Impossible? I'm possible!

The Most Challenging Subway Project in History,

Seoul 923 Subway Station

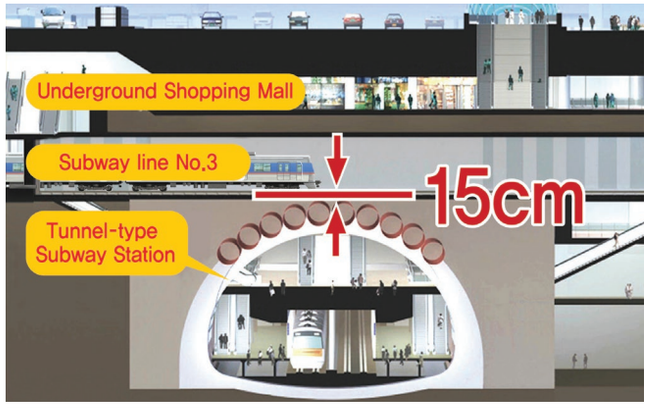
[The largest cross-section tunnel-style subway station in Korea. It was the first instance in the world where both the TRcM and the CAM were used for a single project.]

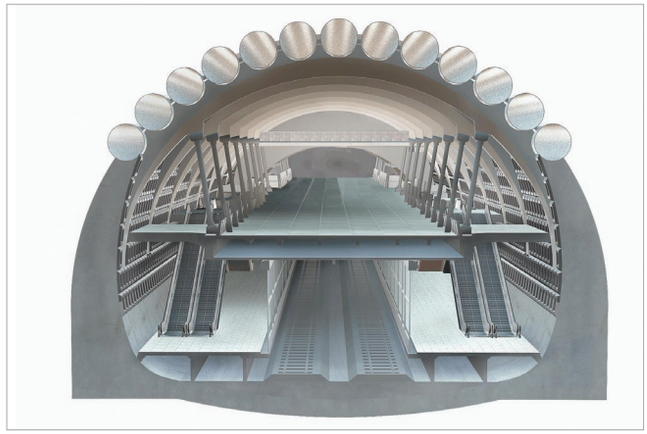
Miraculous 15cm that Astonished the World: A Brand New Chapter in History of Subway Construction in Korea

From the early 2000s, Ssangyong E&C began to focus its energy fully on turnkey projects, a type of contract under which a single contractor carries out the entire project from design to engineering and construction. Ssangyong E&C's ongoing effort and outstanding capability was recognized in September 2002 with the company winning the Seoul Subway Nine 923 Express Bus Terminal Station project, one of the largest turnkey projects at the time and the section in the Seoul Subway Nine that presented the greatest technical challenge.

Ssangyong E&C won this turnkey project, which is only awarded to a firm with extensive knowhow and technological capability, by far exceeding Hyundai in design and prequalification, which account for 45 points and 20 points, respectively, in bid evaluation.

The project site was in the Banpo area, which had a 200-meter section packed with large commercial buildings, such as the Gangnam Express Bus Terminal, the Marriot Hotel and Shinsegae Department Store, and mega apartment complexes.





[Existing Underground Structures - 15 cm between the existing subway line and the tunnel-type station]

Project Overview

- **Location:** Seoul, Korea
- **Client:** Seoul City Urban Infrastructure Headquarters
- **Project Period:** November 2002 to June 2009 (80 months)
- **Project Scope:**
  - Construction of a 1.78-km long subway line including two subway stations
  - Engineering Method: Cut and Cover (L=730 m), NATM (L=850 m), TRcM and CAM (L=200 m)
- **Project Value:** USD 160 million (in past value)

Beneath the ground of this bustling area sprawled an underground shopping mall built over three decades ago and converged three different subway lines (Lines 3, 7 and 9), with a large station to accommodate transfers. With only fifteen centimeters of the distance separating it from Line 3, the Seoul 923 Station presented many technical challenges, including the site's soft ground and proximity to the Han River that posed the risk of groundwater inflow.

The project presented extreme levels of engineering challenges, and Ssangyong E&C had to forego commonly used engineering methods to avoid a huge risk of sinking Line 3 and the underground shopping mall during construction. After repeated meetings, hours and hours of research and exploring subway construction cases overseas, Ssangyong E&C's engineering experts found a solution in the Cellular Arch Method (CAM) used for constructing the Venecia Station in Milan, Italy.

In order to avoid impact on structures in the surrounding area, Ssangyong E&C first built a tunnel structure that cuts across the road underground using the Tubular Roof construction Method (TRcM) as it was putting up the wall structure.

As the next step, Ssangyong E&C used the CAM, driving in 10 to 13 large pipes with two-meter-diameters towards the direction of the subway and filling the pipes with steel and concrete to create a foundation support before excavating the earth underneath it. This creative idea of using the two engineering methods enabled Ssangyong E&C to build the massive tunnel-type station with 21 meters in height and 30 meters in width.

This was the first project in the world to implement the two engineering methods simultaneously, which would never have been attempted without strong confidence in technology and construction capability.

With 48 percent of the total budget allocated to the station, the project cost USD 0.4 million for every meter, and the total project cost reached USD 160 million.



▶Construction Process

Emerges as Must-visit Site for Experts, Earning Numerous Civil Engineering Awards

As the construction of the Seoul Subway Nine 923 Express Bus Terminal Station progressed, it drew increasing attention from civil engineering, tunneling and transportation experts across the world, attracting visitors from France, Belgium, Swiss, Netherlands and Japan with its engineering and construction ingenuity.

For instance, some 40 international experts who visited Korea in 2006 for the ITA WTC were astonished by the massive underground structure created with the advanced engineering methods underneath the soaring high-rise buildings.

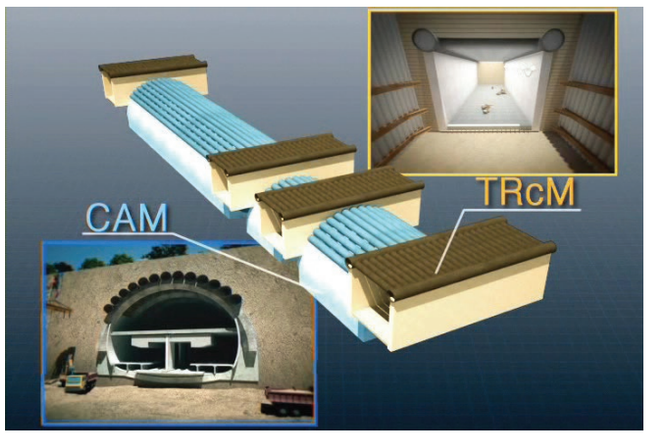
In June 2009, Ssangyong E&C celebrated the successful completion of the Seoul Subway Nine 923 Express Bus Terminal Station, the most challenging project in the history of Korean subway construction. Featuring large, exposed steel pipes, the arch-shaped ceiling of the station gives a sense of openness and expresses the beauty of civil engineering structures, which have earned many prestigious awards for the project both in Korea and overseas.

Awarded 2009 Brunel Medal

[Awarded the 2009 Brunel Medal by the Institute of Civil Engineers (ICE) of UK - ICE was established in 1818 for the purpose of continuing the development in civil engineering and to promote the status of civil engineers. ICE has since grown to have a worldwide membership of over 84,000 registered members in 150 countries.]

In March 2009, the station was named the "Beautiful Station" by the Seoul City Urban Infrastructure Headquarters, an organization that oversees the construction of the Seoul Subway. In the same year, the project also received the "Civil Engineering Structure of the Year" award bestowed by the Korea Society of Civil Engineers in celebration of "Civil Engineering Day" and won the Grand Prize at the Fifth Korea Civil Engineering & Architecture Awards.

These accolades were the testament of the station's aesthetic quality as well as its technological achievement. In October 2009, the station received the internationally-renowned Brunel Medal from the Institute of Civil Engineers of UK.



In October 2009, Ssangyong E&C presented the Seoul Subway Nine 923 Express Bus Terminal Station project with the model at the World Road Conference 2009 hosted by the Land Transport Authority (LTA) of Singapore and showcased its technological capability.
As illustrated, the Seoul Subway Nine 923 Express Bus Terminal Station was the mega project that opened a new chapter in the history of civil engineering of Korea. Through this major achievement, Ssangyong E&C demonstrated an unwavering passion capable of overcoming any challenge, technological creativity and outstanding construction capability that translates into perfection.

[Inside the station that boasts the beautiful curves of the arch-shaped structure]



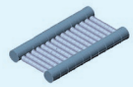
[Station, from inside]

[Station entrance, from outside]

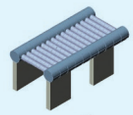
[Ssangyong E&C Chairman and CEO S. Joon Kim explains the engineering and construction method to then Minister of Transport of Singapore Raymond Lim Siang Keat (center) and LTA Chairman Michal Lim Choo San at the 2009 World Road Conference – October 26, 2009]

Ⅰ. TRcM Process

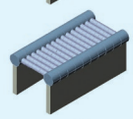
From the "open cut and cover" site, drive 2.5 meter-diameter gallery pipes into the upper parts of both sides.



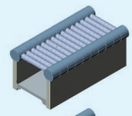
From inside the gallery pipes, drive 1.5 meter-diameter slab pipes across the gallery tubes and pour in concrete.



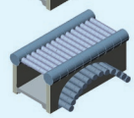
Underneath the gallery pipes, excavate trenches in regular interval and pour in concrete.



Pour concrete into the gallery pipes.

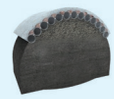


Excavate inside the site and pour in the mid-section concrete slabs.



From the inside the completed section, install steel pipes that form the upper part of the tunnel station.

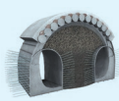
Ⅱ. CAM Process



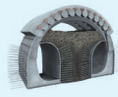
From the propulsion base, drive in two-meter diameter steel pipes towards the arrival base.

From different excavation points, excavate pilot tunnels on both sides of the tunnel's lower parts.

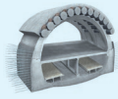
Line the sidewalls of the lower part of the pilot tunnels with concrete.



Pour concrete into the lower part of the arch-shaped steel pipes and girder in phases to connect them with the lower-part concrete.



Excavate a cross-section tunnel and construct structures for the station.



Lay tracks, apply interior finishing and install the ventilation, lighting and power supply systems.