Japan

Name: Japan Tunnelling Association
Type of Structure: Non profit organization
Number of Members: Total number 1431, number of corporate members 2015

ASSOCIATION ACTIVITIES DURING 2020 AND TO DATE

WGs: JTA consists of the following four committees and each committee has WGs and task forces.
Technology/International Communication / Events/Public Relation
In each committee, main activities are:

- Investigation, research and information interchanges on general techniques and on subjects of specific projects.
- Meetings such as online lectures, online symposiums and online workshops and online training :
- "Two-days online seminars" and "Online lectures on topics of the year" (organized by Events committee)
- Publication of reports and documents: Monthly journal "Tunnels and Underground" and the Bi-yearly journal "Tunnelling Activities in Japan 2020"
- International cooperation
- Publicity activities

CURRENT TUNNELLING ACTIVITIES

Building a crossing under a railway using the HEP & JES method at a Terminal Station

To build an underground crossing under one of the major terminal stations in Tokyo, High-speed Element Pull and Jointed Element Structure (HEP & JES) construction methods were adopted. Busy train schedules and confined work spaces as well as existing structures are some of the challenges in this underground construction. Excavation was done manually by hand drill to negate track displacement while drilling, with any underground obstacles removed from inside the cutting edge. The available time for construction is limited to between train operations (1am to 4am). However the second level side wall and lower floor elements were constructed throughout the day and night regardless of the train operations as there would be minimal impacts on track displacement due to excavation. Additionally, friction cut sheets were used during the drilling of the upper floor element to repress horizontal displacement and reduce friction with the ground. Estimated tractive forces by drilling area, which was calculated from the ground and other conditions, were set against real time tractive forces and forces as high as 70% were monitored during actual excavation and no construction suspensions were needed. A measurement system – a Digital camera rail watcher - was used to measure and monitor the track displacement and even though settlement of 8mm was recorded, no malfunctions of the signal system were encountered.

Baba Ramps is situated in the middle of the Metropolitan Expressway North Line, which opened in March 2017. It is a ramp tunnel that has four ramps connecting the main tunnel to the streets at ground level. The area near Baba Ramps is a heavily populated residential area, with the main tunnel connecting at a great depth with overburden of 31-51m. Shield tunnelling method was used. The four shields were constructed from two launch shafts build within the business site and connected to the main tunnels' underground enlargement, which was constructed using the piperoof method when the Expressway was built, thus making it a ramp tunnel.

The four ramp tunnels' diameters were set at the minimum with consideration to construction gauge, evacuation routes, inner section conditions and curve widenings. Large section shield boring machines with outer diameters of 10.13m - 11.13m used. The B ramp tunnel had a sharp curve (minimum curve 50m) and steep slope (maximum grade 7.6%), measures were taken to control the position of the shield while boring. The shield excavated through an overburden of minimum 1.3m, so measures were taken to prevent segment rising.

Ramp tunnel constructions feature small overburden, running below streets and residential areas. The ground under the residential areas here consisted of an alluvial cohesive soil layer with humus soil. A pilot excavation was carried out within the business site after the shield launch to pre-set the excavation management values.

There was a transmission tower 15m ahead of the start of the D ramp tunnel, with the minimum separation to the tower base being 4.7m (0.48D). Effects of excavation to the tower were assessed, and the tower base was reinforced to restrain impacts on the tower. Measurement control and excavation management values of the tower base were set along with measures to prevent looseness of the natural ground during construction.

The A Ramp Tunnel was constructed near to the main tunnel, with the minimum distance of 1.2m. Construction had to be finished without affecting the main tunnel, which was in use at the time. Construction data obtained from the three ramp tunnels excavated before the A Ramp Tunnel was used to pre-set excavation management values, and the main tunnel's real time measurements and inspections were conducted. The shield machine was dismantled after taking safety measures to protect the vehicles going through the main tunnel with a temporary wall built beforehand. The temporary wall was taken out after the A Ramp Tunnel's excavation was finished.

With adequate measures taken, any influence of the construction to houses on the ground and important structures such as the transmission tower and main tunnel (which was in service) nearby were reduced, and the four-ramp tunnel was completed safely.

FUTURE TUNNELLING ACTIVITIES

SENJUSEKIYA Pumping Station, located in north-east Tokyo, is a pumping station designed to cope with the increased water runoff due to the recent increase in heavy rain. This was the first project in the world to simultaneously install two large pneumatic caissons for more than 50m underground. The two caissons, namely the west caisson (2,614m2) and the east caisson (2,289m2) were only 2m apart.

As this was an urban project, there were restrictions on the usage of land, which required the caissons to be installed to such great depths. Also, the construction period had to be as short as possible, considering the inconvenience caused to those living nearby. The Pneumatic Caisson method was the solution to these challenges. The DruckerPrager fracture criterion (a nonlinear dynamics model considering the dilatancy of the ground) was adopted to conduct a reproductive analysis of the ground pressure. Resistance to installation becomes larger as the surface friction increases. The project reached the yellow warning sign during the last phase of instalment (at deeper than GL-45m) as 669,300kN more was necessary to complete the sinking. As a result, the surface friction was reduced by 242,800kN, making the power to install larger than the resistance.

Various measurements and figures from the GPS automatic displacement measurement system showed that the final inclination was 1/2,000 (34mm). The simultaneous instalment of the two caissons was highly accurate.

The fifth phase of the SENJUSEKIYA Pumping Station construction is currently ongoing. This is to connect the two caissons by drilling the 2m distance between them.

The 1,045m long, 4.7m i.d. discharge channel tunnel on the Ishikari Bay Shinko Power Station constructed by slurry shield method is an undersea tunnel that connects the facility to the discharge outlet installed under the seabed. In this project, the protective work for the shield arrival area by the new freezing method using liquefied CO2 as a secondary refrigerant was adopted.

Conventionally, sensible heat generated by the thermal difference between antifreeze (brine) and the ground was utilized, and CFCs, the subject of regulation, were used for the primary refrigerant. In the new CO2 freezing method, heat is taken from the ground (not only by normal heat but also latent heat due to the evaporation of the liquefied CO2). The vaporized CO2 is re-liquefied through heat exchange with NH3, a primary and natural refrigerant.

Latent heat from CO2 is larger than normal heat of the antifreeze solution, so it can form a frozen soil of the same size at a flow rate of about 1/10 of the conventional method. Also, the viscosity of CO2 is about 1/90 of that of the antifreeze solution, so the pipe diameter and the pump power can be reduced, and long-distance pumping is possible. Thus, the CO2 freezing method is extremely advantageous in terms of workability, work period and cost. It is a promising method with highly reduced environmental impacts.

Installation of the freezing plant was completed about a week after the shield machine arrived. The main pipe for the CO2 was installed under railroad sleepers to secure the flow line of the disassembled materials. The connecting work was carried out under constant monitoring of the freezing temperature. No flooding occurred at the time of connection and completion of construction.

The freezing operation was carried out smoothly without interfering with the machine dismantling operation and the process was shortened by about one month compared to that of the conventional method. Power consumption was reduced by about 40%, contributing significantly to cost reduction and environmental impact reduction.

STATISTICS

1. Length of tunnels excavated during 2020

27.8 % mechanized / 55.8% conventional during 2020

2. Amount (USD or EUR) of tunnelling / underground space facilities awarded in 2020

US$37bn

3. List of tunnels under construction

-	Road	Railway	Waterway	Overseas	Others	Grand Total
Number under construction	196	71	139	20	39	465
Total length (km)	278	226	239	105	92	940
Contract amount (US$bn)	18	7.6	5.7	4.4	1.3	37

EDUCATION ON TUNNELLING IN THE COUNTRY

Hokkaido University, Muroran Institute of Technology, Kitami Institute of Technology Iwate University, Tohoku University, Akita University, Ibaraki University, Nagaoka University of Technology, Tokyo Institute of Technology, Yokohama National University, Niigata University, Kanazawa University, University of Yamanashi, Gifu University, Nagoya University, Nagoya Institute of Technology, Toyohashi Universityo oOf Technology, School/Graduate School of Engineering, Osaka University, Tottory University, Ehime University Faculty of Engineering, Kumamoto University, Kagoshima University, University of The Ryukyus, Maebashi Institute of Technology, Osaka City University, Hokkai-Gakuen University, Tohoku Gakuin University, Tokyo University of Science, Nihon University, Hosei University, Tokyo City University, Ritsumeikan University, Setsunan University, Fukuoka University, Ashikaga University, Kinday University, Okayama University, Kyushu Institute of Technology, Nagasaki University, University of Miyazaki, Kanazawa Institute of Technology, Meijo University, Aichi Institute of Technology, Osaka Institute of Technology, Osaka Sangyo University, Kanazawa University, Kansaiuniversity, Gunma University, Saitama University, Kyushu Sangyo University, Shibaura Institute of Technology, Chubu University, Tokyo Denki University, Tohoku Institute of Technology, Nagaoka University of Technology, Hachinohe Institute of Technology, Hiroshima University, University of Fukui, Yamaguchi University, National Institute of Technology, Kagawa College, National Institute of Technology, Kochi College, National Intstitute of Technology, Toyota College, National Institute Of Technology(Kosen), Kure College, The University of Tokyo, Tokyo Metropolitan University, Waseda University, Kokushikan University, Yokohama National University, Chiba Institute of Technology, Ustunomiya University, Osaka Institute of Technology, Kyoto University, Kobe University, Yamaguchi University