Introduction
The construction of the Millennial Underground Railway Line
Introduction
The construction of the metro line 4 in Budapest

Preparation of construction

- Planning
  - Planning the route, locating the stations
  - Selecting the construction methods
- Geotechnical investigation
  - Investigating soil structure, soil strength, permeability, ground water condition etc.
  - Collecting samples / non-destructive tests
- Geodesy
  - Laying out - using coordinate system or reference system
  - Geometrical control
Preparation of construction

The ground conditions of the metro line 2 in Budapest

Preparation of construction

The ground conditions of the metro line 4 in Budapest
## Construction methods

| Construction of the Tunnel | Cut-and-cover methods  
Mining methods  
Special methods |
|----------------------------|---------------------|
| Construction of the Stations | Cut-and-cover methods  
Mining methods  
Other methods |
| Other connecting operations | Solidifying the soil  
Water removal works |

The tunnel of the metro line 4 in Budapest
### Construction methods – Tunnel

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**Cut-and-cover methods**

- One
- One and a half
- Two
- Two and a half

Levels of cut-and-cover tunnels
### Construction methods – Tunnel

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- **Ground support**
  - Sloped trench (a)
  - Partly sloped (b)
  - Sheet pile wall (c, d)
  - Steel and timber bracing (soldier piles)(e)
  - Slurry-wall (f)
  - Pile wall (f)
  - With propping or tie-back
Open working pit with slurry wall and props in Vienna and in Budapest

The New York Subway
### Construction methods – Tunnel

#### Metro construction in Vienna

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Construction methods – Tunnel

Installation of decking

Construction methods – Tunnel

Excavation and soil removal
Construction methods – Tunnel

construction of subway structure

Construction methods – Tunnel

removal of decking/street restoration
### Construction methods – Tunnel

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Construction of Fort George Tunnel
### Construction methods – Tunnel

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The Belgian method (proportions in m)
# Construction methods – Tunnel

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The German method (proportions in m)
### Construction methods – Tunnel

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The New Austrian tunnelling method

The New Austrian tunnelling method in Budapest
Construction methods – Tunnel

**Cut-and-cover methods**

- Bottom-up methods (with different ground support methods)
- Top-down method (Milan-method)

**Mining methods**

- Belgian method
- German method
- New Austrian Tunnelling Method (NÖT / NATM)
- Tunnel Boring Machines (shields)

**Special methods**

- Caisson

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Tunnelling shield at the Thames Tunnel, London
Schematic diagram of an EPB shield

The shields in Antwerpen and Hamburg
Construction methods – Tunnel

The shield in Zürich

Construction methods – Tunnel

TBM, Budapest
1. Rock environment
2. Cutting wheel
3. Supporting earth mass
4. Watertight steel separator wall
5. Hydraulic pressing jacks
6. Earth mass screw conveyor
7. Segment erector
8. Segment ring
Construction of the TBM, Budapest

Prefabricated RC segments of the tube
The construction of metro line 2, Bp.
The construction of the subway at the Navy Yard, Washington DC

Construction methods – Tunnel

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Mining methods
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Special methods
Caisson
Construction of a four track tunnel in Stockholm

Caisson
- Cutting edge types
- Creating an underground station
**Construction methods – Station**

Stations of the metro line 4 in Budapest

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Construction methods – Station

Construction of metro stations in Budapest

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Cut-and-cover methods for metro stations

Nagyvárad tér

Ground support – Pile wall

Budovatelu station, Prague
Construction methods – Station

Construction equipment
Baross tér
Tétényi út

Construction methods – Station

Móricz Zsigmond körter
Construction methods – Station

Tétényi út

Bocskai út

TBM arrives to Bocskai út
### Construction methods – Station

**Cut-and-cover methods**

**Bottom-up methods (with different ground support methods)**

**Top-down method (Milan-method)**

**Mining methods**

- One Vault method
- Three Vault method
- Five(six)–tunnel method

**Special methods**

- Caisson

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TBM arrives to Bocskai út
Construction methods – Station

Déli pályaudvar metro station
**Construction methods – Station**

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**Construction methods – Station**

- „Budapest-type“ metro station
- Kálvin tér metro station
Construction methods – Station

Cut-and-cover methods

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Mining methods

One Vault method

Three Vault method

Five(six)–tunnel method

Special methods

Caisson
Construction methods

Other connecting operations

Solidifying the soil
Freezing the soil
Grouting methods

Water removal works
Drainage
Sinking groundwater level
Watertight working pit

Wall

Solidified soil
Working pit
Anchoring

Well
Planned object

Groundwater level

Sheet pile wall
Working pit

Anchoring
Slurry wall
Solidified soil
- [http://www.nycsubway.org/articles/irtbook_index.html](http://www.nycsubway.org/articles/irtbook_index.html)
- [http://science.howstuffworks.com/engineering/structural/tunnel.htm](http://science.howstuffworks.com/engineering/structural/tunnel.htm)
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