

On grade drilling !!!

Guidelines to install products with
high precision on grade using
HDD.



Challenges step by step

- Soil conditions
 - A drillhead is always looking for the path of least resistance
 - Soil with consistent hardness at the depth where the installation needs to be done.
 - Soil investigation is recommended.
- Drill a pilot bore with high precision in inclination, keep grade.
 - The location system needs to be accurate enough to measure the required inclination
 - The drillhead should have very limited steering
- The reamer should precisely follow the pilot.
- Product should be installed using tooling that will follow the exact trajectory of the reamed hole.



Soil conditions/investigation



CONE PENETRATION TEST CPT
Split spoon sampler - 50 mm diameter
Driving in soil by hammer blows
Hammer: 63 kg
Fall height 750 mm (2,5 ft)
Penetration 450 mm (1,5 ft)
N-value: # blows over last 300 mm (1 ft)



SPT - UNDRAINED SHEAR STRENGTH

SPT N value	Consistency	Undrained shear Strength [kPa]
< 2	Very soft	< 10
2 - 4	Soft	10 – 20
5 - 8	Firm	20 – 40
9 - 15	Stiff	40 – 75
16 - 30	Very stiff	75 – 150
> 30	Hard	> 150

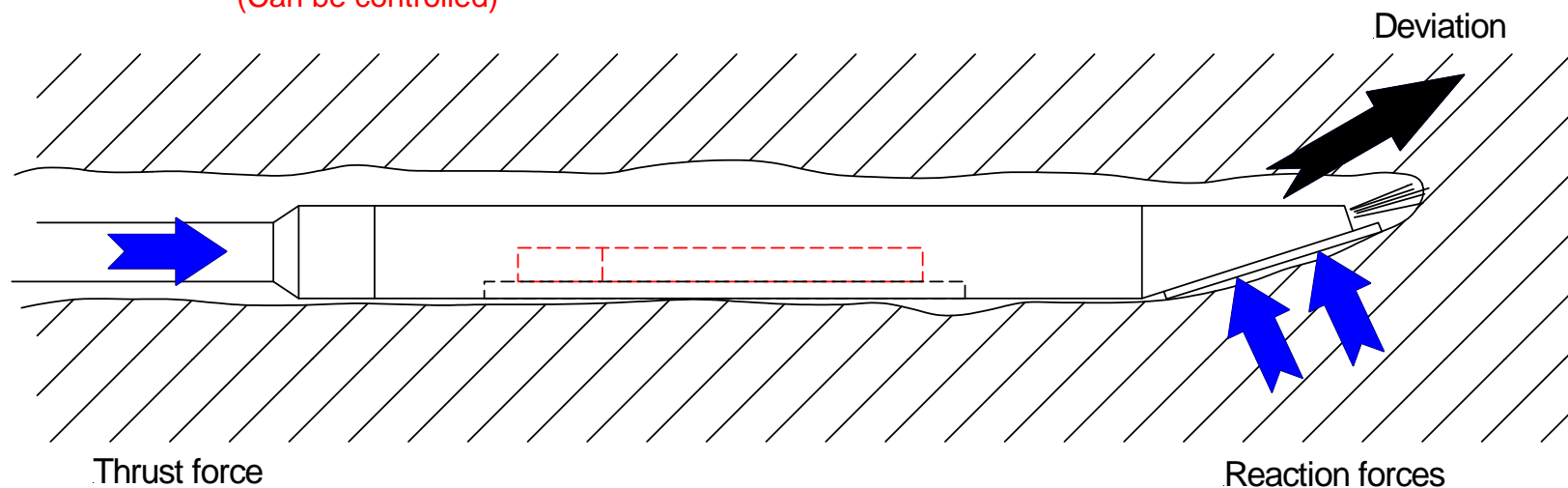


ROCK STRENGTH

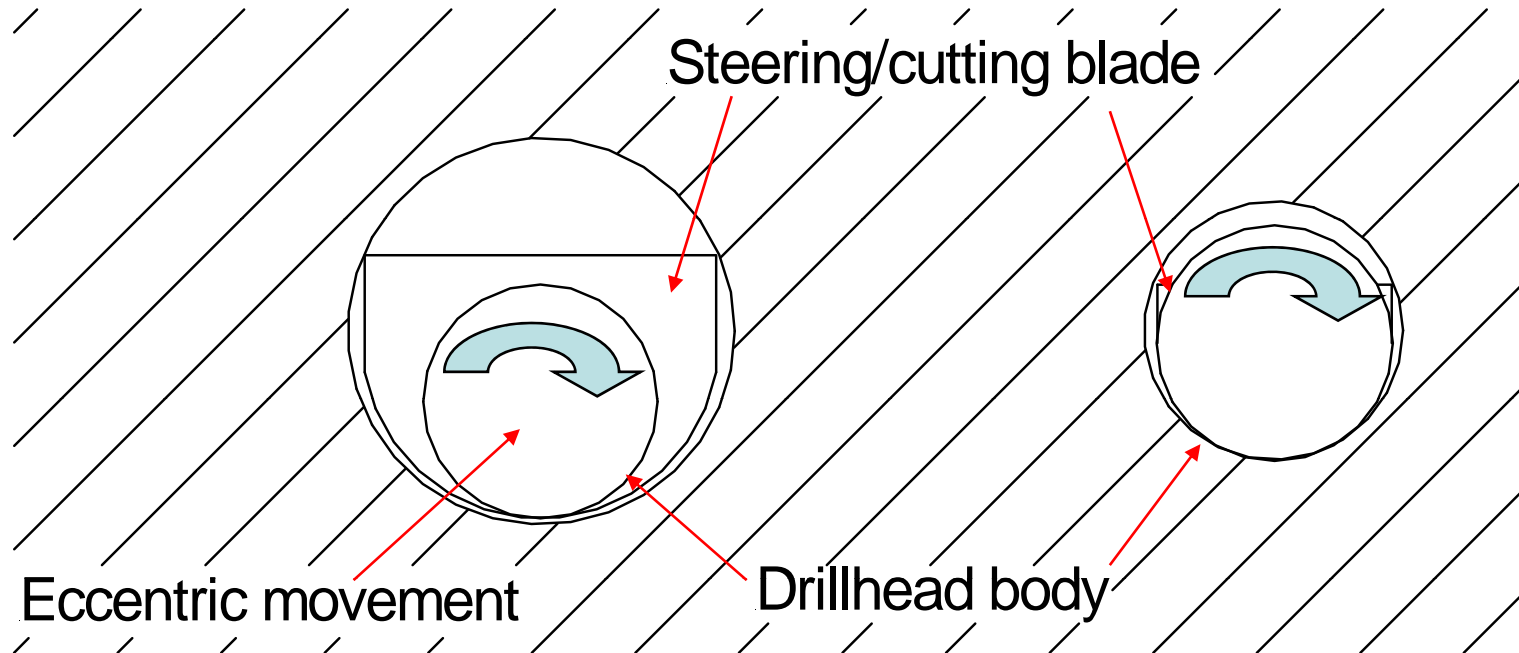
Term	Field definition	Unconfined compressive strength (MN/m ²)
Very weak	Gravel size lumps can be crushed between finger and thumb.	< 1.25
Weak	Gravel size lumps can be broken in half by heavy hand pressure.	1.25 to 5
Moderately weak	Only thin slabs, corners or edges can be broken off with heavy hand pressure.	0.5 to 12.5
Moderately strong	When held in the hand, rock can be broken by hammer blows.	12.5 to 50
Strong	When resting on a solid surface, rock can be broken by hammer blows.	50 to 100
Very strong	Rock chipped by heavy hammer blows.	100 to 200
Extremely strong	Rock rings on hammer blows. Only broken by sledgehammer.	> 200

Steering

- The reaction forces on the steering plate force the drillhead to deviate.
- In soft soil the drillhead will act as a compaction tool when pushed forward (without rotation)
- In harder soils segment cutting will be needed to move forward.
- Increased nozzle fluid pressures are sometimes used to facilitate steering (read less thrust force)
- The amount of deviation is related to:
 - Angle and **Size** of the slant face
 - Strength of the formation
 - **Nozzle fluid pressure**
 - **Size of the hole**
 - Length and diameter of the entire drill head assembly
 - Flexibility of the rods**(Can be controlled)**



Cutting action



- A large overcut versus the drillhead body can easily result in deflections
 - The more room we give the drillhead to bend in the hole, the less we can control the amount of steering
 - Natural tendency
 - Drillhead moves right and up in compact conditions
 - Drillhead moves down right in soft conditions
- The overcut should be kept as small as possible still allowing drilling fluid to clear the face

Universal Drillhead



- Take a minimum over cut.
 - Fluid passage for cuttings transport and cooling.
- A pointed duckbill positioned in the center will prevent eccentric cutting !
- The size and shape will have to be fine-tuned for the local soil conditions !!!

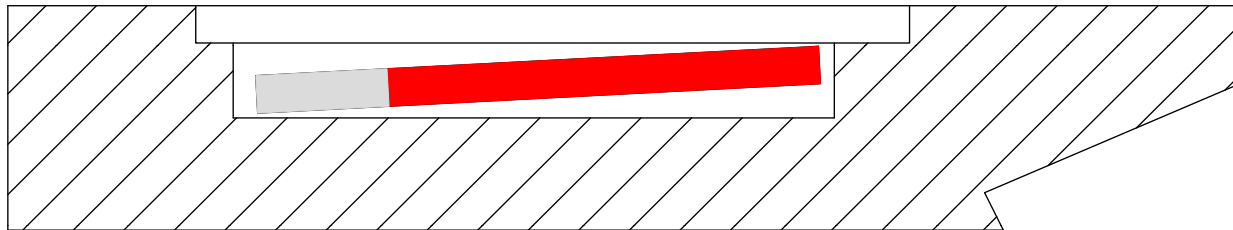
Location system

- Digitrak
 - Each Mark series locator system has at least one 0.1% precision transmitter in its range
 - With the Eclipse multiple 0.1% transmitters are available
- Radio detection
 - Transmitters available with a precision up to 0.2%

$$\begin{aligned} 0.1\% &= 0.057 \text{ degrees} \\ 0.2\% &= 0.114 \text{ degrees} \\ \dots\% &= 100 \times \tan(\dots \text{ degrees}) \end{aligned}$$



Drillhead & transmitter



- The probability for a misalignment between the transmitter and the drill head.
- The inclination measurement from the transmitter can have an error towards the actual inclination (90 degrees towards the earth gravity vector)

Universal Transmitter Housing-Sewer Kit



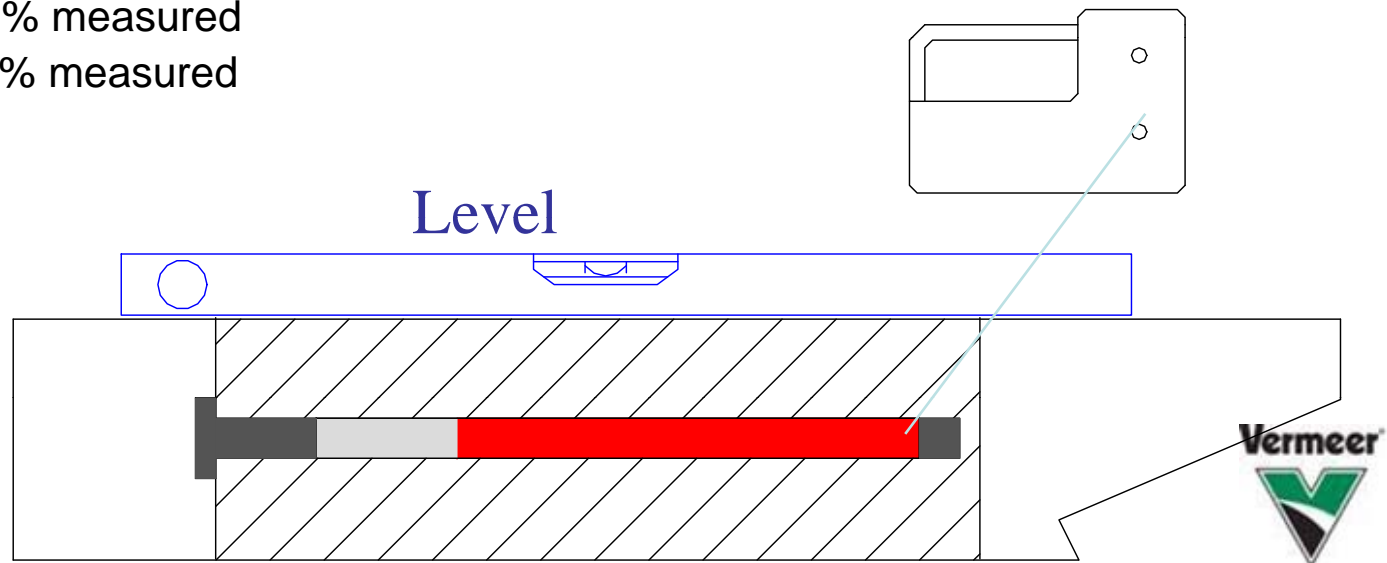
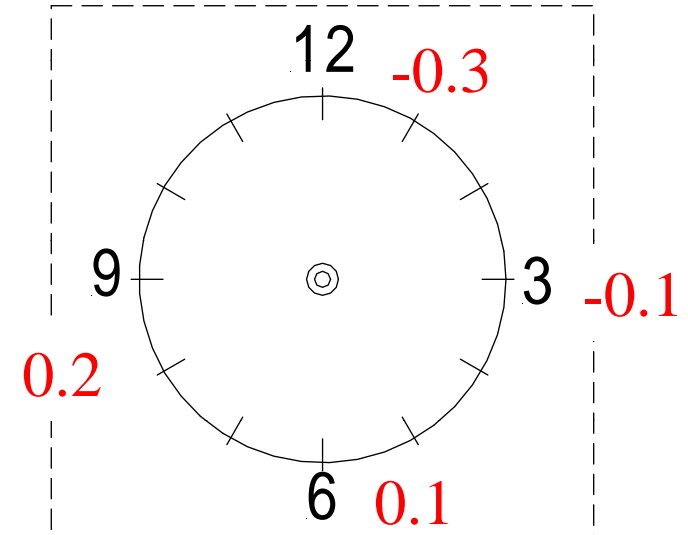
- Transmitter shown installed with Sewer Components; Pitch Adjustment block at upper right

- Pitch Adjustment Block Assy, Transmitter Cap, and Isolator Strip shown at right with Transmitter ready to install

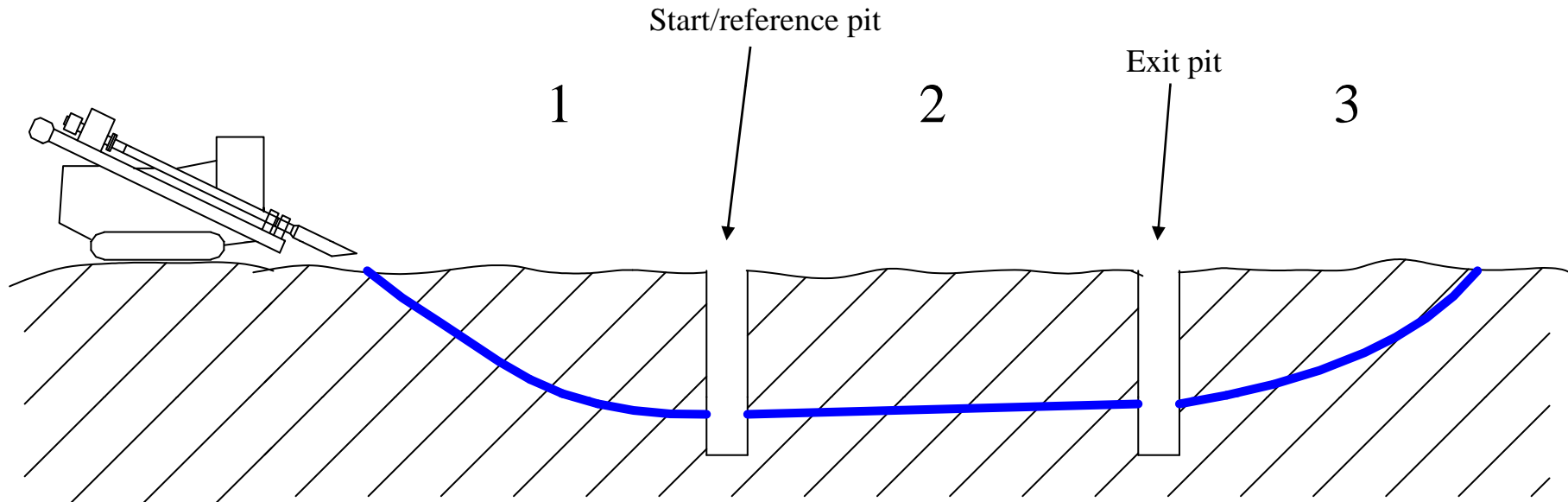


Transmitter/drill head calibration

- Measure the inclination at 3,6,9 and 12 with the drill head to confirm 0% inclination (by means of a level).
- Always measure the inclination at that same clock position during drilling
- Use the given inclination at the chosen clock position as 0% reference
eg always measuring at 3 means that
 - 0 % real= - 0.1 % measured
 - 0.7% real = 0.6% measured



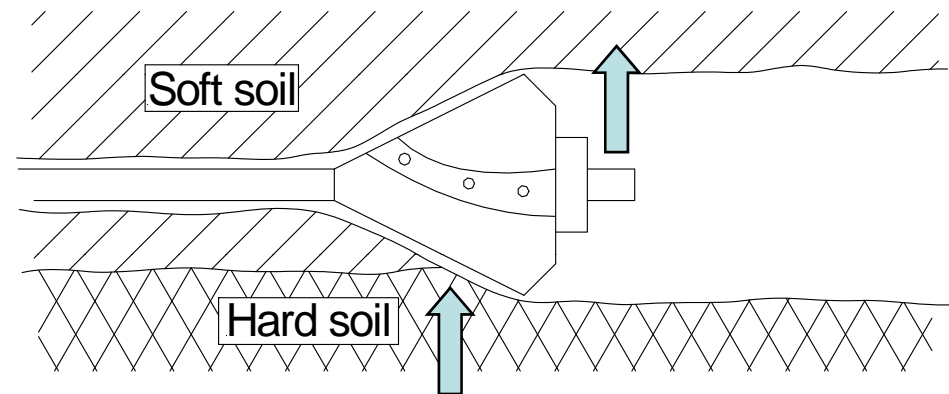
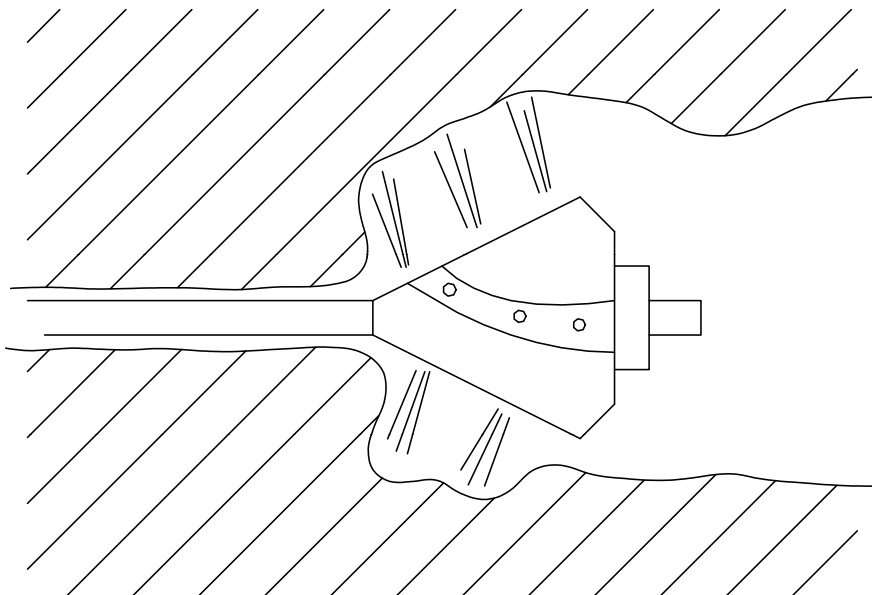
Pilot bore setup.



- Use a standard drillhead to steer the pilot up to where the on grade part starts, be sure that the last rod before the pit is approximately on the same inclination as in section 2 and straight.
- Replace or adjust the drillhead/drillbit to fit the required precision and soil conditions, hold the drillhead on the right depth and inclination level at the start of the on grade part.
- If there is an exit pit then drill-out with the standard drillhead, without an exit pit just pull the drillhead back in the start/reference pit, change it by the standard one and drill through the already made hole (section 2) and steer out.

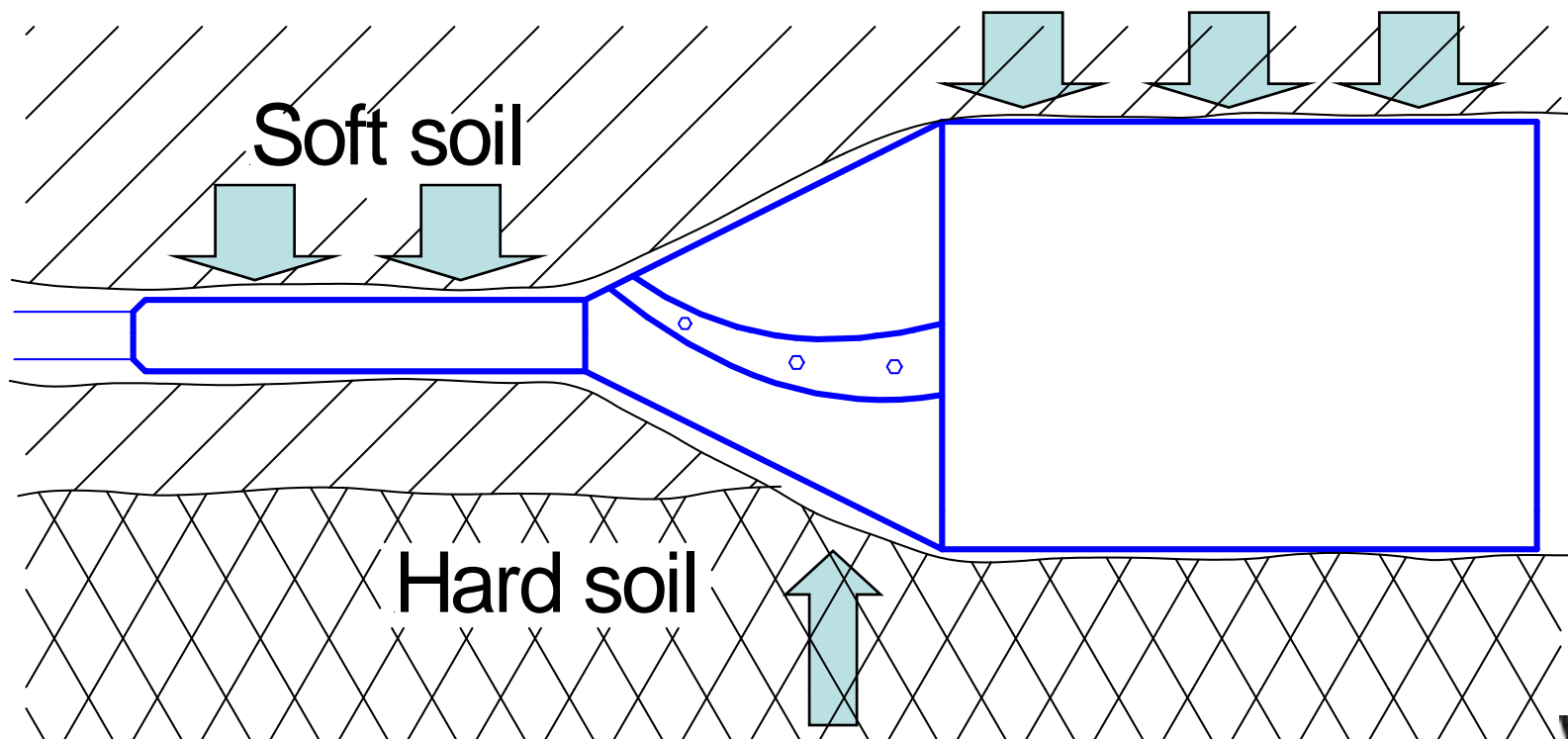
Reaming

- Traditional
 - 20 – 50 % overcut towards the product related to the length of installation.
 - Buoyancy will determine if the pipe is on top or on the bottom from the hole.
 - The hole diameter can change when using high fluid pressures during reaming
 - Reamer is always looking for the easiest way, deflection can occur in both inclination and deviation (limited surface contact)



How to ream?

- Ream the hole 10 % bigger than the product !
- Use a reamer with a large surface area (front and or back)
 - Surface area avoids deflection



How to install the product ?

- Pre-ream with the final reamer size to:
 - Make the hole
 - Use borefluid to stabilize the hole and to make sure that the soil is transported out (Fluid density in-hole should be low)
- The product is then pulled in with a minimum amount of fluid



Conclusion!

- Installing product with high precision in inclination can be done by means of HDD
- Pay attention to:
 - Soil conditions
 - Small steering surface and overcut
 - Tool and transmitter calibration
 - Preream with large surface reamer
 - Pull with low amount of fluid



Questions?

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