

Tunnel Construction and Tunneling Methods

1. Shallow Tunnels

Open Cut,
Cut and Cover,
Pre-Deck

by

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According to the **International Tunneling and Underground Space Association** shallow tunnels are defined:

A tunnel constructed by excavating a trench from the surface, building the structure within the trench, and then backfilling to restore the surface.

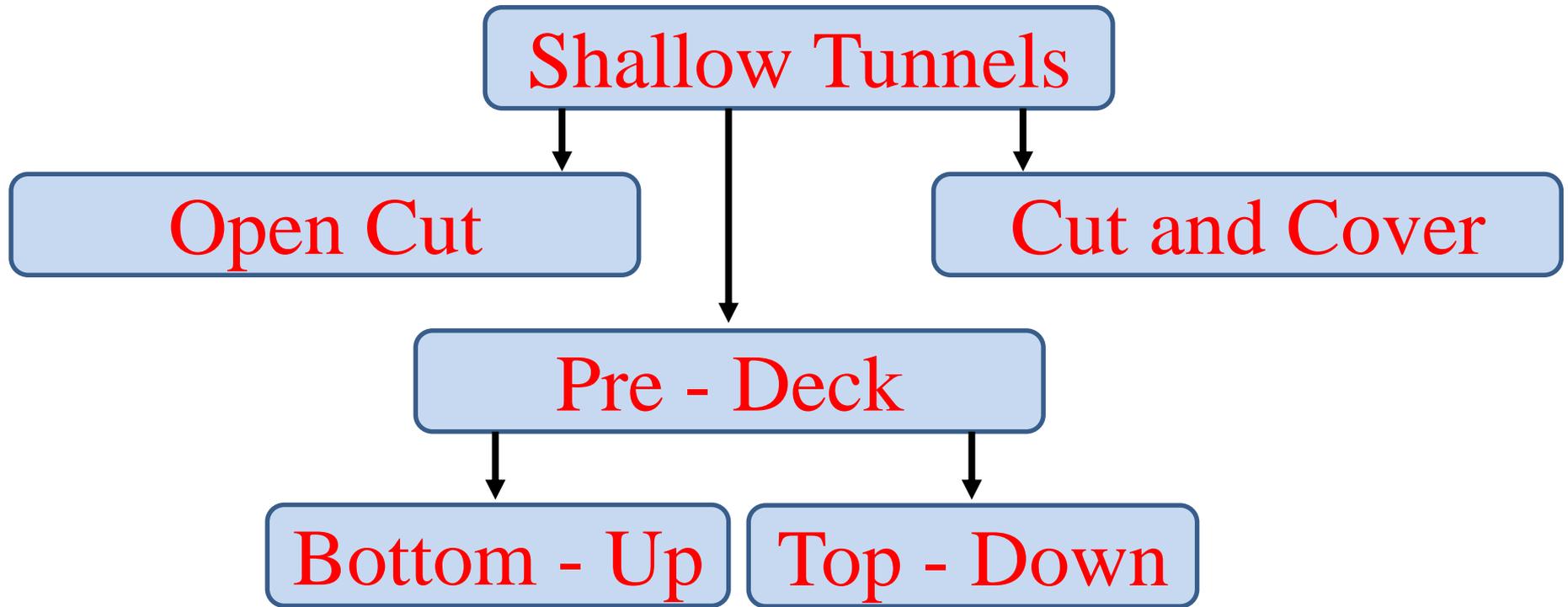
Shallow tunneling is the oldest method of tunneling.

When shallow tunnel **construction is used?** the tunnel profile is shallow and the excavation from the surface is possible, economical, and acceptable.

For which shallow construction is used? for underpasses, the urban or cities and for tunnels in flat terrain or where it is advantageous to construct the tunnel at a shallow depth.

How many types of construction are employed to build shallow tunnels?

Classify the shallow tunnels according to the depth?



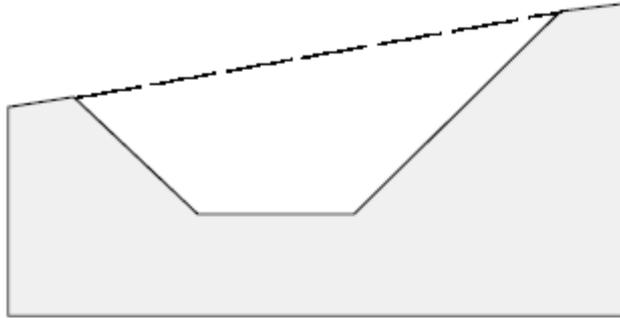
For depths of about 10 m to 12 m, shallow tunnels are usually more economical and more practical than mined or bored tunneling, depths to 18 m are not uncommon; depths rarely exceed 30 m.

OPEN CUT

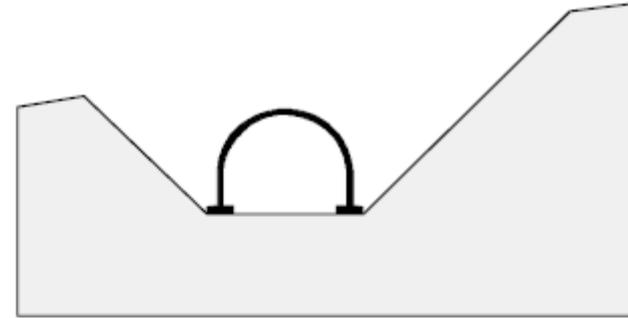
Open cut method often refers to excavation with battered sides such that **no lateral support is required**. In its simplest form, a trench is excavated, the tunnel structure is built, the trench is backfilled and the surface is restored. Precast tunnel units can also be employed **to speed up** to construction process.

The major problem of this method is causing **interference with traffic and other urban activities**. Moreover, it is only suitable for **shallow tunnels** only because with increased depth, direct costs of trench excavation and backfilling increase rapidly.

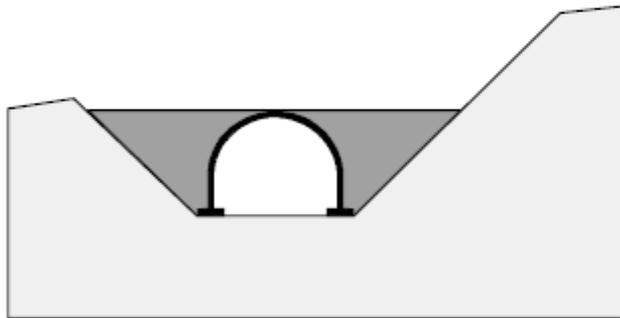
OPEN CUT



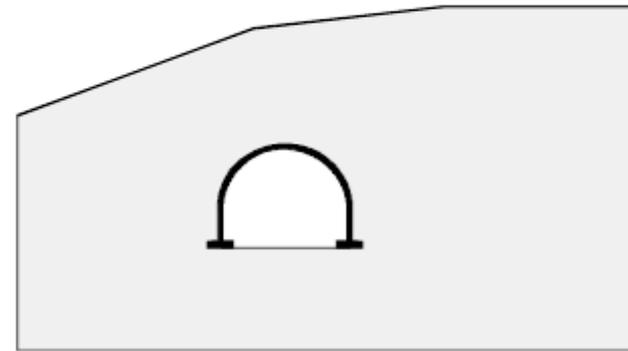
a)



b)



c)

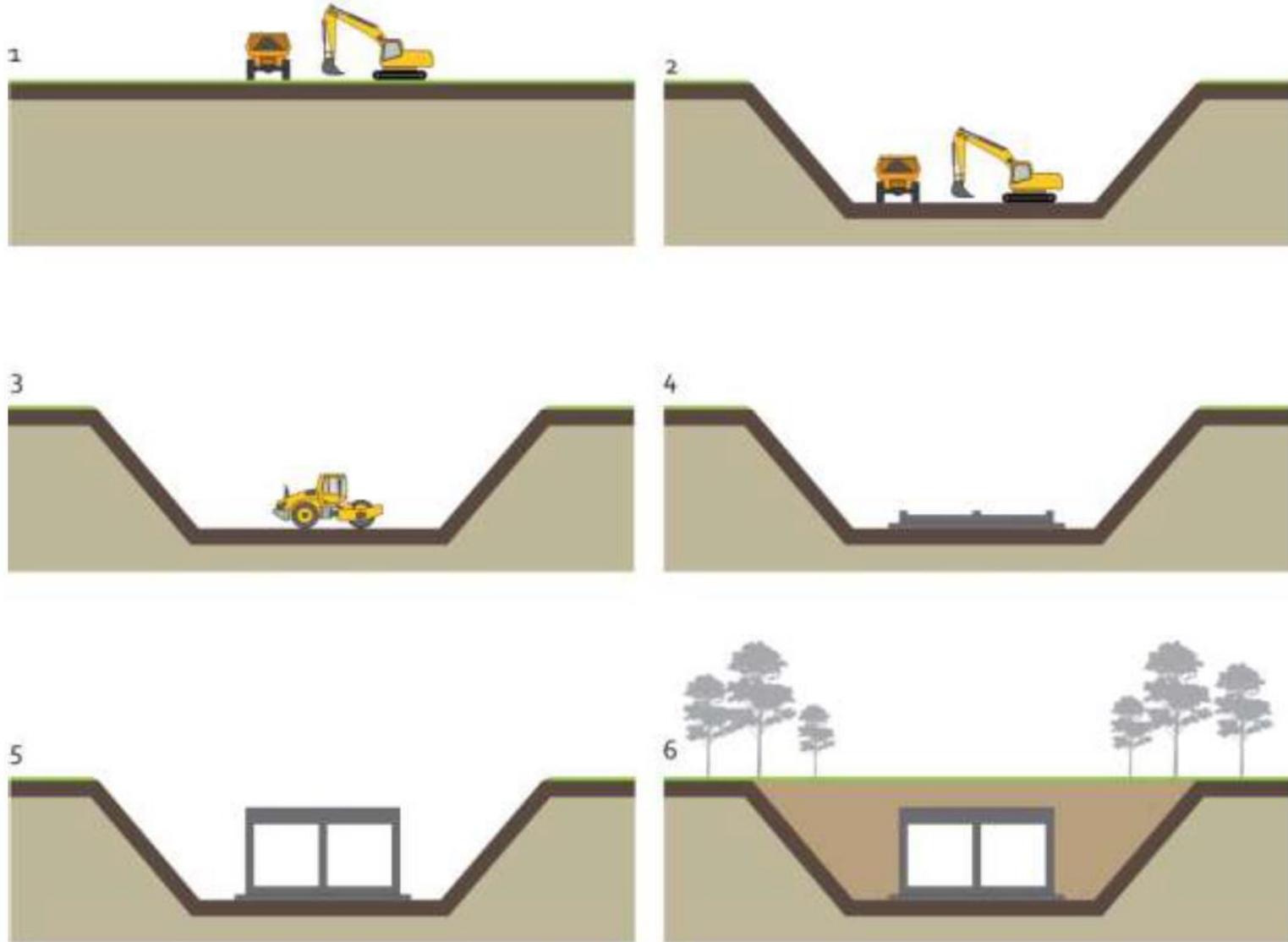


d)

The different construction stages of a typical open cut tunnel

<i>a) Excavation</i>	<i>b) Construction of concrete arch</i>
<i>c) Lateral backfilling</i>	<i>d) Backfilling over tunnel</i>

OPEN CUT



Open cut construction using Side Slopes



Cut and Cover

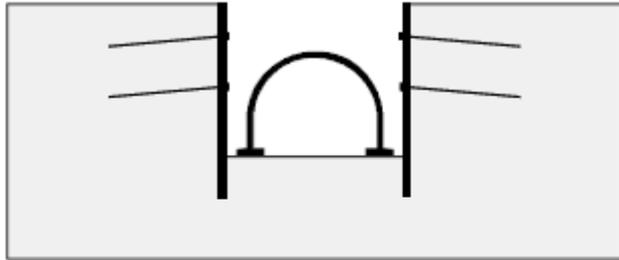
What are the difference between open cut and cut and cover methods?

The construction process of **cut and cover** method is very similar to that of **open cut** method except that the **excavation sides are vertical and temporary supported are provided**.

The main **problems** associated with cut and cover method are the stability of the soft ground, impact on the existing underground services and utilities and traffic disruption in urban areas.

Temporary steel decks may be used to maintain the traffic while the construction works proceeds underneath. This method is also only suitable for high level tunnels.

Cut and Cover

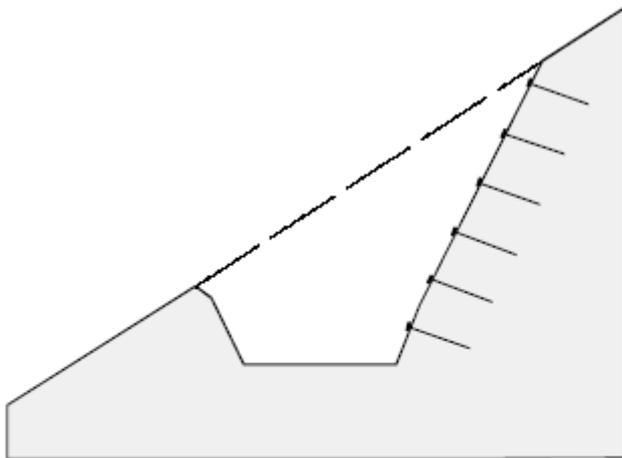


a)

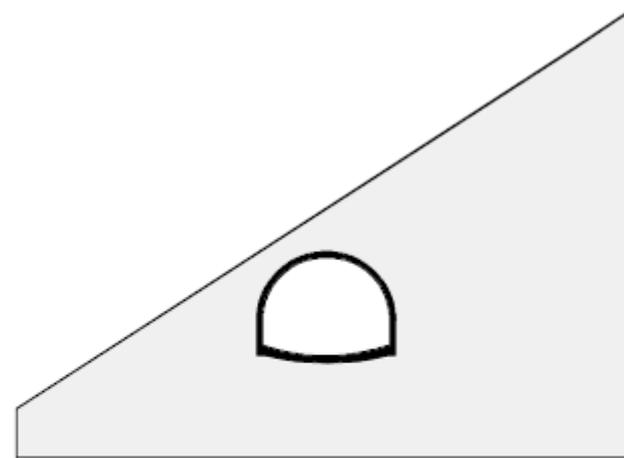


b)

Cut-and-cover tunnel in an excavation supported by pile walls



a)



b)

Cut-and-cover tunnel in sloping ground

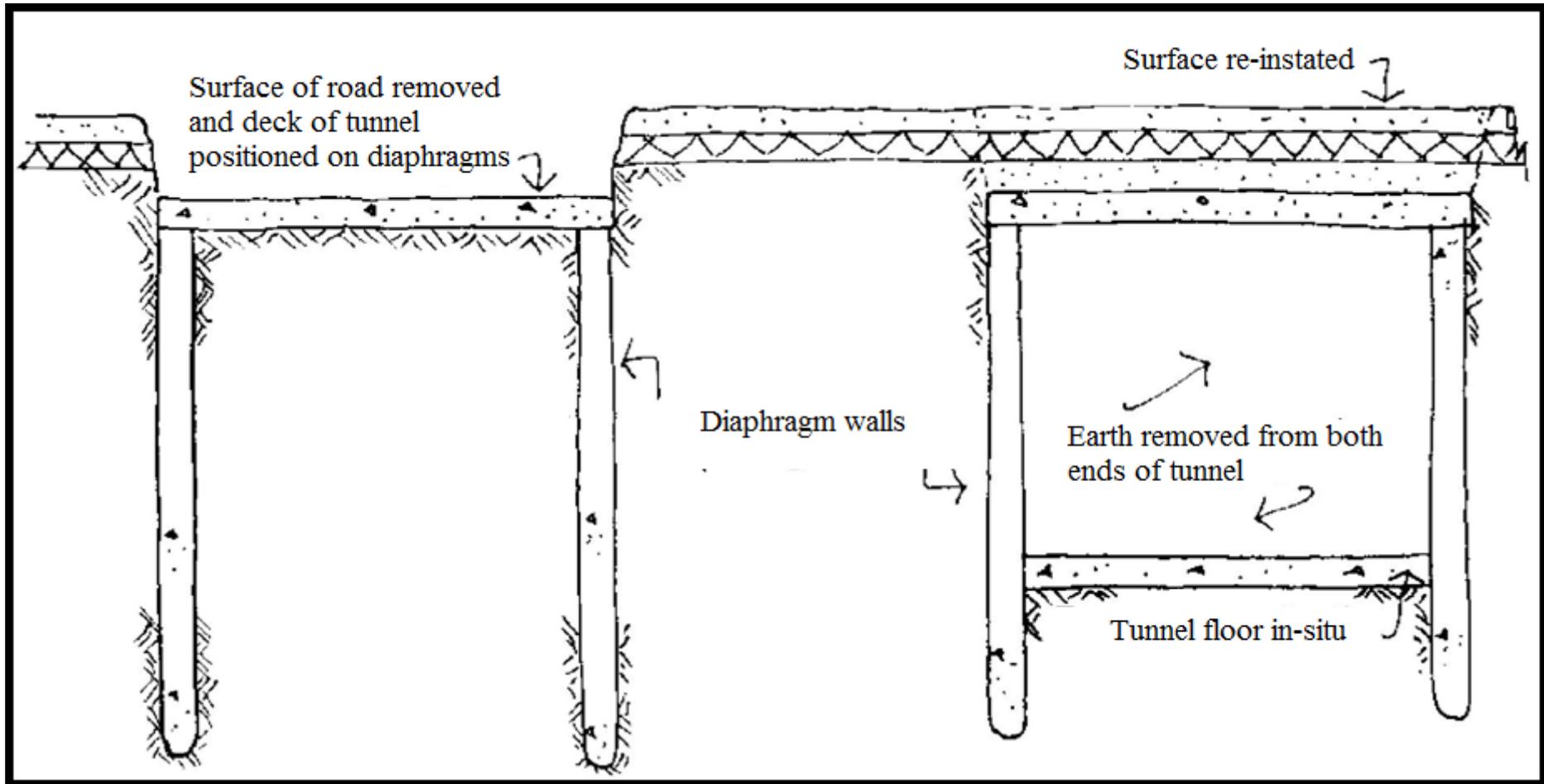
a) Excavation and support of slope

b) Construction of tunnel arch and backfilling

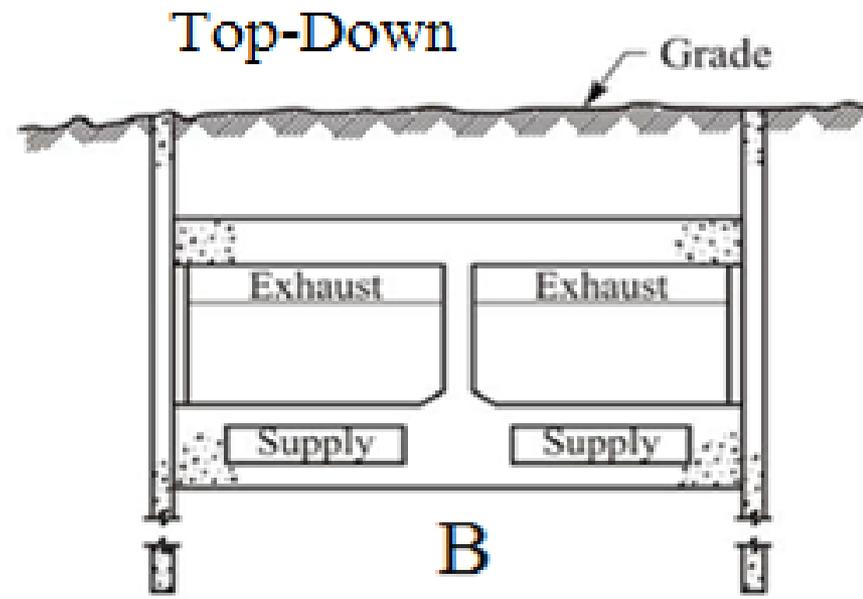
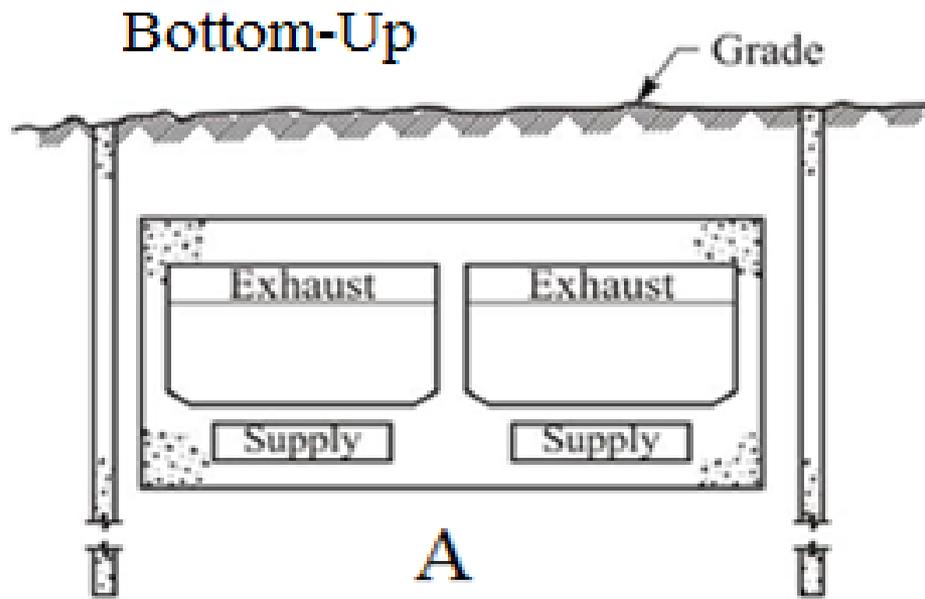
Cut and Cover



Pre-Deck Method



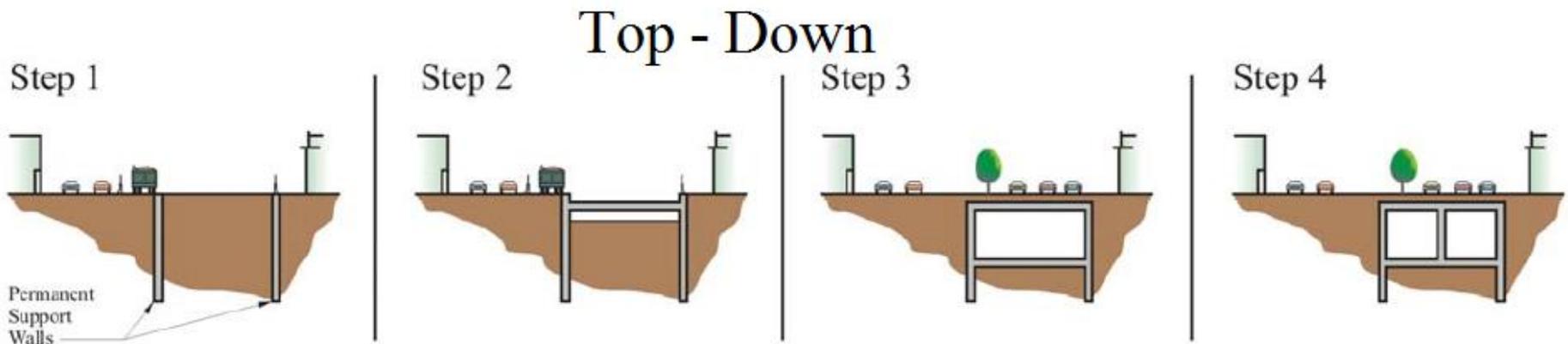
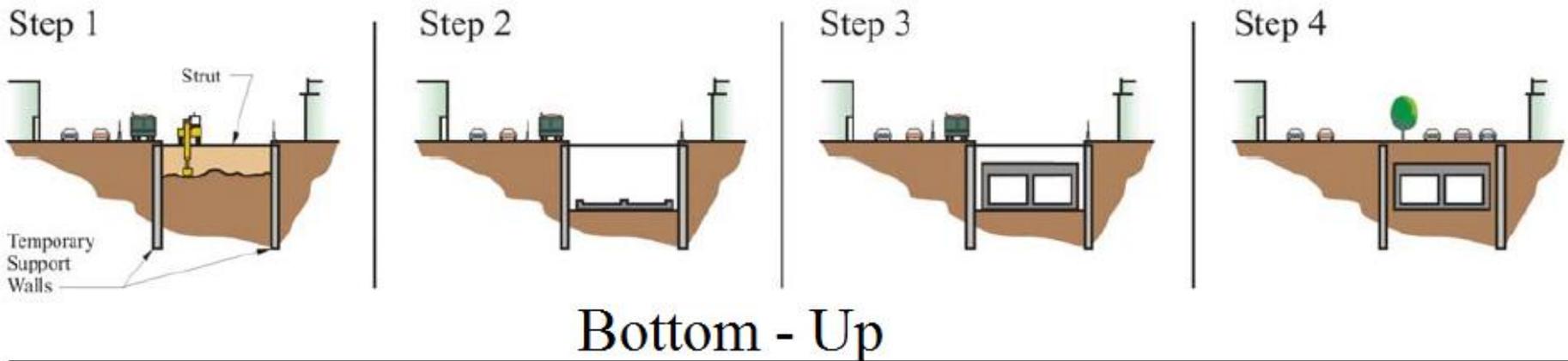
What are the more modern method for shallow tunneling?



- (A) Bottom-Up Construction where the final structure is independent of the support of excavation walls.
- (B) Top-Down Construction where the tunnel roof and ceiling are structural parts of the support of excavation walls.

Pre-Deck Method

Same as the cut and cover method, the pre-deck method is suitable for high level tunnels. The tunnel walls are constructed by the diaphragm walling method first and then the upper surface of the ground is removed. The upper deck of the tunnel is cast supported on the diaphragms. It is then backfilled and the road surface is reinstated. Now the tunnel excavation can be started from both ends of the tunnel without the fear of collapse and with minimum disturbance to traffic and services.



Conventional Bottom-Up Construction

Conventional bottom-up sequence of construction in Figure generally consists of the following steps:

Step 1a: Installation of temporary excavation support walls, such as soldier pile and lagging, sheet piling, slurry walls, tangent or secant pile walls.

Step 1b: Dewatering within the trench if required.

Step 1c: Excavation and installation of temporary wall support elements such as struts or tiebacks.

Step 2: Construction of the tunnel structure by constructing the floor.

Step 3: Complete construction of the walls and then the roof, apply waterproofing as required;

Step 4: Backfilling to final grade and restoring the ground surface.



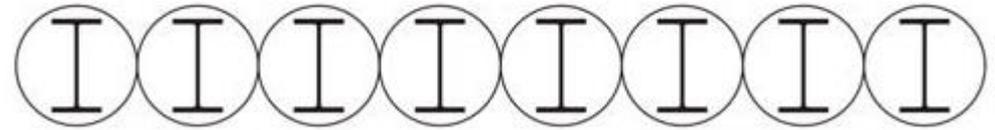
Sheet piling



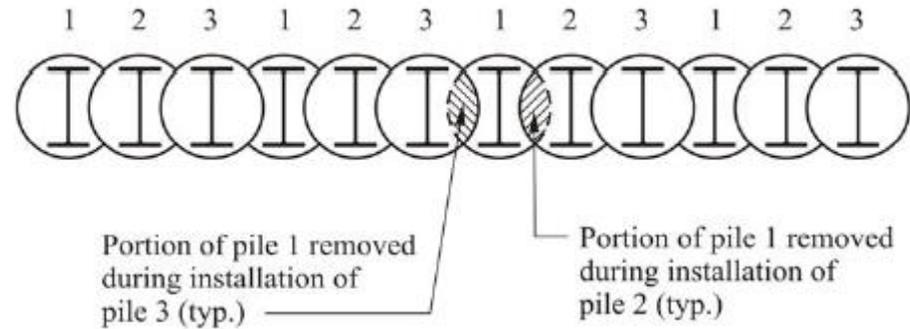
Soldier Pile and Flaggng



slurry walls



Tangent Pile Wall Support



Completed Secant Pile Wall Plan View

Advantages:

- It is a conventional construction method well understood by contractors.
- Waterproofing can be applied to the outside surface of the structure.
- The inside of the excavation is easily accessible for the construction equipment and the delivery, storage and placement of materials.
- Drainage systems can be installed outside the structure to channel water or divert it away from the structure.

Disadvantages:

- Somewhat larger footprint required for construction than for top-down construction.
- The ground surface cannot be restored to its final condition until construction is complete.
- Requires temporary support or relocation of utilities.
- May require dewatering that could have adverse affects on surrounding infrastructure.

Top-Down Construction

With top-down construction in Figure, the tunnel walls are constructed first, usually using slurry walls, although secant pile walls are also used.

Top-down sequence of construction generally consists of the following steps:

Step 1a: Installation of excavation support/tunnel structural walls, such as slurry walls or secant pile walls.

Step 1b: Dewatering within the excavation limits if required.

Step 2a: Excavation to the level of the bottom of the tunnel top slab.

Step 2b: Construction and waterproofing of the tunnel top slab tying it to the support of excavation walls.

Step 3a: Backfilling the roof and restoring the ground surface.

Step 3b: Excavation of tunnel interior, bracing of the support of excavation walls is installed as required during excavation.

Step 3c: Construction of the tunnel floor slab and tying it to the support of excavation walls.

Step 4: Completing the interior finishes including the secondary walls.

Advantages:

- It allows early restoration of the ground surface above the tunnel.
- The temporary support of excavation walls are used as the permanent structural walls.
- The structural slabs will act as internal bracing for the support of excavation thus reducing the amount of tie backs required.
- It requires somewhat less width for the construction area.
- Easier construction of roof since it can be cast on prepared grade rather than using bottom forms.
- It may result in lower cost for the tunnel by the elimination of the separate, cast-in-place concrete walls within the excavation and reducing the need for tie backs and internal bracing.
- It may result in shorter construction duration by overlapping construction activities.

Disadvantages:

- Inability to install external waterproofing outside the tunnel walls.
- More complicated connections for the roof, floor and base slabs.
- Potential water leakage at the joints between the slabs and the walls.
- Risks that the exterior walls (or center columns) will exceed specified installation tolerances and extend within the neat line of the interior space.
- Access to the excavation is limited to the portals or through shafts through the roof.
- Limited spaces for excavation and construction of the bottom slab



Thank you