Construction

The Development Process

Recall from Lecture 1:

- Block of land (owner/developer)
  - OLS
    - Reference R-Plan (Boundary Survey)
    - Topographic Survey
  - Consultants (Planning, Civil, Environmental, etc.)
  - Official Plan/Zoning
  - draft plan of subdivision
  - distributed to local agencies
    - City / Region / Conservation Authority
    - police - fire - School Boards - other utilities (Bell, Cable) for comments
  - Revisions as Needed
  - Submitted to Council for Official Plan and zoning approval (as req'd)
  - provincial ministries - MMAH, MTO, MOEE etc
  - subdivision agreement (between municipality and owner)
  - engineering drawings approved
  - Go to Tender / Contract
  - **Construction**
  - Turns roads over to municipality (if applicable)

Layout and Excavate

- Layout Sewer
  - Stake sewer and created an offset line
  - Offset line must be out of the way of construction
  - location is contractor's choice

- Excavate Trench
  - Must conform to occupational Health and Safety Act
  - Must confirm to associated regulations for construction projects

Safety

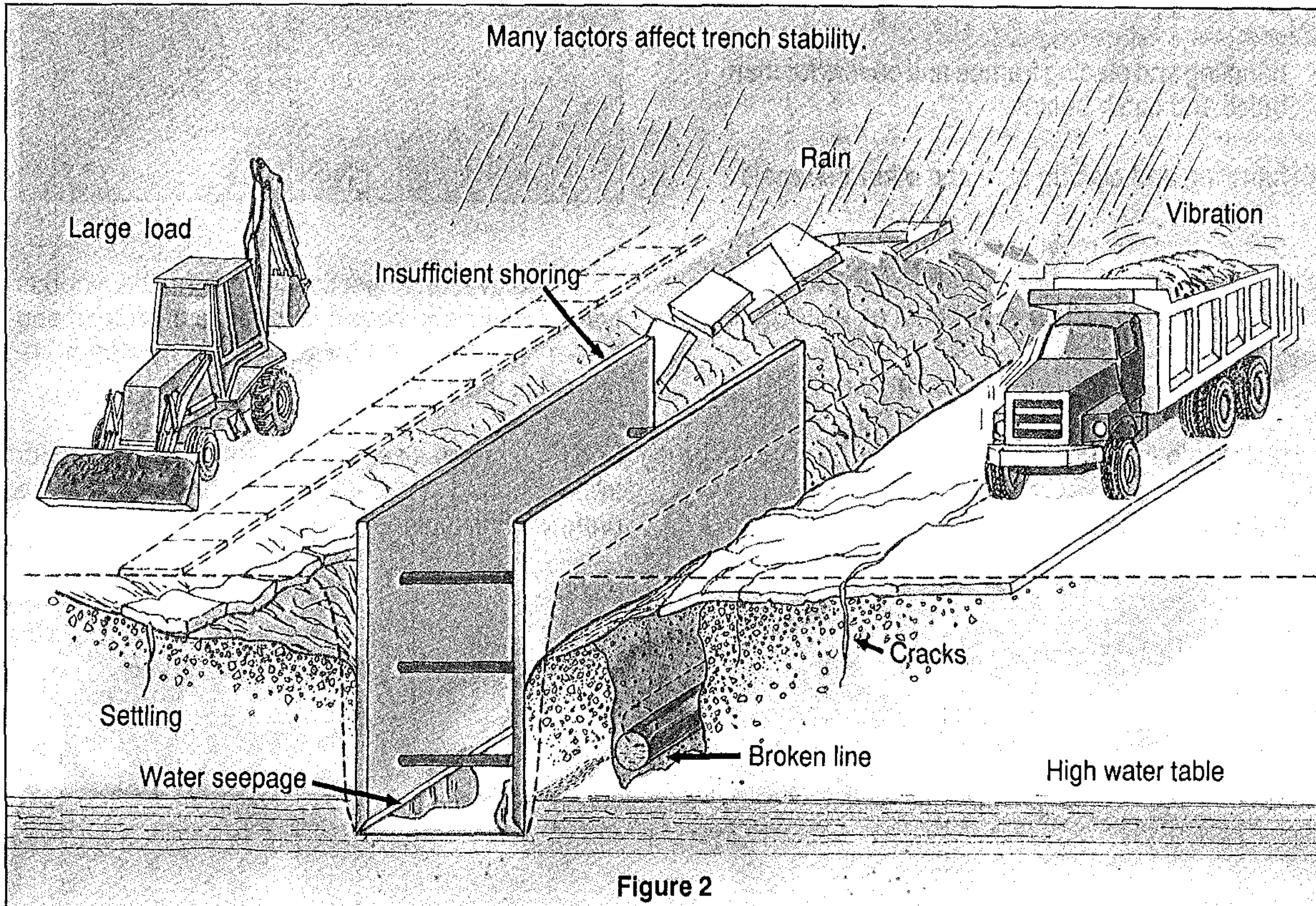


Figure 2

Find potential issues that may affect trench stability and safety

Can you spot the Danger?

Cave-ins

- There are **three** basic methods of protecting workers against trench cave-ins:

a) Sloping – cut back slope on an angle flat enough to prevent collapse
b) Shoring – is the process of supporting a building, vessel, structure, or trench with shores (props). Shoring may be vertical, angled, or horizontal.
c) Hydraulic Support Systems / Trench Boxes

- The method chosen will depend on:
  - type of construction
  - Site conditions
  - Soil type

Sloping

Shoring

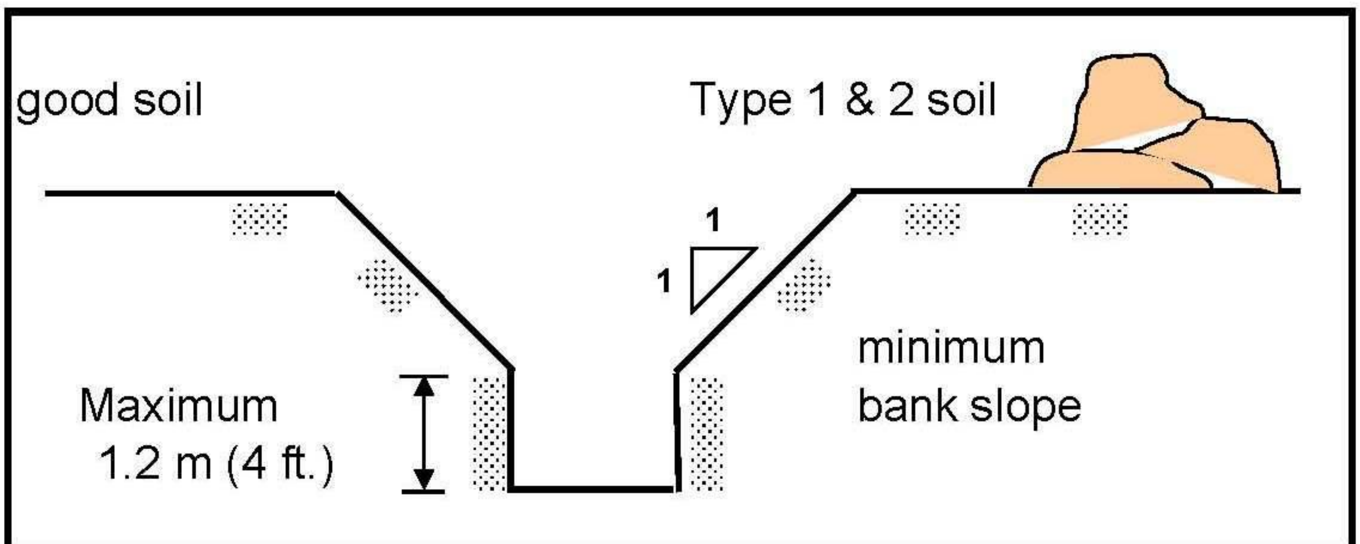
Trench Box

Soil Types

For safety purposes, soil is classified into <u>FOUR</u> different types:

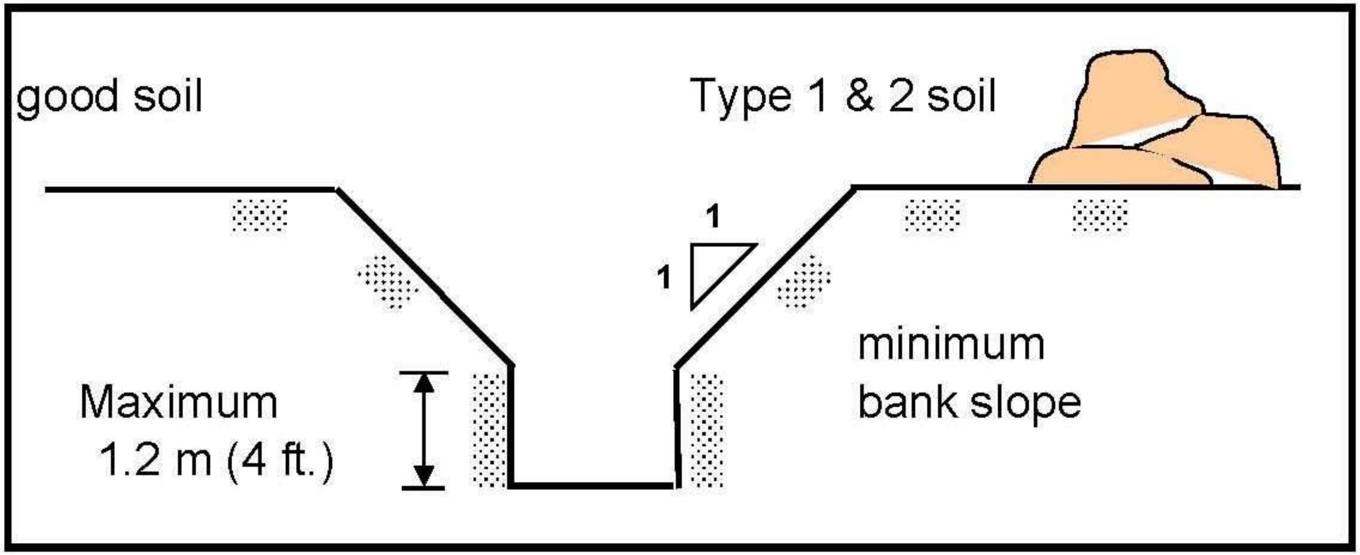
Type 1 Soil

1) hard, very dense and only able to be penetrated with difficulty by a sharp object
2) has a low natural moisture content and a high degree of internal strength
3) has no signs of water seepage
4) can be excavated only by mechanical equipment. (rock)



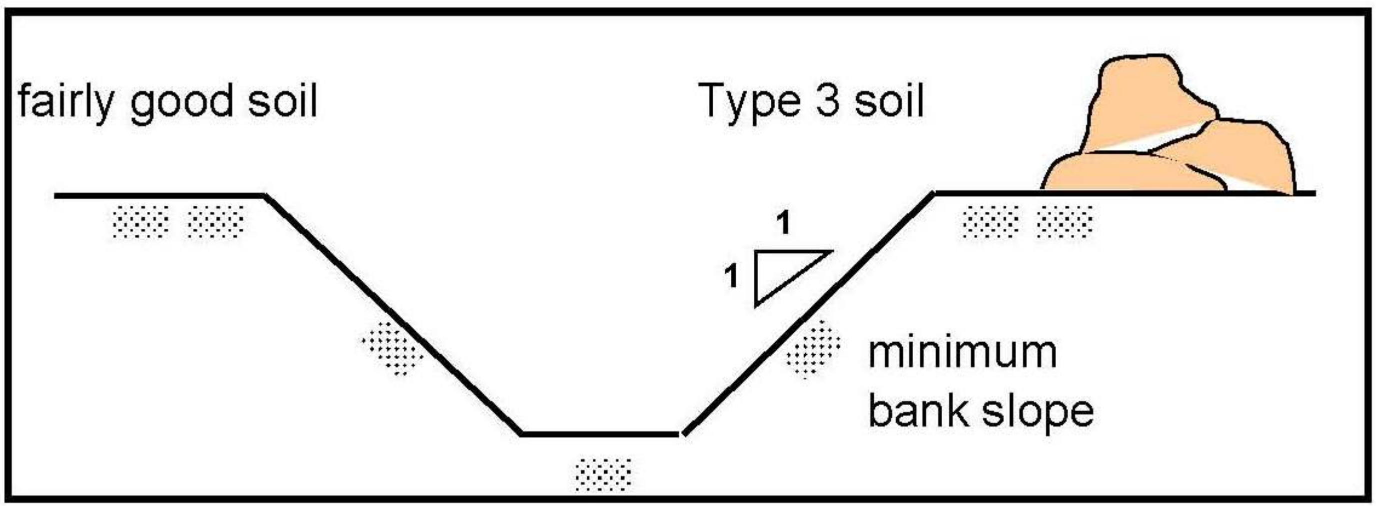
Type 2 Soil

1) is very stiff, dense and can be penetrated with moderate difficulty by a small sharp object
2) has a low to medium natural moisture content and a medium degree of internal strength
3) has a damp appearance after it is excavated (compacted angular gravels stiff or firm clay)



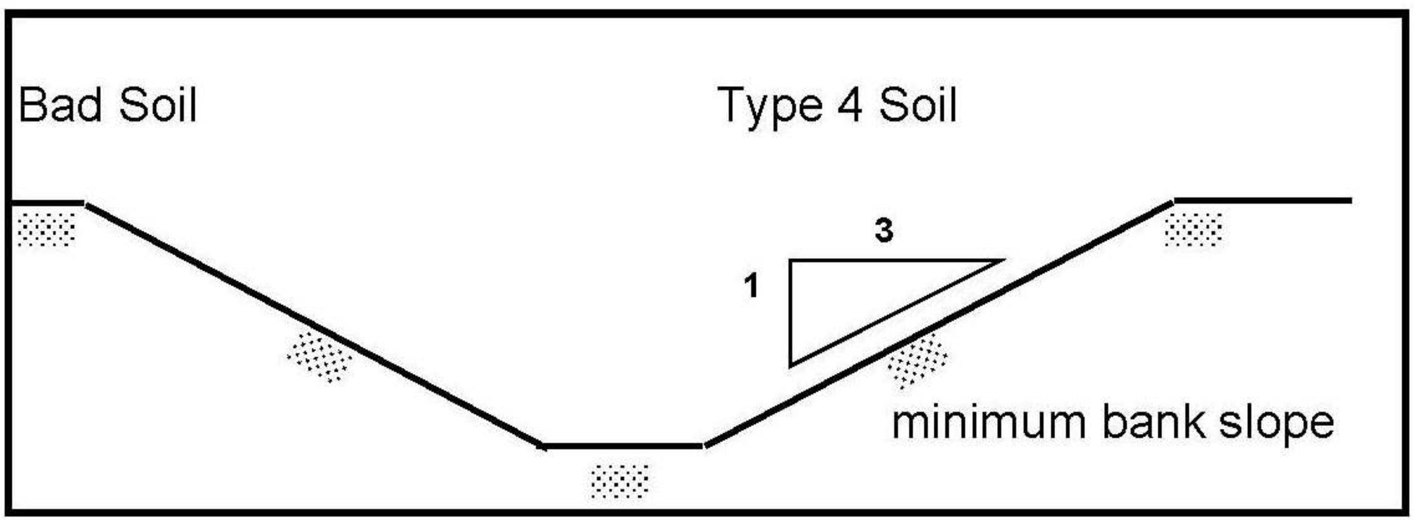
Type 3 Soil

1) is stiff to firm and compact to loose in consistency or is previously excavated soil
2) exhibits signs of water seepage. If it is dry, may run easily into a well-defined conical pile
3) has a low degree of internal strength (compacted angular sand)



Type 4 Soil

1) is a soft to very soft and very loose in consistency, very sensitive and upon disturbance is significantly reduced in natural strength
2) runs easily or flow, unless it is completely supported before excavating begins;
3) has almost no internal strength
4) is wet or muddy
5) exerts substantial fluid pressure on its supporting system.

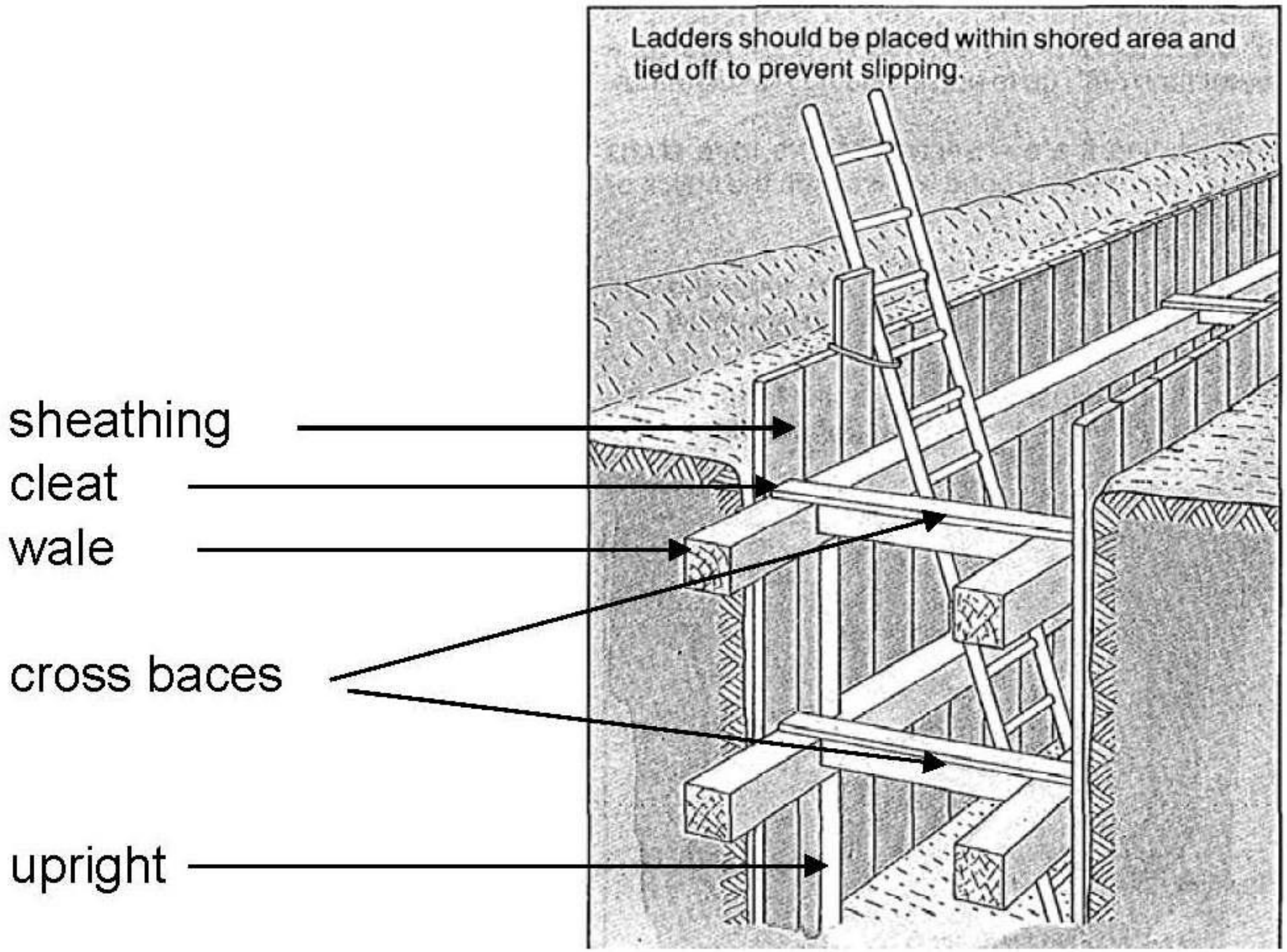


Excavation / Trench Selection

- The type of soil in which an excavation is made shall be determined by visual and physical examination of the soil at the walls of the excavation, and within a horizontal distance from each wall equal to the depth of the excavation measured away from the excavation.
- Determine the type of soil that most closely resembles it.
- If a soil contains more than one type, choose the soil of highest number (poorest soil type)

Shoring

- Shoring is used when the location or depth of the trench makes sloping back to the maximum allowable slope impractical



Shoring – Hydraulic Support System

- The Hydraulic Support system means a system that is capable of being moved as a unit, designed to resist the earth pressure from the walls of an excavation by applying a counter pressure through the struts.
- Hydraulic shoring provides a critical advantage over timber shoring because workers do not have to enter the trench to install them.
- They are also light enough to be installed by one worker, they are gauge-regulated to ensure even distribution of pressure along the trench line and they can be adopted easily to various trench depths and widths.
- Hydraulic shoring must be checked at least once per shift for leaking hoses and/or cylinders, and any other damaged or defective parts. The top cylinder of hydraulic shoring shall be no more than two feet from the top edge of the excavation. Two feet of trench may be exposed beneath the bottom of the rail or plywood sheeting.

Trench Boxes

- The prefabricated support system means a trench box. Trench boxes are different from shoring because instead of shoring up or otherwise supporting the trench face, they are intended primarily to protect workers from cave-ins.
- The components are connected to together and capable of being moved as a unit. Trench boxes are generally used in open areas, but may be used in combination with sloping and benching.

Trench Boxes (Cont'd)

- Trench boxes shall be inspected for good condition before each use.
- The excavated area between the outside of the trench box and the face of the trench should be minimized. The space between the trench box and the excavation side must be backfilled to prevent lateral movement of the box.
- Workers must enter and leave the shield in a protected manner, such as by a ladder. Workers may not remain in the shield while it is being moved.

General Requirements

a) Work shall not be performed in a trench unless another worker is working above ground in close proximity to the trench.
b) Every excavation that a worker may be required to enter shall be kept reasonably free of water
c) The walls of an excavation shall be stripped of loose rock or other material that may slide, roll or fall upon a worker
d) The walls of an excavation cut in rock shall be supported by rock anchors or wire mesh to prevent the spalling of loose rock.
e) A level area extending at least one metre from the upper edge of each wall of an excavation shall be kept clear of equipment, excavation, soil, and construction material.
f) The stability of a wall of an excavation shall be maintained where it may be affected by stockpiling excavated soil or rock or construction materials.
g) No person shall operate a vehicle or other machine and no vehicle or other maching shall be located in such a way as to affect the stability of a wall of an excavation.
h) If a person could fall into an excavation that is more than 2.4 metres deep a barrier at least 1.1 metres high shall be provided at the top of every wall of the excavation.

Construction Steps

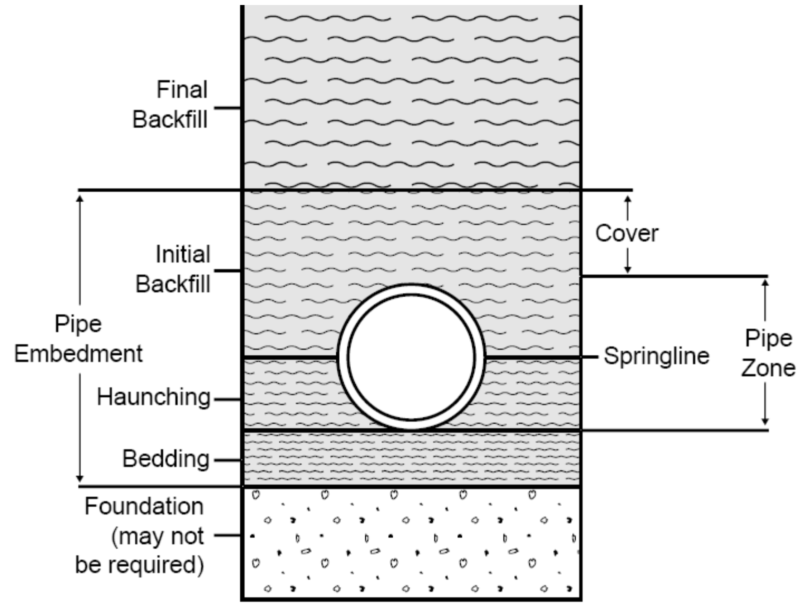
1) Select Support System
2) Prepare Trench Bottom
3) Lower Pipe Into Trench
4) Join Pipe
5) Bed the Pipe
6) Backfill and Compact
7) Restore the Cut
8) Inspection Construction

Construction Steps

1. <u>Select Support System</u>
   The walls of an excavation shall be supported by a support system unless:
   - the excavation is less than 1.2 metres deep
   - no worker is required to enter
   - no worker is required to be closer to a wall than the height of the wall
2. <u>Prepare Trench Bottom</u>
   - smooth, level, firm
   - that way the pipe is fully supported on trench bottom
   - may require stone or granular mat'l to level invert of trench
3. <u>Lower pipe into the trench</u>
   - cable, not a chain
   - slings, lifting hooks
4. <u>Join Pipe</u>
   - lubricate gasket
   - pipe is laid going upstream with bell end upstream
   - "shove the pipe home”
   - must protect the bell end

Construction Steps (Cont'd)

5. Bed the Pipe (see detail)
6. Backfill and Compact
   - selected excavated mat'l
   - no organics, rocks, frozen material
   - typical minimum - 95% standard Proctor Test
   - Compact in layers - 300 mm lifts
7. Restore the Cut
   - stone, granular, asphalt, sod, etc.
8. Inspect Construction
   - check for infiltration (adds flow, reduces capacity)
   - check for exfiltration (reduces flow, pollutes groundwater, reduces strength of backfill)
   - may require close circuit TV inspection
   - simple inspection - look up the pipe to next MH - look for a full moon

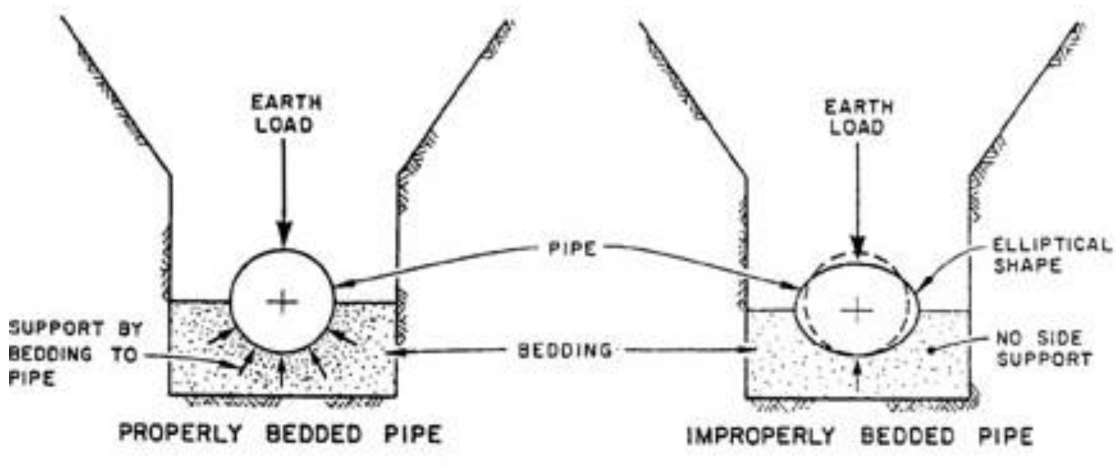


Pipe Bedding Detail

REMEMBER:
Never enter a trench more than 1.2m (4 ft) deep unless it is sloped, shored, or protected by a trench box.

Bedding

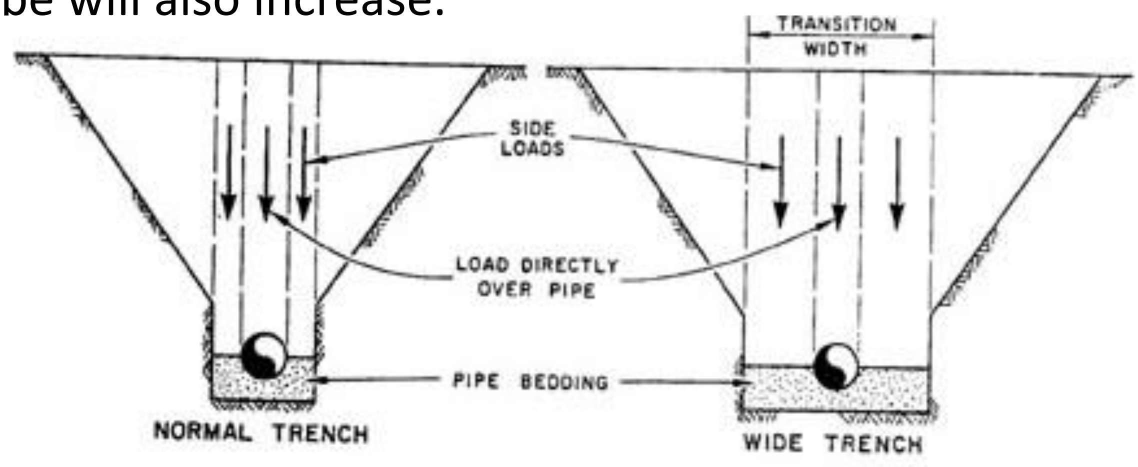
- Preparation and proper compaction of the pipe bedding is very important. The pipe's ability to support the overlying earth loads is influenced by the degree of support that the pipe has under it and at its sides.
- For FLEXIBLE pipes, such as PVC, the pipe chiefly relies on the support given by the bedding. If PVC pipe is improperly supported, the pipe will deflect vertically.
- Improperly supported PVC pipe may be either damaged or deformed possibly causing leakage at the pipe joints. The effect of bedding is illustrated in the figure above.
- As shown below, the pipe is capable of resisting earth loads and deflects only slightly when properly bedded.
- If improperly bedded, the pipe is unable to support the overlying load and deflects vertically
- For rigid pipe such as concrete pipe, the pipe will break if unsupported since the pipe cannot flex in response to loads.



BEDDING

Trench Influence

- The most important factor influencing the earth loading is the WIDTH of the trench at the level of the pipe.
- Wider trench widths increase earth loads on pipe in proportion to the horizontal width of the trench.
- The applied earth load on a pipe is a combination of two earth loads:
  - the applied earth load DIRECTLY over the pipe; and
  - a portion of the earth load ADJACENT to the pipe. The portion of earth load transferred by the adjacent soil is limited to a maximum load for a trench width termed the TRANSITION WIDTH.
- Note that widths greater than the transition width do not increase the loads beyond the maximum loading created by the transition width.
- As a general rule, trench width should not exceed the pipe diameter plus 60 cm (2 feet). If the trench width increases, the load that will be carried by the pipe will also increase.

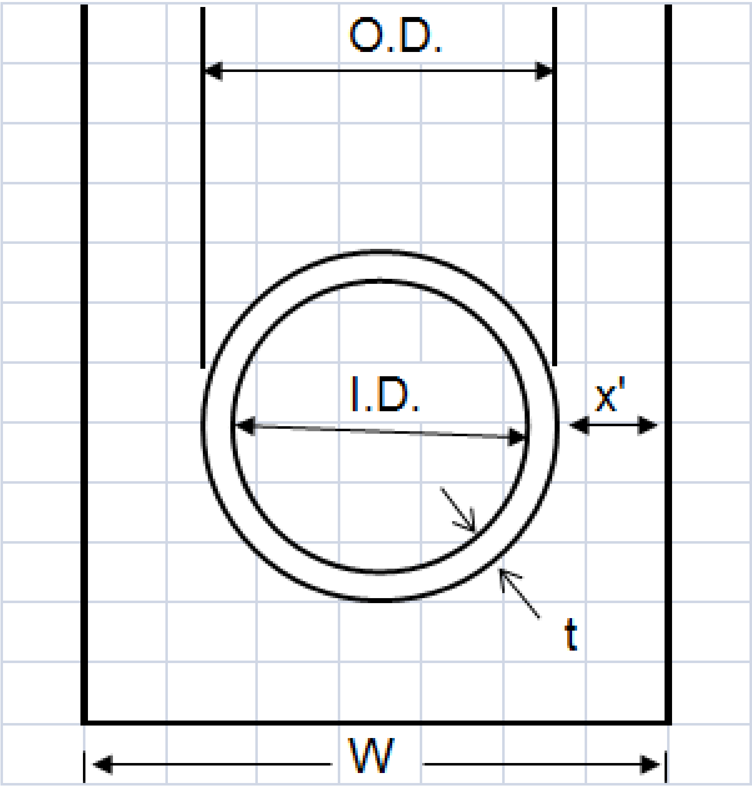


TRENCH CONFIGURATION

Trench Width Calculation

- Width = O.D. + 2('x')
  - O.D. = I.D. + 2t

  (circular pipe)

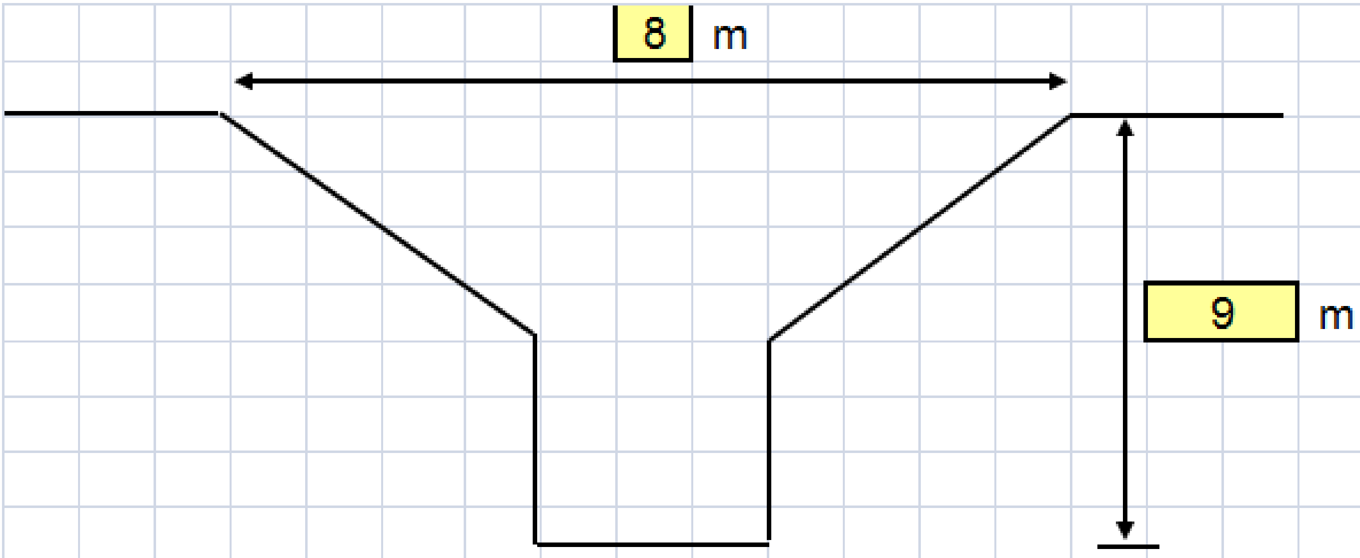


If thickness of pipe is unknown, then calculates using:

$$t = \left(\frac{I.D.}{300} + 1 \right) \times 25$$

<u>Note: 'x' is the CLEARANCE on each side of the pipe. This value varies but is usually between 150mm and 800mm. If not given, make assumption of I.D. / 4. but NOT less than 150mm.</u>

Example 1: Trench Width Calculation



Given:

- Trench depth = 9 m
- Pipe dia. = 1800 mm
- Max. width = 8 m

Assumptions:

- Assume 300mm clearance between pipe and trench wall
- Must add 0.3m to height of trench box as safety factor

<u>Determine the HEIGHT of Trench Box Support System</u>

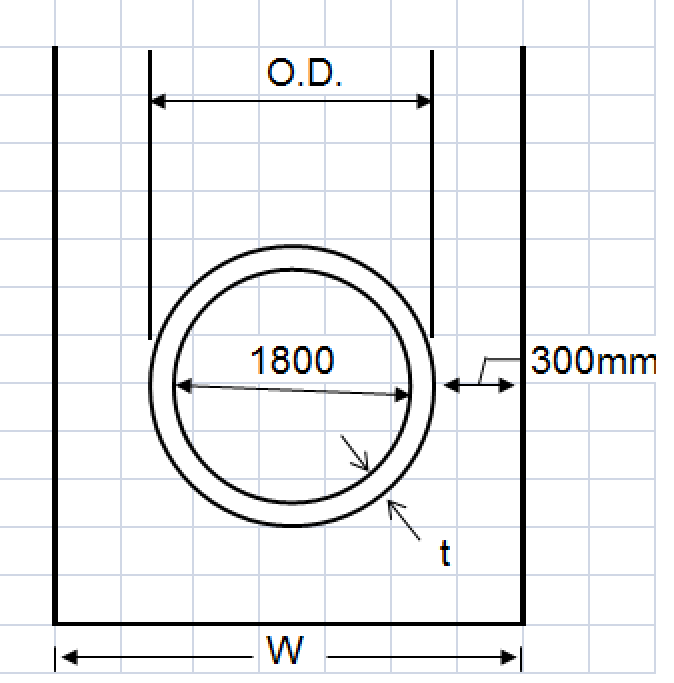
Example 1 (Cont'd)

Step 1: Calculate Thickness of pipe

- $t = (I.D./300 + 1) \times 25$
- $t = (1800/300 + 1) \times 25$
- $t = 175$ mm

Step 2: Calculate O.D.

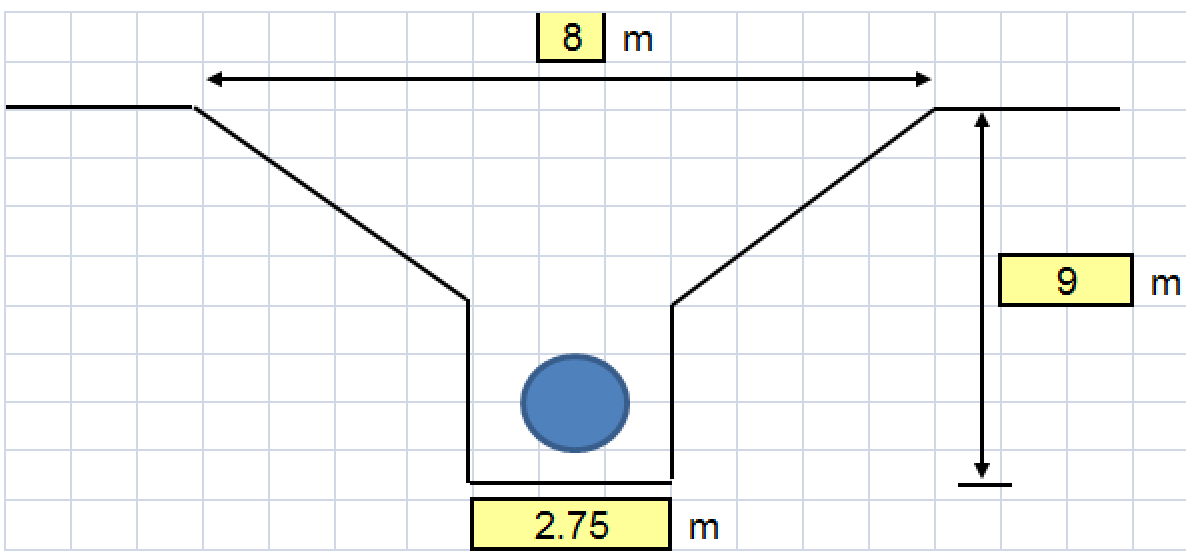
- O.D. = I.D. + (2)x(t)
- O.D. = 1800 mm + (2)x(175 mm)
- O.D. = 2150 mm



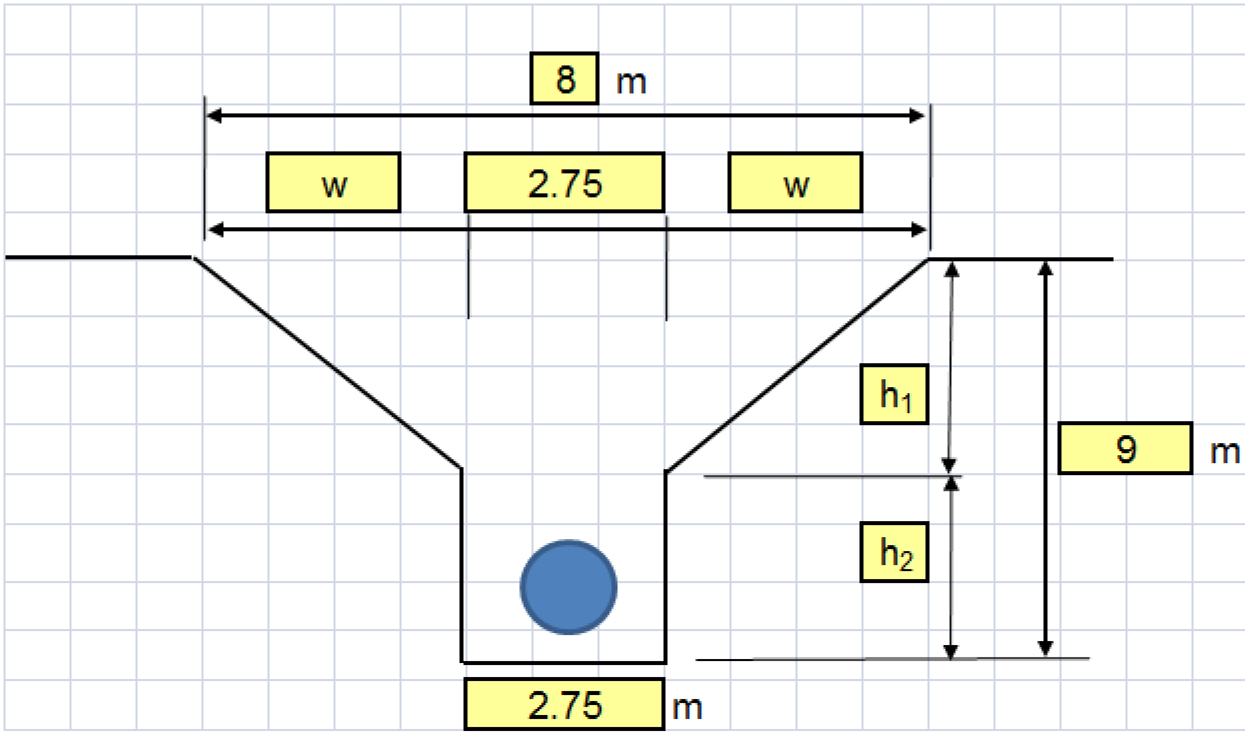
Example 1 (Cont'd)

<u>Step 3</u>: Calculate Width of Trench

- Width = O.D. + 2('x') (recall: x=300 mm)
- Width = 2150 mm + 2(300 mm)
- Width = 2750 mm or 2.75 m



Example 1 (Cont'd)



<u>Step 4</u>: Calculate 'w'

- 8m = 2.75m + (2)x(w)
- w = (8-2.75) / 2
- w = 2.625 m

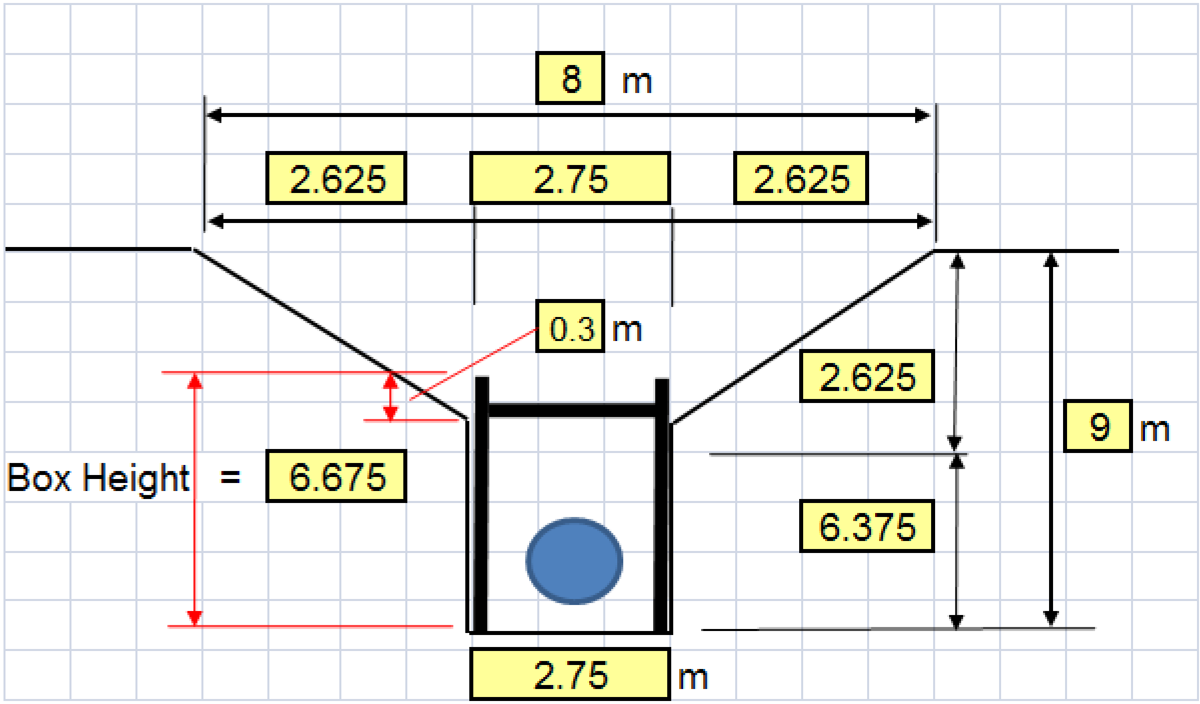
<u>Therefore</u>

- H_1 = 2.625 m

(assuming a 1:1 slope)

- H_2 = 6.375 m

Example 1 (Cont'd)



<u>Step 5</u>:

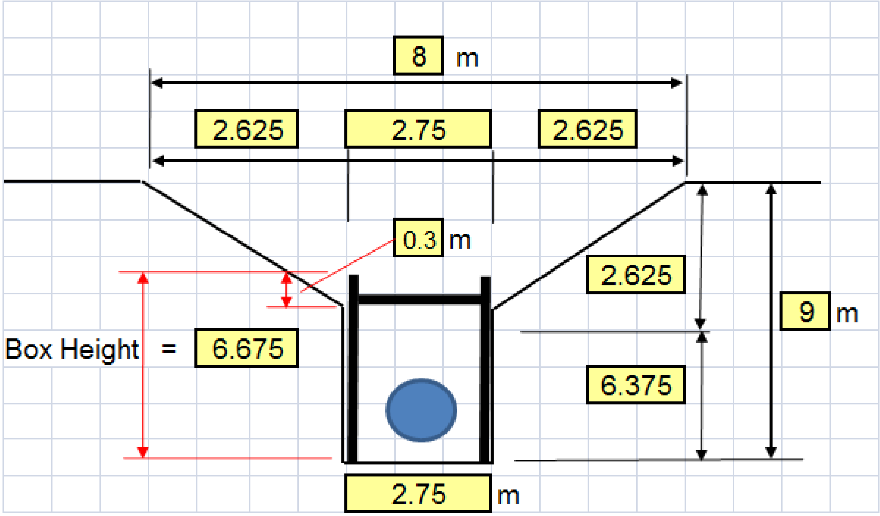
Box Height = 6.375m + 0.300m

<u>Box Height = 6.675 m</u>

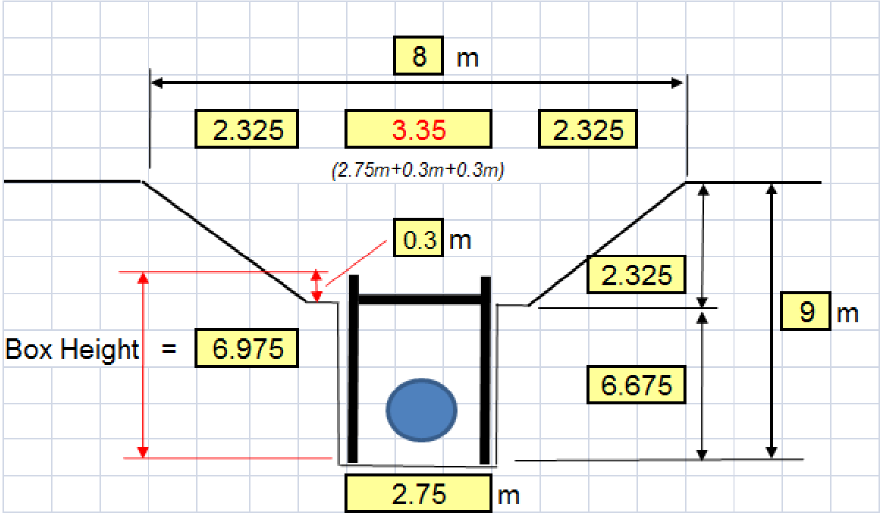
(remember we had to add 300mm to box height as safety factor)

Let's EXPAND Example 1
What if we want to add a 0.3m BENCH?

Previously we had:



But with the bench, we have:



Note how the 1:1 cut slope changes:

Both WIDTH and HEIGHT is reduced by 0.3m

OUR TRANSITIONAL HEIGHT IS REDUCED, THEREFORE OUR TRENCH HEIGHT INCREASES

Box Height = 6.675 m+ 0.300m = 6.975m