

Construction methods of metro lines



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05-11-14

Construction methods of metro lines

Introduction

The construction
of the Millennial
Underground
Railway Line



Construction methods of metro lines

Introduction

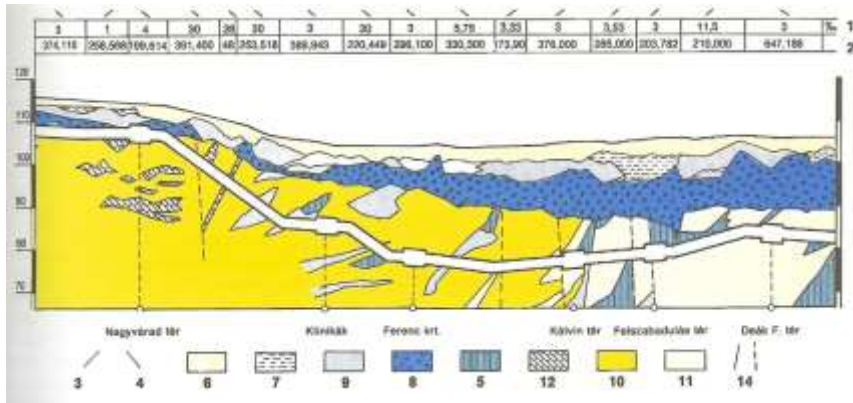
The construction of the metro line 4 in Budapest



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

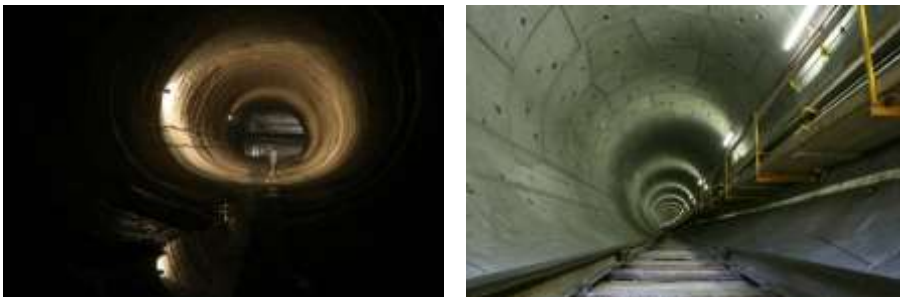


The ground conditions of the metro line 4 in Budapest

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

Construction methods



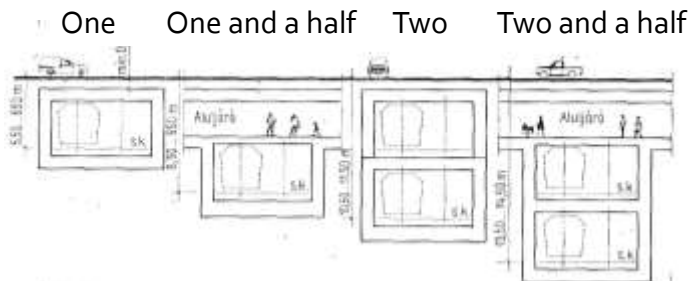
The tunnel of the metro line 4 in Budapest

Construction methods – Tunnel

Construction of the 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

Construction methods – Tunnel

Cut-and-cover methods



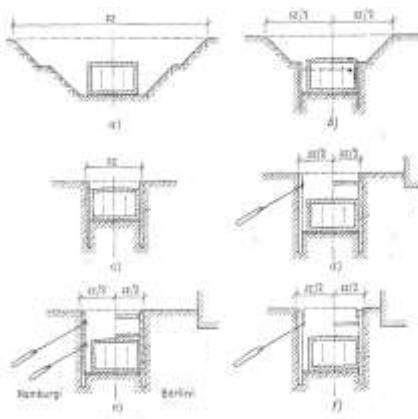
Levels of cut-and-cover tunnels

Construction methods – Tunnel

Construction of the Tunnel	Cut-and-cover methods	Bottom-up methods (with different ground support methods)
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Special methods	Caisson	

Construction methods – Tunnel

- 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

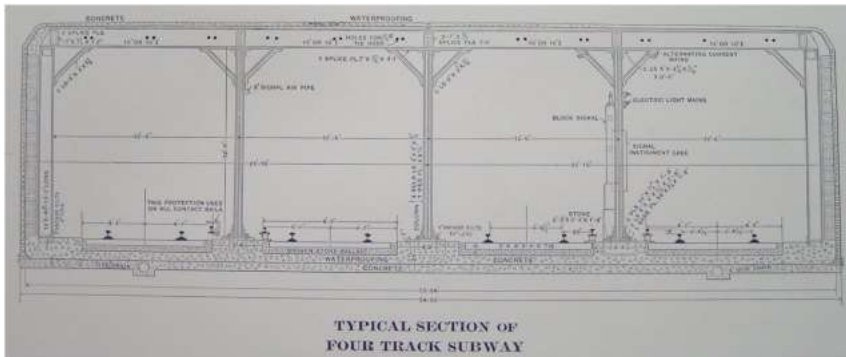


Construction methods – Tunnel



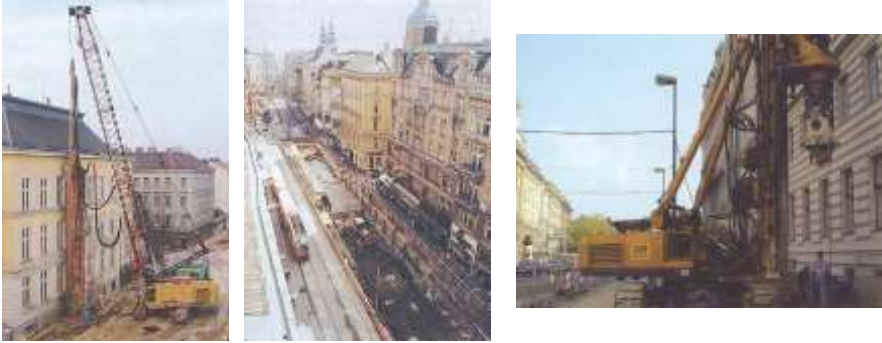
Open working pit with slurry wall and props
in Vienna and in Budapest

Construction methods – Tunnel



The New York Subway

Construction methods – Tunnel

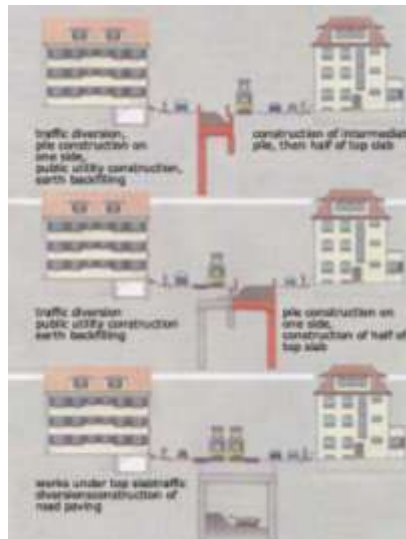


Metro construction in Vienna

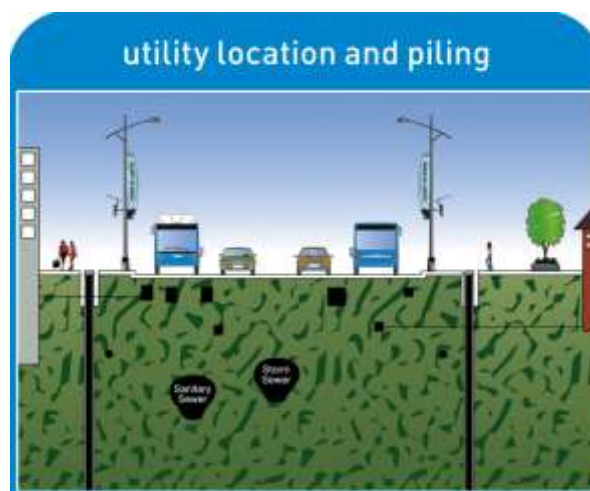
Construction methods – Tunnel

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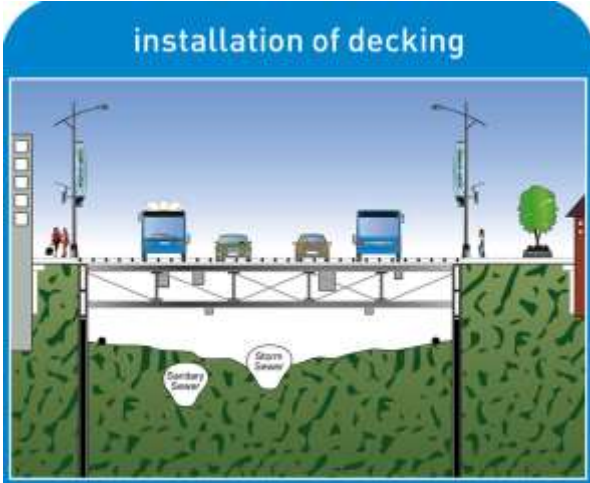
Construction methods – Tunnel



Construction methods – Tunnel



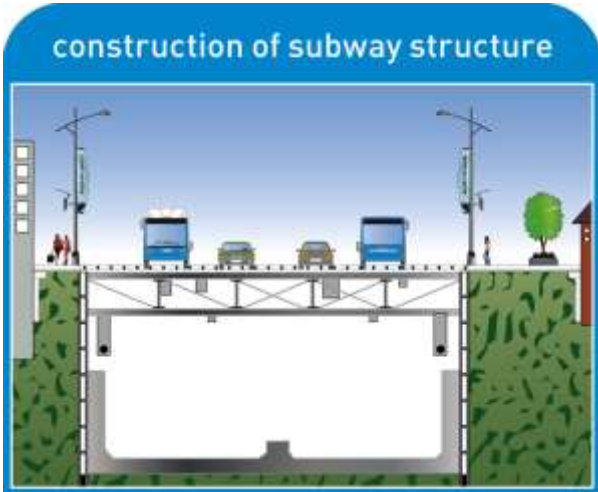
Construction methods – Tunnel



Construction methods – Tunnel



Construction methods – Tunnel



Construction methods – Tunnel



Construction methods – Tunnel

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Construction methods – Tunnel

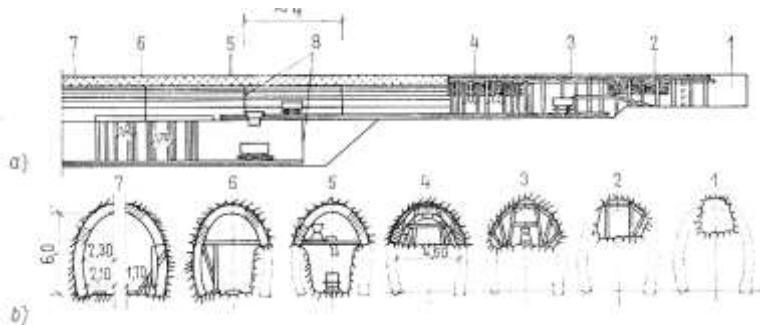


Construction of Fort George Tunnel

Construction methods – Tunnel

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Construction methods – Tunnel



The Belgian method (proportions in m)

Construction methods – Tunnel

Construction of the Tunnel

Cut-and-cover methods

Bottom-up methods (with different ground support methods)

Top-down method (Milan-method)

Mining methods

Belgian method

German method

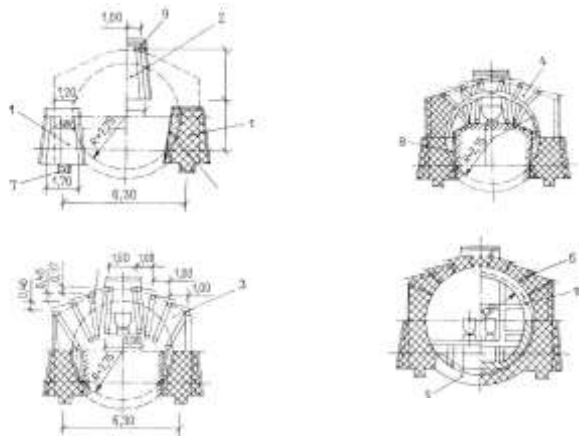
New Austrian Tunnelling Method (NÖT/ NATM)

Tunnel Boring Machines (shields)

Special methods

Caisson

Construction methods – Tunnel

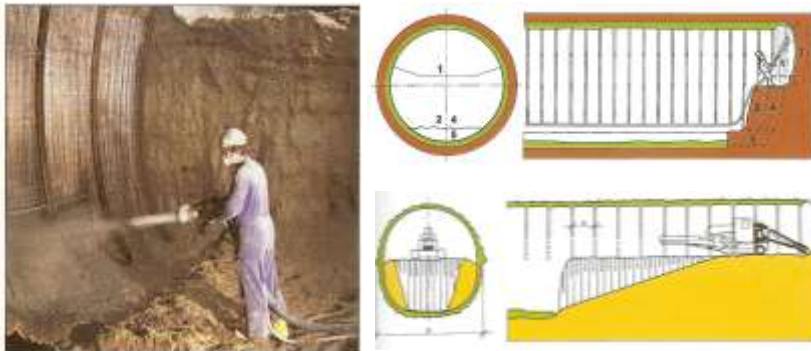


The German method (proportions in m)

Construction methods – Tunnel

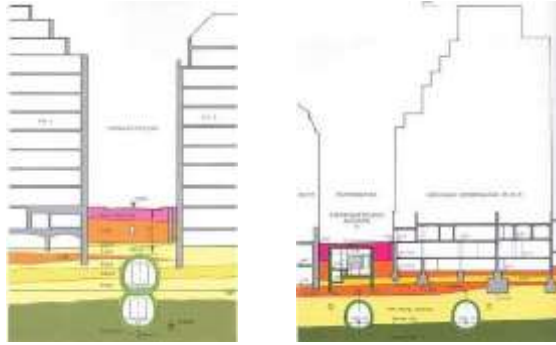
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Construction methods – Tunnel



The New Austrian tunnelling method

Construction methods – Tunnel



The New Austrian tunnelling method

Construction methods – Tunnel

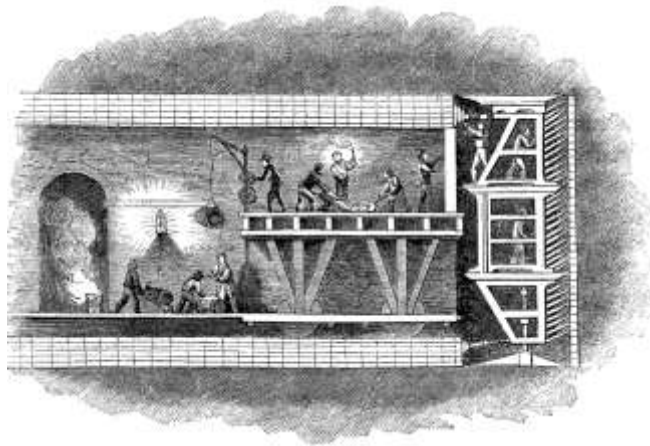


The New Austrian tunnelling method in Budapest

Construction methods – Tunnel

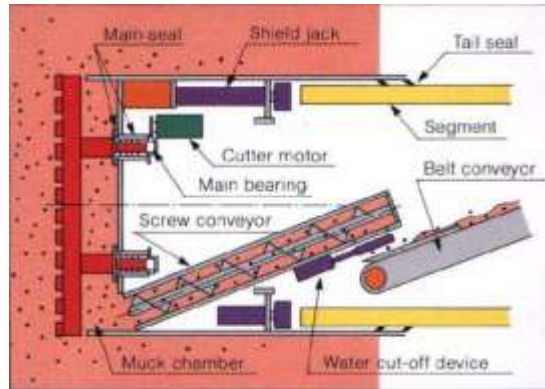
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Construction methods – Tunnel



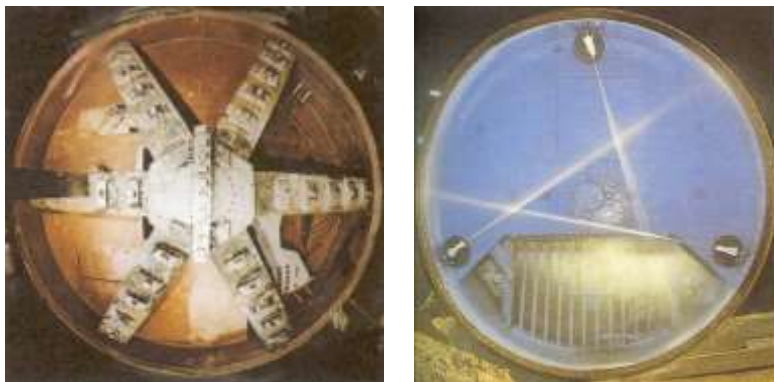
Tunnelling shield at the Thames Tunnel, London

Construction methods – Tunnel



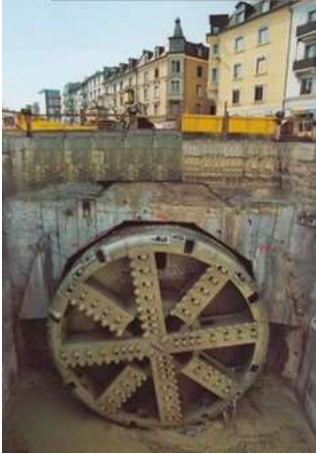
Schematic diagram of an EPB shield

Construction methods – Tunnel



The shields in Antwerpen and Hamburg

Construction methods – Tunnel



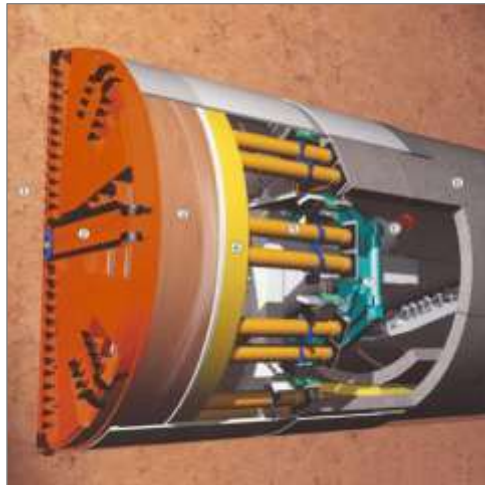
The shield in Zürich



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



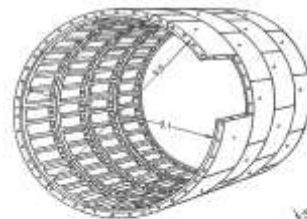
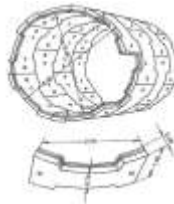
Construction methods – Tunnel

Construction of the TBM,
Budapest



Construction methods – Tunnel

Prefabricated RC
segments of the tube



Construction methods – Tunnel

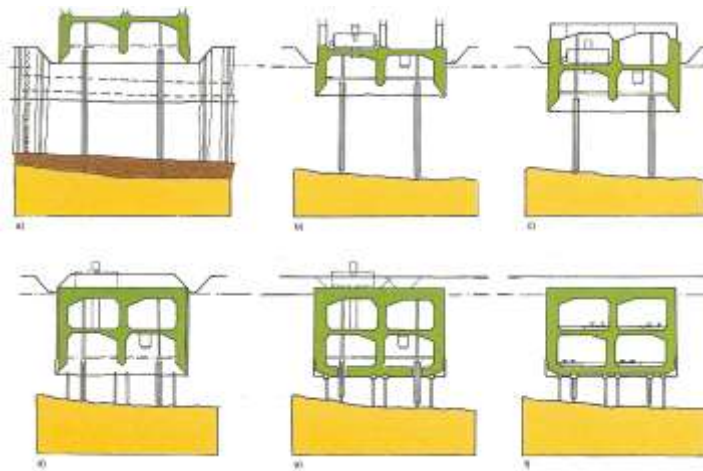
The construction of metro line 2, Bp.
The construction of the subway at the
Navy Yard, Washington DC



Construction methods – Tunnel

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Construction methods – Tunnel

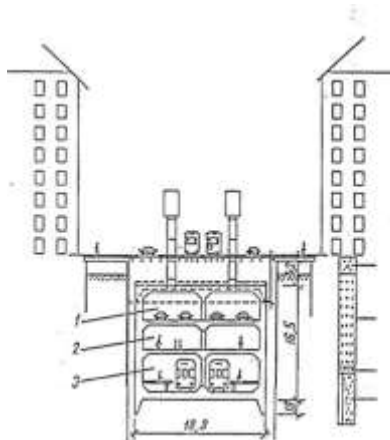
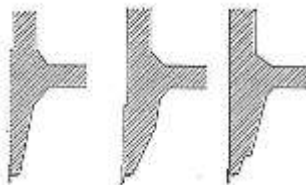


Construction of a four track tunnel in Stockholm

Construction methods – Tunnel

Caisson

- Cutting edge types
- Creating an underground station



Construction methods – Station

Stations of the metro line 4 in Budapest



Construction methods – Station

Construction of the Stations

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

Construction methods – Station



Construction of metro stations in Budapest

Construction methods – Station

Construction of the Stations

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

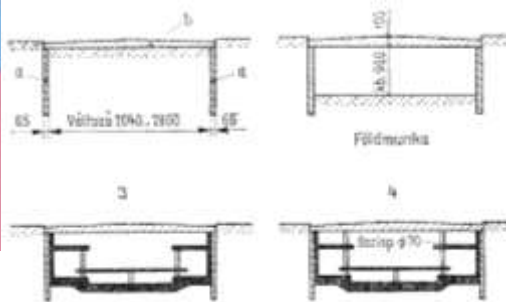
Special methods

Caisson

Construction methods – Station



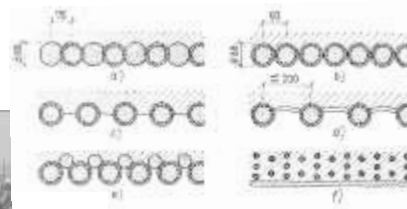
Cut-and-cover methods for metro stations



Nagyvárad tér

Construction methods – Station

Ground support – Pile wall



Budovatelů station,
Prague

Construction methods – Station



Construction equipment
Baross tér

Tétényi út



Construction methods – Station



Móricz Zsigmond
körtér



Construction methods – Station



Tétényi út

Bocskai út



Construction methods – Station



TBM arrives to Bocskai út



Construction methods – Station



TBM arrives to Bocskai út

Construction methods – Station

Construction of the Stations

Cut-and-cover methods

Bottom-up methods (with different ground support methods)

Top-down method (Milan-method)

Mining methods

One Vault method

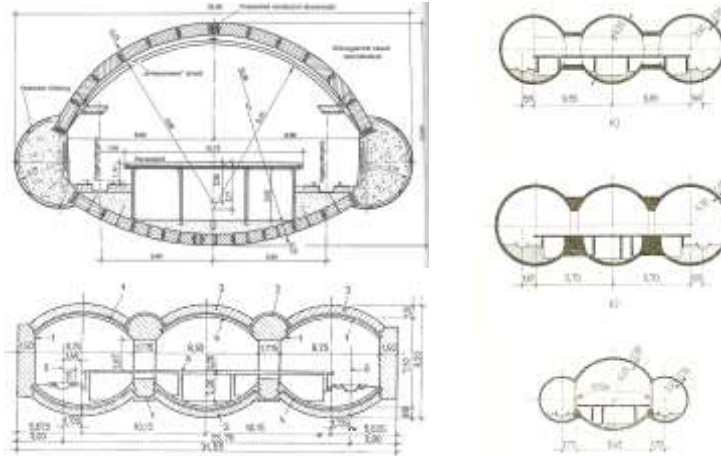
Three Vault method

Five(six)-tunnel method

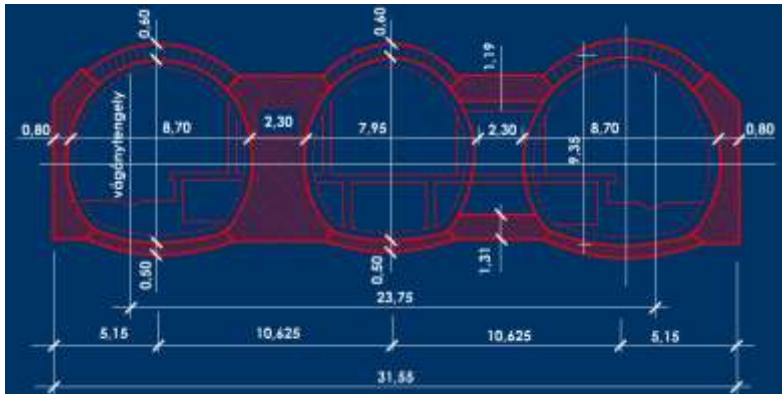
Special methods

Caisson

Construction methods – Station



Construction methods – Station



Déli pályaudvar metro station

Construction methods – Station

Construction of the Stations

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One Vault method

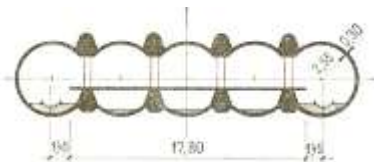
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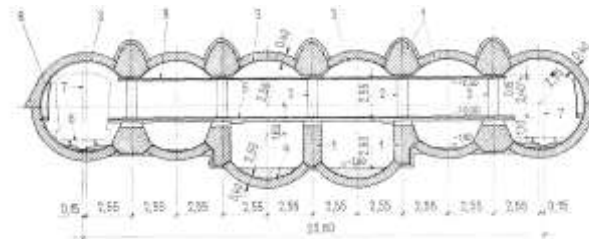
Special methods

Caisson

Construction methods – Station

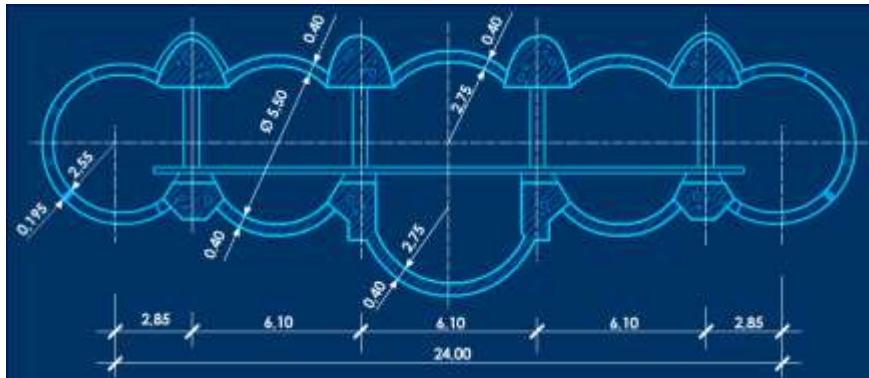


„Budapest-type“ metro station



Kálvin tér metro station

Construction methods – Station



„Budapest-type“ metro station

Construction methods – Station

Construction of the Stations

Cut-and-cover methods

Bottom-up methods (with different ground support methods)

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Special methods

Caisson

Construction methods

Other connecting operations

Solidifying the soil

Freezing the soil

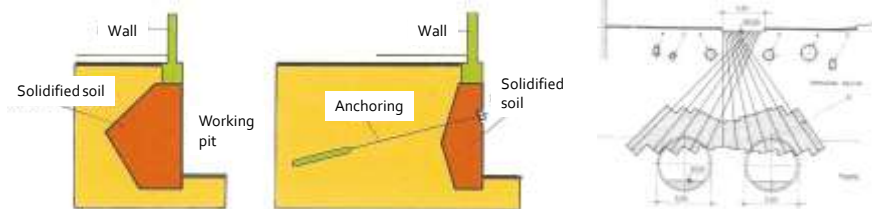
Grouting methods

Water removal works

Drainage

Sinking groundwater level

Watertight working pit



Construction methods

Other connecting operations

Solidifying the soil

Freezing the soil

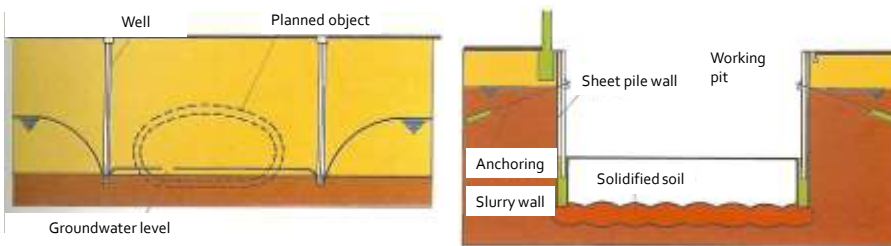
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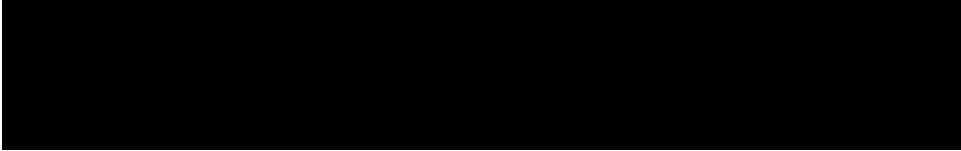
Water removal works

Drainage

Sinking groundwater level

Watertight working pit



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- http://www.nycsubway.org/articles/irtbook_index.html
 - <http://science.howstuffworks.com/engineering/structural/tunnel.htm>
 - http://www.vivanext.com/gallery_subways
 - <http://en.wikipedia.org/wiki/Tunnel>
 - <http://www.metro4.hu/hogyanepul.php>
 - <http://metros.hu/mutargy/allomas.html>