**Special Report** (Deep Underground Tunneling Project)

# The World's 4th Longest Deep Underground Tunneling Project!

## Metropolitan Area HSR (Suseo-Pyeongtaek) Section 6-1

### Korea's Longest Deep Underground Tunnel Makes History

The Metropolitan Area High-Speed Railway (HSR), now known as the Super Rapid Train (SRT), which connects Suseo, Dongtan, and Pyeongtaek (Line length: 61.1 km), was completed five years and seven months after the project's commencement. The new railway began operations in December 2016.

The 50.3-kilometer Yulhyeon Tunnel used by the SRT is the longest tunnel in Korea and the fourth longest one in the world—after the Gotthard Base Tunnel in Switzerland, Seikan Tunnel in Japan, and Channel Tunnel between England and France.

The SRT project was developed to expand high-speed train lines to the southeastern part of the Seoul Metropolitan Area (e.g. Seoul's Gangnam and Gangdong districts) and to establish an X-shaped network by connecting the new line with the existing Gyeongbu and Honam KTX lines.

- **Project Name:** Metropolitan Area HSR (Suseo-Pyeongtaek) Section 6-1
- **Location:** From Osan-ri, Dongtan-myeon, Hwaseong, Gyeonggi Province to Gohyeon-ri, Jinwi-myeon, Pyeongtaek, Gyeonggi Province
- **Client:** Korea Rail Network Authority
- **Project Value:** USD 90 million
- **Project Period:** January 3, 2012 – December 20, 2016 (60 months)
- **Project Scope**
  - Tunnel (double-track railway): 5.67 km Section 14: 1.93 km)
  - Vertical Shaft (Ventilation Shaft): 2 shafts (74 m and 47 m deep)
  - Track (Track Concrete Layer): 5.67 km

**50.3Km** Miracle

**The World's 4th** Tunnel

In this national railway project, Ssangyong E&C was in charge of Section 6-1, a 5.67-kilometer stretch between Hwaseong City and Pyeongtaek City. The entire section consisted of a deep underground tunnel at a depth of 40-74 meters, and the only entrance/exit points were two vertical shafts. Despite such unusual and unique circumstances at the site, the firm successfully completed the project with appropriate alternative construction methods and technical ingenuity.

The project began by excavating a vertical shaft, followed by the construction of adits and the main tunnel. The two vertical shafts (74 m and 47 m deep) were built by utilizing earth retaining walls and the shotcrete method. The adits and the main tunnel were created using the New Austrian Tunneling Method (NATM).

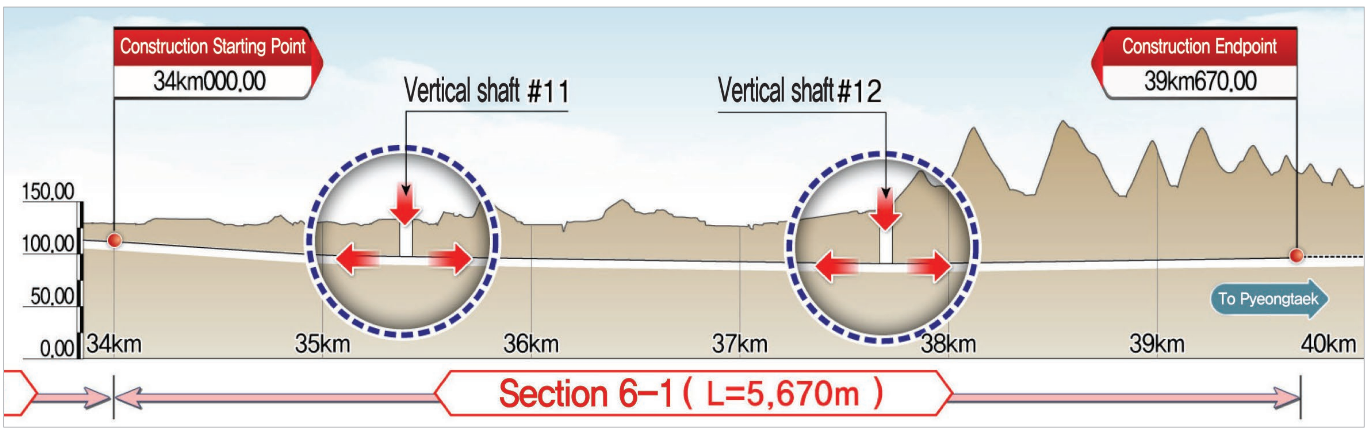
From the two vertical shafts, earth was excavated in two outward directions along the same line to create the main tunnel. Capitalizing on the firm's precision construction knowhow, the two tunneling segments (each originating from their respective vertical shafts) were joined to within 3 cm accuracy.

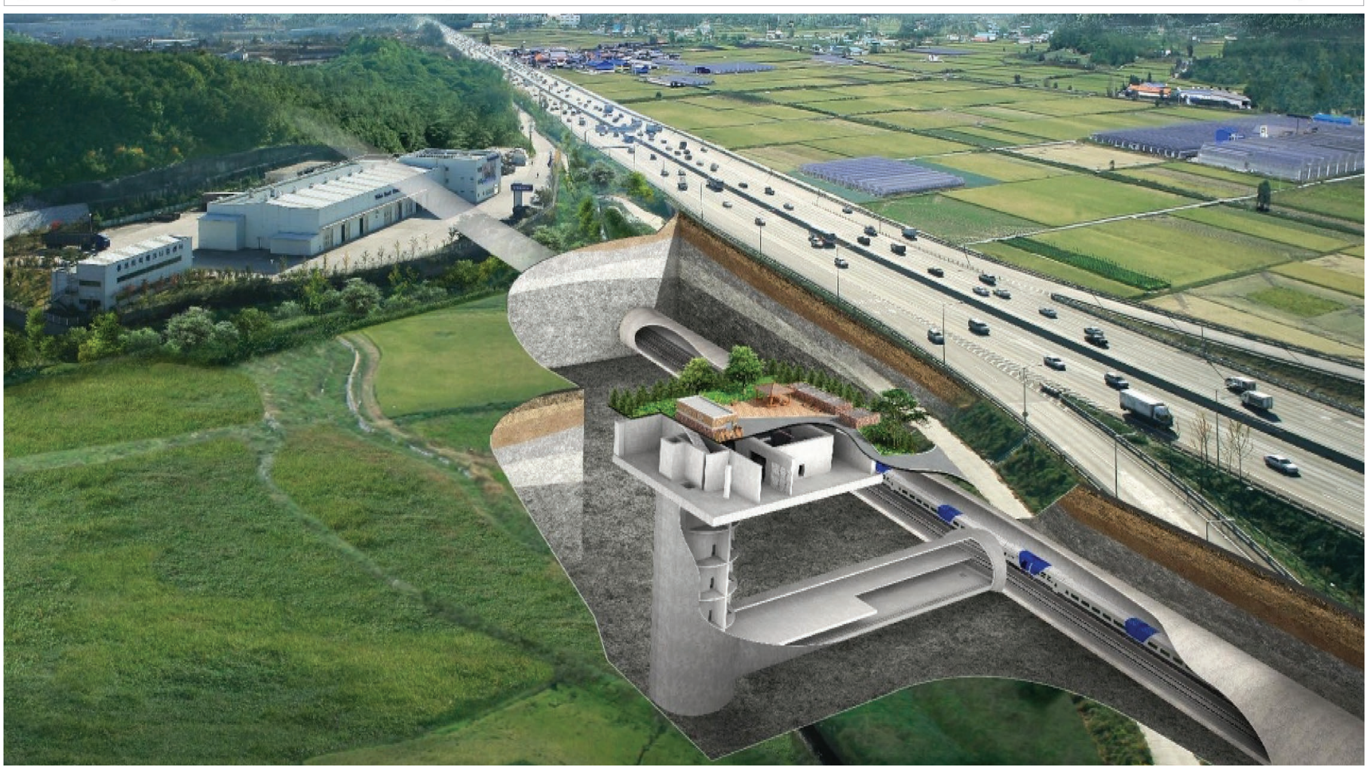
Since the deep underground tunnel constituted the entire project site, the two vertical shafts were the only entrance/exit points available. These shafts were used for all major categories of construction (e.g. tunnel excavation, earth removal, concrete placement for lining and Track Concrete Layer, and material delivery), presenting a serious obstacle to efficient project management.

In particular, after the lining was completed, during foundation work, the shafts had to be shared with non-construction teams (e.g. teams for rails, signals, and communications). With very little workspace, the underground site resembled a "battle field."

### Rationale behind a deep underground tunnel

Due to high land prices and complicated land usage caused by high-density population clusters, construction projects involving Seoul Metropolitan Area are increasingly taking advantage of underground spaces. As such, the construction of deep underground tunnels for automobiles, metro, and bullet trains is being actively utilized, particularly because deep underground spaces that are more than 40-50 meters deep can be freely used for public works projects that serve the common good—without the consent of land owners or associated compensation.



# TUNNEL

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construction procedure

[Tunnel excavation and penetration]


[Illumination management / Pedestrian passage to prevent collisions with vehicles

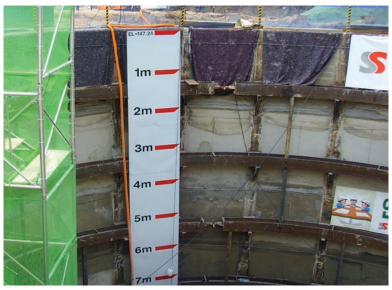
## Safety Management at Max. 74 Meters Underground

As the entire project site comprised a deep underground tunnel, safety management focused on determining and managing the types of accidents most likely to occur during the construction of the tunnel and vertical shafts.

Four major accident types (flying debris accidents during tunnel blasting, collapse accidents, collision accidents with equipment within the tunnel, and fall accidents related to high-elevation work) were selected for special management. During the project period, accident prevention activities and safety measures for each type of accident were thoroughly implemented.

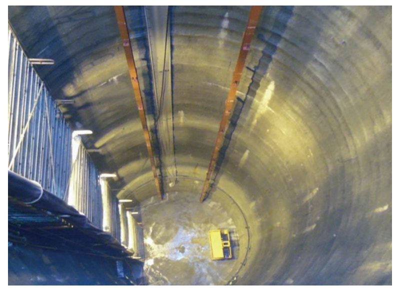
### Vertical shaft construction procedure

[1. Site clearance and H-pile driving]




[2. Ring-beam installation around earth retaining walls of vertical shaft]

[3. Blasting and earth removal at vertical shaft]



[4. Completed vertical shaft]

[Image of a 74-meter-deep vertical shaft adjacent to the main tunnel]

[Installation of structural elements for the main tunnel]

[Temporary installation of rails]

[Completed tunnel]

## Deep Underground Tunneling Solutions Created by Sweat, Effort, and Deliberation

Unlike in ordinary tunneling projects, vertical shafts were the only entrance/exit points for this project, making it impossible to meet the project deadline by following the originally prescribed schedule.

Moreover, the multiple types of construction involved caused continual interference and delays, resulting in increasing cost pressures on Ssangyong E&C and its partners. Such challenges pushed project staff at the site to engage in painstaking research and deliberation. After thoroughly reviewing other similar cases, they boldly applied new solutions.

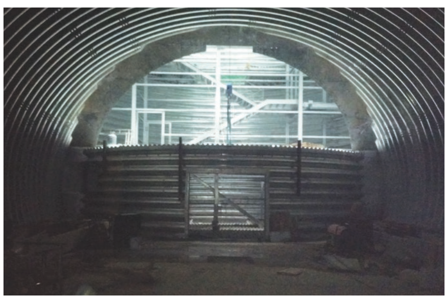
First, the reinforced concrete (RC) method (using plywood forms and supporting posts), originally proposed for the adits and vertical shafts, was replaced by the corrugated steel pipe method because the latter is more cost-effective and safer while facilitating vehicle operations and allowing for concurrent implementation of other types of construction work.

Second, the installation of conveying pipes for ready-mixed concrete at the vertical shafts saved considerable time during concrete placement (e.g. for sub-ballast, lining, and TCL work).

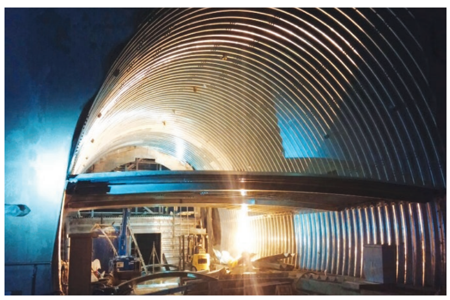
Third, for structural construction, the length of a lining form was increased from 10 to 12 meters. The central drain was moved to a location near side walls. Sub-ballasts were installed at half the normal width. These and other ingenious engineering efforts resulted in a significant reduction of construction time and costs.

Such unwavering efforts by the project staff, both at the site and HQ, to make improvements in construction methods enabled the company to meet the project deadline—what seemed a nearly impossible task at first, thereby gaining the client's trust and leading to the successful completion of the project.

### Construction procedure for adit and corrugated steel pipe



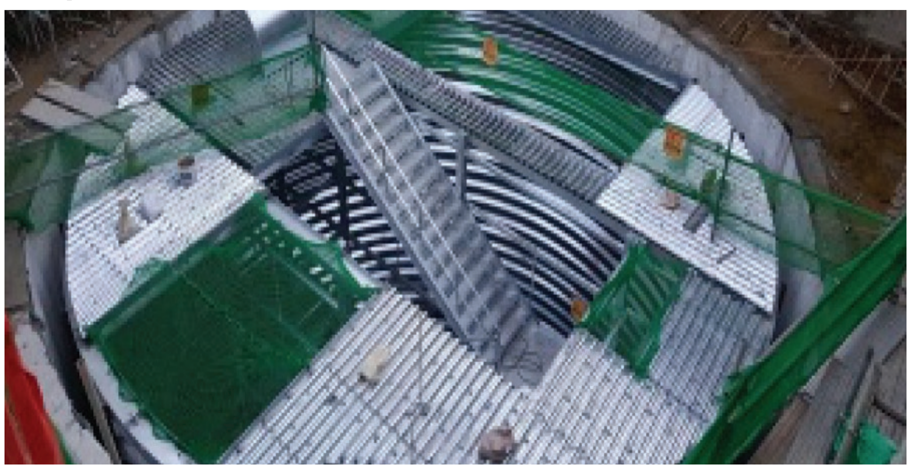
[1. Connecting an adit near the main tunnel with vertical shaft at 74 m dept]



[2. Slab installation to create two floors within an adit]

[3. Outdoor production of corrugated steel pipe]

[4. Lifting corrugated steel pipe]



[5. Completed installation of corrugated steel pipe for vertical shaft]