



ITA TUNNELLING
AWARDS 2017

MAJOR
PROJECT OF THE YEAR
- MORE THAN €500 MILLION -



Tehran Metro Line 6

A Lightning-Project

Seyed Mahdi Pourhashemi
Project Manager

Ali Akbar Golshani
Consultant





Stakeholders



Owner

Tehran Metro and Suburban Railway Group of Companies

Consultants

Tehran Behro Consulting Engineers Co.
Rahsaz Tarh Consulting Engineers Co.
Pazhooresh Omran Rahvar Engineering Co.
Gueno Consulting Engineering Co.
Hexa Consulting Engineers Co.
Sazbon Consulting Engineering Co.
Omran Mohit Zist Co.

Contractors

Ahab Co.
Sabir International Co.
Chilco Co.



شرکت راه آهن شهری تهران و حومه (مترو)



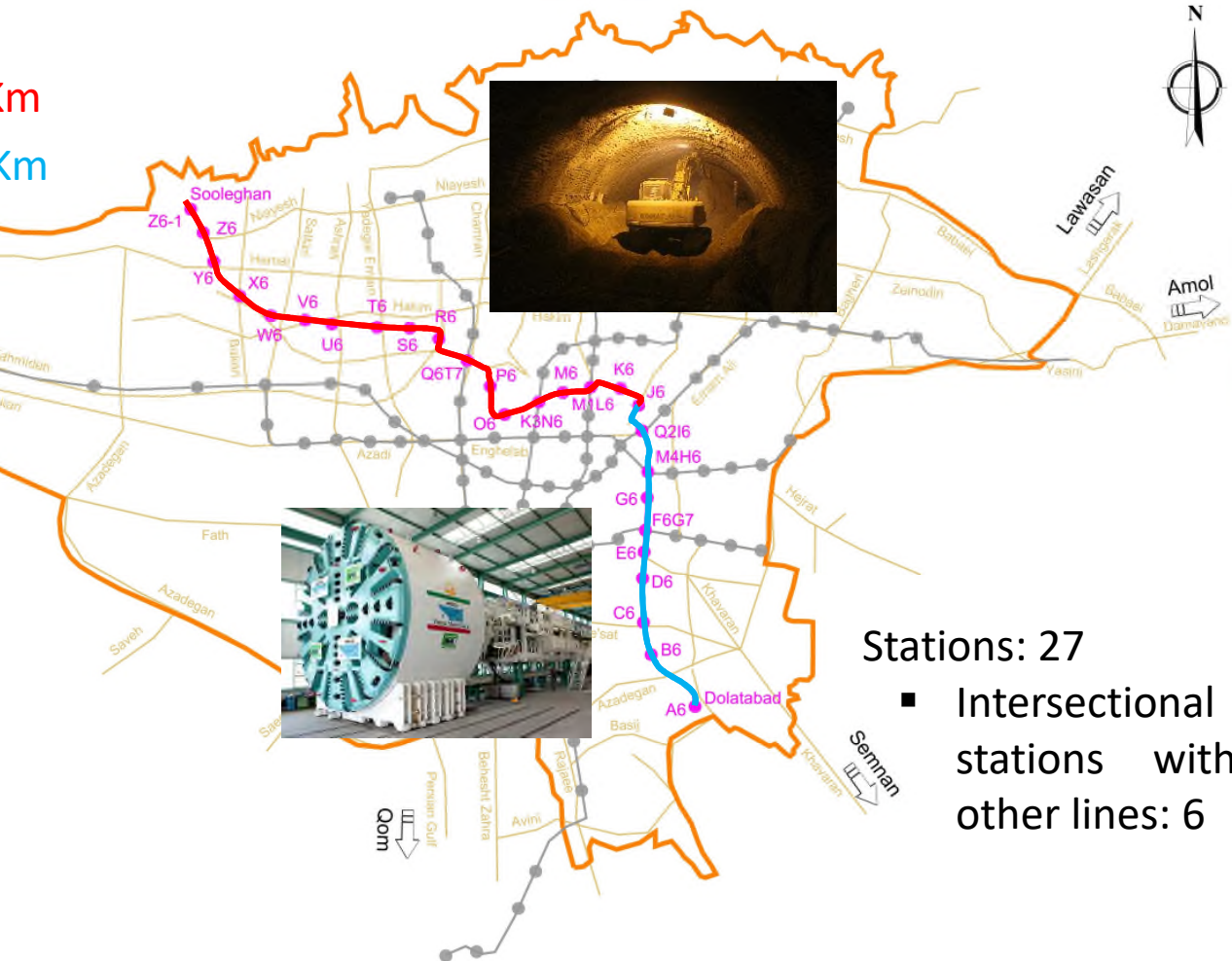
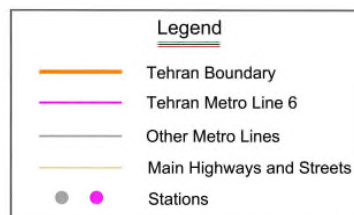
Methods Statement

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Length: 31.2 Km

- NATM Part: 21 Km
- TBM Part: 10.7 Km

The steel weight and the volume of concrete used in this project is about **20 times** and **1.5 times** more than the steel and concrete used in construction of **Eiffel Tower** and **Kariba Dam**, respectively.



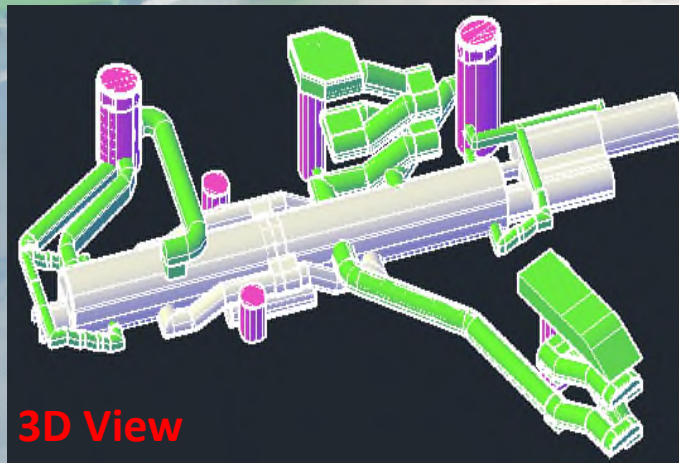
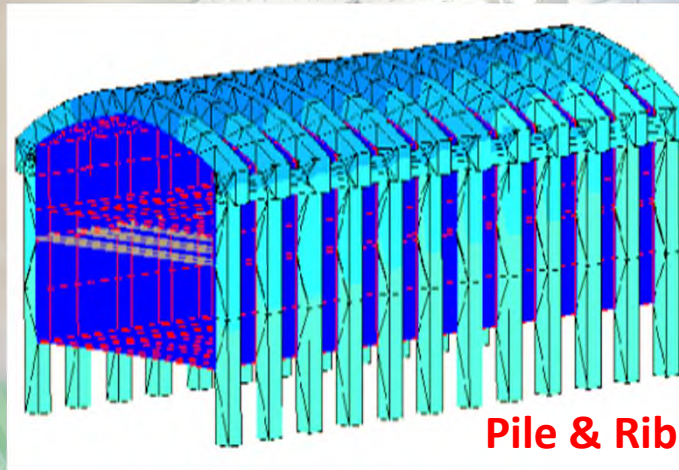
Stations: 27

- Intersectional stations with other lines: 6

Methods Statement



- Construction of Stations



Important Indicators of This Project



➤ Time and Planning Management

- Using LSM (Linear Scheduling Method) to Control Project during Construction
- Designing the Position of Access Tunnels
- Resource Management such as Number of Formworks, Concrete Pumps and Batching

➤ Risk Management

- Building Risk Assessment in Urban Area
- HSE
- Engineering Solutions for Sensitive Structures

➤ Consulting during Construction

- Instrumentation and Monitoring
- TBM Performance Analysis
- Back Analysis based on Monitoring Data and Geological Mapping

➤ Cost Management

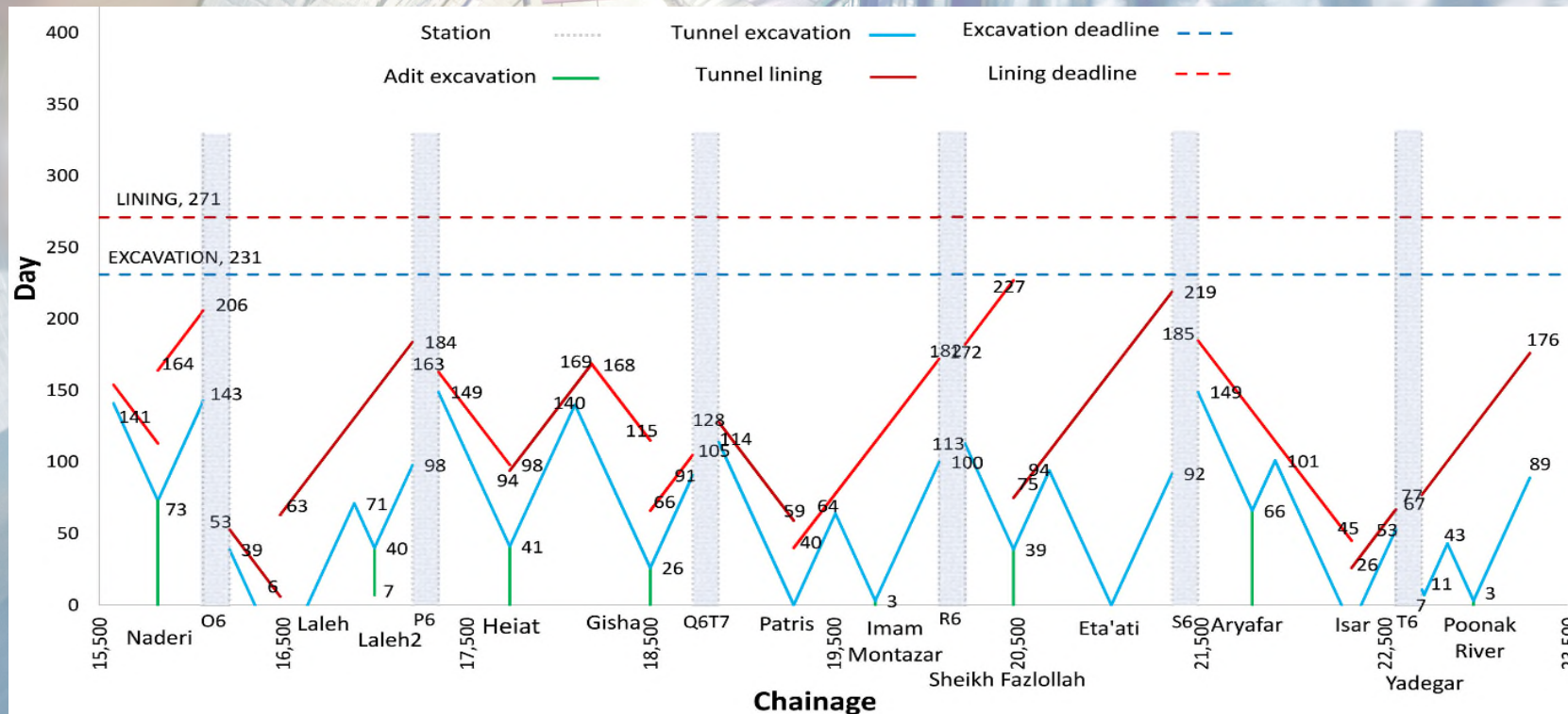
- Design Optimization
- Quality Control
- Value Engineering



Time and Planning Management



- In this project, the **LSM (Linear-Scheduling-Method)** was used for planning, executing, and monitoring the progress of tunnel works.
- With regard to particular planning of this project, **36 access tunnels** were used to construct the NATM part.





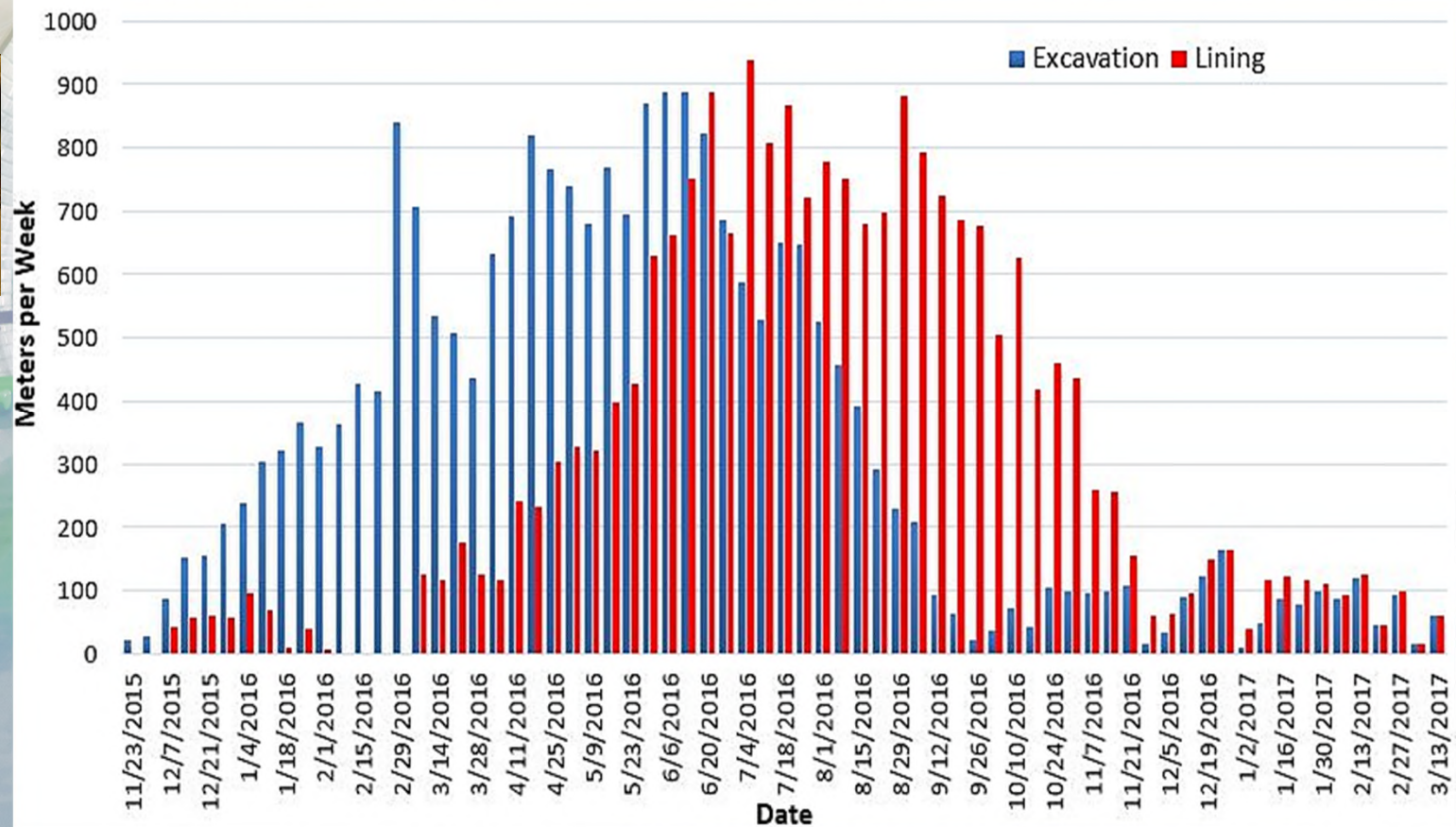
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Time and Planning Management



Unique Rates of Excavation and Final Lining

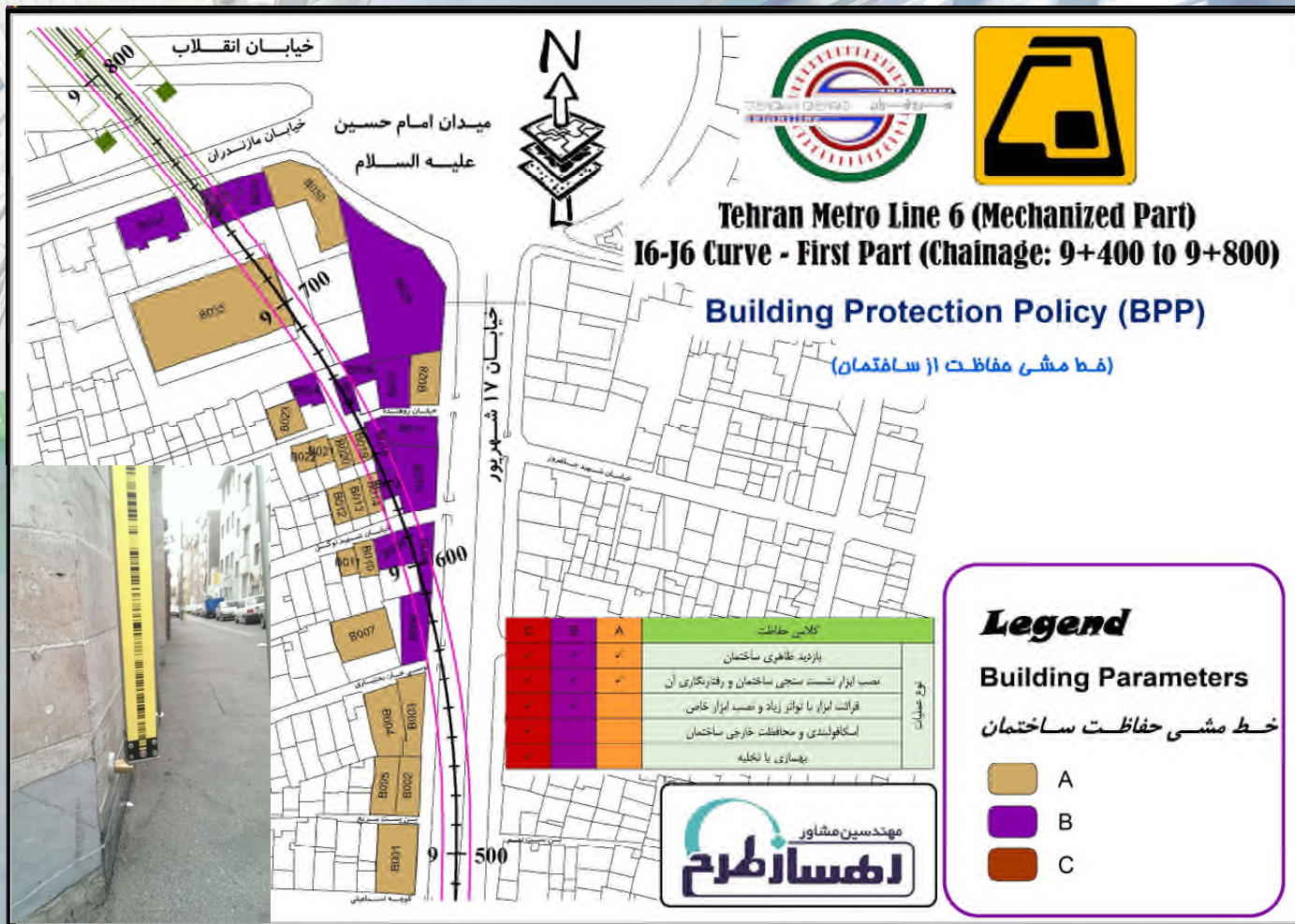


Risk Management

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- ✓ Building Condition Survey (B.C.S.)
- ✓ Building Risk Assessment (B.R.A.)
- ✓ Building Protection Policy (B.P.P.)



Risk Management

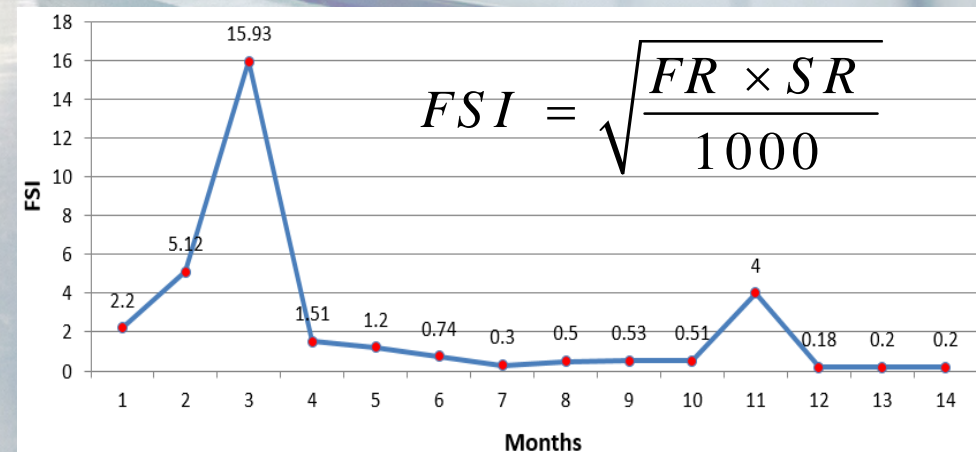


✓ HSE

- Providing HSE PLAN.
- Continuous safety training courses at work site.
- Emergency response exercises at the workplace.
- Risk assessment to reduce workplace hazards.
- Training workshops by the HSE director of consulting engineers.
- Weekly, evaluation the HSE performance of contractors.
- Safety meetings with HSE managers.
- Providing safety and the related check lists.
- More than 50 HSE meetings with presence of owner.
- Health, environment and so on.



- ✓ Some important safety parameters such as accident **Frequency Rate (FR)** and accident **Severity Rate (SR)** were continually determined and registered. Furthermore, the parameter **FSI** which is obtained from FR and SR were calculated. The accidents could be described using FSI.





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Risk Management

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✓ Engineering Solutions for Sensitive Structures

- Particular engineering solutions were applied to pass near the obstacles or from falling areas such as **forepoling**, **micropiling**, **contact grouting**.



Micropiling



Forepoling



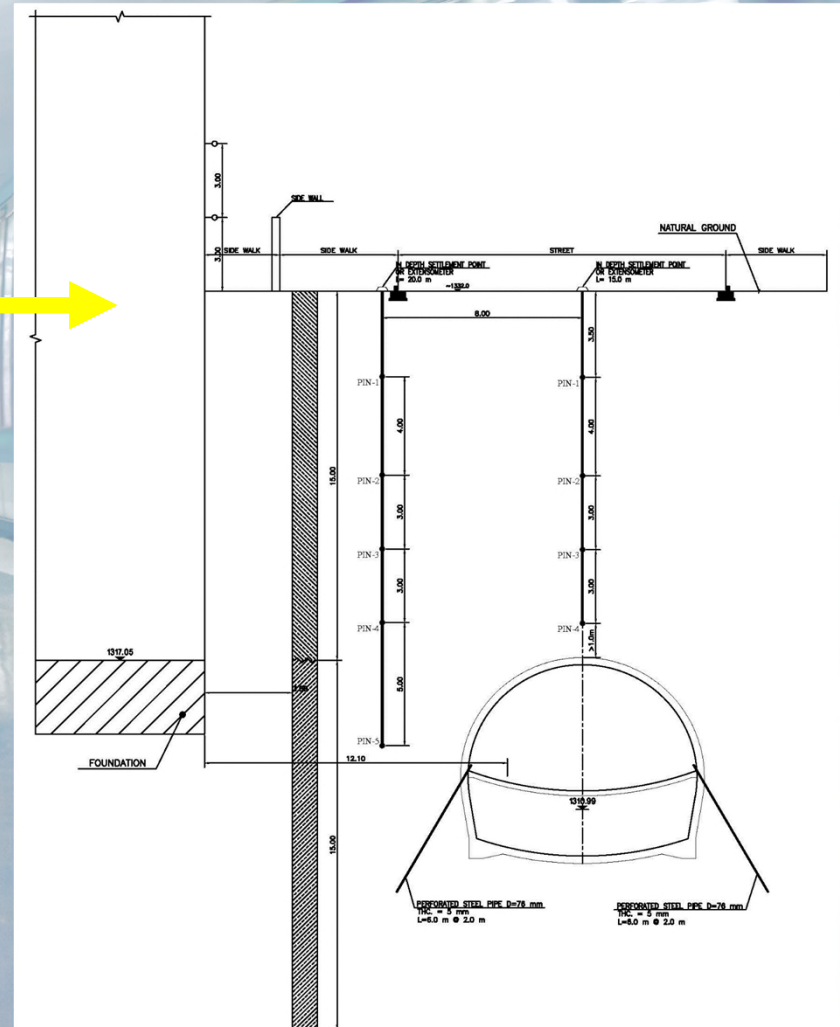
Temporary Supports



Risk Management



- ✓ Engineering Solutions for Sensitive Structures
- A special plan for crossing near a **24 floors building** including retaining pile, micropile, contact grout, extensometer, ground leveling pin and etc.



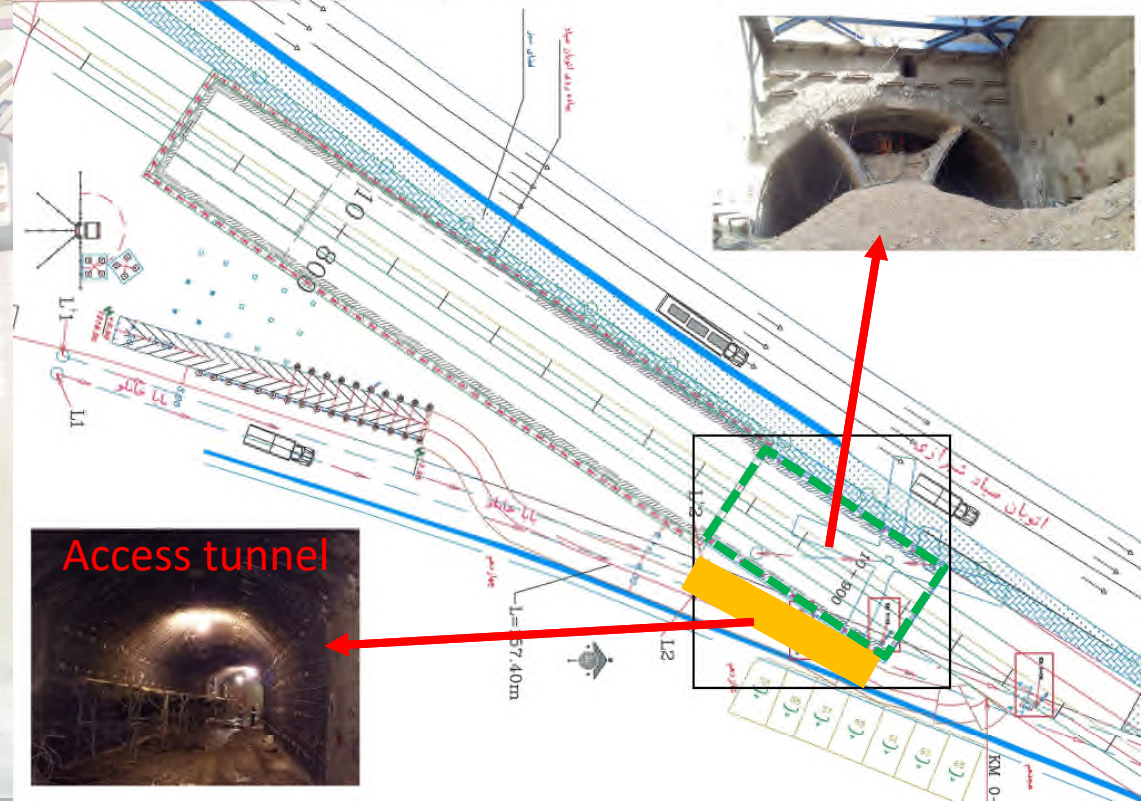
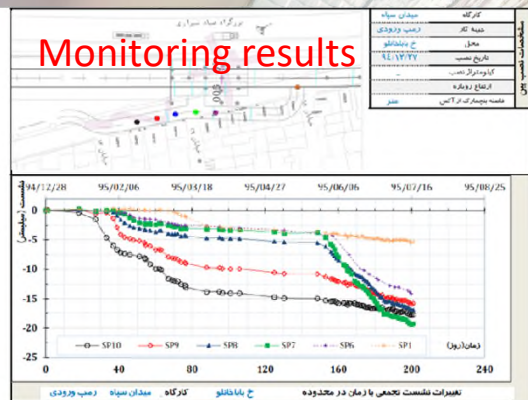
Risk Management



✓ Engineering Solutions for Sensitive Structures

- Executing lining of the access tunnel of station J6, adjacent NATM part of station, based on monitoring results.

Monitoring results

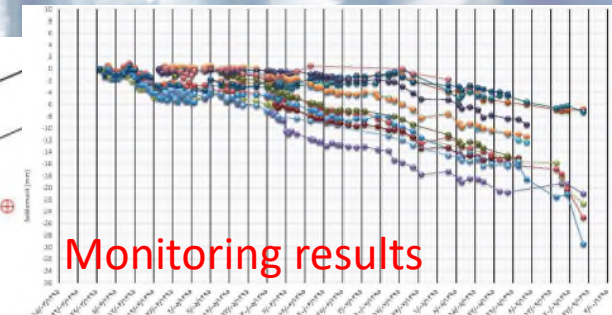
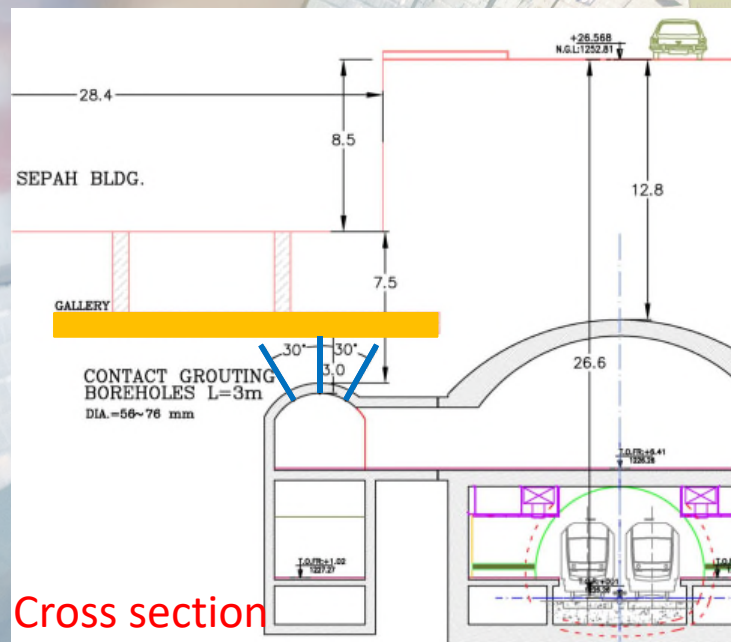


Risk Management



✓ Engineering Solutions for Sensitive Structures

- Controlling the settlement of an old building near station P6 by executing horizontal concrete beams and radial injection.

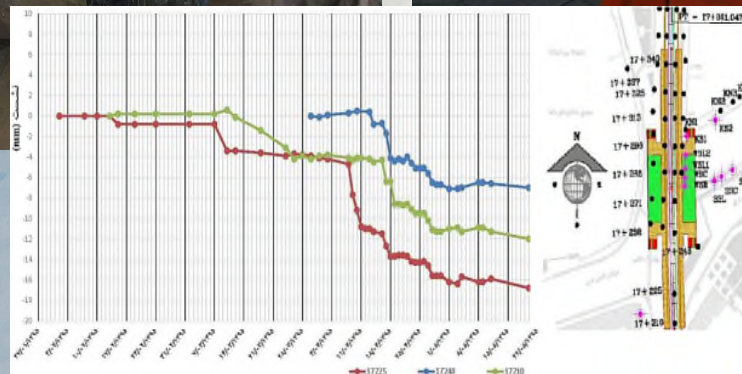
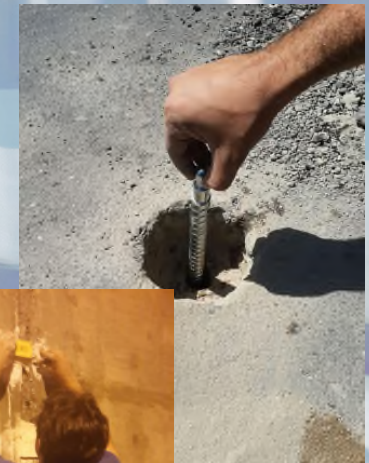
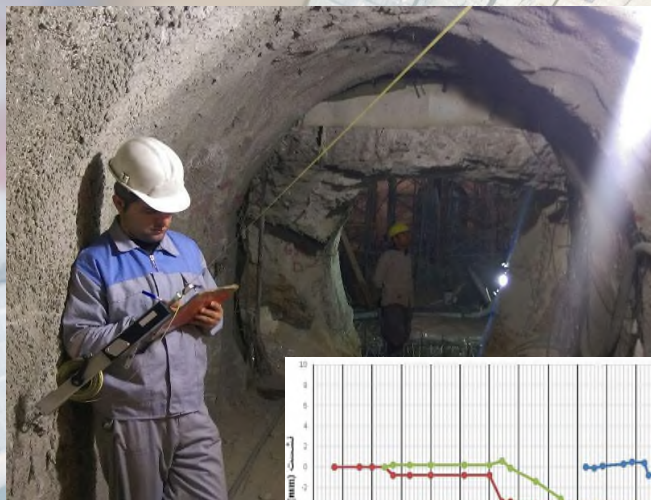


Consulting during Construction



✓ Instrumentation and Monitoring

To have a safe and fast tunneling process, various instruments were used such as ground leveling points, building settlement pins, convergence pins, extensometers, inclinometers, crack meters and etc.



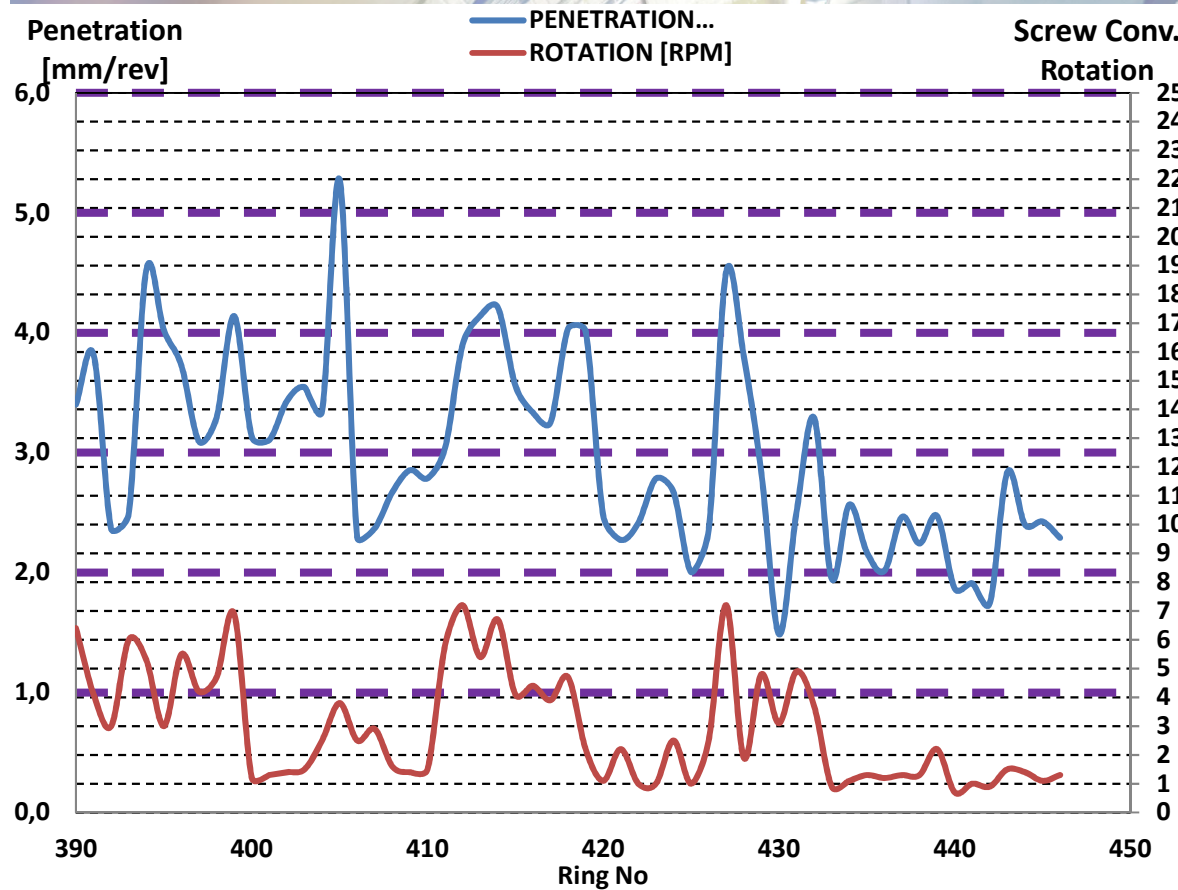


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Consulting during Construction

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✓ TBM Performance Analysis





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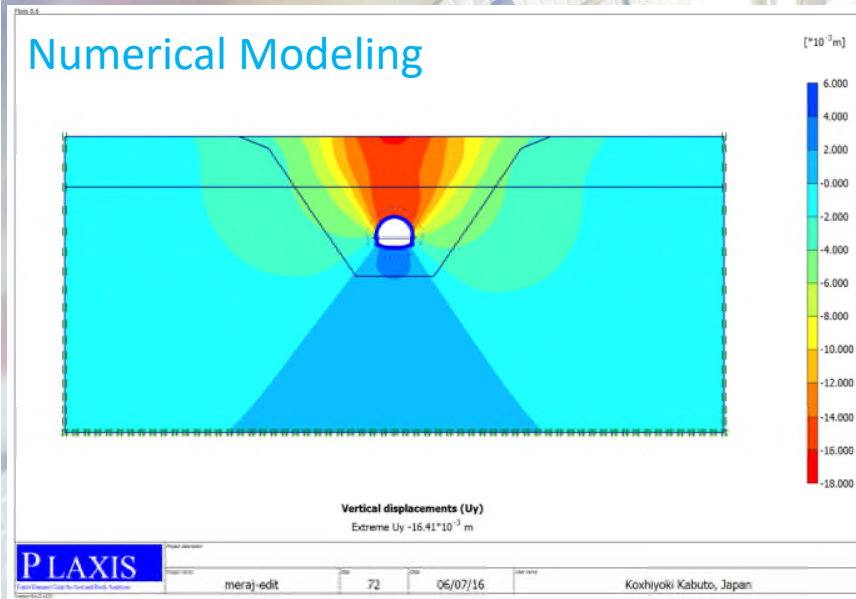
Consulting during Construction

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- ✓ Back Analysis based on Monitoring data and Geological Mapping

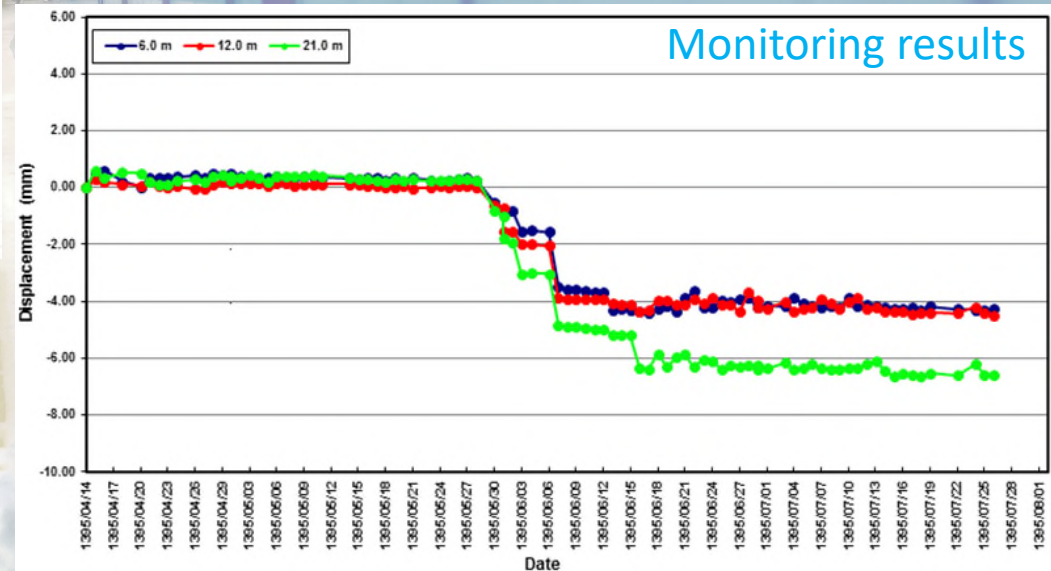
Numerical Modeling



Geological mapping



Monitoring results



Cost Management



✓ Design Optimization

- Using the regulations and recommendations related to the design of underground structures, such as AASHTO and FHWA.
- ❖ Technical Manual for Design and Construction of Road Tunnels Civil Elements – U.S. Department of Transportation Federal Highway Administration (FHWA)
- ❖ American Association of state Highway and Transportation Officials (AASHTO) "AASHTO LRFD Bridge Design Specifications"
- ❖ Building Code Requirements for Structural Concrete (ACI 318)
- ❖ American Institute of Steel Construction (AISC)
- ❖ Tunnels & Shafts in Rock U.S. Army Corps of Engineers





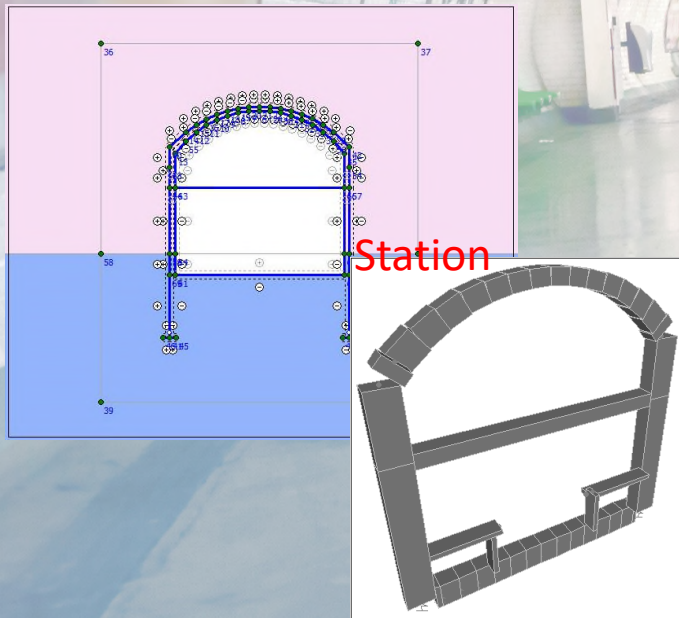
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Cost Management

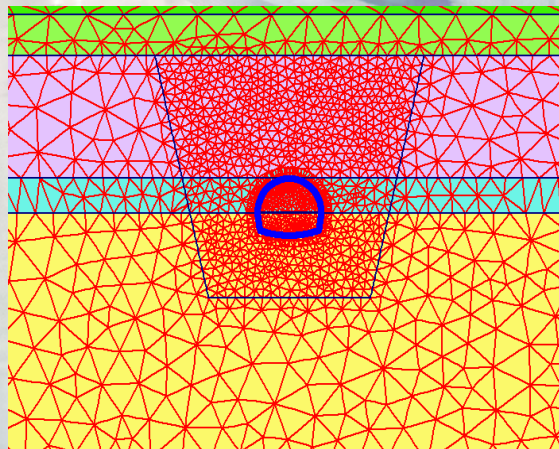


✓ Design Optimization

- Using geotechnical modeling to evaluate the loads applying on the structures.
- Analysis and design using structural softwares for synchronization with geotechnical models to consider the interaction of ground and structure.
- Using geotechnical parameters based on field tests instead of using laboratory test parameters on remolded samples.



NATM tunnel



In-situ direct shear test

Cost Management



✓ Quality Control

- Monitoring of operations and using various tests on concrete, shotcrete, steel, insulation, weld and so on.



Concrete test



PVC test



Approved beams



Formatting and reinforcement operations



Weld test



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Cost Management



✓ Value Engineering

- Some issues of value engineering, which directly reduced the costs and also indirectly by reducing the execution time of project:
 - 70,000 m³ of concrete less used at stations.
 - 17,000 tons of steel less used at stations.
 - 10000 m³ of concrete less used in ventilations.
 - Using of useless space below the arched roof of the stations for ventilation purposes, instead of independent shaft which resulted in 10,000 m³ of concrete, 1500 tons of steel and 20,000 m³ of excavation less used in the project.

Reducing about **43 million euros** of Costs
by Value Engineering



Reducing about **8%** of Civil Costs



VALUE ENGINEERING



Outcomes



Conventional and mechanized methods were used in the Tehran metro line 6 project. Tunnel excavation was performed in urban area, old and high risk structure by national experts. In this project, instrumentation and monitoring of ground and tunnel constructions were of great importance. So, various accurate tools were applied for safe excavation. In summary, this project has three important characteristics:

- Great risk management with minimum ground subsidence in urban area.
- Proper quality management using multiple tests such as concrete, steel, insulation and so on.
- Unique construction speed even in difficult geological conditions.

✓ Why is Tehran Metro Line 6 a **Lightning-Project**?

- More than 20 km tunnel excavation in a year
- More than 800 m tunnel excavation in a week
- 530 m excavation by TBM in a month
- More than 900 m final lining in a week
- Execution of 8 parts of final lining by one formwork in a week



Seyed Mahdi Pourhashemi

*Project Manager of Tehran Metro Line 6
and Member of Board*

Sadegh Tarigh Azali

Executive of Tehran Metro Line 6



Tehran Metro Line 6



شرکت راه آهن شهری تهران و حومه (مترو)