11th Annual
First Nations Northern Housing Conference

Soils, Foundations & Moisture Control

Soil

- The top ‘loose’ layer mineral and/or organic material on the surface of the Earth that serves as a natural medium for the growth of plants…

  and support for the foundations of our structures.

Soils

Mineral Soil

- Consists of mineral matter of variable size.
- Ideal to support foundations.

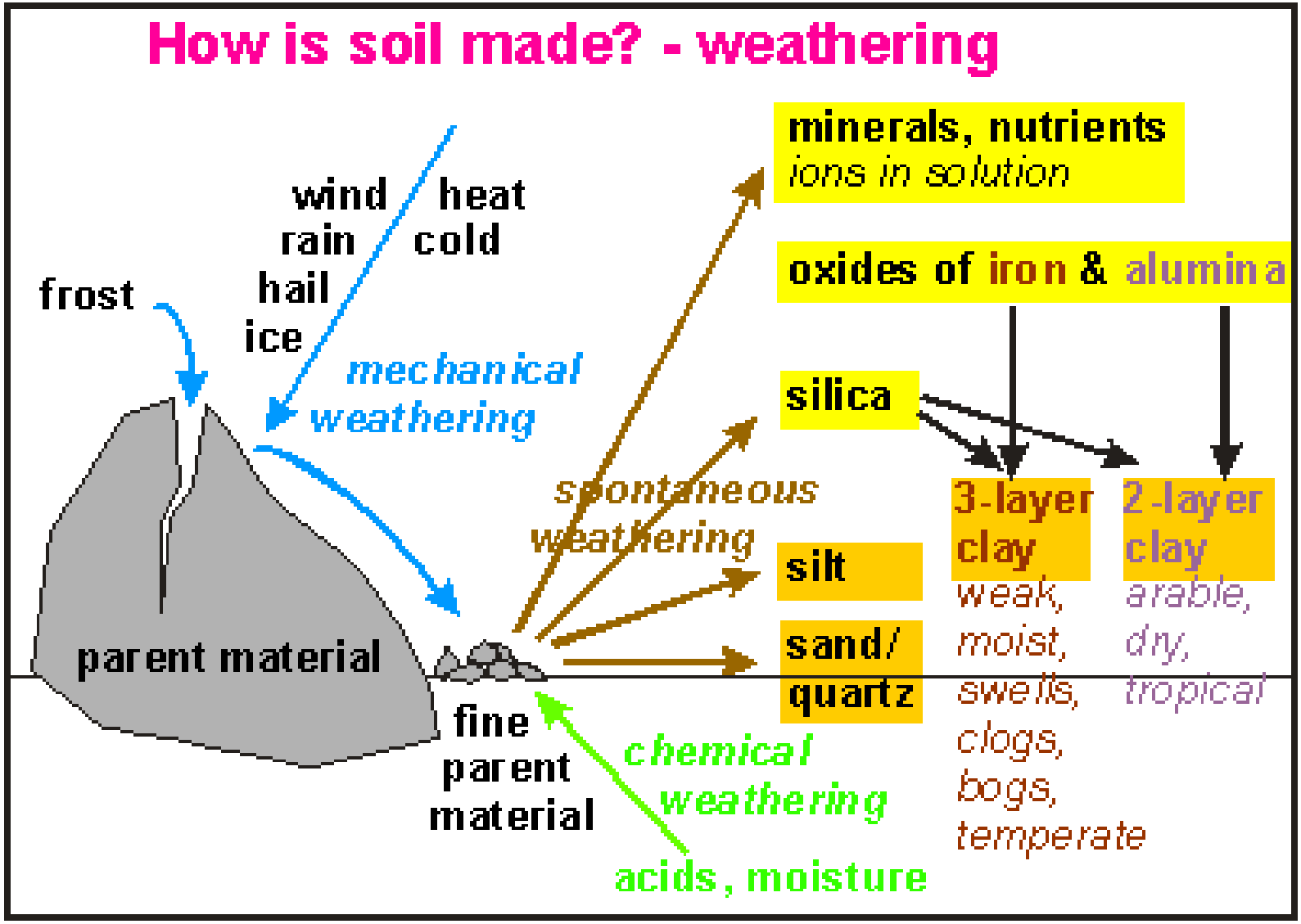
Organic Soil

- Contains at least 30% organic matter, consisting of decomposing plant and animal matter (organic carbon compounds).
- Poor bearing capacity.
- Poor support for foundations.

How Is Mineral Soil/Aggregate Formed?

Mineral soil is formed by the breakdown of a parent material (rock) by chemical or physical (wind, water, ice, glacial, etc.) forces which wear away the material.

How Is Mineral Soil/Aggregate Formed?



Aggregate Size Range

name			size range
Very coarse soil		Large boulder, LBo	>630 mm
		Boulder, Bo	200 – 630 mm
		Cobble, Co	63 – 200 mm
Coarse soil	Gravel	Coarse gravel, CGr	20 – 63 mm
		Medium gravel, MGr	6.3 – 20 mm
		Fine gravel, FGr	2.0 - 6.3 mm
	Sand	Coarse sand, CSa	0.63 - 2.0 mm
		Medium sand, MSa	0.2 - 0.63 mm
		Fine sand, FSa	0.063 - 0.2 mm
Fine soil	Silt	Coarse silt, CSi	0.02 - 0.063 mm
		Medium silt, MSi	0.0063 - 0.02 mm
		Fine silt, FSi	0.002 - 0.0063 mm
	Clay, Cl		≤0.002 mm

Clay (up to 0.002mm)

High Moisture Content Clay

Dry Clay

Silt (Between 0.002 & 0.063 mm)

High Moisture Content Silt

Dry Silt

Sand (Between 0.063 & 2.00 mm)

Sand with small pebbles

Dry Sand

Pebbles, Gravel, Cobbles and Boulders

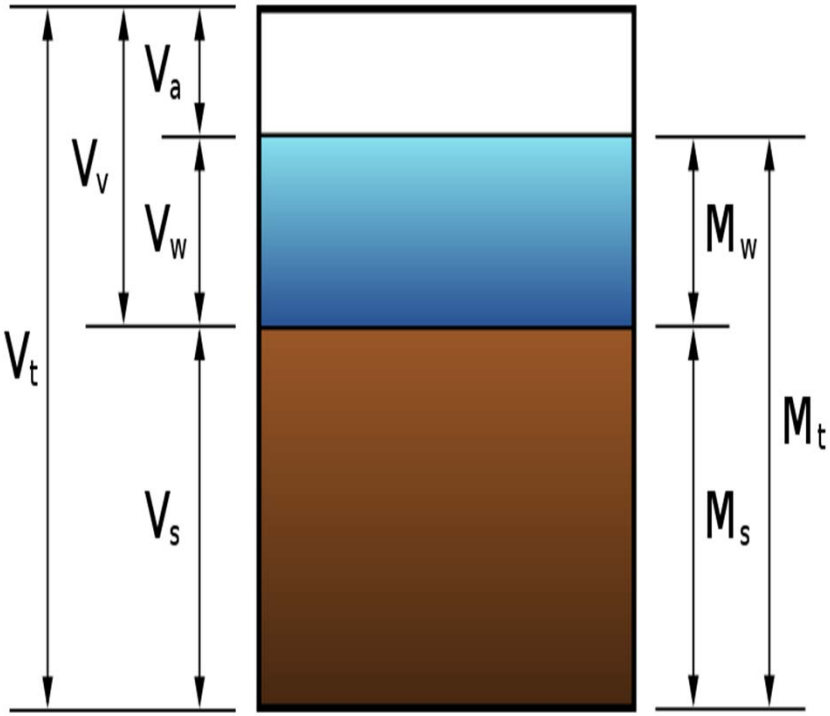
Pebbles and Gravel

(Between 2.00 & 63.00 mm)

Cobbles and Boulders

(63.00 mm and up)

Soil Phases


V_a
V_v
V_w
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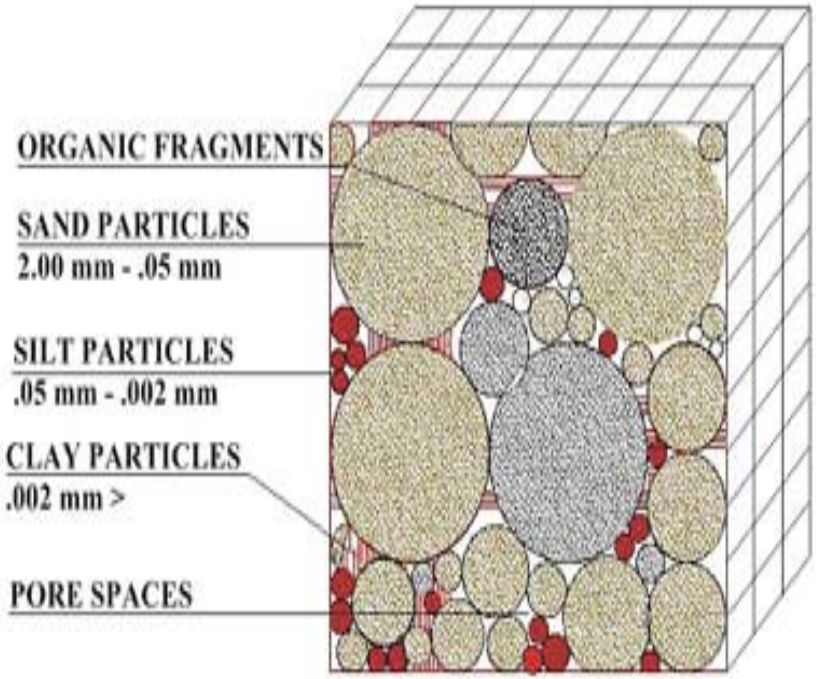
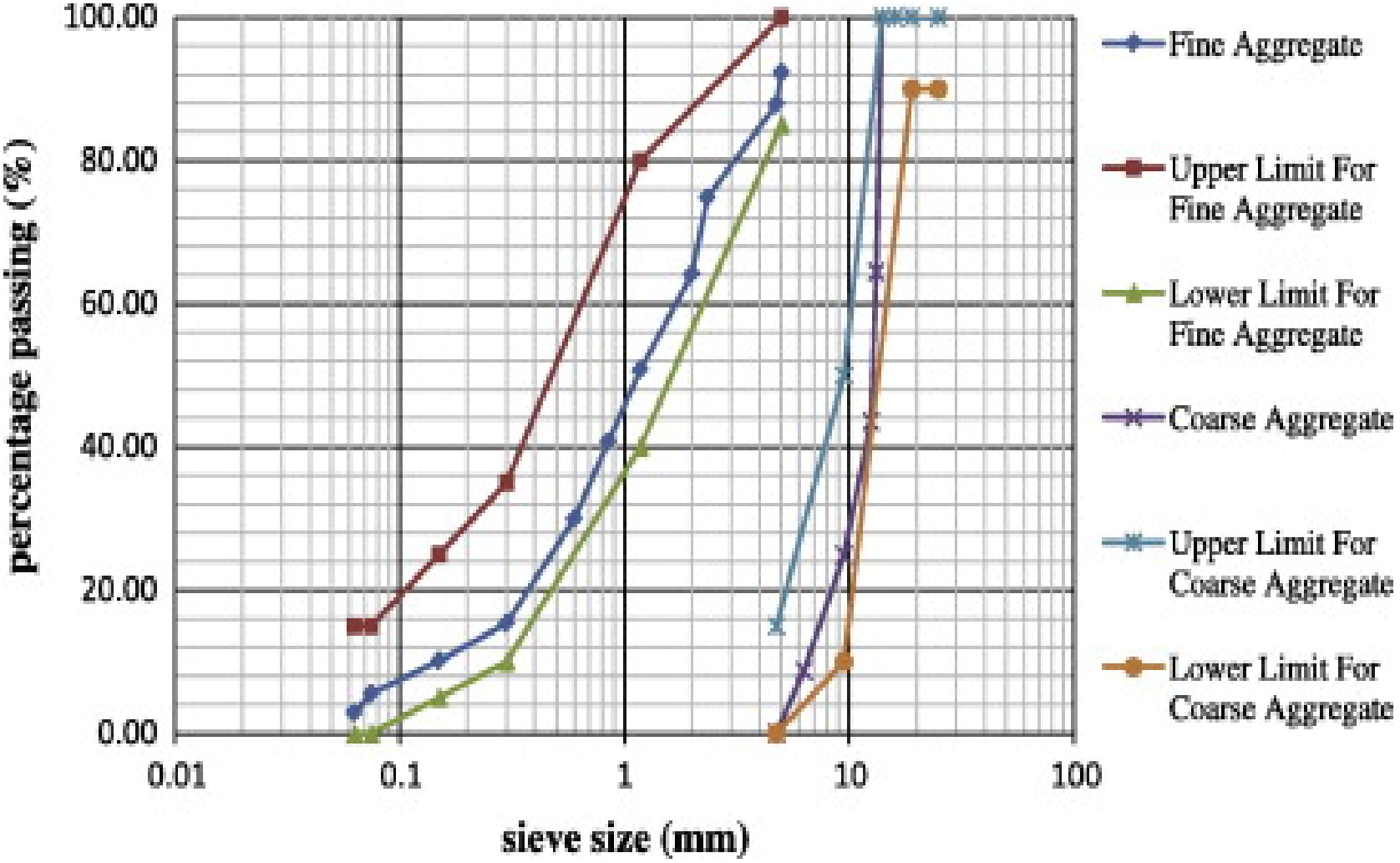

ORGANIC FRAGMENTS
SAND PARTICLES
2.00 mm - .05 mm
SILT PARTICLES
.05 mm - .002 mm
CLAY PARTICLES
.002 mm >
PORE SPACES

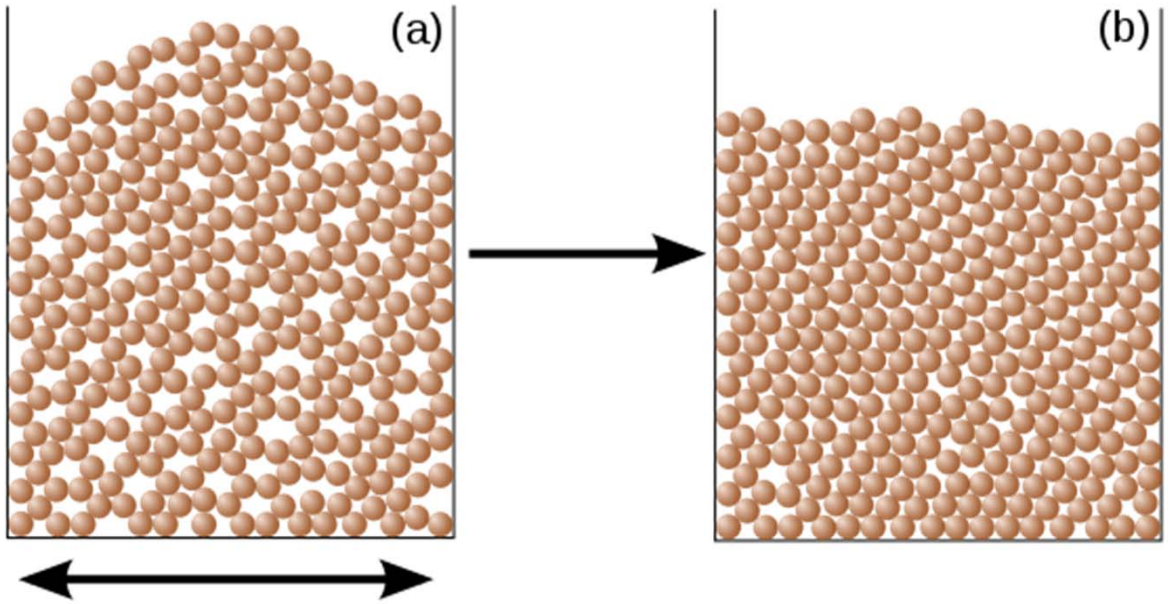
Grading of Soils



Aggregate Sizing & Sieve Analysis

Compaction

The process in which stress or force is applied to soil causing it to pack tightly as air and/or water is displaced by the soil grains.



Proper Compaction Methods

- Use well graded soils (gravel).
- Avoid large cobble and rock.
- Backfill in lifts (layers). The smaller the thickness of the layer the better (less than 6”)
- Damp soil compacts more easily, but keep in mind over saturated soil does not compact properly.

Benefits Of Proper Compaction

- Prevention of settlement and movement of foundations.
- Reduction of water movement.
- Reduction in frost movement.
- Prevention of volume change.

Clay/Silt

- Can act as a water barrier.
- When moisture within the material is high; there will be reduced bearing capacity, it will be prone to movement and susceptible to movement from frost.
- Expansion and contraction issues.

Granular & Sandy Material

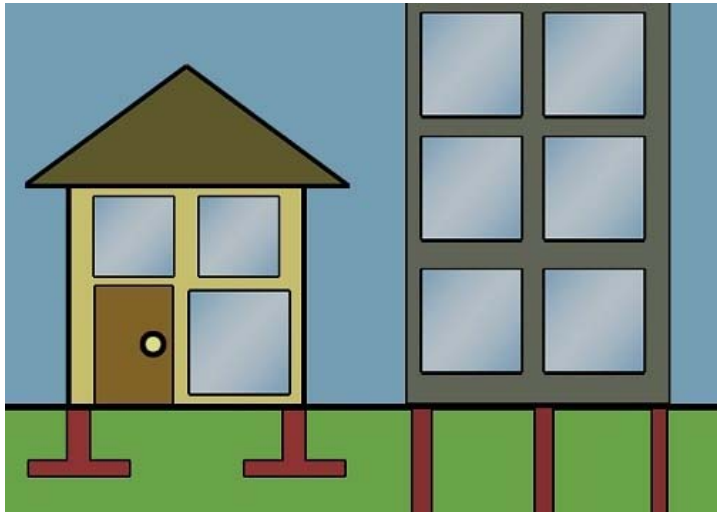
- Good drainage.
- Good bearing capacity if compacted (only well graded material).
- Does not easily hold large amounts of moisture.

Footings and Foundations

The footing (foundation) of a building is used as a means of distributing the load of the structure to the ground (soil) below. It is the lowest supporting layer of the structure. There are two types of foundations

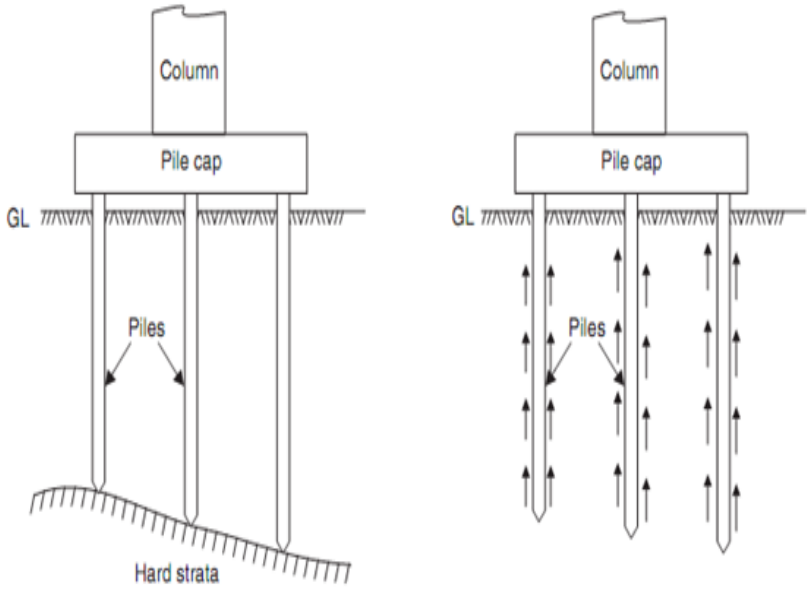
Deep and

Shallow.



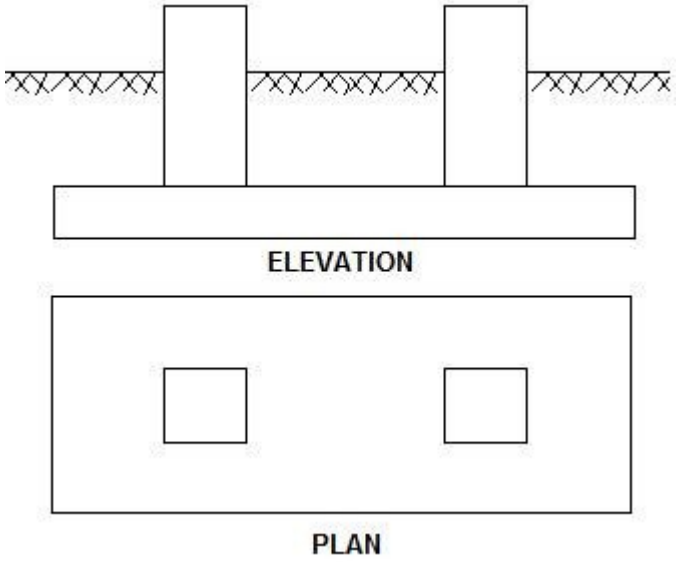
Deep Foundations

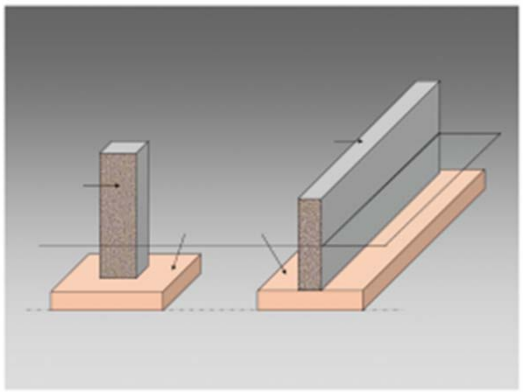
- Piles (includes helical piles) are used if the soil has a low bearing capacity.
- Are generally more expensive and difficult to install, therefore not as common in residential construction.



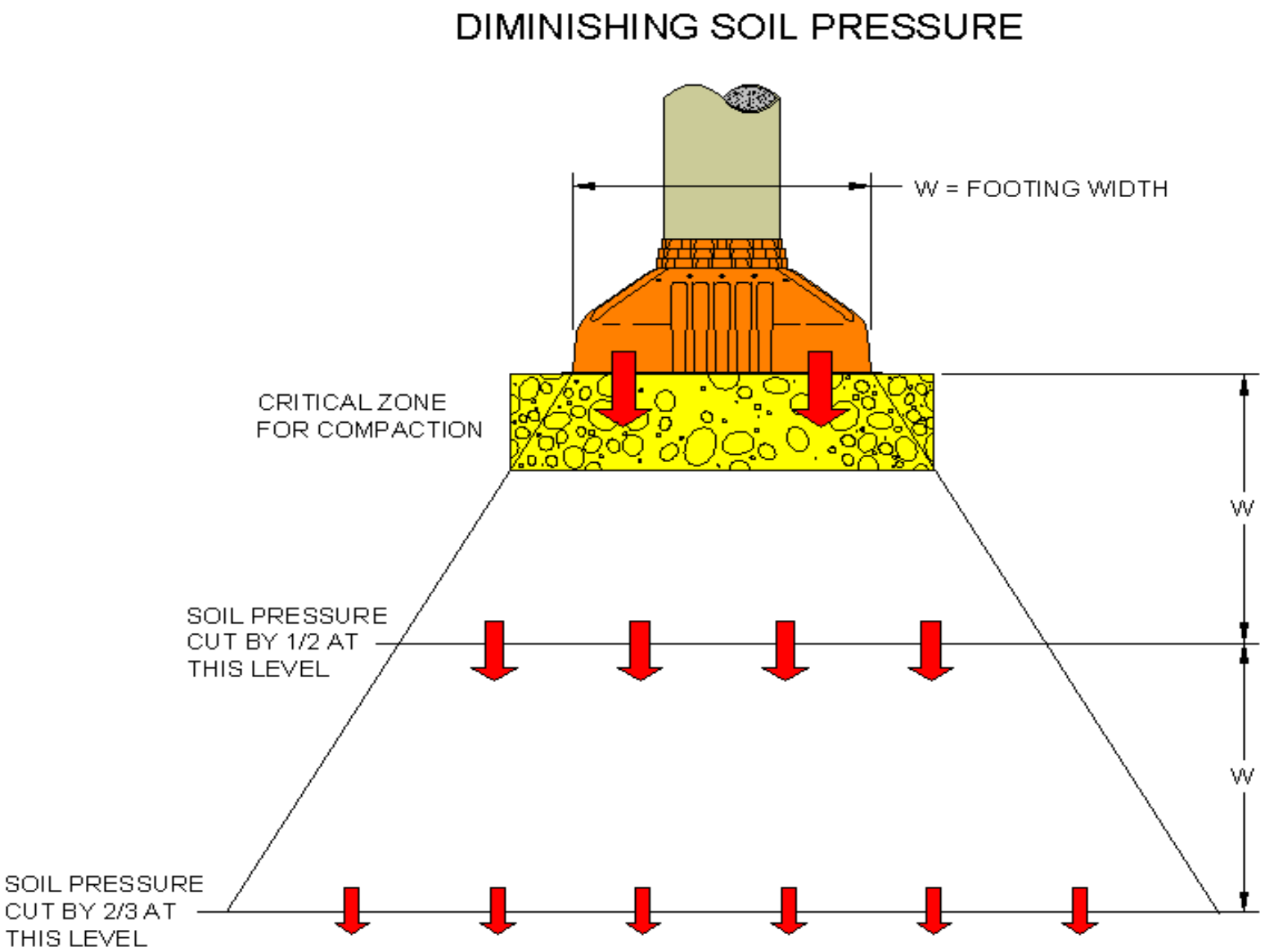
Shallow Foundations

- Strip, pads, slab type footings are used in areas where the soil is stable and has a higher bearing capacity.
- Shallow footings are usually the lowest cost option.
- Special consideration is needed to protect from frost movement.



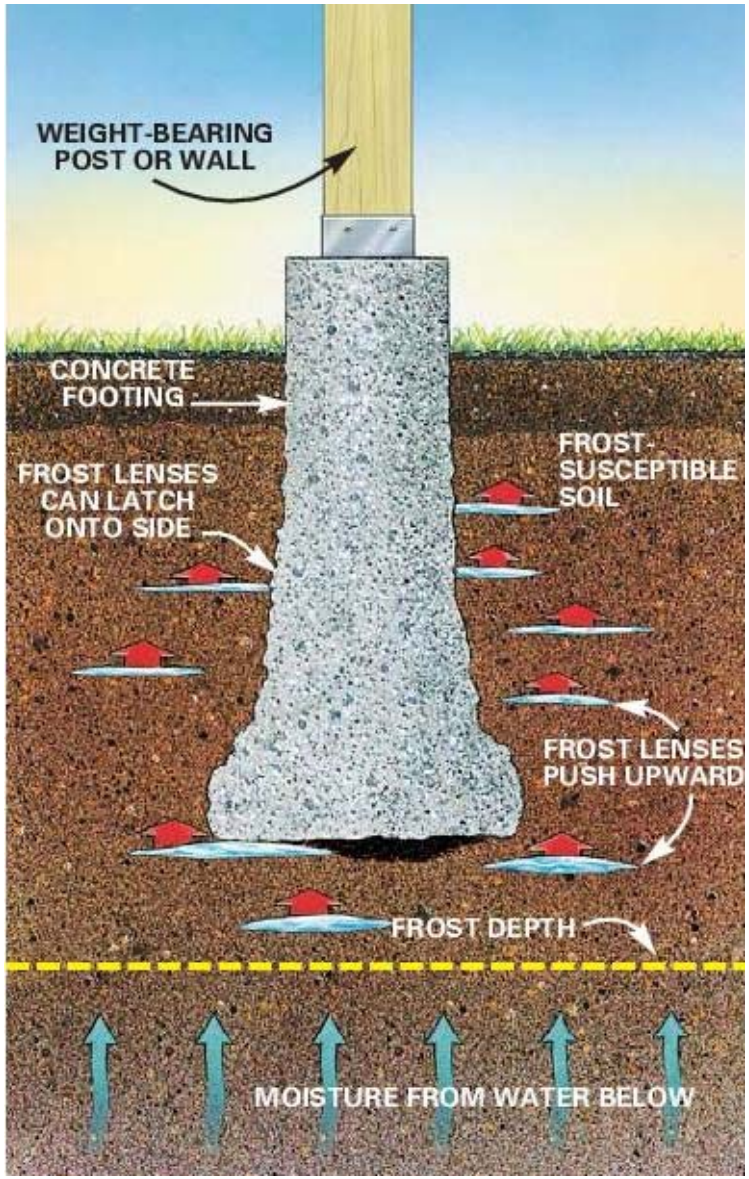


Load Bearing



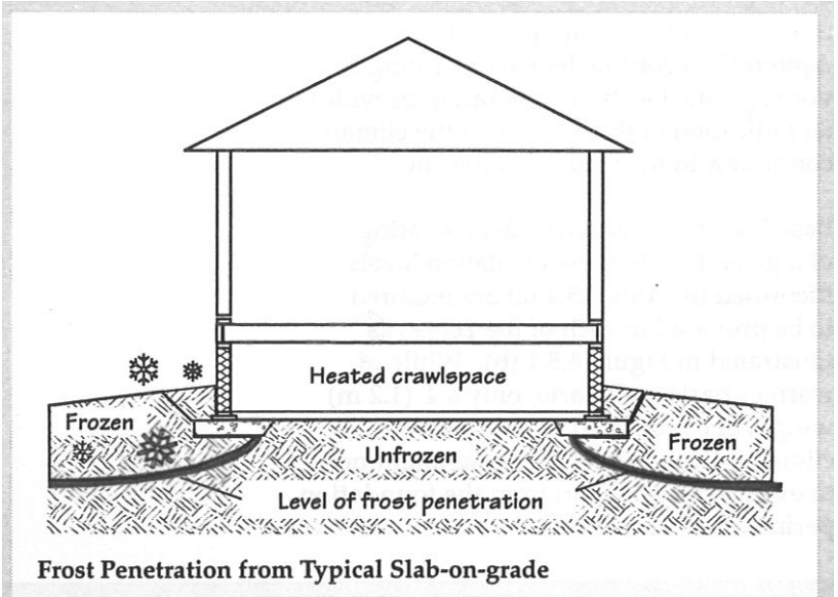
Frost

- Frost action is the result of water trapped in the soils pore spaces turning to ice.
- As water freezes it may adhere to structural components.
- As water freezes it expands and can exert very large forces on structures.
- If structures are not protected from frost there is a high potential for movement, damage or failure.

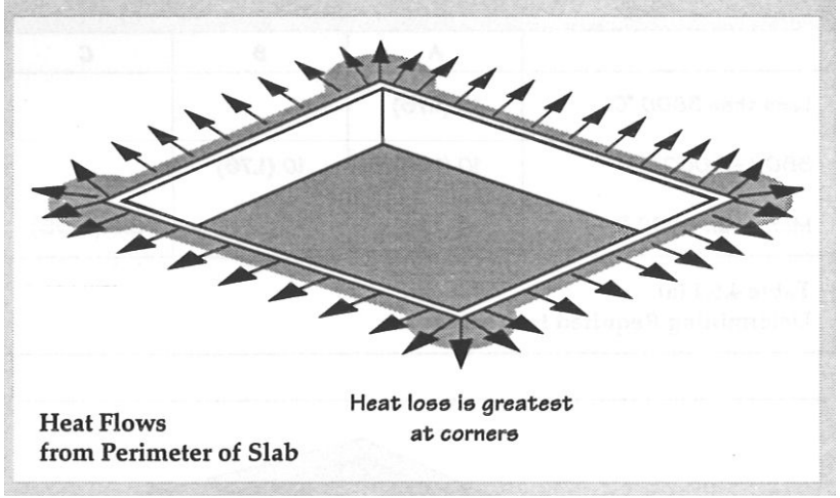


How Frost Penetrates and How Heat Is Lost

- Frost penetration can be accelerated by packing or removing snow.
- Frost penetration can be affected by ground water and ground water movement.
- More heat is lost at the corners of a structure.
- Heat is lost at areas of little or no insulation.
- Heat transfer is from hot areas to cold areas.



Frost Penetration from Typical Slab-on-grade



Heat Flows from Perimeter of Slab

Frost Protection

- Frost protection is essential to prevent damage to the foundation of a home.
- Frost penetration is calculated based on “degree days” below zero. Information on different regions can be found in the OBC/NBC Division B Appendix C
- The amount of frost protection required would be calculated using weather and temperature information for the region of construction.
- Additional protection in the corners is recommended as heat loss is the greatest in these locations.

Degree Days Below 18 °C	Required R (RSI) Value of Insulation by Zone Representing 2' (600 mm)		
	A	B	C
Less than 3800 °C	10 (1.76)		
3800 – 6000 °C	10 (1.76)	10 (1.76)	
More than 6000 °C	10 (1.76)	10 (1.76)	5.0 (0.88)

Table 4.5.1 (a)
Determining Required Insulation

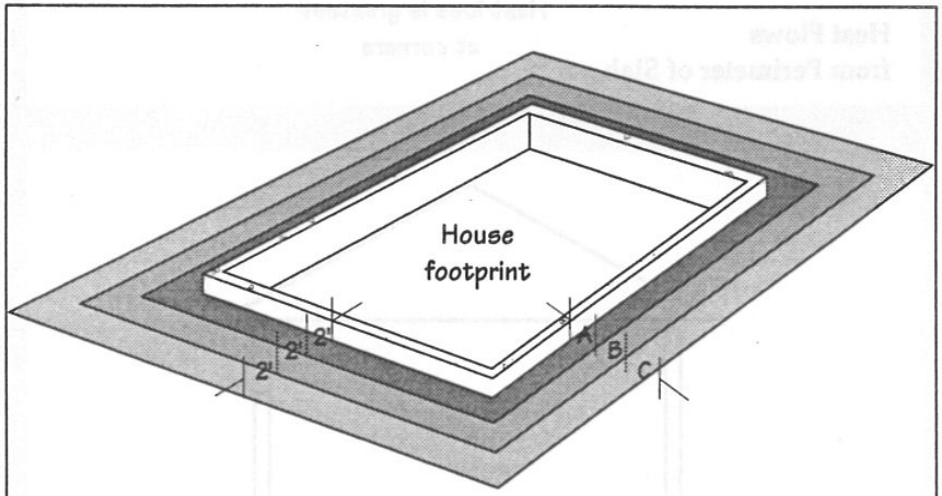
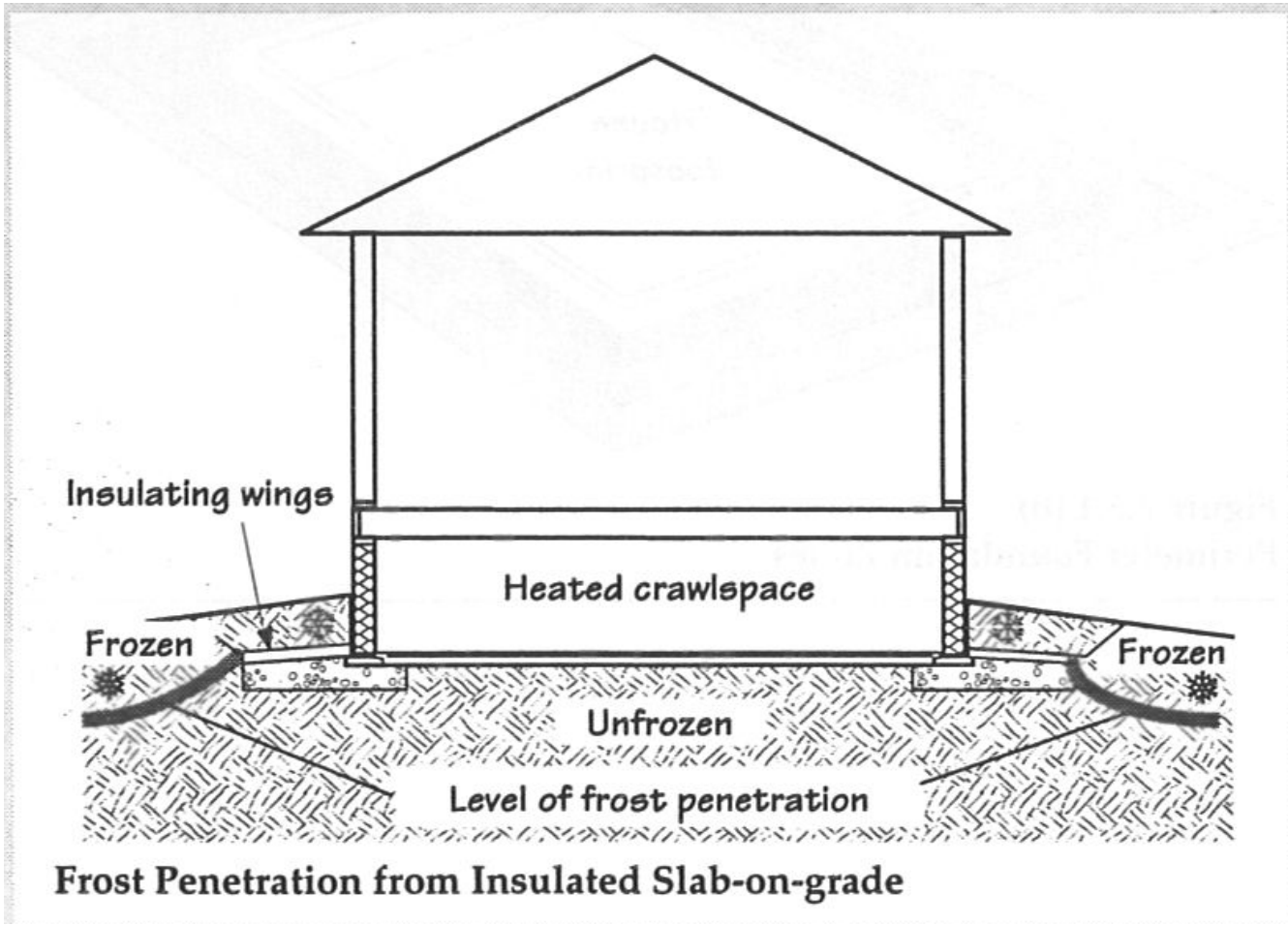


Figure 4.5.1 (b)
Perimeter Foundation Zones

Frost Protection



Frost Penetration from Insulated Slab-on-grade

Note: For frost protection to work it must be a heated space.

Why Control Moisture?

- Moisture damages materials within the home.
- Moisture may lead to mould, mildew, fungal or other biological growths.
- Can lead to odours.
- May lead to pest infestations.
- Can cause sagging/uneven floors, sticking doors, etc.
- May lead to structural damage.
- Moisture and the by products of the moisture can lead to a variety of negative health effects.

Site Selection

- Select an appropriate lot based on topography, soil conditions, owner preference and serviceability.
- Ensure that positive drainage away from the buildings can be achieved on the lot.
- Higher ground is always preferred.

Lot Development

- Ensure that all organics are removed from the footprint of the new construction (include a buffer).
- Store usable top soil on site for future use.
- Stockpile useable aggregate or inorganic soil for use while landscaping.
- Provide compacted granular fill for the building footprint and driveway area. PWF construction granular requirements can be found in the Canadian Preserved Wood Foundation Manual.

Lot Development Cont.

- Survey and mark out foundation.
- Stub out the piped servicing into the crawlspace area.
- Early installation of servicing and proper compaction of the cover will prevent differential settling.
- On the undisturbed soil ensure that there is positive drainage to the sump location within the foundation.
- If a granular cover is to be installed ensure that it has very little fines and is dry prior to installation.
- Ensure that the excavation is kept clear of water.

What If You Encounter Water?

- Is it surface runoff?
- Is it groundwater; high ground water levels (source runoff) or nearby bodies of water or natural spring (source aquifer).
- Ensure that runoff is controlled by appropriate grading and ditching of the site.
- If it is not possible to keep water from the site, then a new construction location should be selected.

Notes & Tips During Construction

- Moisture often ends up trapped during construction.
- Ensure that the site (especially the crawlspace/foundation) is dry during construction. This can be aided with a construction fan or dehumidifier in the crawlspace area. Ensure that there is a vent or opening for the moisture to escape.
- Ensure that the sump system is active as soon as possible.

More Tips

- Once the roof is on ensure that there are proper downspouts and splash pads directing water away from the building.
- Inspect the foundation/crawlspace area regularly.
- Complete site grading and landscaping as soon as possible.
- Make the grade steeper than the final designed/expected grade in order to account for settling.

Signs of Moisture

During the regular foundation inspections look For the following:

- Dew.
- Water staining.
- Water pooling.
- Discoloration of wooden members, notably in the joist pockets.
- Condensation, frost, snow, etc.

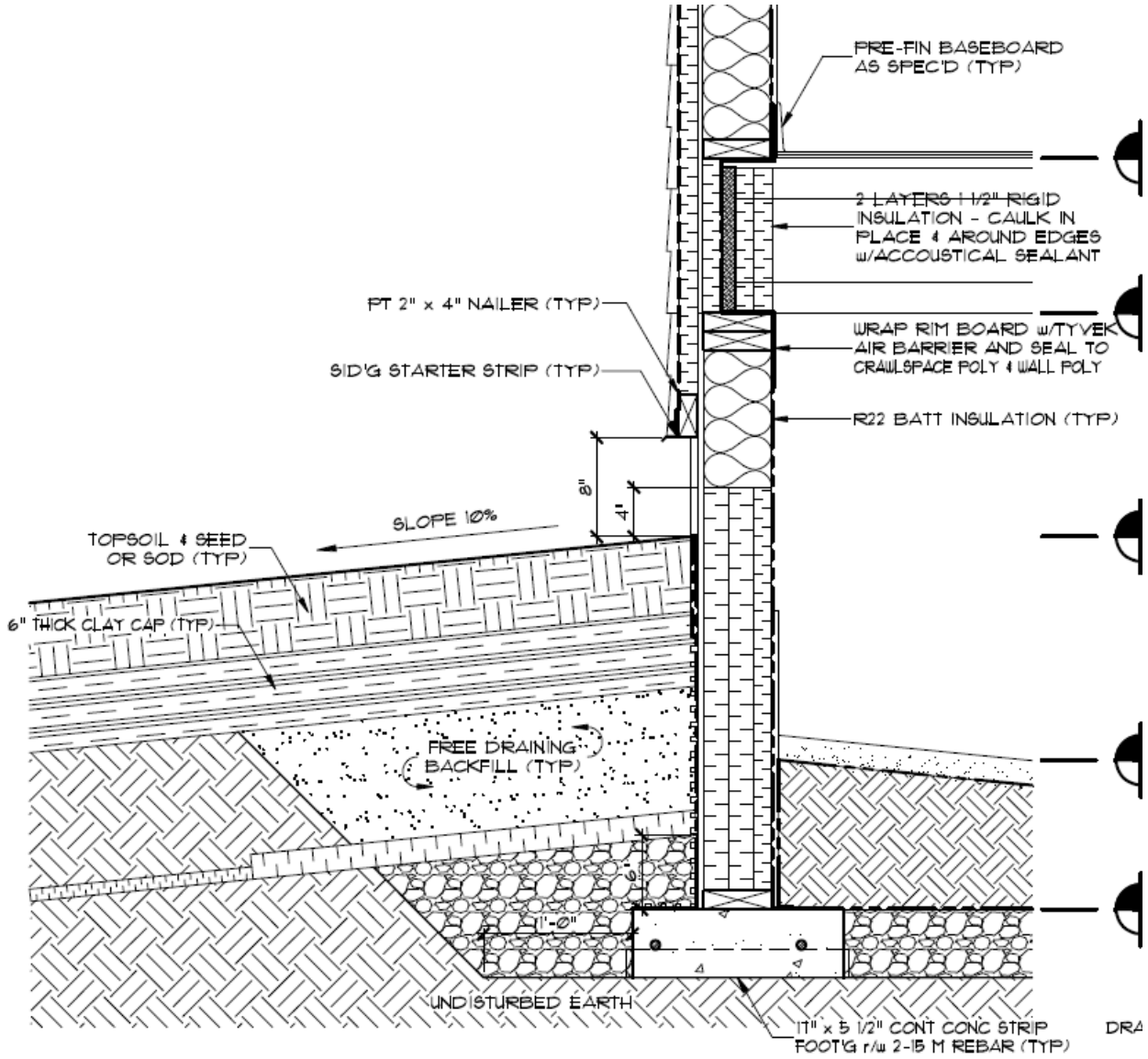
Damage Resulting From High Moisture

Damage Resulting From High Moisture

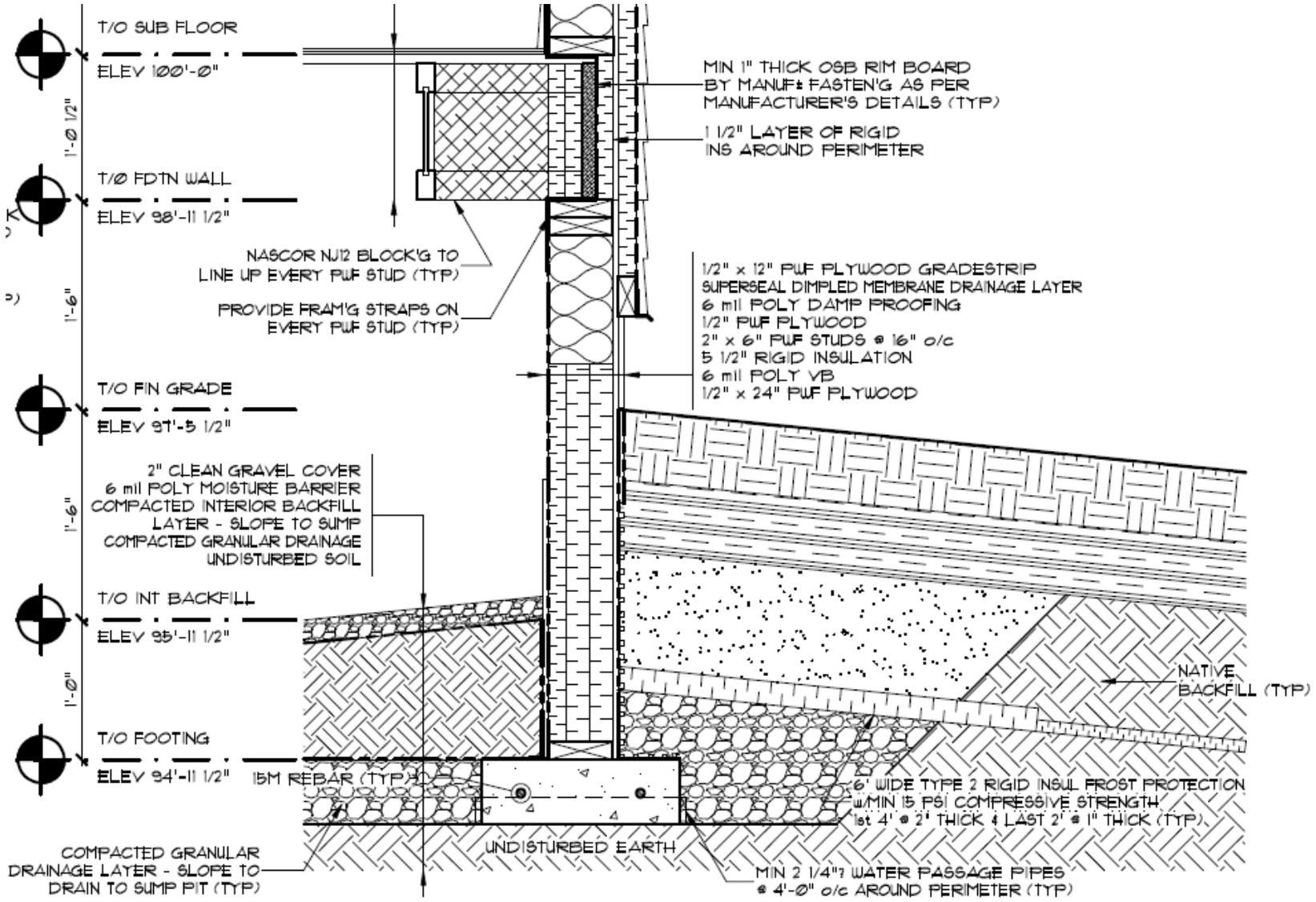
Damage Resulting From High Moisture

Damage Resulting From High Moisture

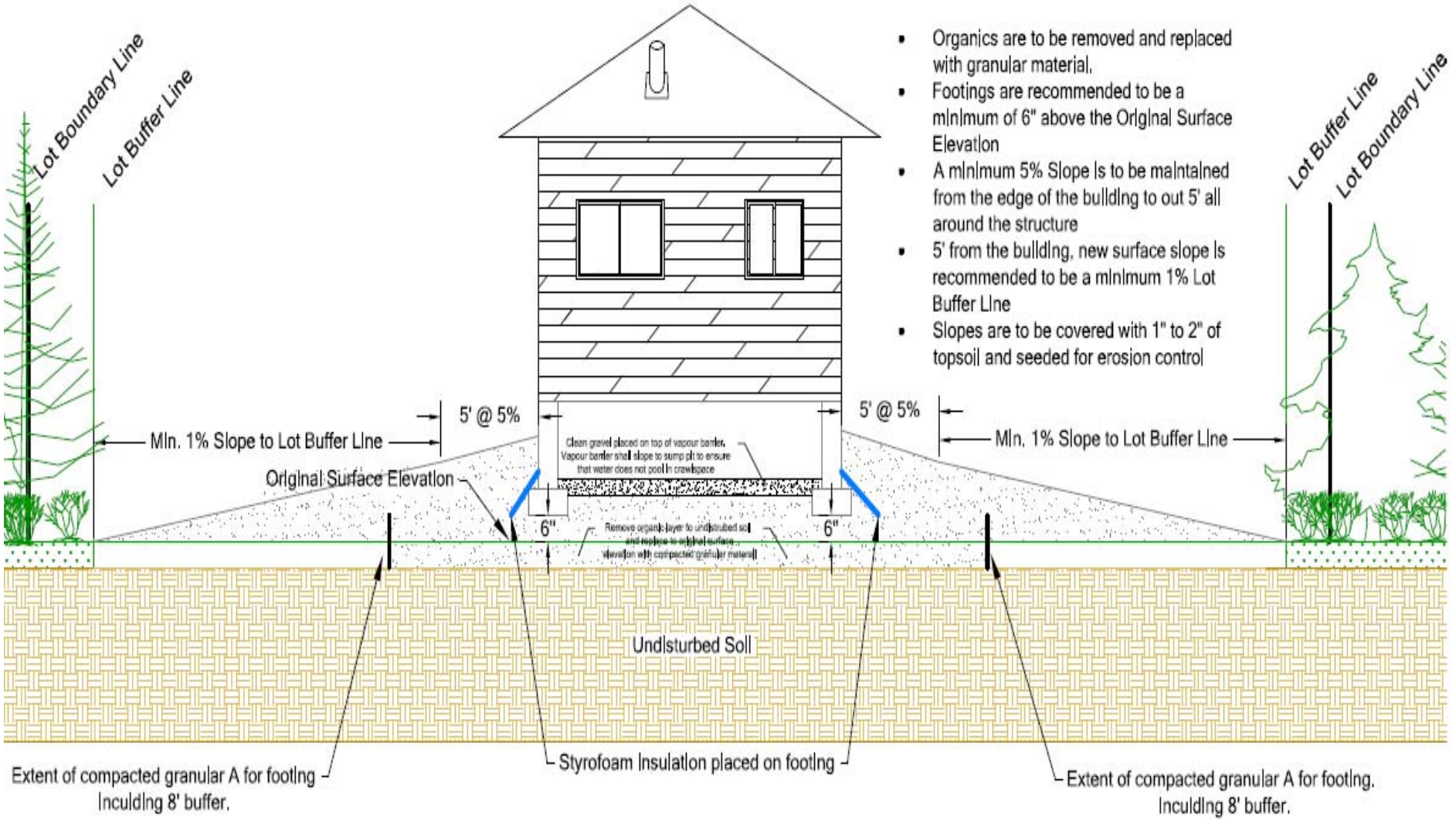
Crawlspace Construction



Crawlspace Construction Cont.



Recommended Sitework For A Crawlspace In A Low Lying Area



Granular & Formwork

Rebar

Ready To Pour

Wait For Concrete To Set

Ground Cover Sealed to Footing
Ensure All Punctures Are Sealed

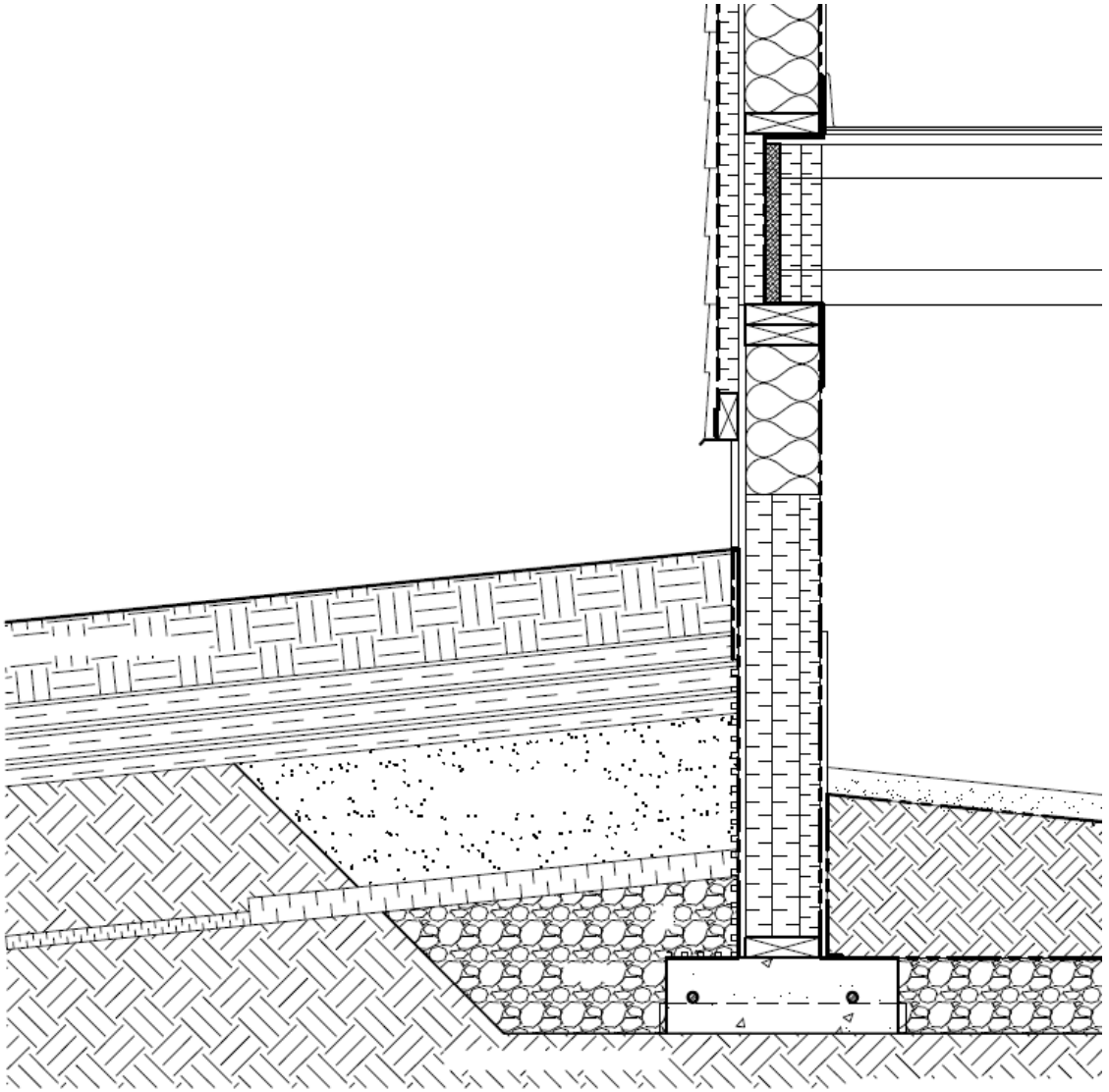
Install Posts and Beams

Optional Concrete “Mud” Slab

Crawlspace Construction Alternatives

- Use a puncture resistant membrane (durable crawlspace liner) as an alternative or included as part of an upgrade to the ground cover.
- Avoid using sand or other fine material as bedding above the ground cover.
- Must weigh down and protect the ground cover. Recommend a 2” (min.) concrete slurry as an alternative to sand or similar.
- Ensure that the joist pockets are properly insulated (including vapour barrier).

Discussion & Questions



References

- Health Canada
- OFNTSC – Illustrated Housing Guide
- OBC
- NBC
- Permanent Wood Foundations Manual
- Wood Construction Handbook
- Munhi Budhu (2000). Soil Mechanics and Foundations