URUP (ULTRA RAPID UNDER PASS) METHOD THE FIRST IMPLEMENTATION IN A PUBLIC PROJECT

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ABSTRACT

The URUP (Ultra Rapid Under Pass) Method was originally developed to construct an underpass within shorter period and smaller environmental impacts than conventional construction methods. The demonstration work has proved applicability of the URUP method for ordinary shield tunnelling projects. The first project of the URUP method in the world is currently in progress.

This paper presents the URUP method, the demonstration work, the outline of the actual tunnel construction by the URUP method.

INTRODUCTION

Many intersections in urban areas are chronically congested. Traffic congestion causes an economic loss, and time consuming in passing intersections are having adverse effects on not only the local living environment but also on the global environment due to exhaust emissions from vehicles.

The URUP (Ultra Rapid Under Pass) method has been developed to solve those problems, and the method shortens construction period of an underpass and decreases noise, vibration and secondary traffic congestion by its innovative technology, i.e. launching a shield machine from a ground level, driving the shield machine under thin overburden and having the shield machine arrive at the ground level (Fig.1).

Fig.1 URUP method

In order to verify the feasibility of the URUP method, a demonstration work was performed with a rectangular-shape shield machine. Technical information gained from the demonstration work indicates applicability of the URUP method for ordinary tunnelling projects even for circular tunnels.

The first implementation of the URUP method in the world has been in progress in a public project of the Metropolitan Expressway in Tokyo of Japan.

URUP METHOD

Overview of the URUP Method

The URUP method is a new shield tunnelling method originally developed for underpass construction.
The method makes a shield machine launched at the ground level, driven under thin overburden and arrived at the ground level.
The major advantages of the URUP method are as follows:

(1) Shorter construction period
The URUP method eliminates time-consuming construction of cut-and-cover tunnels, shafts and approaches. In addition, continuous tunnelling works by the URUP method in between the tunnel portals shortens construction period. A case-study shows that the URUP method saves two-third of time for an underpass construction that has two carriage lanes in length of 500m comparing with conventional construction methods. (Fig.2, 3&4)

(2) Environment Friendly
Since the URUP method does not require cut-and cover tunnel, shafts and approaches, it can reduce noise, vibration and secondary traffic congestion. The method can also reduce CO_2 emission because the work volume of temporary works and permanent structures will be smaller than those by conventional methods.

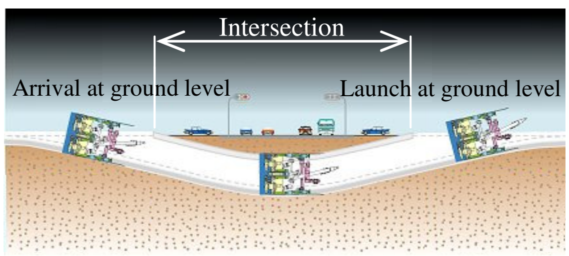


Fig.2 Concept of the URUP method

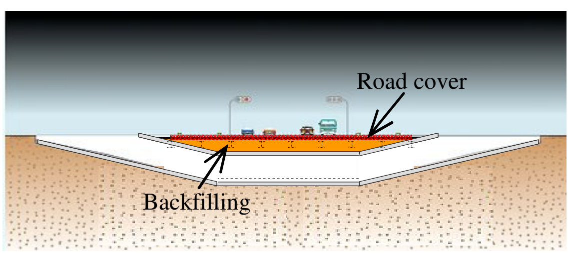


Fig.3 Conventional method: concept of cut-and-cover method

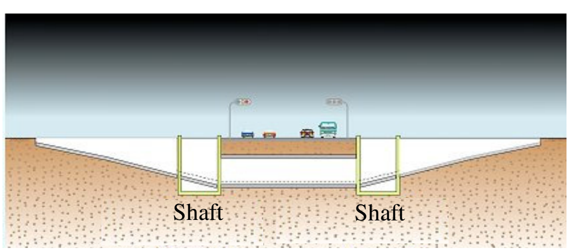


Fig.4 Conventional method: concept of non-cut-and-cover method

Demonstration Work

Feasibility of the URUP method

The feasibility of the URUP method was verified through the demonstration work.
In the demonstration work, an EPB shield machine (Fig.5) with the sizes of 2.15m in height and 4.8m in width was used to excavate over a distance of 100m. The tunnel alignment for the demonstration had a horizontal curve with a radius of 300m and a vertical curve with a radius of 100m as shown in Fig.6. The objectives of the demonstration were to verify the feasibility of "Departure and Arrival at the ground surface" and "excavation under a thin overburden layer."
The results of the demonstration work are summarised as follows:

(1) Departure and arrival of shield tunnelling at ground level
Visual observation at the launching phase was effective to maintain the stability of the cutting face by proper adjustment of the shield machine face pressure and the admixture injection rate. The maximum ground displacement was within ±3 mm at the points (1 m laterally from the shield machine) in the approach sections. The results indicates that the ground deformation was well minimised.
The control of the shield machine attitude during excavation were easily made as well as ordinary shield machines driving by selective use of thrust jacks and articulation adjustment.

(2) Excavation under a thin overburden layer
The face earth pressure in the demonstration work was controlled to keep it at the level of total overburden pressure. The final ground displacement was within ±10 mm. Use of lubricant was confirmed effective to minimise ground displacement as well as proper control of face earth pressure and backfill grouting pressure.

Knowledge gained from the demonstration work

The demonstration work verified not only the feasibility of the URUP method for underpass construction in rectangular shape but also indicated applicability of the method for other types of construction such as ramp tunnels in circular shape when proper face earth pressure, admixture injection rate and attitude control are provided.

Fig.5 Shield machine for the demonstration work

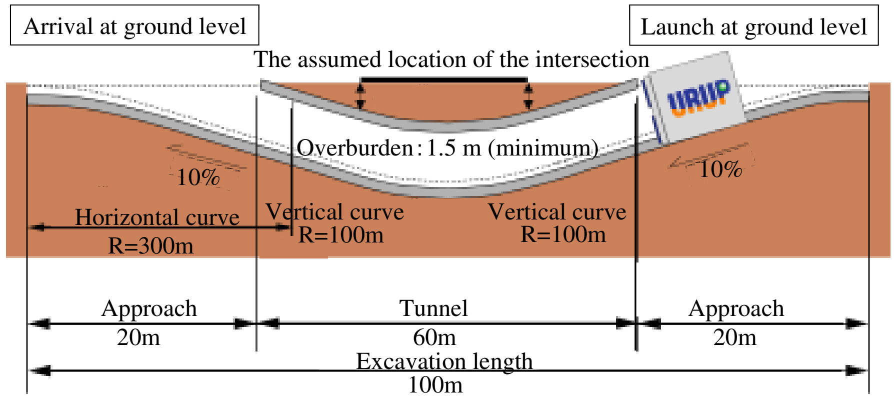


Fig.6 Alignment and profile in the demonstration

OVERVIEW OF OI AREA TUNNEL CONSTRUCTION BY URUP METHOD

1) Description of Work

The Central Circular Shinagawa Route of the Metropolitan Expressway is currently under construction in order to mitigate chronic traffic congestion in central Tokyo. OI Area where the URUP method has been adopted is a part of the Central Circular Shinagawa Route and located between a viaduct section at Oi Junction and a main tunnel section. (Refer Fig.7)

Tab.1 shows construction data. Since the project area has heavy traffic, residents and important utilities near the sites, the URUP method is expected:

i) to reduce cut and cover tunnel area that has much work volume and causes traffic congestions for long period, and
ii) to minimise impacts on the existing structures and environmental impacts.

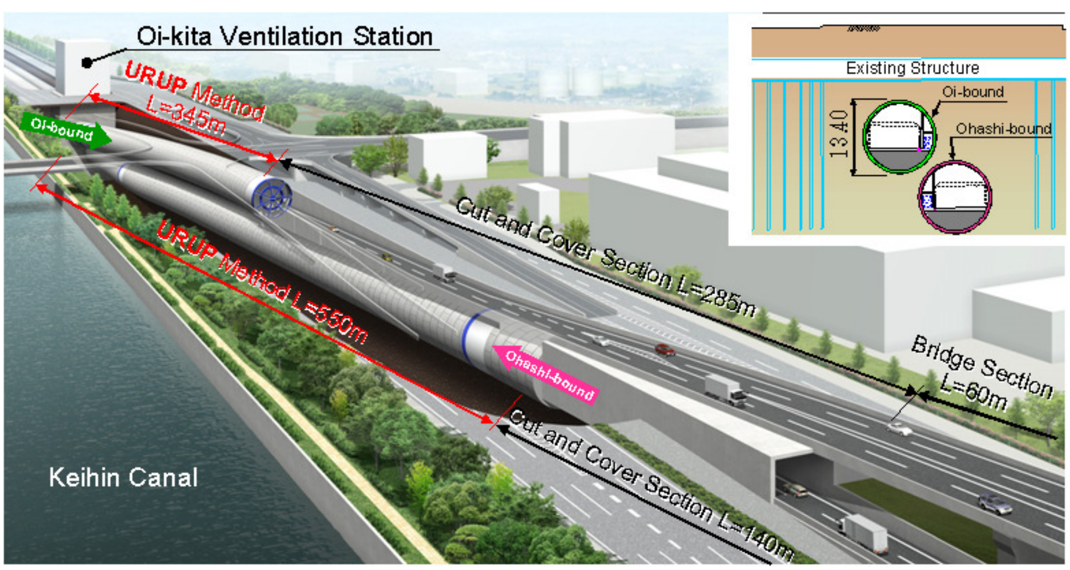


Fig.7 Overview of the construction project

Tab.1 Data on the Oi Area Tunnel Construction Project

<table>
<tr><td>Name of Project</td><td colspan="2">Central Circular Shinagawa Route Oi Area Tunnel Construction Project</td></tr>
<tr><td>Construction Period</td><td colspan="2">25 June 2008 to 30 June 2011</td></tr>
<tr><td>Owner</td><td colspan="2">Tokyo Metropolitan Government</td></tr>
<tr><td colspan="3">Construction Data</td></tr>
<tr><td colspan="2" rowspan="2">Tunnel:
Shield Tunnelling Method / URUP method
Earth Pressure Balance Shield</td><td>Ventilation Station:
Pneumatic Caisson Method</td></tr>
<tr><td>Shape of Structure plan: 39m x 35m
Inside Cross Section: 32m x 28m
Excavation Depth: 44m</td></tr>
<tr><td colspan="2" rowspan="2">Shield Outer Diameter: 13.6m
Segment Outer Diameter: 13.4m
Inner Diameter: 12.5m
Width: 1,700mm
Tunnel Length: 895m
Oi-bound: 345m
Ohashi-bound: 550m</td><td>Retaining Wall and Culverts: Cut & Cover method
Retaining Wall Length: 265m / Oi:205m,Ohashi:60m
Culvert Length: 80m</td></tr>
<tr><td>Bridge Section Two-span prestressed concrete bridge
Bridge Length: 90m
Piers: 3</td></tr>
</table>

PLANNING OF URUP FOR OI AREA TUNNEL

Tunnel Construction Sequence

The sequences of the tunnelling works by the URUP method are described below:

1) The URUP shield machine launches from ground level and arrives to Oi-Kita Ventilation Station for construction of Ohashi-bound tunnel.
2) The URUP shield machine turns around in the ventilation station and is to be elevated to the re-launching position of construction of Oi-bound tunnel.
3) The URUP shield machine re-launches from the Ventilation station and arrives to ground level for the construction of Oi-bound tunnel.

Fig. 8 illustrates the tunnel construction sequence

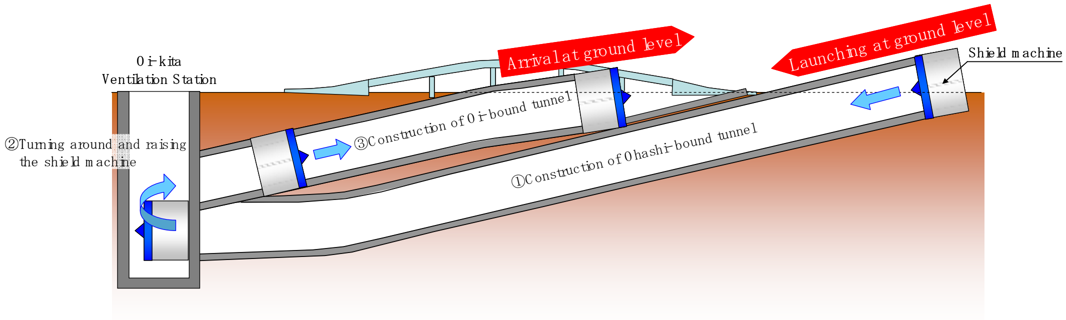
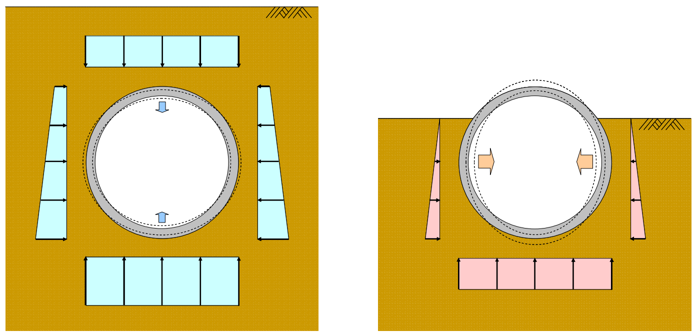


Fig.8 Tunnel construction sequence

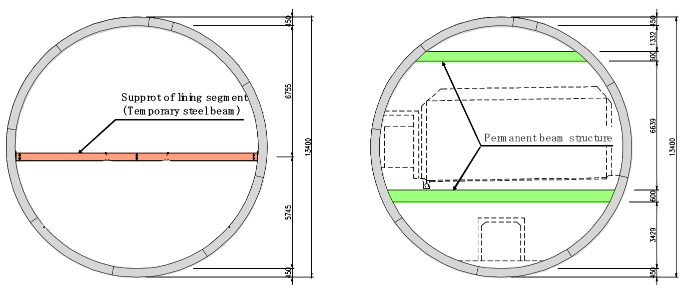
Lining Support Structures at the Launching/Arrival Points

As shown in Fig. 9, the lining segments with less or no vertical pressure in the shallow tunnel sections will have different section force and deformations as compared with the lining segments with overburden in general case. Temporary support members are installed horizontally as Fig. 10 shows to minimise such section force and deformations of the lining segments. The temporary support members are replaced with the permanent beams after the tunnel driving.



(General case) (Launching at ground level)

Fig.9 Image of earth pressure and underground water pressure



(During the driving tunnel) (After the driving tunnel)

Fig.10 Support and lining segment

Face Pressure Control

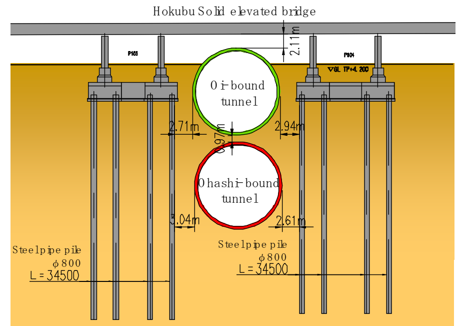
Stabilisation of tunnel cutting face particularly for shallow tunnel driving requires proper control of face earth pressure and plastic flow of excavated soil in a shield machine chamber (Fig.11). The earth pressure monitoring was made with the earth pressure gauge at the highest location in the chamber which is effective under the thin overburden. Plastic flow of the excavated soil in the chamber was controlled upon visual observation of the properties of the soil in the chamber.

Fig.11 Launching at ground level (demonstration work)

Monitoring Method of Adjacent Existing Structures

As shown in Fig. 12, the tunnel alignment is close to the footings and the foundation piles of the flyover. Prior to commencement of the tunnel excavation by the URUP method, no adverse impact on the structures was confirmed by advance analysis.

Trial measurement was performed in the first 100-meter section where there was no adjacent structure and by utilising a real-time monitoring system to identify ideal tunnel driving parameters for safe tunnelling works.



(A – A Section)

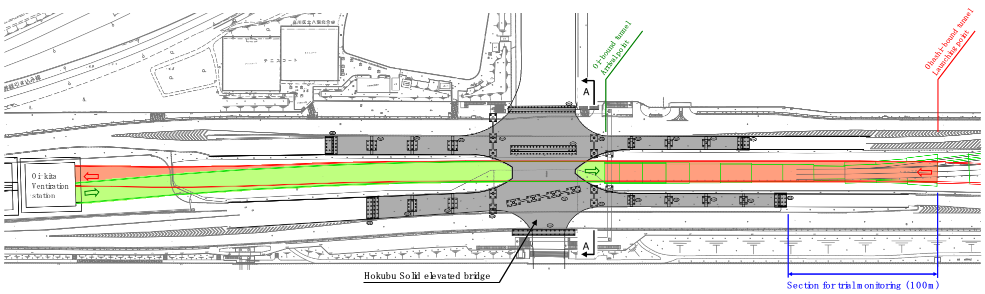


Fig. 12 Adjacent Structures

CONCLUSIONS

The URUP method, which has been originally developed to construct an underpass in a short period of time, was adopted in Oi Area Tunnel project. Adoption of the URUP method solved a number of technical issues in the cut and cover tunnel method which was planned originally.

The URUP tunnel driving commenced on 1st March 2010 (Fig.13&14). The progress as of the end of September 2010 is 481m of the first driving (Ohashi-bound). The control of the shield machine including the face earth pressure has been well maintained, and no impact on the adjacent structures was observed.

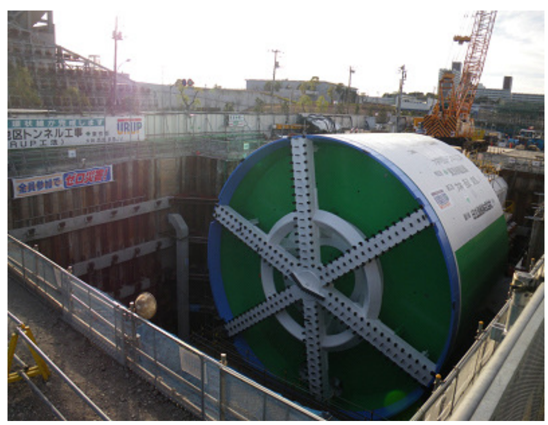


Fig. 13 URUP shield machine before launching

The progress and results of the shield tunnelling work with the URUP method at Oi Area Tunnel Project will be summarised and reported after the completion of the whole tunnelling works.

Fig.14 URUP shield machine launching and temporary segment

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BRIEF BIOGRAPHY OF PRESENTER

Toshiaki Nakamura is the general manager of the Shield Tunnel Engineering Department of Obayashi Corporation. He graduated in Civil Engineering from Nagoya University in 1979. He has more than 30 years construction experience in heavy civil construction mainly of shield tunnelling projects including Trans-Tokyo-Bay Tunnel Construction Project.

Kenji Kato is a project engineer of Swietelsky-Obayashi Consortium of Budapest Metro Line nr. 4 construction project as the representative of Obayashi Corporation. He graduated the master degree in Civil Engineering from Nagoya University in Japan in 1999. Since he joined the Obayashi Corporation, he participated several tunnelling projects in Japan and in America.