PÅLDAG 17

Bored Piling in Sweden - forty years experience is one year's cock-ups forty times

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- Introduction
- Experience
- Lessons learned over the years
- 2m Ø bored piles to 60m

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Experience

- Graduated in Civil Engineering in 1976
- Short term research project at Von Karmen Institute (Brussels) (Mach 5 model tests on NASA Shuttle)
- Norsk Vandbygningskontor A/S (Oslo) (1977-1980)
- ICOS (GB) Ltd (1980-1982) – Norges Bank
- Stent Foundations – Middle East (1982-1986)
- Bachy Soletanche Northern Europe (1986-1999)
- Ceecom Consult (1999-present)
- Current Chairman on EFFC Contracts WG (21 years)
- Deputy Chairman on EFFC/DFI Concrete and Fluids Guides

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Top 10 Lessons Learned

1. Deep foundation construction is an art, not a science
2. Most major problems are created by simple human error(s)
3. Minor error(s) are often compounded to create serious problems (rarely one reason for a problem)
4. Contractors do not always learn from their mistakes or those of others
5. “Reinventing the wheel” is alive & well
6. Teamwork between parties pays dividends
7. Collaborative forms of contract work
8. Fair allocation of risks reduces problems
9. On complex projects, full scale trials are invaluable & save money overall (e.g. Heathrow T5 roof)
10. Independent expert advice & experience is invaluable

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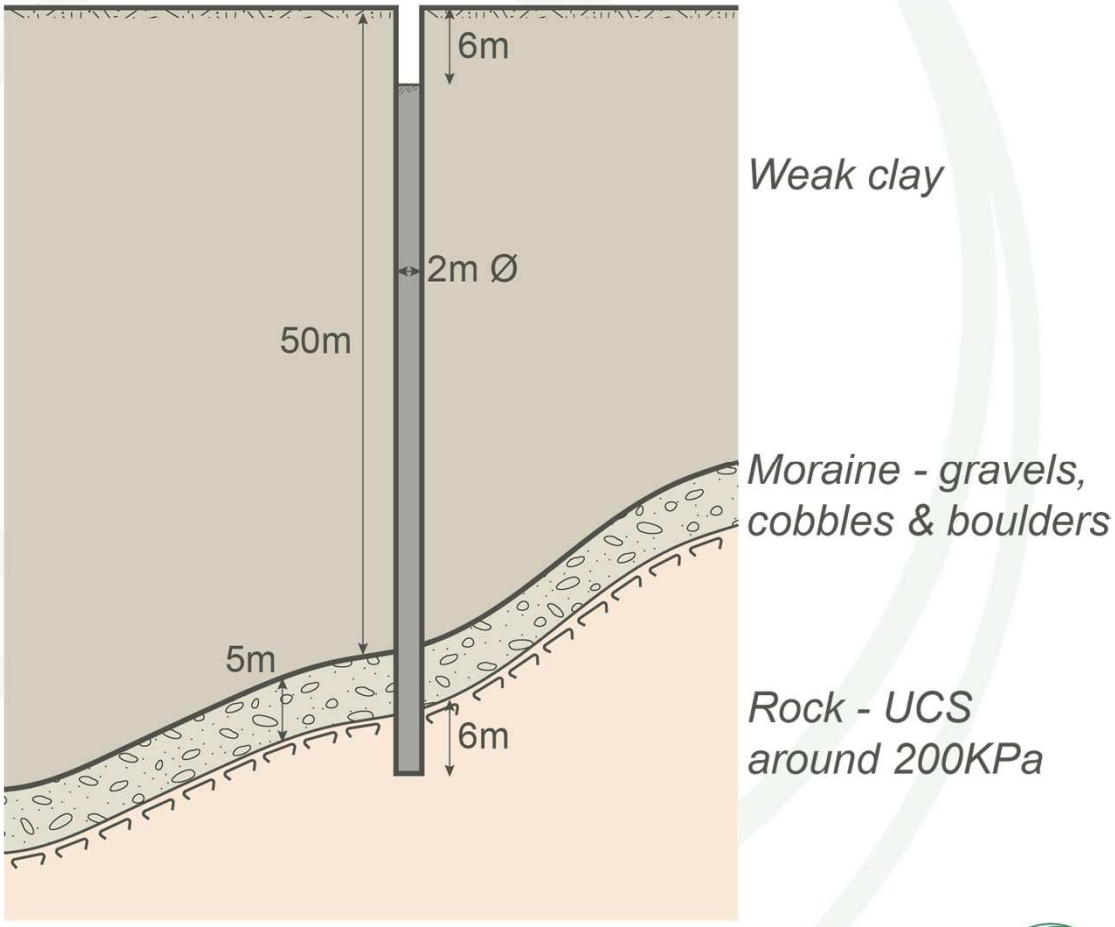
2m Ø bored piles to 60m in Göteborg

How hard can that be? Answer: *Very!*

A. Drilling the clay
B. Drilling the moraine
C. Drilling the rock
D. Cleaning the base
E. Detailing the cage
F. Concreting the pile
G. Testing the completed pile



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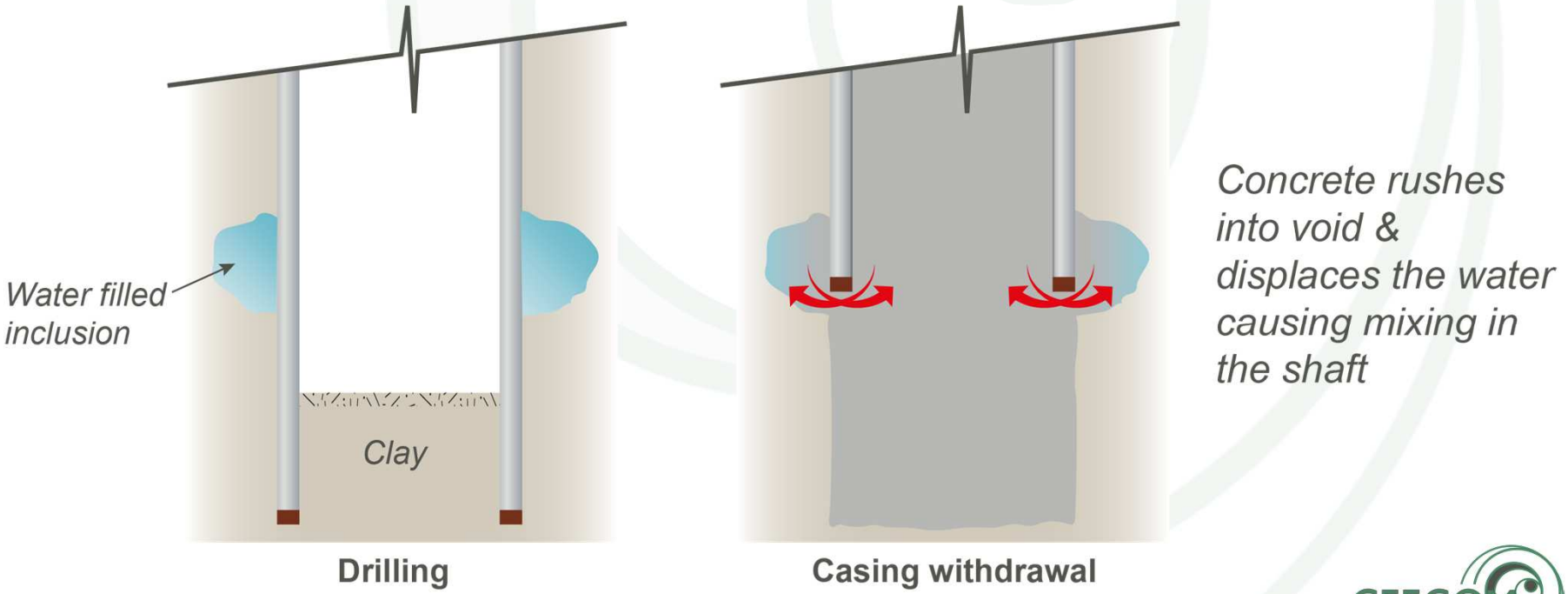
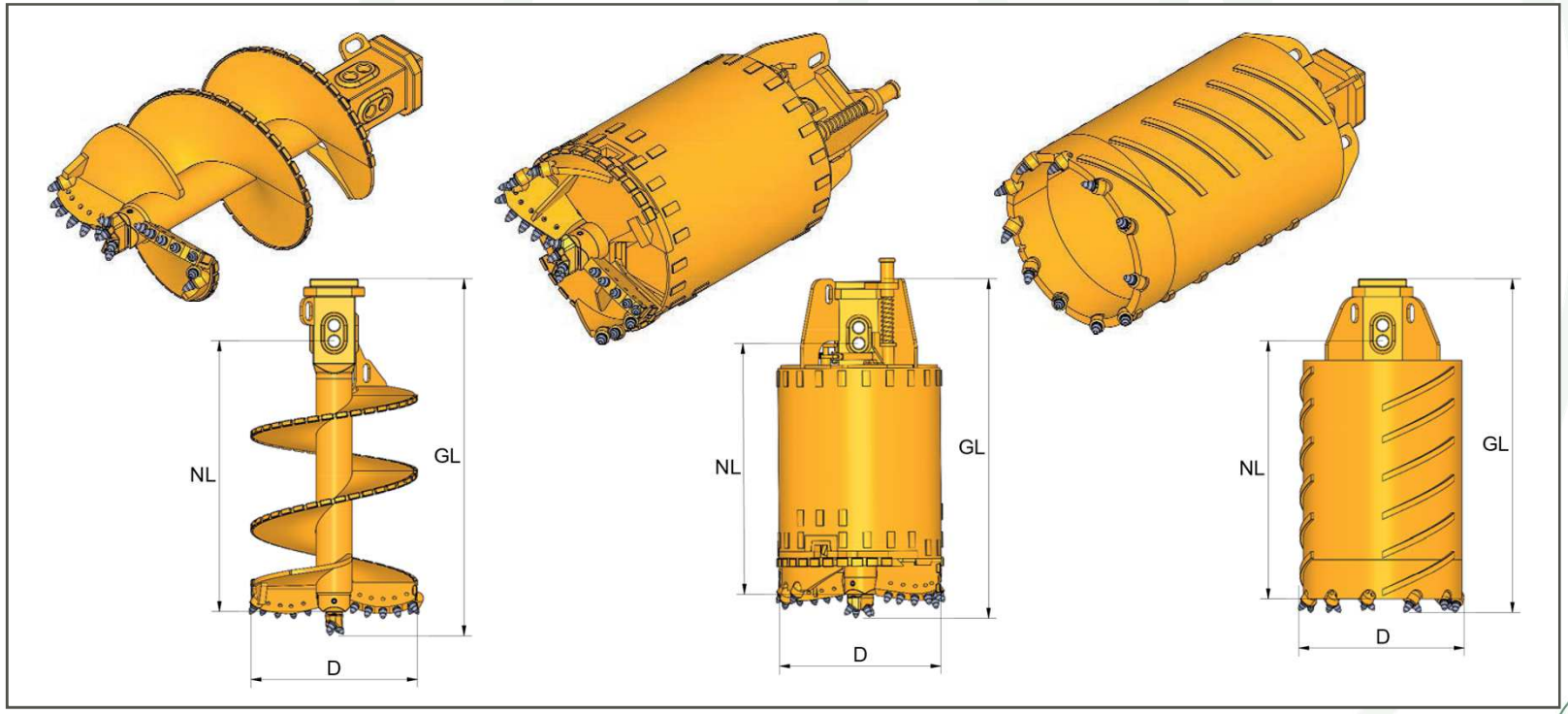
A – Drilling the clay

- Ideal material for augers
- Casing, bentonite, polymer or water required for support
- 50m of double wall 2m Ø casing = 95t
- Inclusions behind casings



B – Drilling the moraine

- Gravel can cause instability
- Large cobles and boulders difficult
- “Smash & grab”
- Rotary drilling – augers, buckets, core barrels



C – Drilling the rock

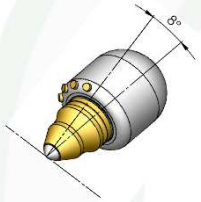
- “Smash & grab”
- Core barrels with chisels, augers and buckets
- Air flush core barrels with chisels, augers and buckets
- Full face reverse circulation (e.g. Wirth Rig)
- Cluster drills

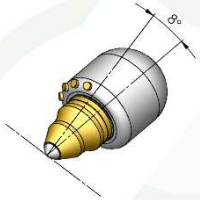
Many of the above require a horizontal starting surface to avoid deviations. This may give additional requirements on the moraine drilling.

Rock Drilling - Kelly Mode (Rotary Drilling)
Suitability of conventional tools

Unconfined Compressive Strength UCS [MPa]

5 — 12.5 — 50 — 100 — 200





Rock Auger

Core Barrel

Roller Bit
Full Face Cutter

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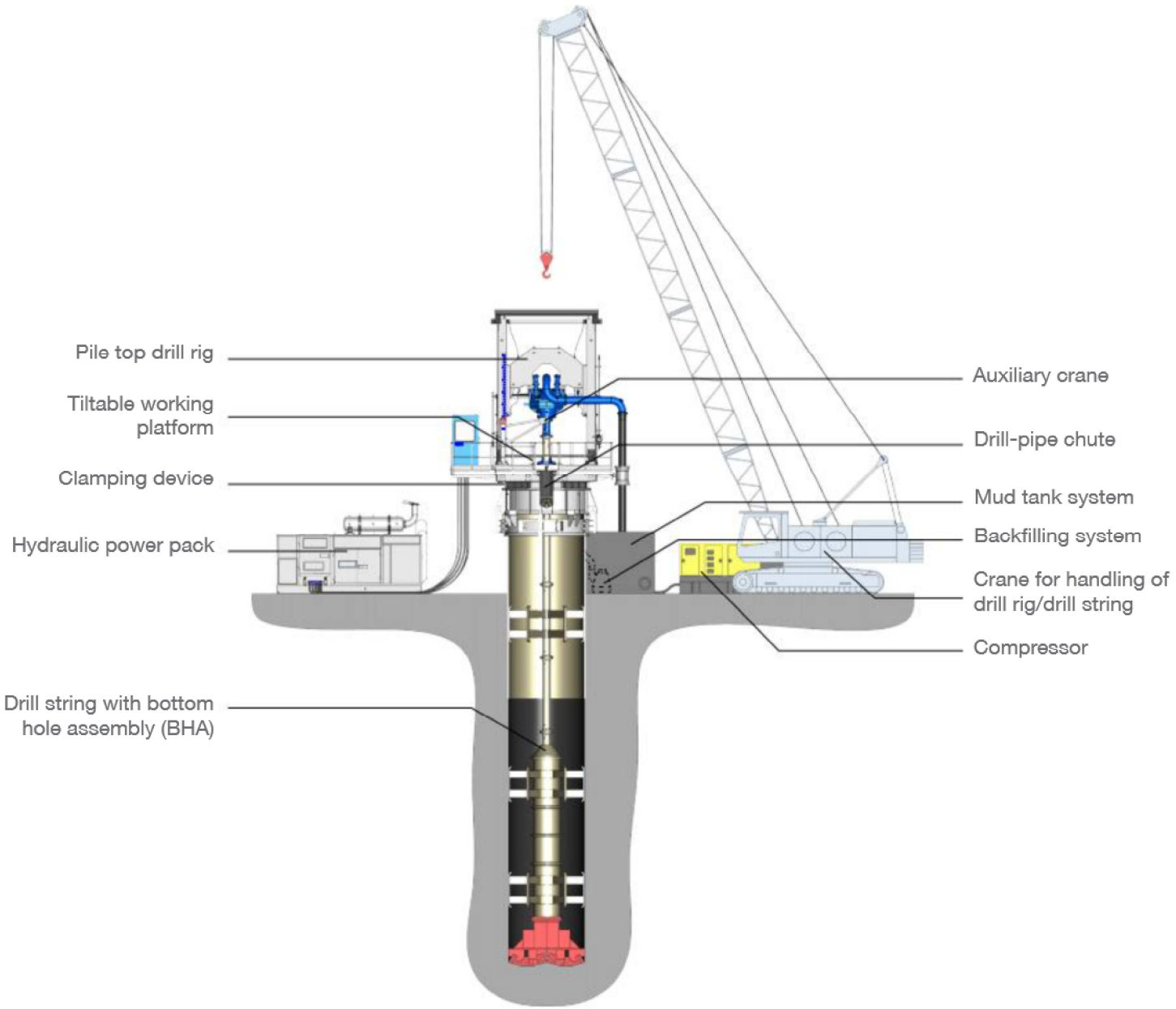

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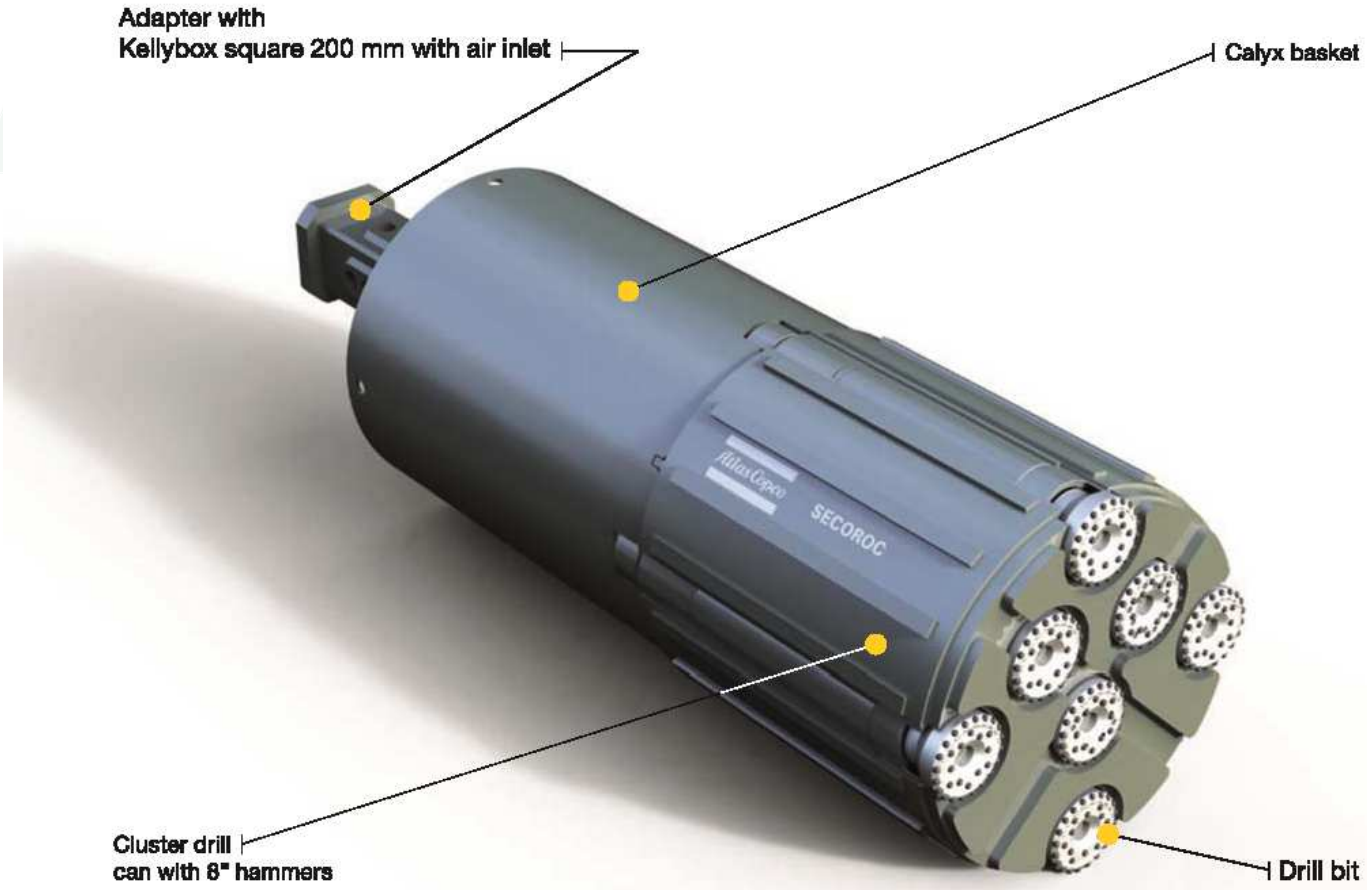
Atlas Copco Secoroc cluster drills

Concept and characteristics



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D – Cleaning the base

- Absolutely essential to clean both the base & the mud
- Cleaning buckets
- Air lift
- Submersible pumps (e.g. Toyo)
- Using the cutter with reverse circulation methods

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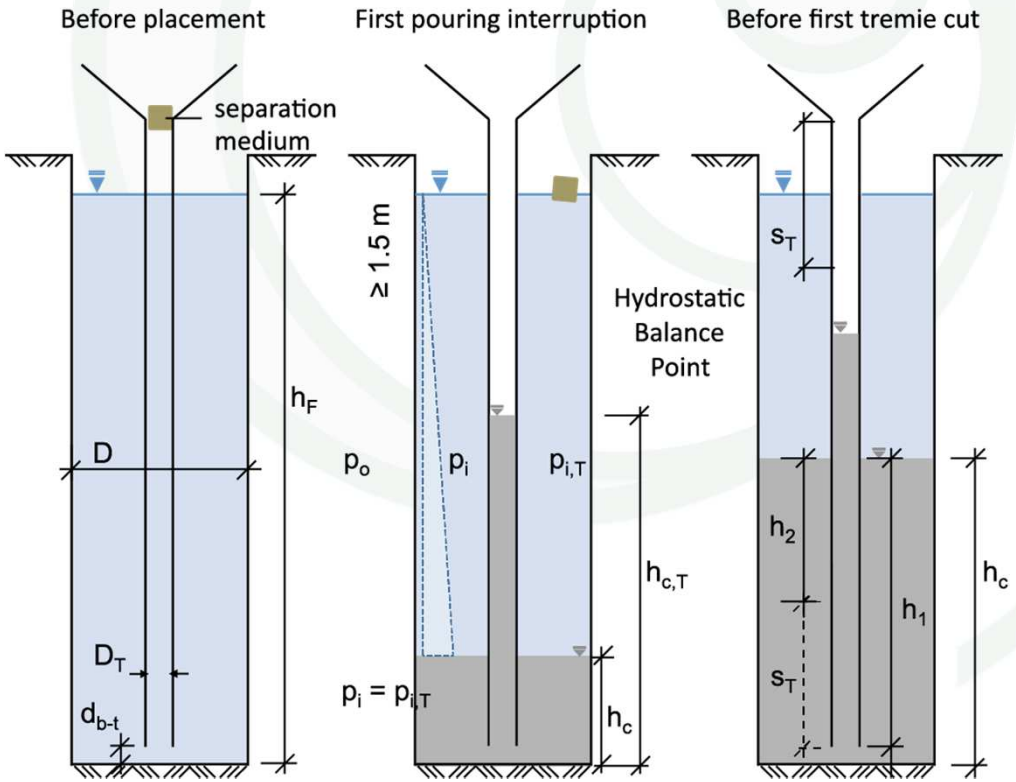
E – Detailing the cage

- Double the reinforcement clear spacings in EN1536 if possible

  i.e. 200mm clear
- Use larger bar sizes (40ø & 50ø)
- Curtail some meters above toe to minimise disruption to concrete flow at the base
- Always consider constructability & assembling the cage in sections
- Assess cover both for durability & constructability

F - Concreting

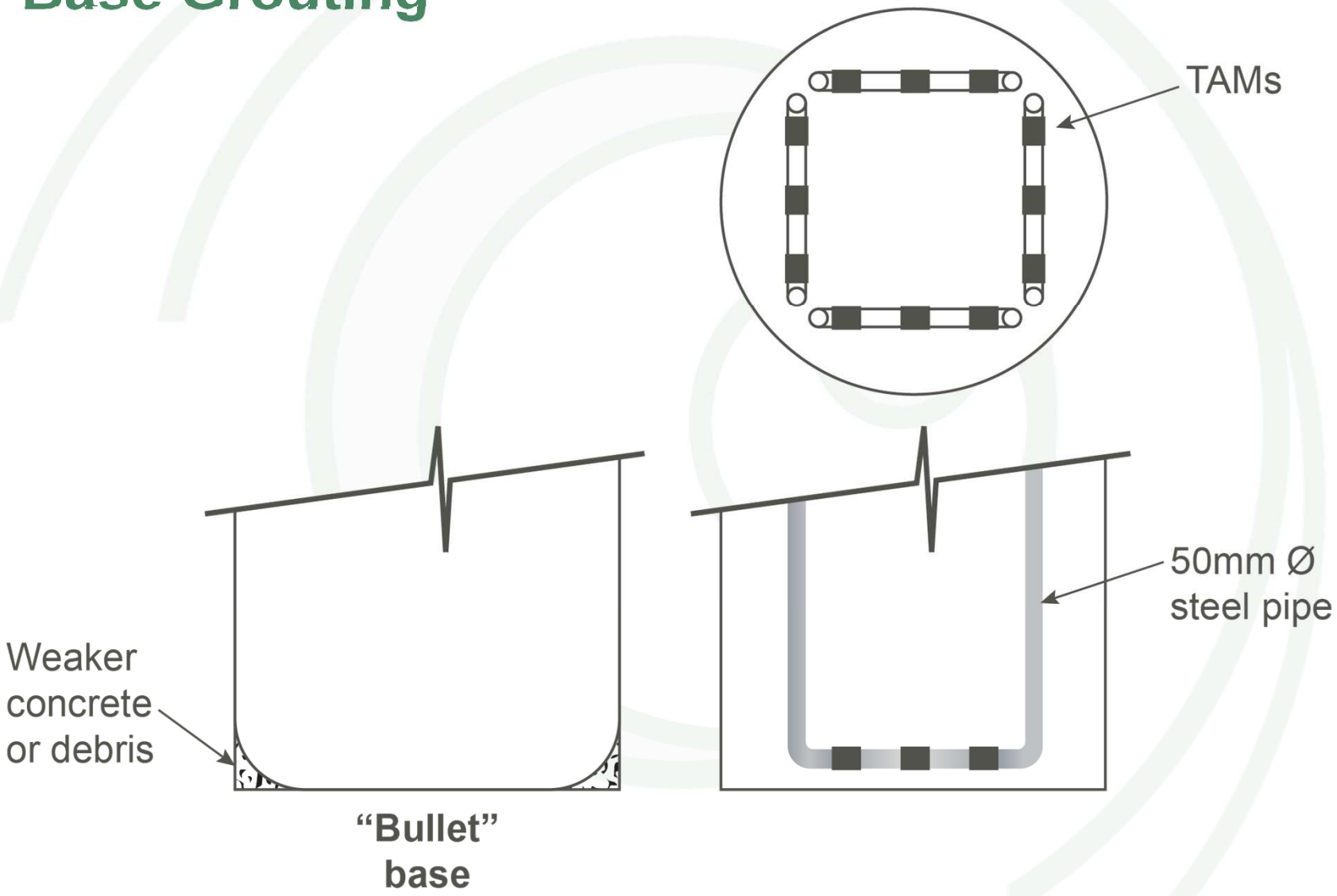
- Closely follow EFFC/DFI Tremie Guidelines
- Obtain >50m^3/hour supply
- Stop concrete mixing with support fluid on initial charge
- Follow tremie embedment rules



G – Testing the finished pile

- Static load test (impractical)
- Sonic coring (concrete strength/velocity and interpretation)
- TIP
- Osterberg cell
- Coring through the toe
- Base grouting

Base Grouting



Advantages of Base Grouting

- by monitoring head movement every pile is tested
- resolves the “bullet” base issue
- multi-stage grouting until acceptance criteria achieved
- eliminates the need to core through the toe
- “repairs” rock surface which may have been damaged during drilling
- ensures minimal differential settlement between piles
- grout tubes can also be used for sonic coring

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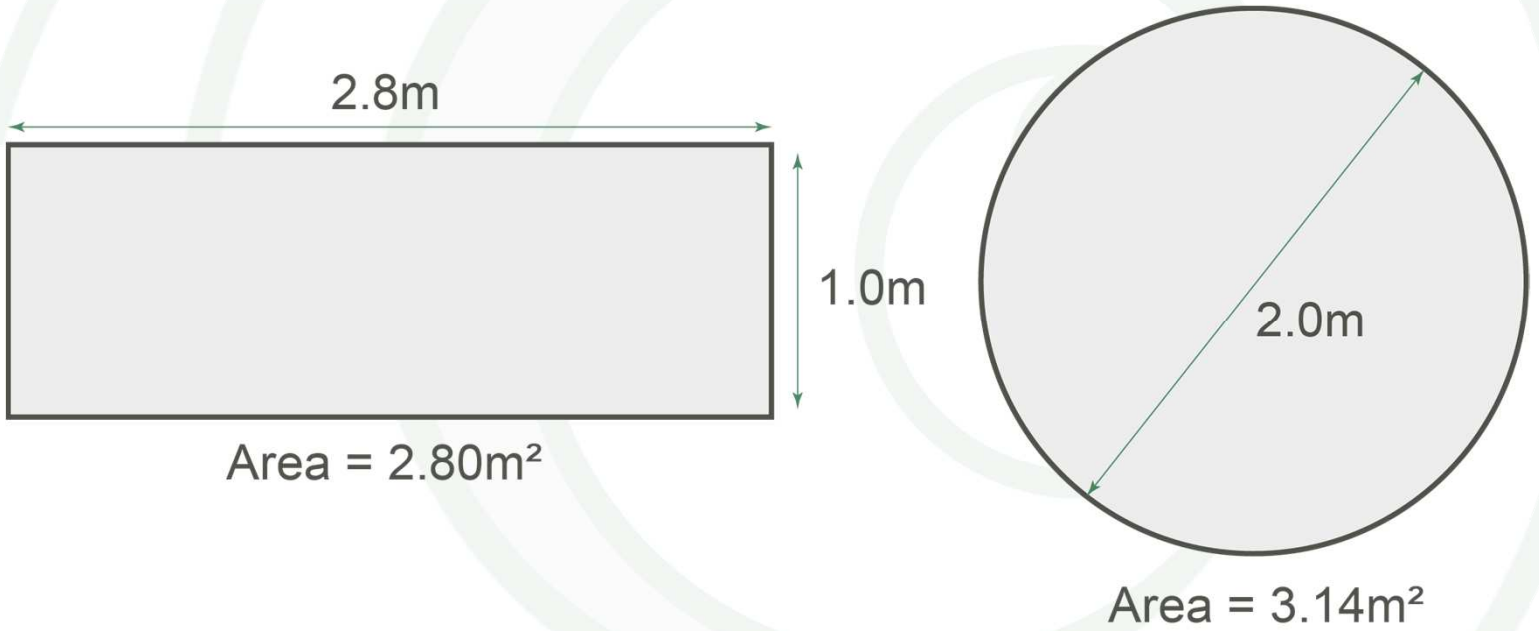
Barrettes – An Alternative



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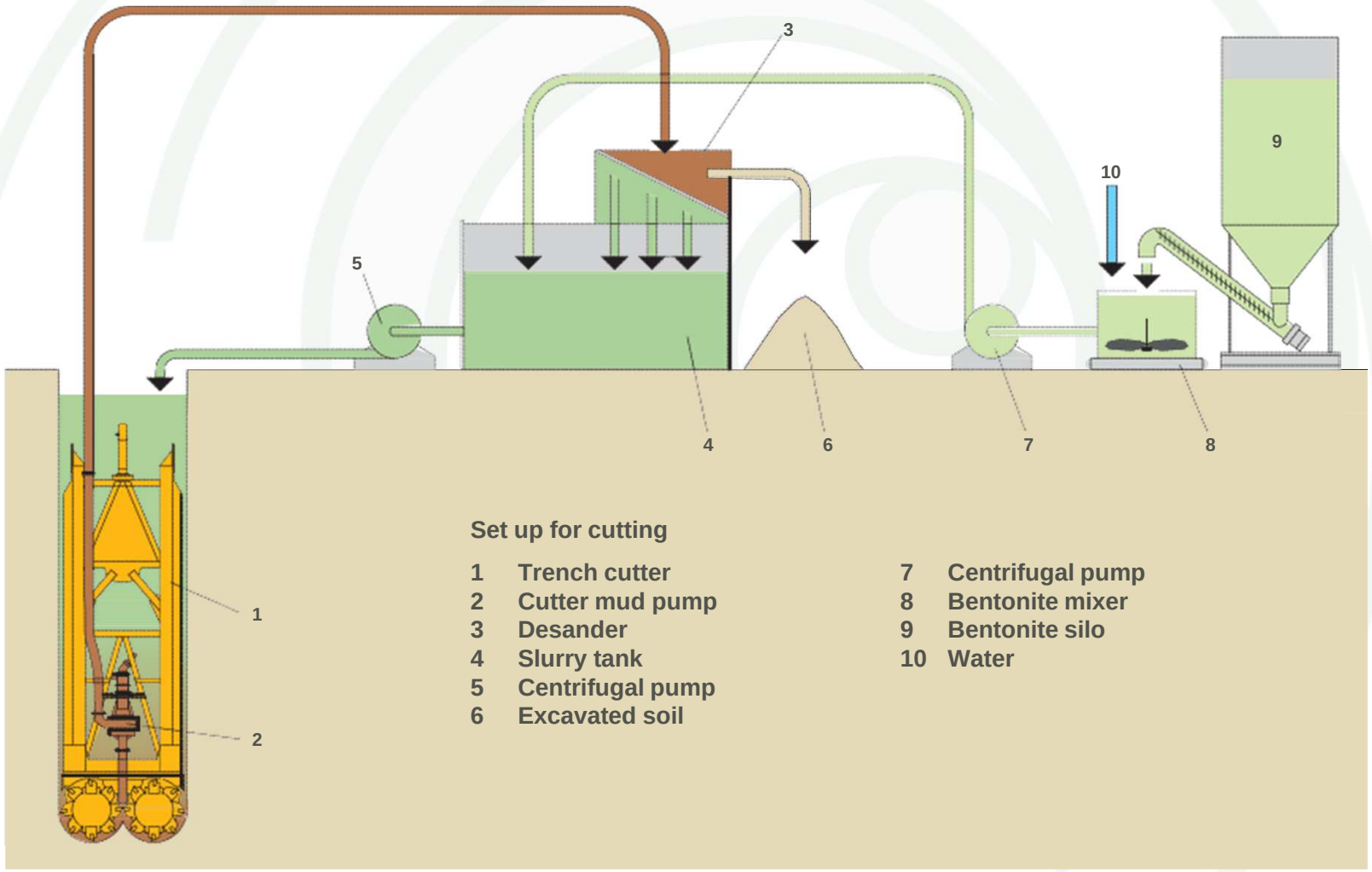
Diaphragm Wall Cutter Schematic



Set up for cutting

1	Trench cutter	7	Centrifugal pump
2	Cutter mud pump	8	Bentonite mixer
3	Desander	9	Bentonite silo
4	Slurry tank	10	Water
5	Centrifugal pump		
6	Excavated soil		

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Cutting Wheels

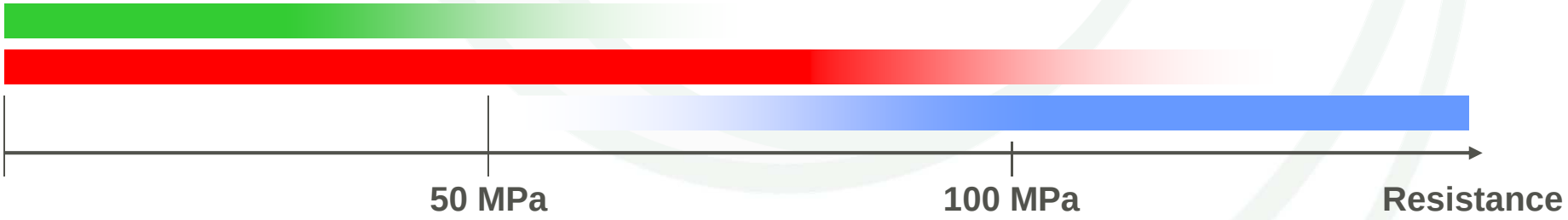
In rock and large boulders

various types of cutting teeth with a high breaking capacity

Standard

Round Shank Chisel

Hard Rock Cutter



Advantages

- grabs are very efficient in clays
- cutters can be “steered” on sloping surfaces
- cutters can cope with moraine & rock
- cutters have onboard instrumentation
- base grouting equally possible
- orientation of panels can cater for horizontal loads (e.g. wind)
- can also be used as external retaining wall

Disadvantages

- mobilisation cost may be higher than piles

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