DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 5.41: Method of Tunnelling in Soft soil, in Rock and contraction Equipment

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Civil Engineering

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Introduction to Tunnelling Ground Conditions I

Tunnelling methods vary significantly depending on the geological conditions. The primary distinction is made between soft soil (or ground) and hard rock. Each requires distinct excavation techniques, support systems, and safety measures.

Key Points

- Soft soil requires immediate support to prevent cave-ins during excavation.
- Hard rock provides varying degrees of self-support, allowing for different excavation strategies.
- Groundwater conditions heavily influence the choice of tunnelling method in both soil types.

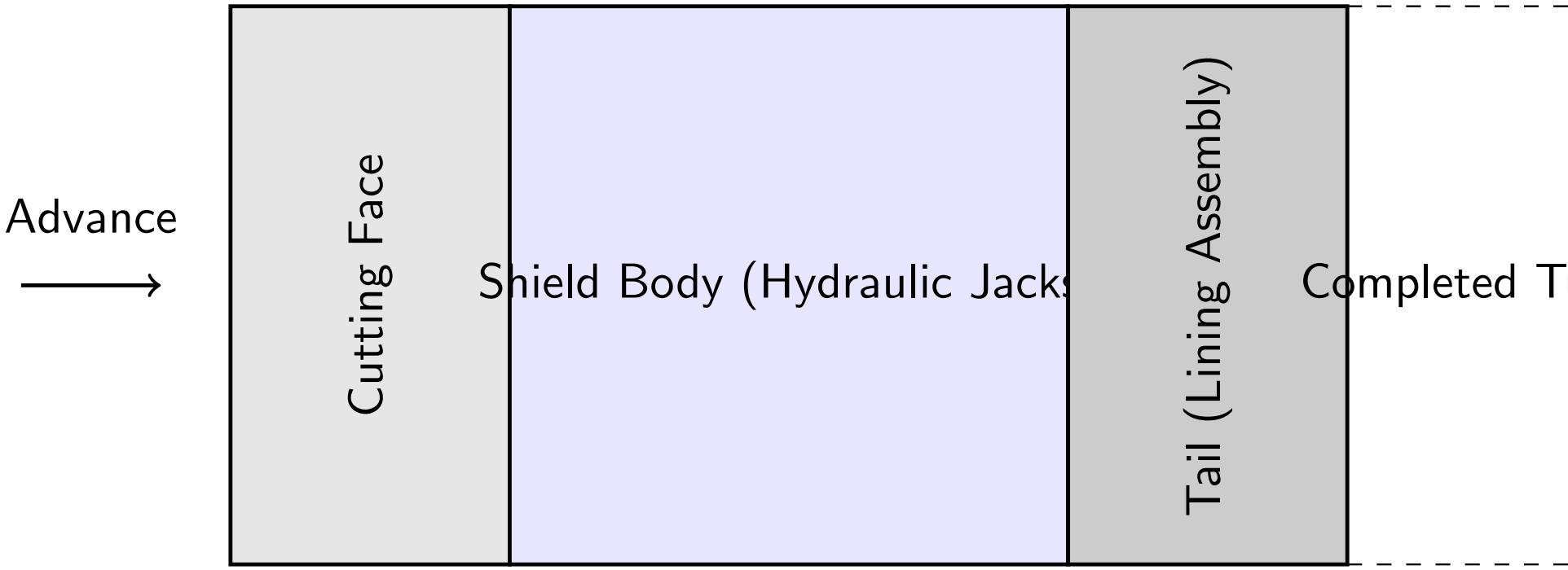
Tunnelling in Soft Soil I

Soft soil tunnelling necessitates methods that provide immediate and continuous support to the excavated face and perimeter. Traditional methods include the forepoling method, needle beam method, and the modern shield method.

Key Points

- Forepoling Method: Uses timber or steel poles driven ahead of the excavation face for support.
- Needle Beam Method: Employs a stout timber beam to support the roof during excavation.
- Shield Method: The most common modern approach, utilizing a protective steel cylinder during excavation.

Shield Method Mechanism I



Shield Method Mechanism II

Key Points

- The shield provides temporary support while the permanent lining is erected within the tail section.
- Hydraulic jacks push against the completed lining to advance the shield into the soft ground.
- The cutting face can be open or closed depending on ground stability and water pressure.

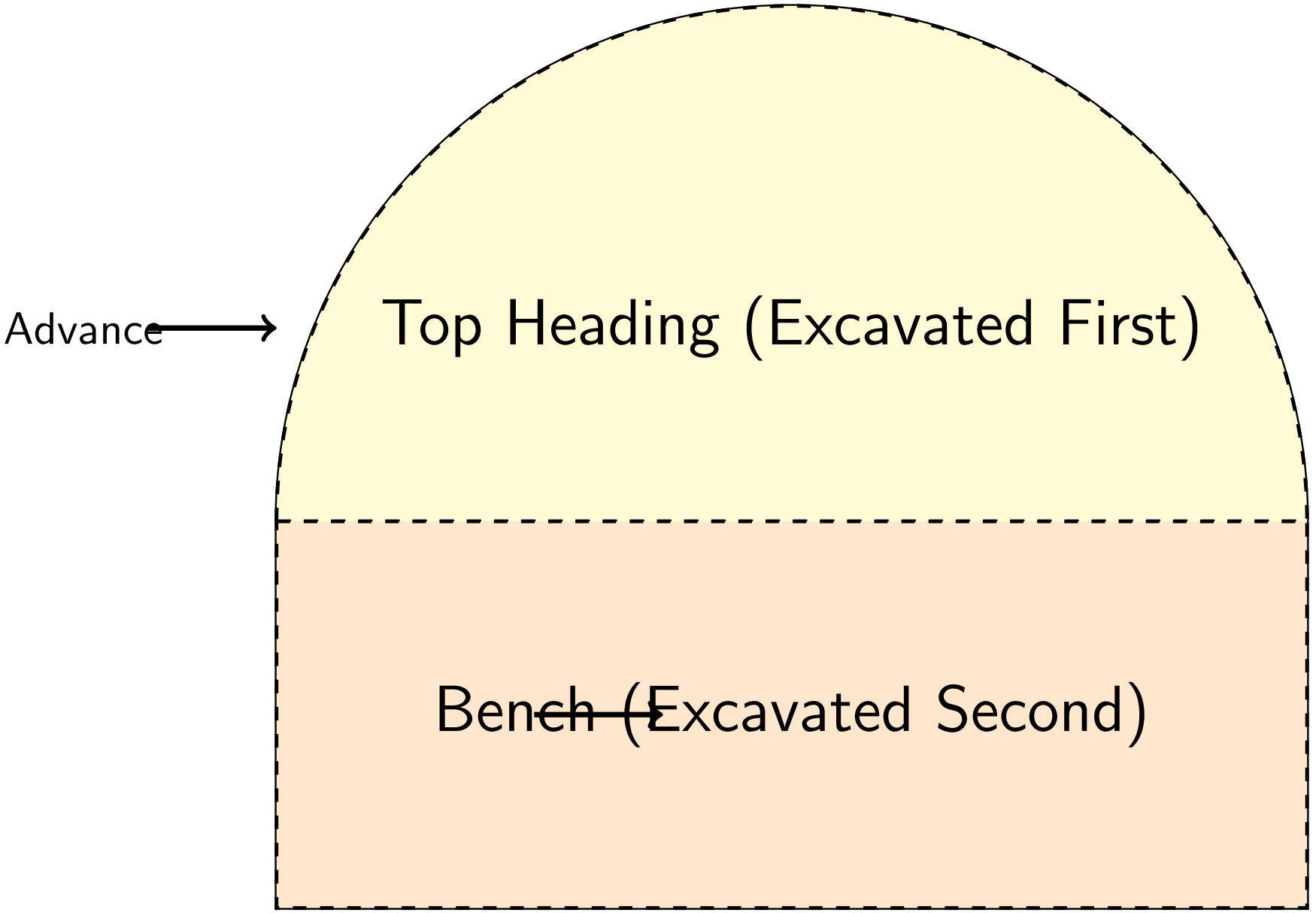
Tunnelling in Hard Rock I

Excavation in hard rock typically relies on drilling and blasting or mechanical boring. The stability of the rock dictates whether the entire face can be excavated at once or if it must be done in stages.

Key Points

- Full Face Method: The entire tunnel cross-section is drilled, blasted, and mucked in a single operation.
- Heading and Bench Method: The top portion (heading) is excavated first, followed by the lower portion (bench).
- Drift Method: A small pilot tunnel (drift) is driven first, then enlarged to the full section.

Heading and Bench Method I



Heading and Bench Method II

Key Points

- The top heading provides an initial working area and helps assess rock conditions.
- The bench can be excavated concurrently with the heading, separated by a safe distance.
- This method allows for simultaneous drilling of the heading and mucking of the bench.

Drill and Blast Technique I

The conventional drill and blast method remains highly relevant for hard rock tunnelling. It involves a repetitive cycle of drilling boreholes, loading explosives, blasting, ventilating, and removing muck.

Key Points

- Drilling: Jumbo drills are used to bore a specific pattern of holes into the rock face.
- Charging and Blasting: Explosives are loaded and detonated in a sequence to control rock fragmentation.
- Ventilation and Scaling: Fumes are cleared, and loose rock (scaling) is removed before mucking begins.

Tunnel Boring Machines (TBMs) I

TBMs are massive machines used as an alternative to drilling and blasting. They can excavate tunnels with a circular cross-section through a variety of soil and rock strata using a rotating cutterhead.

Key Points

- Hard Rock TBMs: Use disc cutters to induce compressive failure in the rock face.
- Earth Pressure Balance (EPB) TBMs: Used in soft soils, balancing ground pressure with excavated spoil.
- Slurry Shield TBMs: Use pressurized slurry to support the face in highly permeable or water-bearing soils.

Comparison: Soft Soil vs. Hard Rock Tunnelling I

Choosing the correct tunnelling method requires understanding the contrasting behaviors of soft soil and hard rock environments. This table summarizes the key operational differences.

Key Points

- Attribute | Soft Soil Tunnelling | Hard Rock Tunnelling
- Primary Method | Shield method, EPB TBM | Drill & Blast, Hard Rock TBM
- Support Needs | Immediate, heavy lining required | Often self-supporting initially, rock bolts
- Excavation Tools | Scrapers, drag teeth, cutting edge | Disc cutters, explosives, jumbo drills
- Groundwater Control | Critical, requires compressed air/slurry | Often managed with standard pumping

Mucking and Haulage Equipment I

Efficient removal of excavated material (muck) is critical for maintaining the tunnel advance rate. The choice of mucking equipment depends on the tunnel size, length, and excavation method.

Key Points

- Loaders (Muckers): Specialized underground loaders like rocker shovels or LHD (Load-Haul-Dump) vehicles.
- Conveyor Systems: Continuous belts used behind TBMs for rapid, high-capacity muck removal.
- Rail Transport: Locomotives and muck cars are traditional and effective for long, straight tunnels.

Support and Lining Equipment I

Once excavated, the tunnel must be secured. Equipment is needed to install initial ground support and the permanent structural lining to ensure long-term stability.

Key Points

- Shotcrete Machines: Spray concrete onto the rock surface to provide rapid temporary support.
- Rock Bolters: Specialized rigs used to drill and install rock bolts and dowels into the tunnel roof.
- Segment Erectors: Integrated into TBMs to place precast concrete segments for the final tunnel lining.

Summary I

Tunnelling methodologies are strictly dictated by the geological environment, necessitating completely different approaches for soft soil and hard rock. The evolution of construction equipment, particularly TBMs, has revolutionized the efficiency and safety of these projects.

Key Points

- Soft soil requires immediate support, prominently utilizing shield methods or EPB TBMs.
- Hard rock allows for staged excavation like heading and bench, relying on drill and blast or rock TBMs.
- Specialized equipment for mucking, support (shotcrete/rock bolts), and lining are essential for project success.