ISTANBUL STRAIT ROAD TUBE CROSSING
PROJECT BACKGROUND

- One of the three major projects at cross path of Europe and Asia
  - 3rd Bosphorus Bridge Crossing
  - New International Airport
  - Eurasia Tunnel
- Total Length 14.6 km
  - Part 1 – European Side 5.4 km
  - Part 2 – Tunnel 5.4 km
  - Part 3 – Asian Side 3.8 km
First Public-Private Partnership Infrastructure Project in Turkey
Provide Direct and Short Connection between Asian and European Parts of Istanbul
Cars and Minivans
Developer is a JV of Yapi Merkezi and SK Engineers and Construction – ATAS
• CJV – YMSK JV
Total investment is US$1.28B (Equity $320M, Loans $960M)
Guarantee Traffic Volume of 80,000 Vehicle per Day
Project Duration is 55 Months to be Placed in Operation - 2017
Concession Period of 26 Years – Turnover to Ministry of Transport
Connectivity of Istanbul

- Provides shortcut between Bakirkoy and Fatih regions in the West and uskudar and Kadikoy regions in the East
- Considerable relief of traffic on the Bosphorus bridges
- Significant time savings for travelers
- Significant net savings in emission and pollution
- Shortest distance between Ataturk and Sabiha Gokcen airports – easy transfer
- No effect on the appearance or the Silhouette of Istanbul
Global Team

- Design Leader: Parsons Brinckerhoff (USA)
- Design Verification: HNTB (USA)
- Technical Due Diligence: ARUP (UK)
- Traffic Studies: Jacobs (USA) and ARUP (UK)
- Insurance Advisors: Marsh, JLT
- Lead Re-insurers: Münch Re, Zurich Re, Korean Re, Swiss Re
- Tunnel Operation: EGIS (France)
- Geotechnical Studies: Fugro (Netherlands)
- TBM Supplier: Herrenknecht (Germany)
- Environmental Consultant: ERM (Germany)
- Financial Adviser: Unicredit
- Legal Advisers: Clifford Chance, Skadden, Fidan&Fidan, HBO
TBM Bored Tunnel

- **Upper Roadway Deck (Cast in Situ)**
- **Lower Roadway Deck (Precast)**
- **PreCast Segment Lining (t=600mm)**
- **Upper Corbel**
- **Lower Corbel**
- **Utility Gallery**
- **12.000 600 600**
- **13.200**
- **TBM Bored Tunnel Cross Section**
  - Outer Diameter: 13.2m (43'-4")
  - Inner Diameter: 12.0m (39'-4")
- **Water Pressure**: 11.0 bar
- **Tunnel Alignment**: ±5% - Depth 106m
- **Seismic Design**: Consideration of Mw= 7.5 on main Marmara fault
- **Design Life**: 100 years
- **Segment Liner**: 60 cm precast concrete (8+1 configuration) (C50)
- **Upper Road Deck**: Cast in-situ concrete (C40)
- **Lower Road Deck**: Precast concrete (C40)
- **Tunnel Ventilation**: Longt.Ventilation: Jet-fans and Vent Shafts at Portals 20Km/hr vehicle speed
- **Emergency Egress**: 1.12m wide Emergency Walkway / Escape Stairways at every 200m
- **Emergency Stop and Parking**: At every 600m
Risks and Challenges – Difficult Ground Conditions

- Large-diameter/double-deck tunnel configuration
- Complex and variable geology and hydrology
- Mixed face conditions
- High water pressure (11 bars)
- High seismic zone
- Complex Transition Structures on Both Sides
- Trakya Formation – Sandstone, siltstone, and Mudstone – Highly Fractured
  - Volcanic Dike Intrusions of diabase, andesite or dacite up to 45 ft thick
  - Faults at various locations across and adjacent to the tunnel alignment
  - Highly variable rock strengths, abrasive mineralogy, and presence of stiff blocks embedded in soft matrix
- Sand, Gravel, and Cobbles
- Soft Silts and Clays
Challenge – Seismic Conditions

- Three Tectonic Plates: African, Anatolian, Eurasian plates
- A complex fault system
- Close proximity to the Marmara fault system
- Increased probabilities for a strong earthquake
- At least one medium intensity earthquake has affected Istanbul every 50 years.
- Thorough assessment of earthquake hazard critical
- Performance of the tunnel in the mixed face is critical
Tunnel Boring Machine (Mix shield by Herrenknecht)

- Outer Diameter: 13.71m
- Length: 120.0m
- Weight: 3,300 ton
- Water Pressure: 13 bar
- Cutterhead power: 4900 KW
- Nominal Torque: 23,290 kNm (17,200 k-ft)
TBM Tunnel

- Designed to handle mixed-face conditions
- Operates in closed face mode to minimize uncontrolled ground losses and to avoid potential loss of face stability
- Average daily advancement is at 7 m (23 feet) – Maximum 18 m (59 ft)
- Most cutters can be replaced under atmospheric pressure
- A special lock system allows access under pressurized air at over 5 bars
- Launched in April 19, 2014
- Completed the drive on August 22nd, 2015
TBM Launch

April, 19, 2014
TBM Tunnel Liner

- 8 segments plus a key
- 2000 x 600 mm double reinforced concrete segments
- Right and left tapper
- Double Gaskets
- Bolted in both directions
- Shear keys and sliding rods
Seismic Joints

- Accommodate significant differential movements (50mm transversely and 75mm longitudinally)
- Located in transition areas between the rock and soft ground
- Evaluated the merit and location of the special seismic joints through independent analyses
- Checked most effective location of the seismic joints
- Investigated possibility of eliminating seismic joints through use of refined non-linear analysis (plasticity based) techniques or use of compressible bolt washers
Seismic Joint Installation
Breakthrough August 22, 2015