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

<table>
<thead>
<tr>
<th>Aggregate Type</th>
<th>Name</th>
<th>Size Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very coarse soil</strong></td>
<td>Large boulder, LBo</td>
<td>&gt;630 mm</td>
</tr>
<tr>
<td></td>
<td>Boulder, Bo</td>
<td>200 – 630 mm</td>
</tr>
<tr>
<td></td>
<td>Cobble, Co</td>
<td>63 – 200 mm</td>
</tr>
<tr>
<td><strong>Gravel</strong></td>
<td>Coarse gravel, CGr</td>
<td>20 – 63 mm</td>
</tr>
<tr>
<td></td>
<td>Medium gravel, MGr</td>
<td>6.3 – 20 mm</td>
</tr>
<tr>
<td></td>
<td>Fine gravel, FGr</td>
<td>2.0 - 6.3 mm</td>
</tr>
<tr>
<td><strong>Coarse soil</strong></td>
<td>Coarse sand, CSa</td>
<td>0.63 - 2.0 mm</td>
</tr>
<tr>
<td></td>
<td>Medium sand, MSa</td>
<td>0.2 - 0.63 mm</td>
</tr>
<tr>
<td></td>
<td>Fine sand, FSa</td>
<td>0.063 - 0.2 mm</td>
</tr>
<tr>
<td><strong>Fine soil</strong></td>
<td>Coarse silt, CSi</td>
<td>0.02 - 0.063 mm</td>
</tr>
<tr>
<td></td>
<td>Medium silt, MSI</td>
<td>0.0063 - 0.02 mm</td>
</tr>
<tr>
<td></td>
<td>Fine silt, FSi</td>
<td>0.002 - 0.0063 mm</td>
</tr>
</tbody>
</table>
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

- $V_t$: Total volume
- $V_v$: Volume of water
- $V_w$: Volume of air
- $V_s$: Volume of soil solids
- $M_t$: Total mass
- $M_w$: Mass of water
- $M_s$: Mass of soil solids

- ORGANIC FRAGMENTS
- SAND PARTICLES: 2.00 mm - .05 mm
- SILT PARTICLES: .05 mm - .002 mm
- CLAY PARTICLES: .002 mm
- PORE SPACES
Grading of Soils

The graph illustrates the grading of soils, showing the percentage passing through different sieve sizes (mm). The curves represent different types of aggregates:

- **Fine Aggregate**
- **Upper Limit For Fine Aggregate**
- **Lower Limit For Fine Aggregate**
- **Coarse Aggregate**
- **Upper Limit For Coarse Aggregate**
- **Lower Limit For Coarse Aggregate**

The x-axis represents the sieve size (mm), while the y-axis shows the percentage passing (%).
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

DIMINISHING SOIL PRESSURE

W = FOOTING WIDTH

CRITICAL ZONE
FOR COMPACTION

SOIL PRESSURE
CUT BY 1/2 AT
THIS LEVEL

SOIL PRESSURE
CUT BY 2/3 AT
THIS LEVEL
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 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.

<table>
<thead>
<tr>
<th>Degree Days Below 1B °C</th>
<th>Required R (RSI) Value of Insulation by Zone Representing 2' (600 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Less than 3800 °C</td>
<td>10 (1.76)</td>
</tr>
<tr>
<td>3800 - 6000 °C</td>
<td>10 (1.76)</td>
</tr>
<tr>
<td>More than 6000 °C</td>
<td>10 (1.76)</td>
</tr>
</tbody>
</table>

Table 4.5.1 (a) Determining Required Insulation

Figure 4.5.1 (b) Perimeter Foundation Zones
Frost Protection

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.

- **T/O Sub Floor**: ELEV 100'-6"
- **T/O FDTN WALL**: ELEV 98'-11.25"
- **NASCOR N12 BLOCKS TO LINE UP EVERY PUF STUD (TYP)**
- **MIN 1/2" THICK OSB RIM BOARD BY MANUFACTURER'S  AS PER MANUFACTURER'S DETAILS (TYP)**
- **1 1/2" LAYER OF RIGID INSULATION AROUND PERIMETER**
- **NASCO R12 BLOCKS TO LINE UP EVERY PUF STUD (TYP)**
- **PROVIDE FRAMING STRAPS ON EVERY PUF STUD (TYP)**
- **T/O FIN Grade**: ELEV 91'-5 1/2"
- **2" Clean Gravel Cover**
- **6 mil Poly Moisture Barrier Compacted Interior Backfill Layer - Slope to Sump Compacted Granular Drainage Undisturbed Soil**
- **T/O Int Backfill**: ELEV 98'-11 1/2"
- **T/O Footing**: ELEV 94'-11 1/2"
- **Compacted Granular Drainage Layer - Slope to Drain to Sump Pit (TYP)**
- **MIN 3 1/4" WIDE TYPE II RIGID INSUL FROST PROTECTION 4" MIN (PSI COMPRESSIVE STRENGTH 4" @ 2.5" THICK 4 LBS @ 2.5" 1" THICK TYP)**
- **MIN 4'-6" O.C. AROUND PERIMETER (TYP)**
- **2" x 2" PUF PLYWOOD GRADESTRIP SUPERSEAL Dimpled Membrane Drainage Layer 6 mil Poly Damp Proofing 1/2" PUF Plywood 2" x 6" PUF Studs @ 16" O/C 5 1/2" Rigid Insulation 6 mil Poly VB 1/2" x 24" PUF Plywood**

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*Native Backfill (TYP)*

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*Undisturbed Earth*
Recommended Sitework For A Crawlspace
In A Low Lying Area

- Organics are to be removed and replaced with granular material.
- Footings are recommended to be a minimum of 6" above the Original Surface Elevation.
- A minimum 5% slope is to be maintained from the edge of the building to out 5' all around the structure.
- 5' from the building, new surface slope is recommended to be a minimum 1% Lot Buffer Line.
- Slopes are to be covered with 1" to 2" of topsoil and seeded for erosion control.

Min. 1% Slope to Lot Buffer Line

Original Surface Elevation

Undisturbed Soil

Extent of compacted granular A for footing. Including 8' buffer.
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