonry Block: A common material also called cinder block which is set in place with structural mortar.

Fig. 4.6



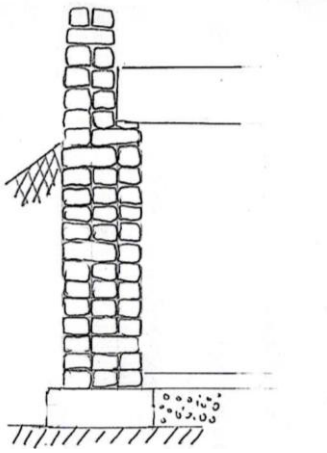
Stone: Older homes, especially those built pre 1900's will usually have a stone foundation, also known as ruble foundation. The stone is set in place with mortar or concrete and often no footing is present.

Fig. 4.7



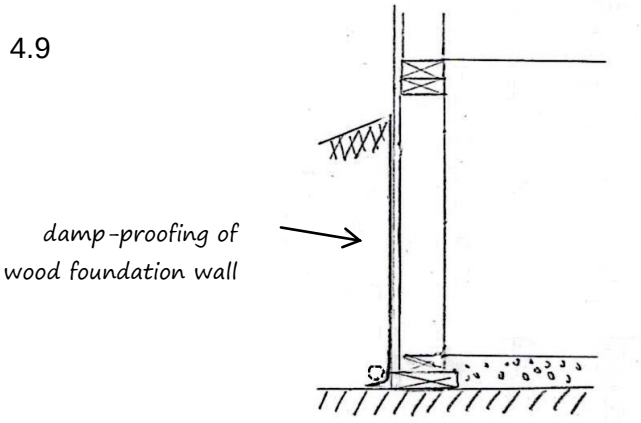
Brick: Older homes will often have a brick foundation that is three brick widths. This type of brick was specially manufactured to resist elements below grade.

Fig. 4.8



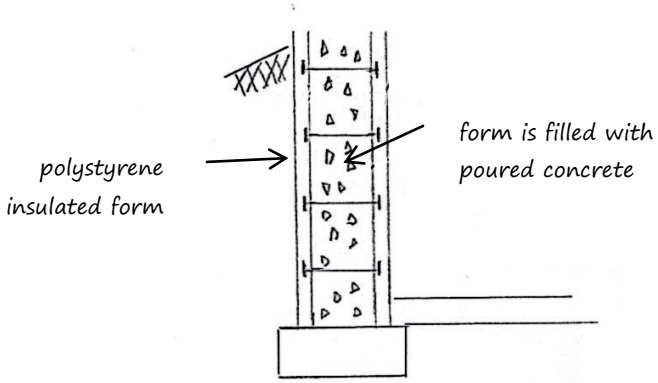
Wood: Although it might seem unlikely a foundation can be made of specially treated wood that can resist moisture and rot over a very long time. It is equally important that conditions around the foundation are such that water infiltration is minimized. This includes grading and damp-proofing materials.

Fig. 4.9



ICF (Insulated Concrete Form): Recently polystyrene insulation is being used as forms in which the concrete is placed. Unlike plywood the forms are not removed and have the added feature of insulating on the outside and inside of the foundation. This also has the advantage of quick foundation installation.

Fig. 4.10



4.1.3 Floors

Fig. 4.11

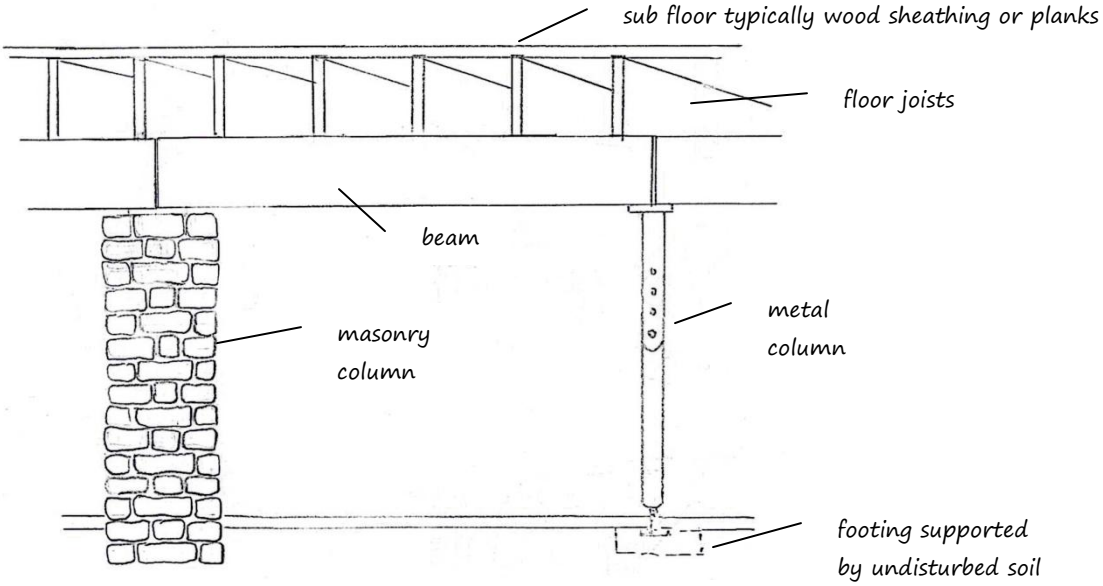
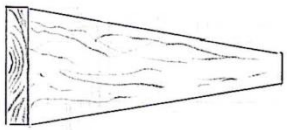
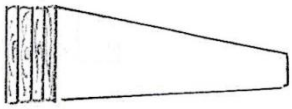


Fig. 4.12 Types of Joists and Beams

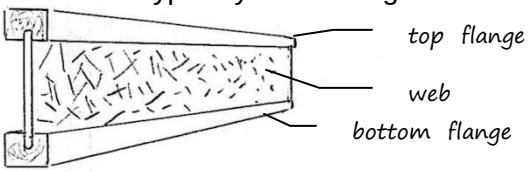
Wood Joist (softwood lumber)



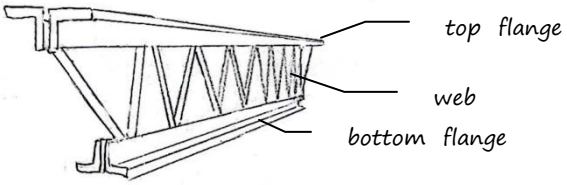
Built Up Wood Beam (two or more joists connected)



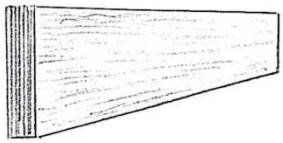
Engineered Wood - typically wood flanges connected with web made of OSB (oriented strand board)



Steel Trusses (OWSTJ - open web steel joists)



Engineered Wood - Glulam (glued laminated). Wood veneer bonded together with durable, moisture-resistant structural adhesives



Steel I-Beam

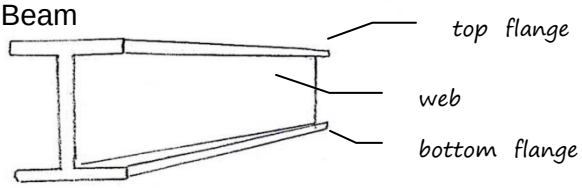


Fig. 4.13 Concrete (suspended concrete slab)

Concrete can resist high compression forces but is poor under tension. Since steel is good for countering tension forces we use reinforcing bars (re-bars).

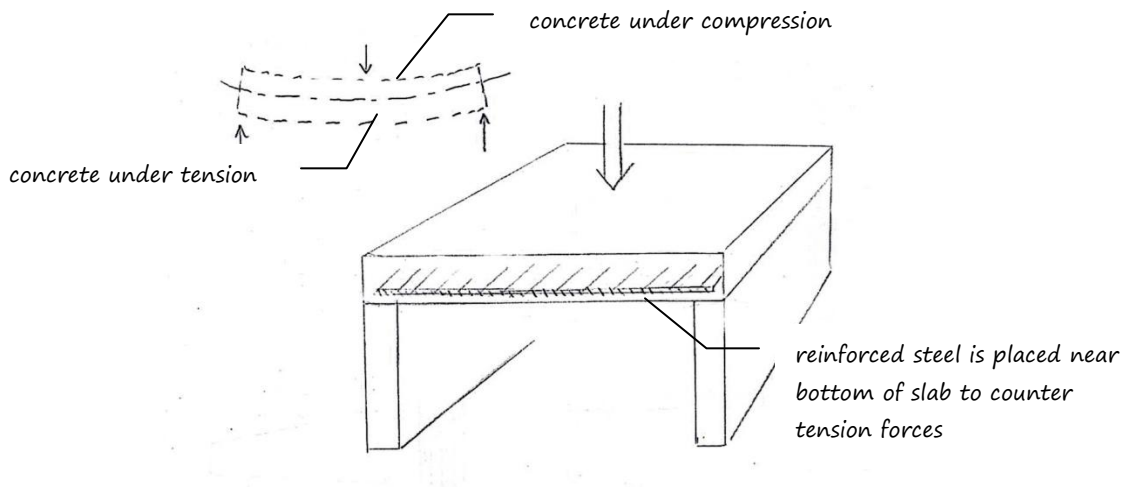


Fig. 4.14 Sub-floor materials

Plywood (4'x8' panel)

OSB (Oriented Strand Board) (4'x8' panel)

Wood Planks

4.1.4 Walls

Fig. 4.15 Masonry (double-brick wall)

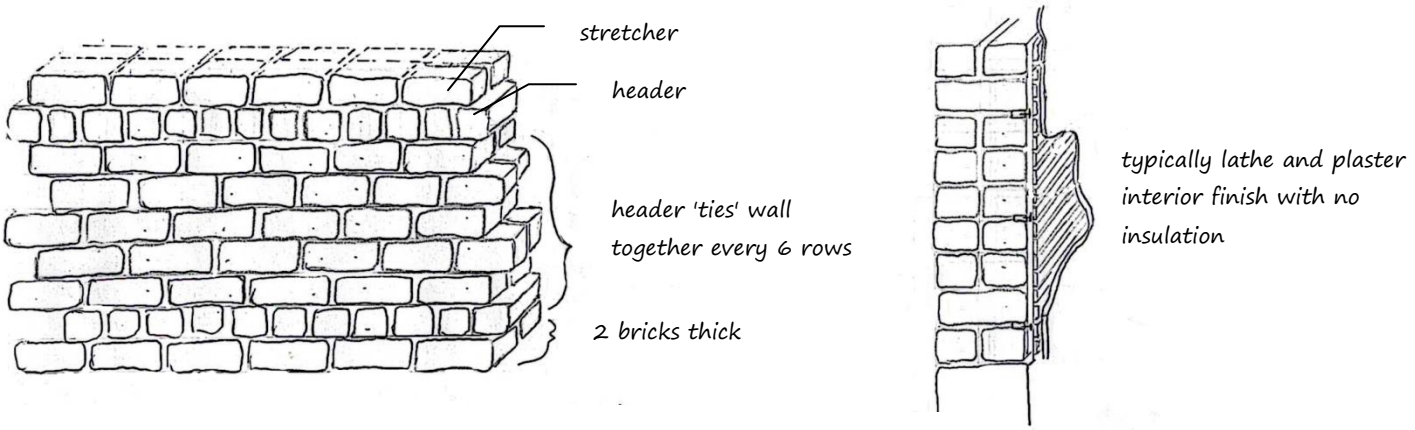
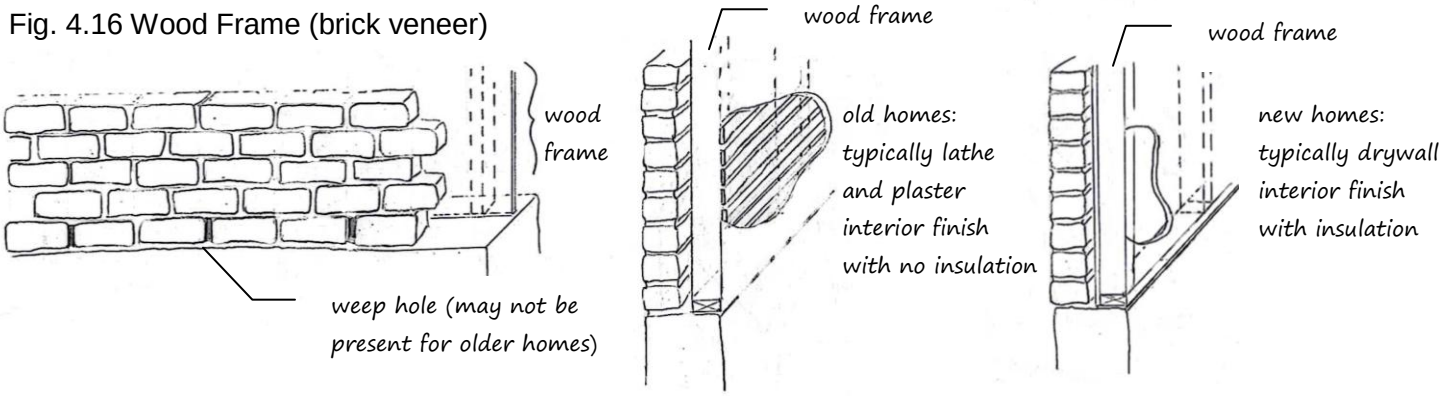
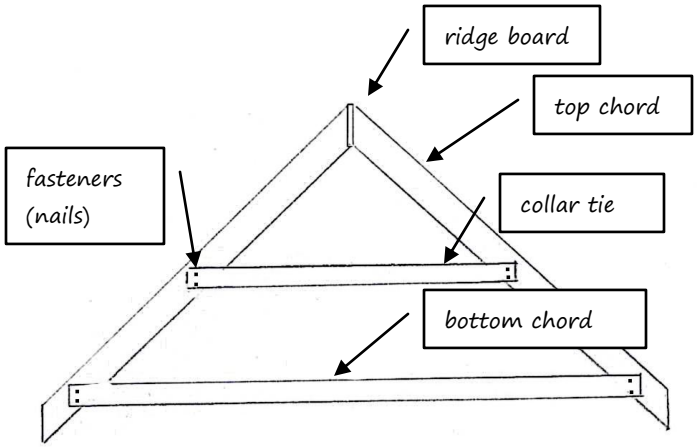


Fig. 4.16 Wood Frame (brick veneer)

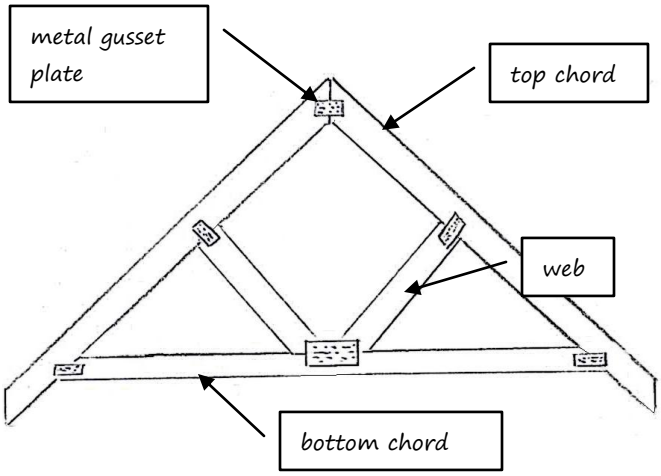


4.1.5 Roof/Ceiling

Fig. 4.17 Wood Rafter



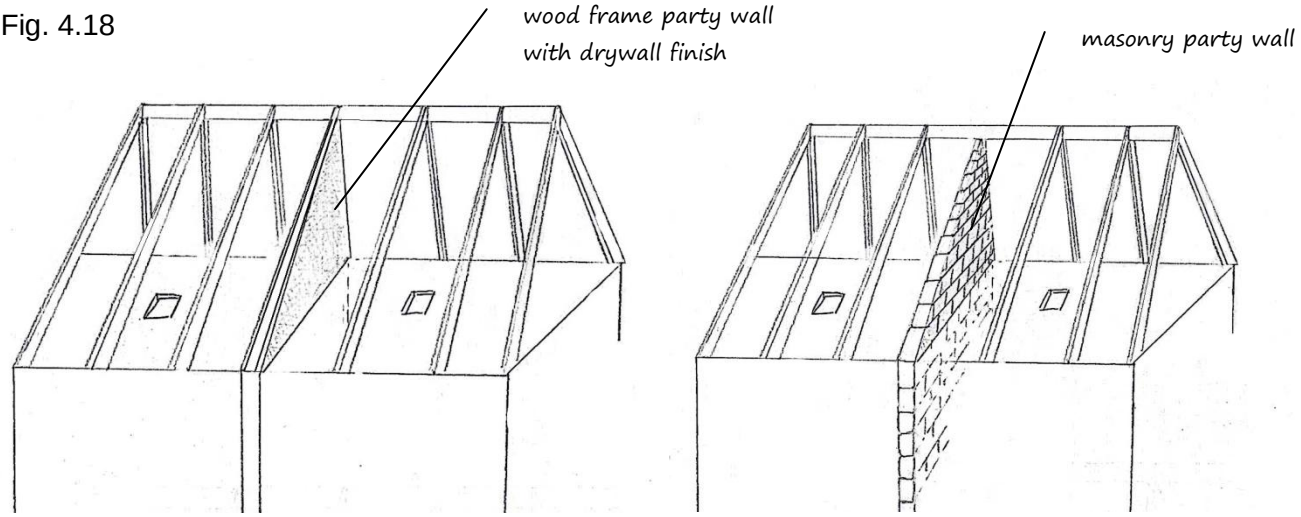
Wood Truss



Party Wall: A party wall (also called a **fire wall**) is a barrier located in the roof space **between homes that are attached** i.e. semi-detached and row homes. Its purpose is to minimize or slow down potential fire and smoke damage from one unit into another.

A party wall can be made of masonry (brick or block) or wood frame with fire-rated drywall. An older house may not have a party wall.

Fig. 4.18



4.2 Limitations

Foundation: From the exterior the obvious reason for this limitation is that the foundation is below grade (incidentally since the foundation is supported by the footings these are very rarely observed). From the interior finished surfaces (i.e. drywall) or insulation and storage will also limit visibility.

The Inspection provides an overall estimate of the **% of foundation not visible**.

Crawl Space: Entrance to the crawlspace will depend on readily available access though safety might be a factor. Often the crawlspace is inspected from the access hatch which will limit the Inspection. Storage can also restrict visibility.

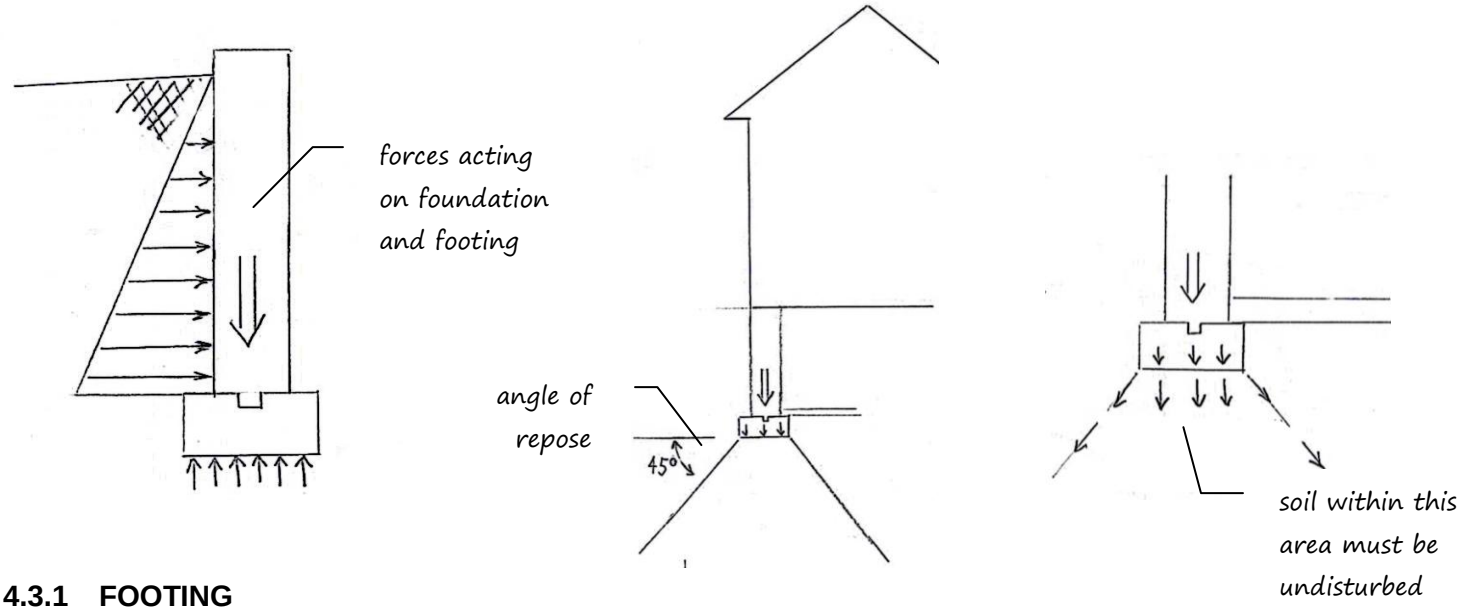
Wall Inspection: Since access to the interior of the wall system is not possible without invasive or destructive probing the Inspection is limited to only what is visible on the surface and/or not obstructed.

Roof Inspection: The roof space is usually accessed through a ceiling hatch. In most homes a **sloped roof** will be accessible. **Flat roofs** and **cathedral roofs** are usually not accessible since there is little or no space between the ceiling and roof surface. **Knee wall** areas are sometimes accessible from a wall hatch.

Safety is a major factor when inspecting a roof therefore most are observed from the access hatch.

4.3 Observations/Recommendations

Fig. 4.19 Basic footing and foundation mechanics



4.3.1 FOOTING

The footing is not visible (as it should be). Therefore when determining if a footing is performing adequately we must depend on indirect evidence such as:

- foundation cracks
- wall cracks
- slanting floor surfaces
- doors and windows are difficult to operate

This of course is often only part of the picture so we must be careful not to come to conclusions too quickly. Other factors must be considered.

Fig. 4.20

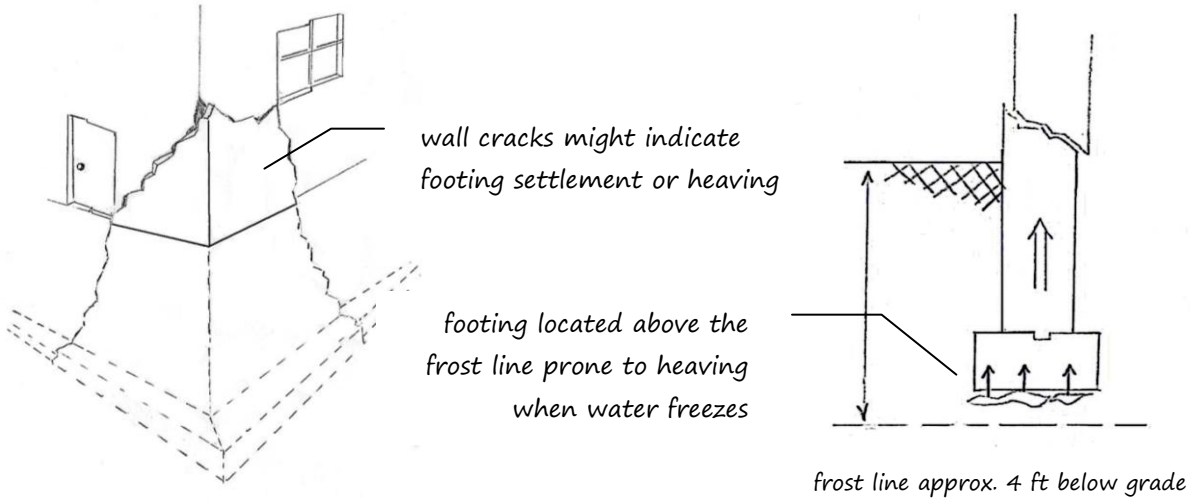
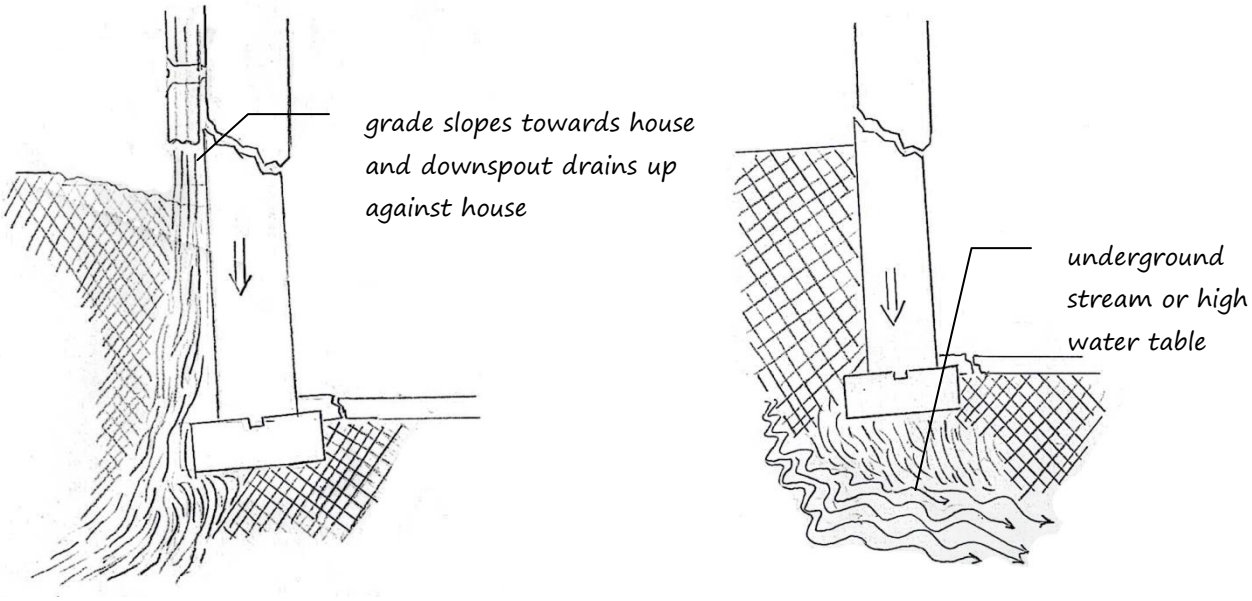


Fig. 4.21 Footing settlement due to water conditions.



Footing settlement due to **soil consolidation**. This refers to soils that settle due to the weight of the house. For example soils with high clay content retain more water. When weight is added the soil the water is 'squeezed' away and the soil settles.

Another example where consolidation can occur is when weight is added to soil that has been previously disturbed. Generally undisturbed soil means it has been in its natural state since the last ice age and will not settle when weight is added.

Fig. 4.22

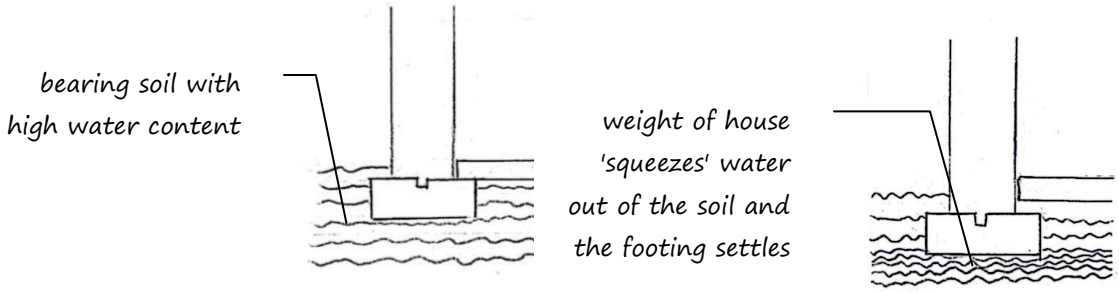
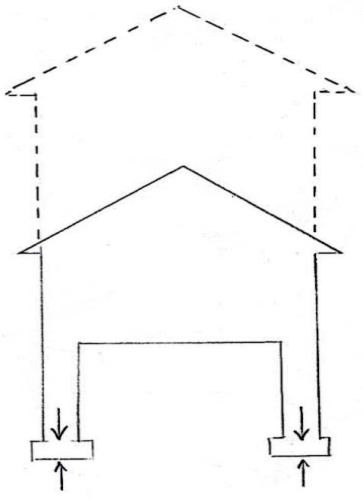


Fig. 4.23

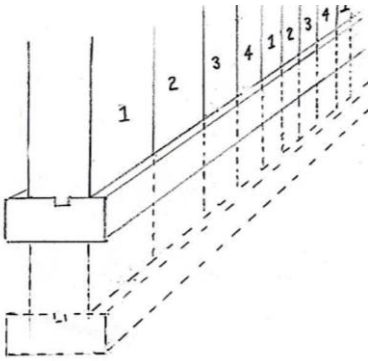
When adding another level to a house the soil bearing capacity must be tested by a geo-technical engineer. This will determine if adding more weight to the structure is feasible. Inadequate soil capacity can result in undue settlement.

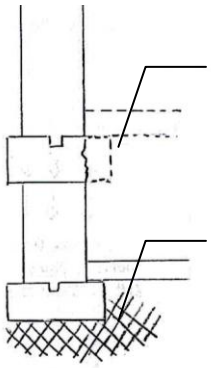


Lowering a basement floor: Bench Footing compared to Underpinning

Fig. 4.24 Underpinned Footing

The foundation and footing is divided into numbered sections along the wall. For example all section 1's are lowered and the concrete is allowed to cure. Then section 2's and so on.



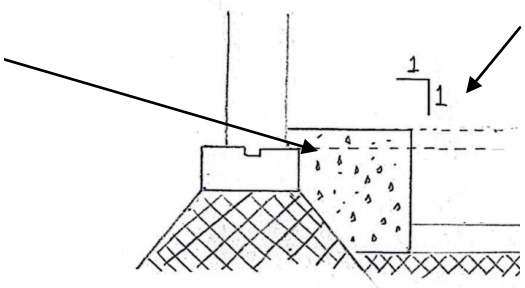


original floor and footing

new floor and footing

Fig. 4.25 Bench Footing

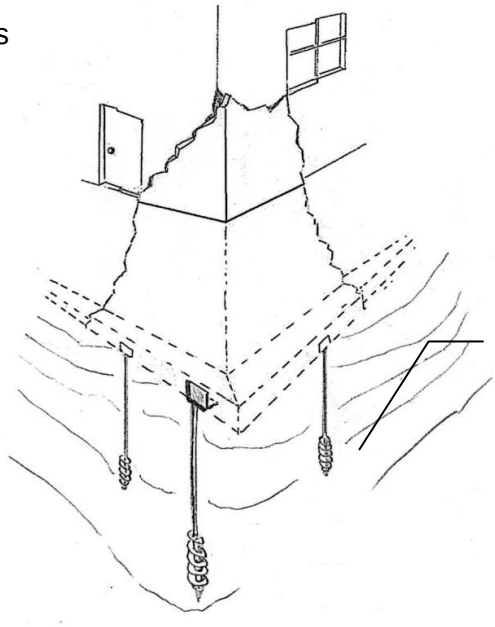
Poured Concrete Footing Added (bench footing)



1:1 ratio means for every unit you lower the floor you must come out an equal unit

When the soil bearing capacity is to too far below the footing it is not practical to reinforce the footing by conventional means such as underpinning. One method is to drill helical screws down to a level where the soil capacity is adequate. This is determined with borehole testing by a geotechnical engineer.

Fig. 4.26 Helical Screws



rods with helical screws are used to support footing where the soil capacity is adequate

4.3.2 FOUNDATION

Fig. 4.27 Vertical Cracks

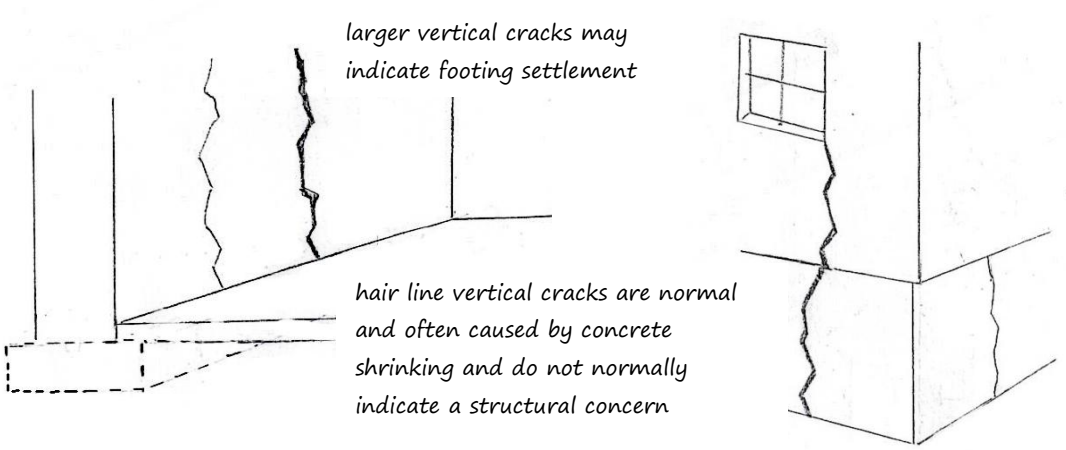


Fig. 4.28 Horizontal Cracks

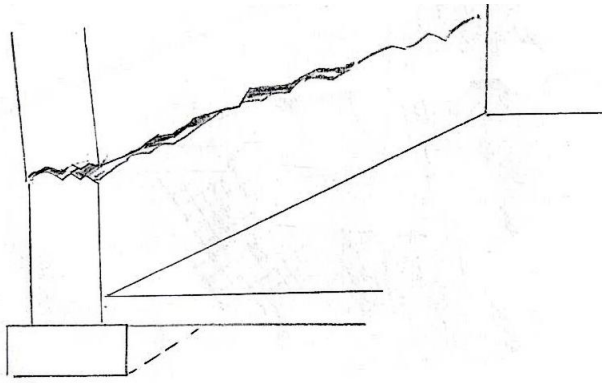


Fig. 4.29 Common causes of horizontal cracks.

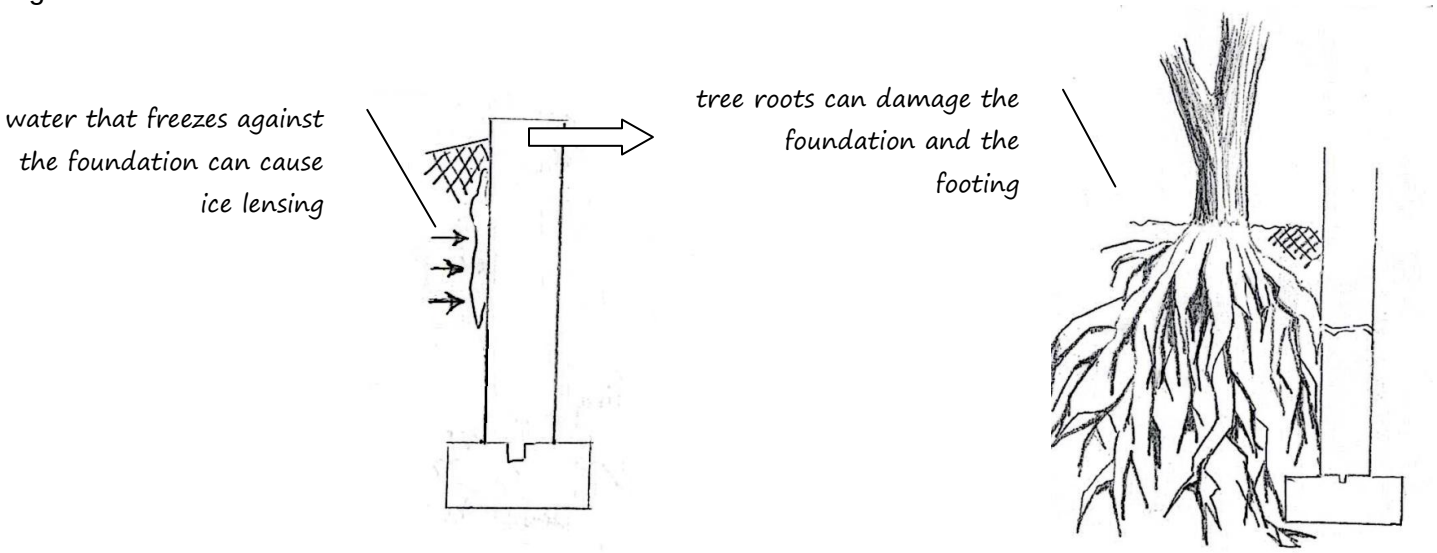
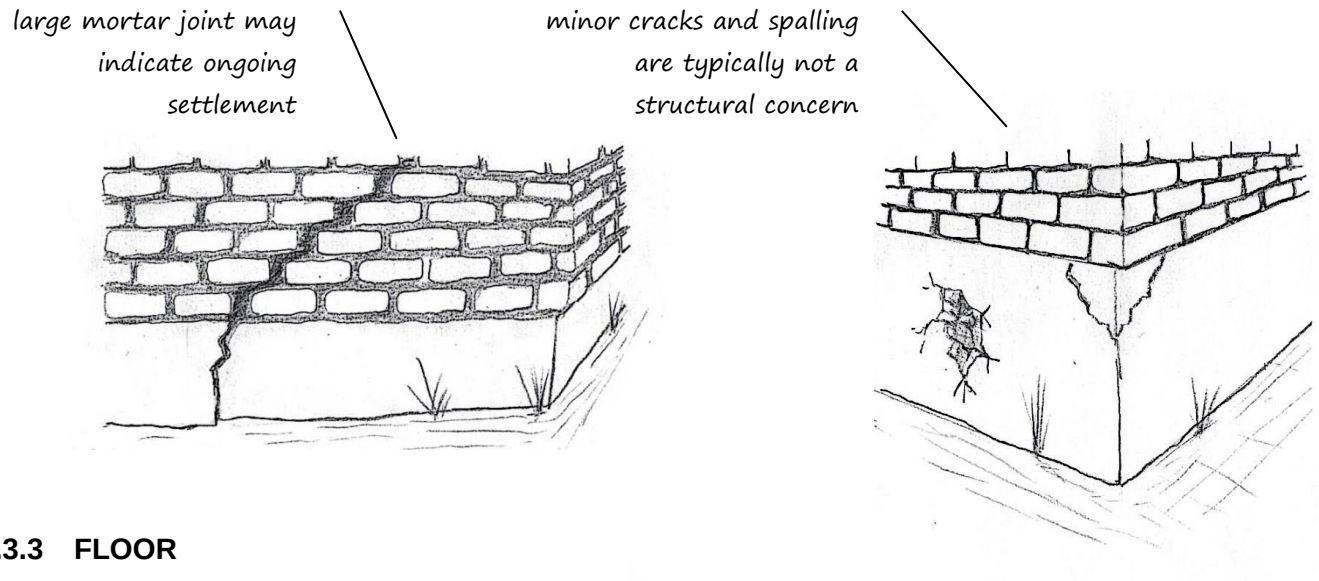


Fig. 4.30



4.3.3 FLOOR

Fig. 4.31 Wood Sill Damage

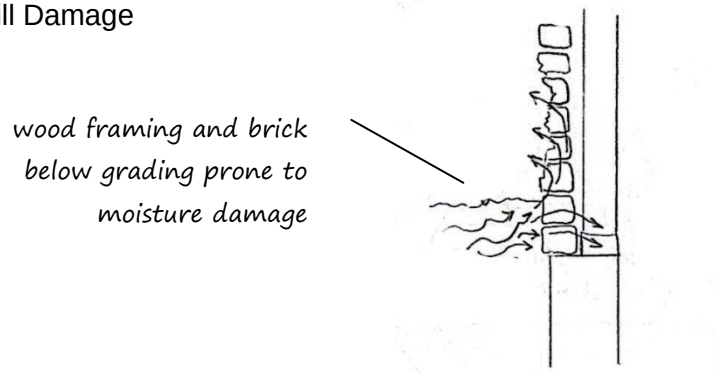


Fig. 4.32 Beam/Wood Column/Metal Post/Wood Post

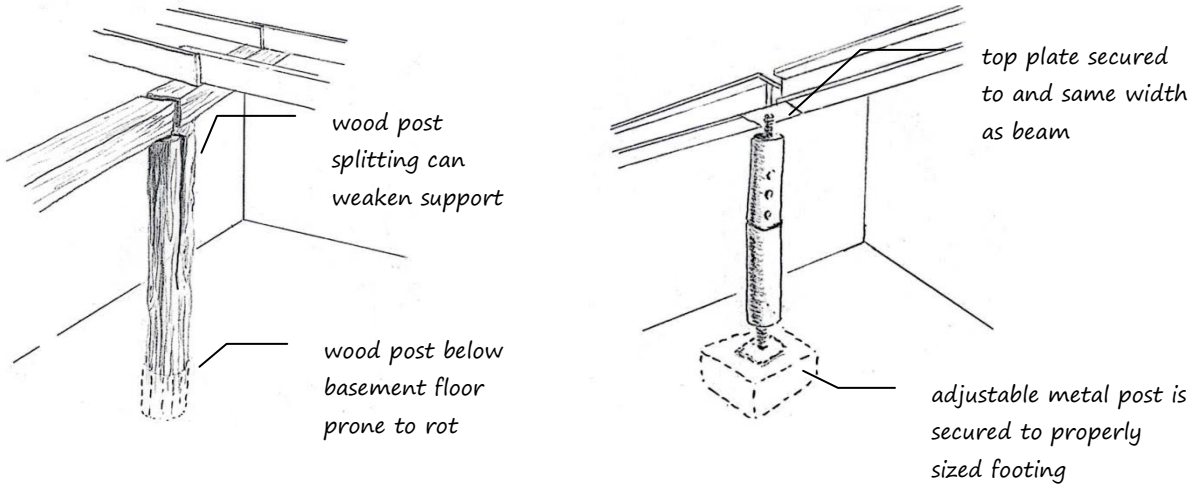
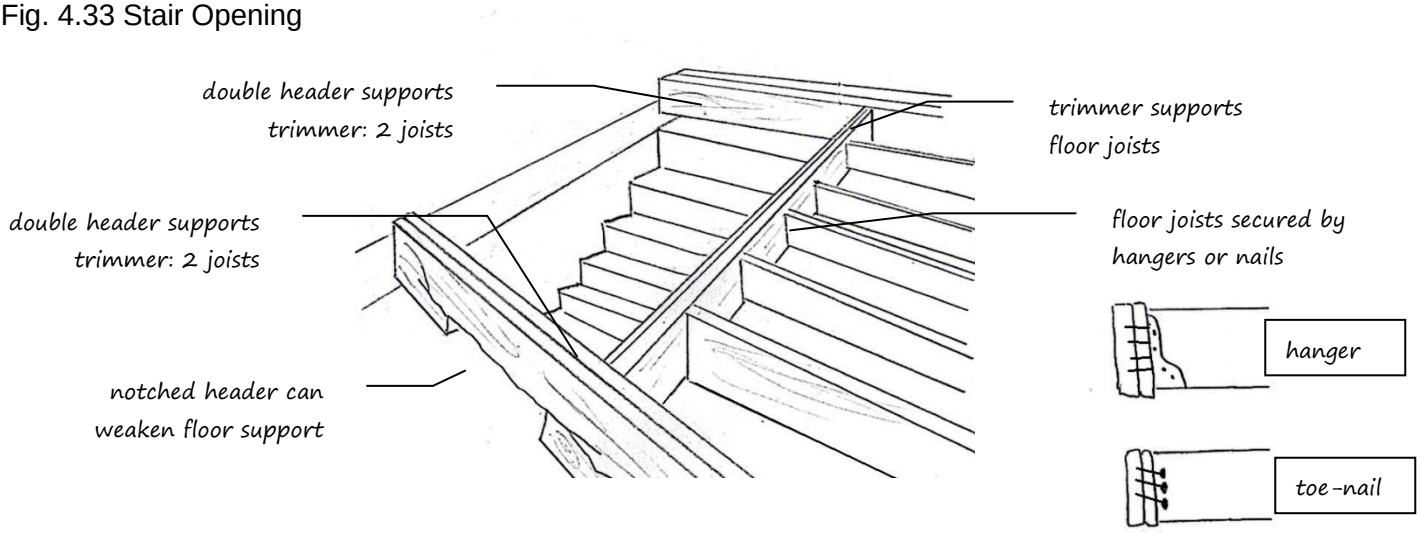


Fig. 4.33 Stair Opening



A stair opening is essentially a 'hole' in the floor system. In many older homes sagging of the floor can be observed. In most cases this is not critical though 'shoring up' the joists should be considered if renovating.

4.3.4 WALLS

A window (or door) opening in a masonry wall is essentially a 'hole' in the wall system. As such this requires support by a masonry arch or a lintel (usually metal). When the arch or lintel moves the brick cracks usually along the mortar joint.

Fig. 4.34 Masonry Arch

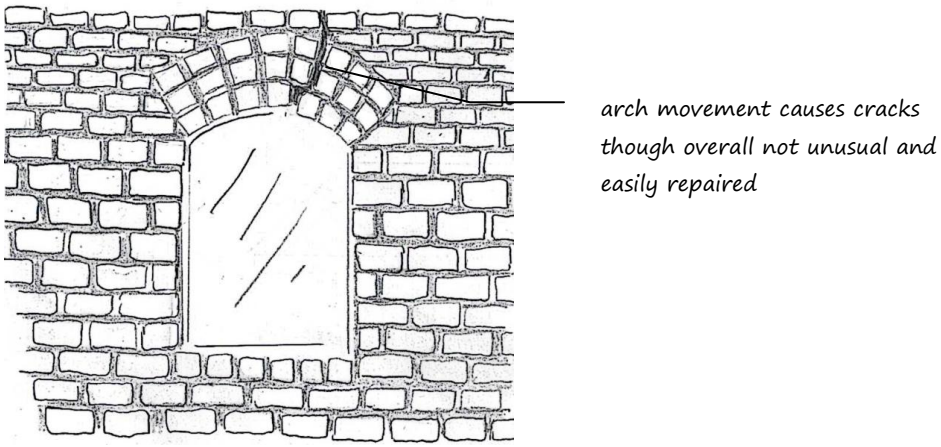
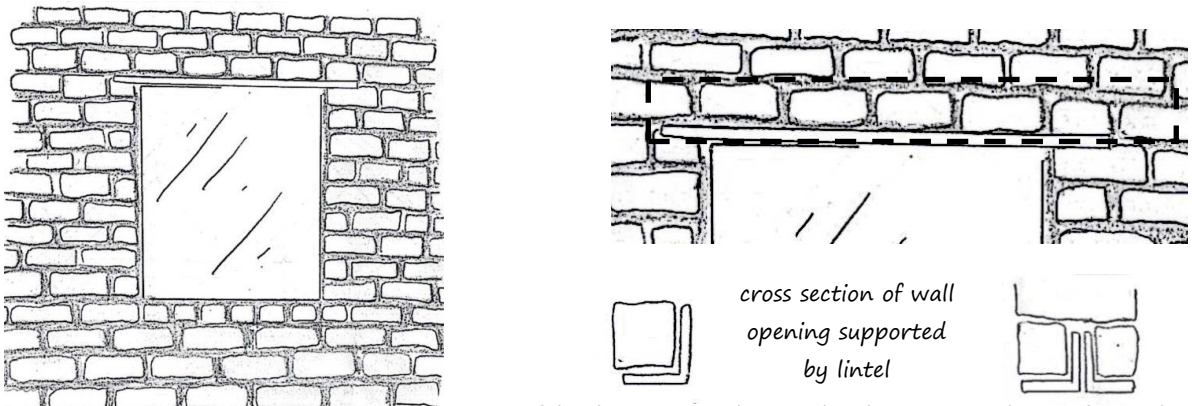


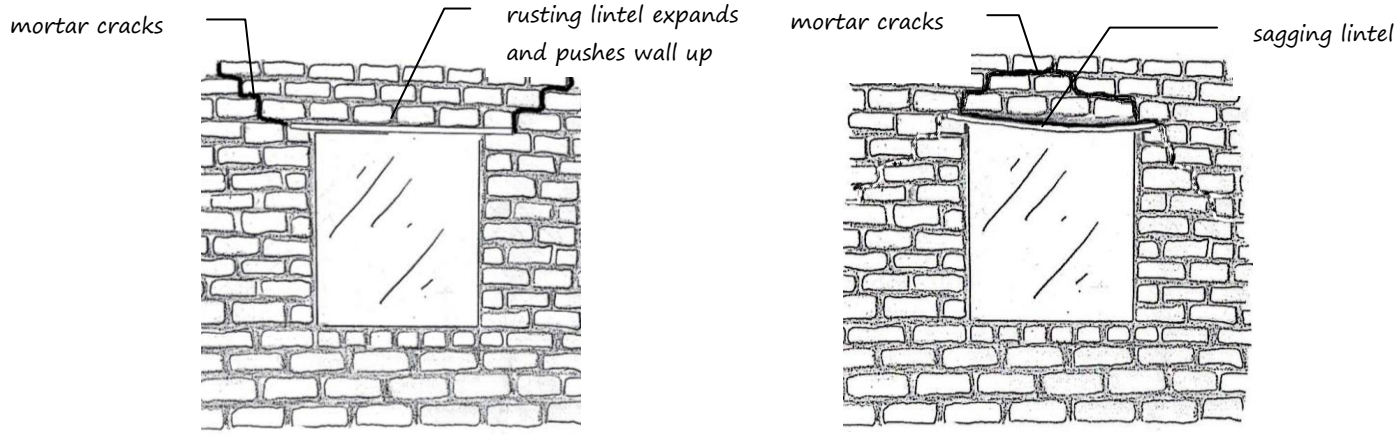
Fig. 4.35 Metal Lintel



single metal lintel for single brick veneer wall

double metal lintel for double brick wall

Fig. 4.36 Metal Lintel Problems



4.3.5 ROOF

Many semi detached and row homes built prior to the 1940's may not have a party wall.

Lack of a proper party wall can be an **insurance issue**.

Fig. 4.37 Missing Party Wall

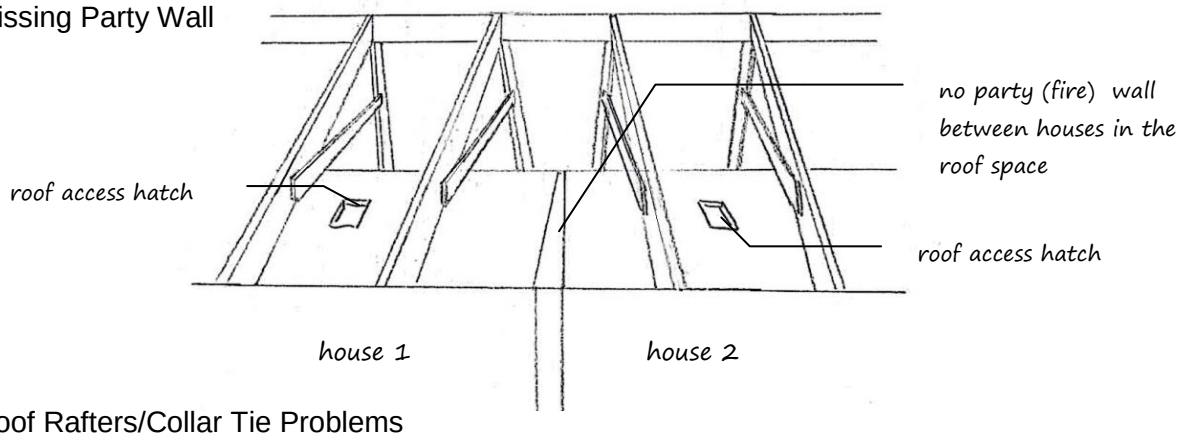
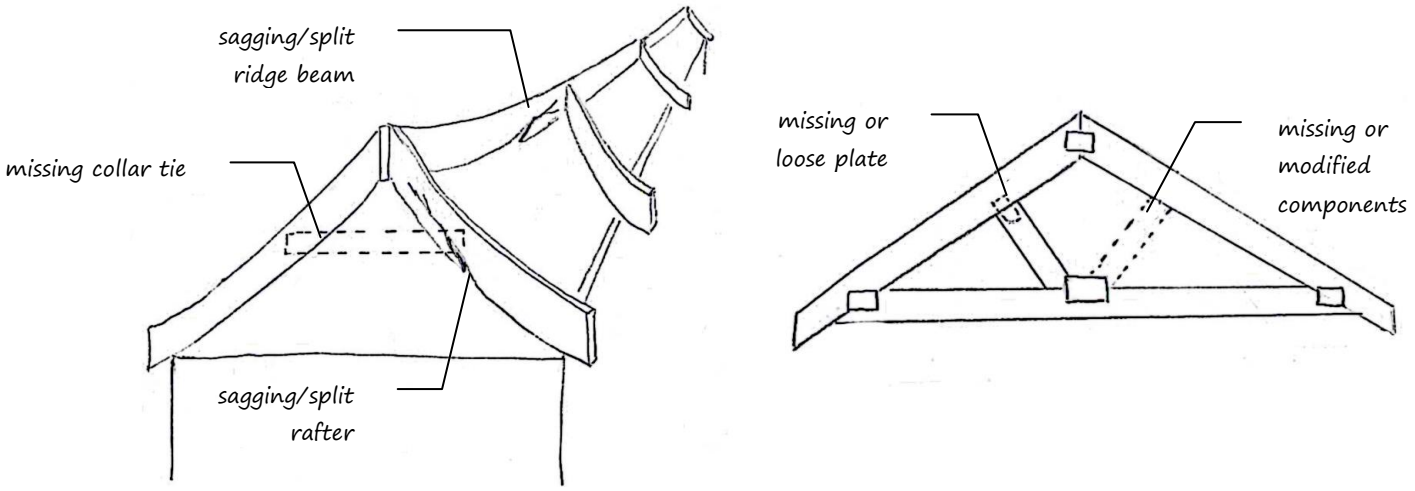


Fig. 4.38 Roof Rafters/Collar Tie Problems



4.3.6 OTHER STRUCTURAL CONCERNS

Termites: Depending on where you live termites may be a concern. Generally local pest control companies or municipal records can be contacted to determine termite activity in your neighbourhood.

If purchasing a house in a neighbourhood with a termite history it is recommended to retain a specialist to investigate.

Termites consume cellulose fibres in wood. They live in subterranean colonies and come up to feed on readily accessible sources - like your house! Over the long term this can become a significant structural problem. However in the majority of cases termite treatment is successful and structural repairs possible though can become expensive.

The key is to inspect your house annually in order to detect infestation early and minimize damage.

Ways to reduce risk of termites infestation:

- minimize or remove wood in contact with soil
- remove dead tree stumps
- lower grade around wood framing

Identifying Termites: termite activity can be identified by the 'sandy' tunnels called shelter tubes.

Termite treatment: generally involves drilling holes around the outside and inside perimeter of the house and inject a poison to kill or repel termites.

Carpenter ants: Carpenter ants generally infest wood that is moist and easily accessible. Like termites they can be very destructive and are identified by sawdust droppings. They can be found to nest in the house or outside in a tree stump for example. A professional should be retained to deal with carpenter ants though there are do-it-yourself products available.

Fire Damage: A house that has had a fire require special investigation by the fire and municipal authorities. Minor surface charring on wood components is usually not a structural concern.