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<https://www.youtube.com/watch?v=oyfj6sZVZEA>

2 Tunnelling

- 2.1 Usage
- 2.2 Terminology
- 2.3 Construction methodologies
- 2.4 Anchoring and stabilization techniques
- 2.5 Compressed Air and Ventilation
- 2.6 Health & Safety

2.1 Usage

- Water works
- Irrigation
- Roads
- Railways
- Sewage Transport
- Drainage
- Services
- Mining

2.2 Terminology

- Heading
- Drifting
- Benching
- Timbering, Shoring
- Poling Boards, Strutting, Waling

2.3 Construction Methodologies

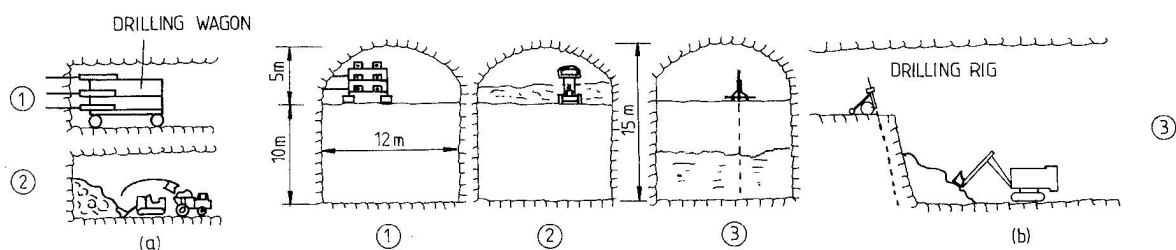
- Hand techniques, Power (mechanized) techniques
- Depends on soil type, ground conditions, length of the tunnel to be excavated etc.
- 6 main techniques used
 - Traditional methods
 - New Austrian method

- Tunnelling with shields
- Tunnel Boring Machines (TBM)
- Mini and micro-tunnelling or boring
- Immersed (includes open cut)

Traditional Methods

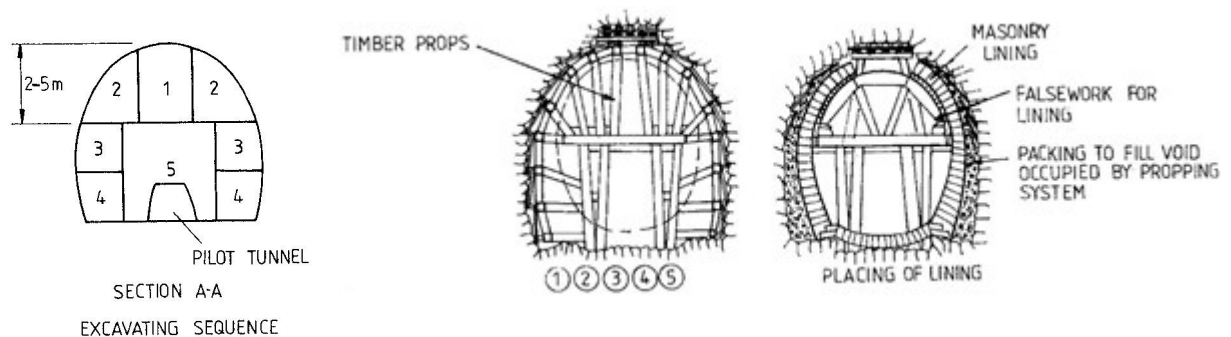
- Full face heading without lining
- Heading in drifts, followed by full face lining
- Heading in drifts followed by lining progressively in stages

Full face heading without lining



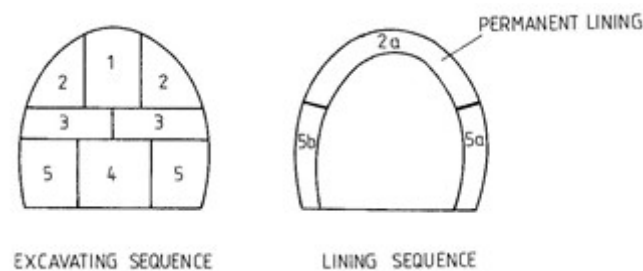
Source: Harris, F. (1994)

Heading in drifts, followed by full face lining

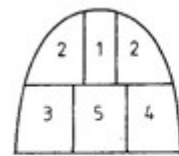


English Method

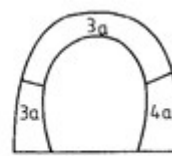
Heading in drifts, followed by lining progressively in stages



Belgian Method

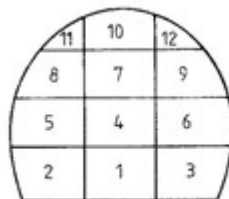


EXCAVATING SEQUENCE

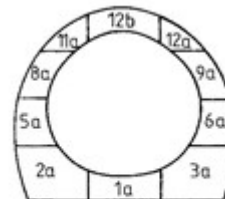


LINING ERECTION

German Method



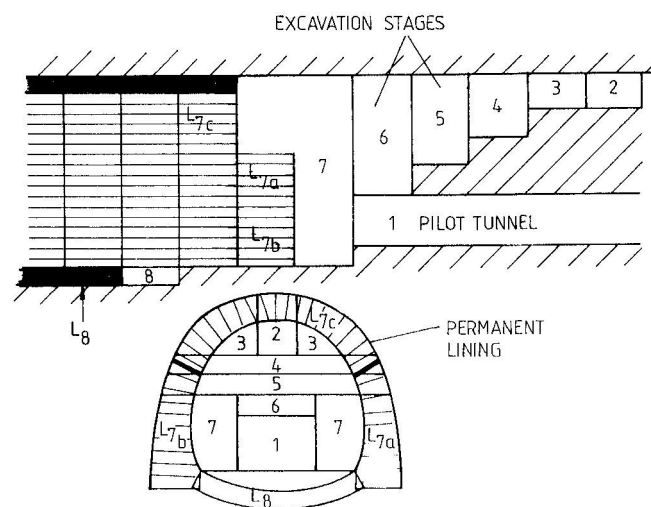
EXCAVATING SEQUENCE



LINING ERECTION

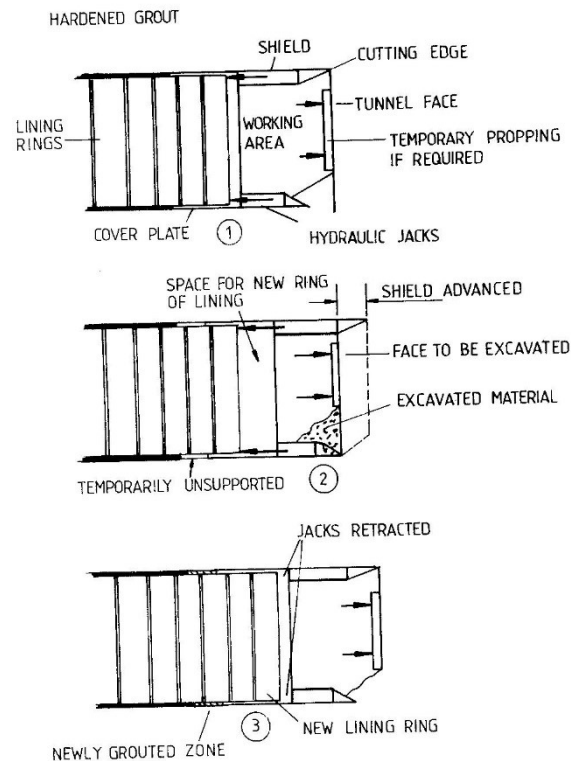
Italian Method

New Austrian Method



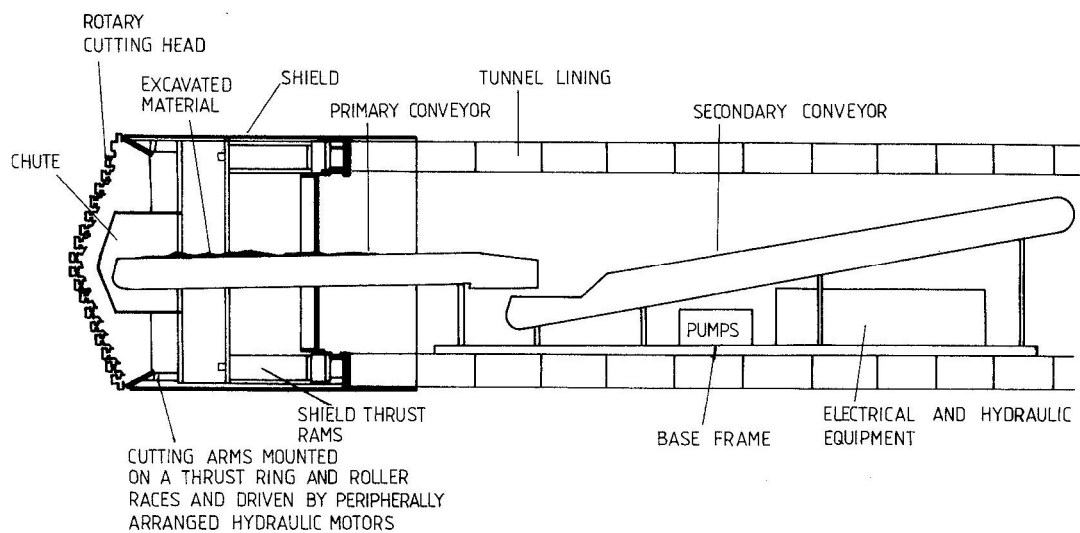
https://youtu.be/GMFo1fN_Exk

Tunnelling with shields

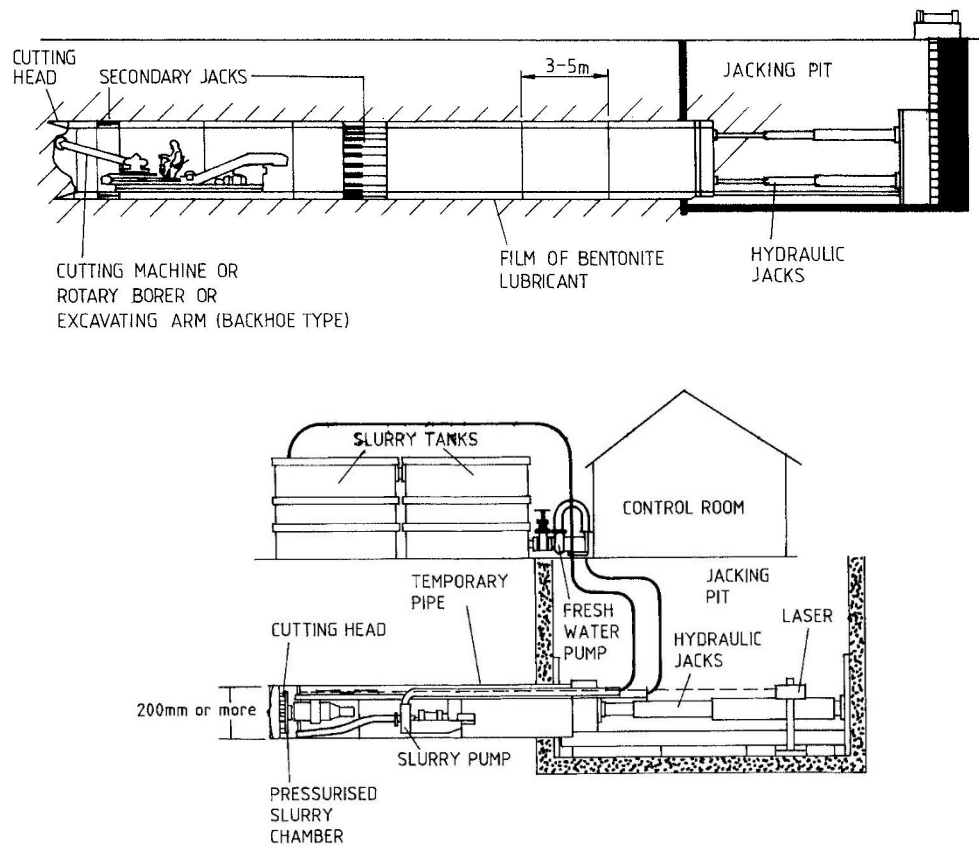


<https://youtu.be/z38JlqGDZVU>

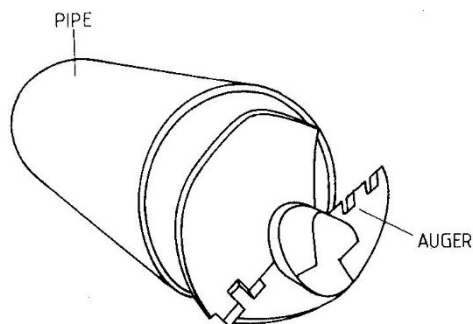
Tunnel Boring Machines (TBM)



Mini and Micro Tunnelling and Boring



Pipe Jacking



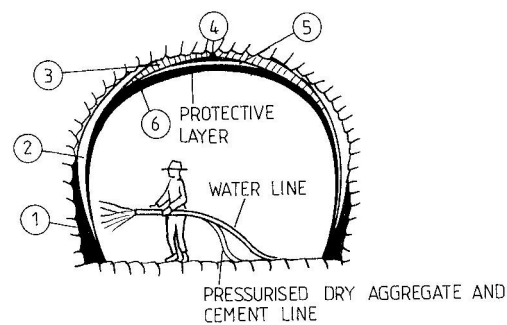
Augurs

Immersed

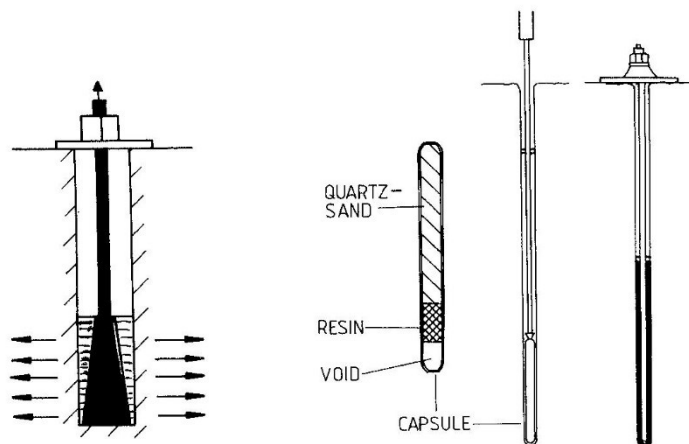
- Cut and cover
<https://www.youtube.com/watch?v=sboDavo84gc>
- Immersed
<https://www.youtube.com/watch?v=9f25Izsqa6I>

2.4 Anchoring and Stabilization Techniques

- Sprayed concrete: depends on;
 - Type of soil
 - Support required
 - End use
 - Additional support from reinforcements may be required

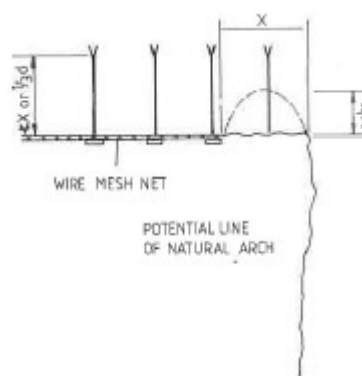


- Rock bolting
 - Often used in combination with sprayed concrete
 - Natural arching, minimum length etc.
 - Rock bolt types

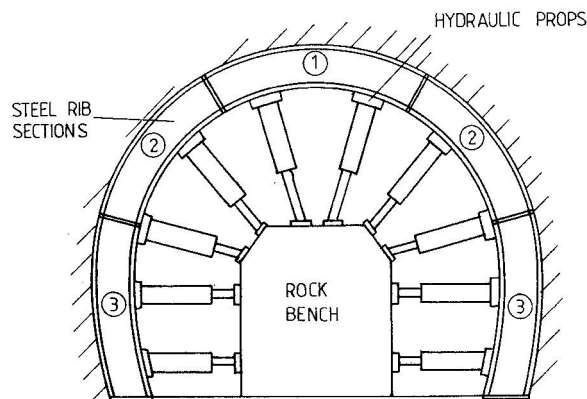


Expanded-base rock bolt

Grout-type rock bolt



- Stiffening ribs and linear plates



- Full lining

2.5 Compressed air and ventilation

- Pressurise the working area to counter balance the surrounding water pressure
- “Blowout” risk
- Reduce risk by a layer of clay
- Extensive grouting may require as the tunnel progresses
- Decompression chamber
- Health and safety issues
 - Inadequate decompression
 - Mild limb pain (niggles), severe limb pain (bends)
 - Vomiting, vertigo, paralysis, choking, headaches, visual defects, heart problems, coma, death
- Oxygen content to be maintained at 20%
- For men, machinery and explosives (oxygen in and carbon dioxide out)
 - Forcing fresh air in
 - Extracting used air out
 - Intermediate shafts may be needed

2.6 Health and Safety

- Risks
 - Nature of the ground, soil conditions
 - Confined spaces
 - Ventilation, Visibility, Hearing
 - Heavy machinery
 - Access, communication
- Mitigation
 - Planning, design
 - Identifying hazards, risk assessments
 - Controlling risks
 - Training, supervision
 - Procedures
 - Responsibilities

- Training
- Legislation (HSE)
 - Health and safety at work act 1974
 - Provision and use of work equipment regulations 1998
 - Personal protective equipment at work regulations 1992
 - Control of substances hazardous to health regulations 2002
 - Dangerous substances and explosive atmospheres regulations 2002
 - Confined spaces regulations 1997
 - Working at height regulation 2005
 - Reporting of injuries, diseases and dangerous occurrences regulations 1995
- Emergencies (CLG)
 - Emergency services take control
 - Save lives
 - Fight and prevent fires
 - Manage hazardous materials
 - Minimize and mitigate the effects of the incident

References Used:

Harris, F. (1994), "Modern Construction and Ground Engineering Equipment and Methods",
Longman Scientific & Technical, ISBN: 0-582-23657-6