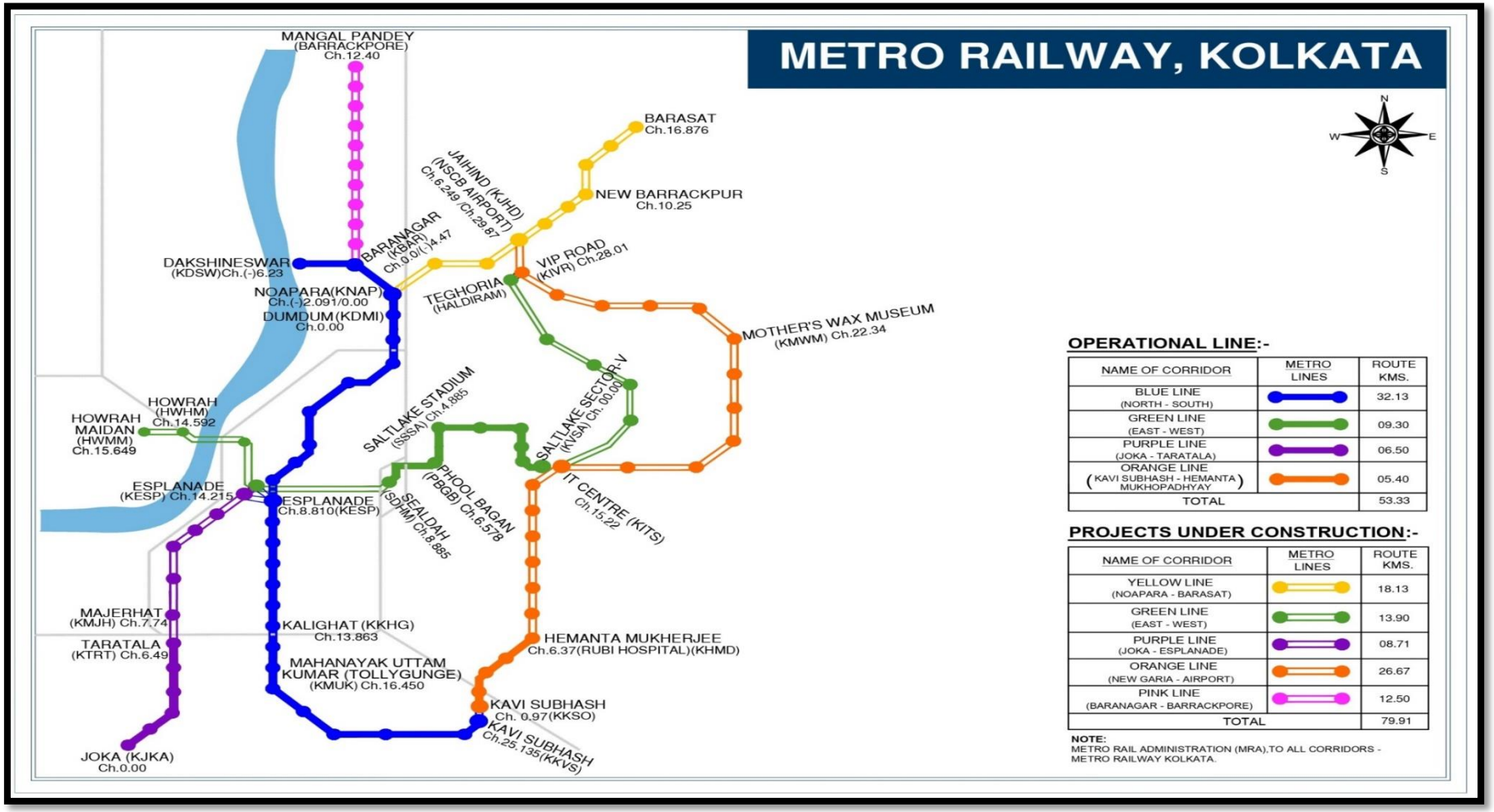
EMBEDDING RESILIENCE IN MASS TRANSIT PROJECTS

METRO RAILWAY, KOLKATA

NATION's JOURNEY
for Mass Urban Transport Begins at Kolkata

- Dum Dum – Tollygunge RTS sanctioned in June, 1972.
- Foundation stone laid on December 29, 1972.
- First train rolled October 24, 1984.

PROJECTS COMMISSIONED & UNDER CONSTRUCTION



OPERATIONAL LINE:-

NAME OF CORRIDOR	METRO LINES	ROUTE KMS.
BLUE LINE (NORTH - SOUTH)		32.13
GREEN LINE (EAST - WEST)		09.30
PURPLE LINE (JOKA - TARATALA)		06.50
ORANGE LINE (KAVI SUBHASH - HEMANTA MUKHOPADHYAY)		05.40
TOTAL		53.33

PROJECTS UNDER CONSTRUCTION:-

NAME OF CORRIDOR	METRO LINES	ROUTE KMS.
YELLOW LINE (NOAPARA - BARASAT)		18.13
GREEN LINE (EAST - WEST)		13.90
PURPLE LINE (JOKA - ESPLANADE)		08.71
ORANGE LINE (NEW GARIA - AIRPORT)		26.67
PINK LINE (BARANAGAR - BARRACKPORE)		12.50
TOTAL		79.91

NOTE:
METRO RAIL ADMINISTRATION (MRA),TO ALL CORRIDORS - METRO RAILWAY KOLKATA.

East West Metro [GREEN LINE]

Route Length [Km] = 16.55		
	Total	Commissioned
Elevated	5.74	5.74 km
UG with ramp	10.81	3.56 Km
Stations	**Total**	**Commissioned**
Elevated	6 Nos.	6 Nos.
Underground	6 Nos.	2 Nos.
	12 Nos.	8 Nos.

Train taken (02 sets) for testing trials under river Hooghly from Sealdah to Howrah Maidan (EB) on 12.04.23

Commissioned

System works in progress

Critical Section

Dum Dum

Existing North-South Metro

Belgachia

Shyam bazar

Sova Bazar

Girish Park

MG Road

Central Park

Karunamayee

Sector-V

Haldiram

City Center

Depot

Sector-V

Proposed Garia-Bimanbandar Metro

Bengal Chemical

Salt Lake Stadium

Phoolbagan

RAMP Section

Tunnel under River Hooghly

Howrah

Howrah Maidan

Incident point

Sealdah

Central

Chandni

Mahakaran

Esplanade

Proposed Metro to Joka

Park St

To Kavi Subhas

5.30 Km

Service started 14.02.20

1.67 Km

Service started 14.07.22

Service started 05.10.20

2.33 Km

9.3 Km

4.80Km - Dec'23

2.45 Km -Jun'24

UNIQUE FEATURES of GREEN LINE

- 1st transportation tunnel under any mighty river in India
- Circular bored tunnel of RCC segmental permanent liner of 275mm thickness at 16.1 m apart, internal diameter 5.55 meter, depth 16 meter below the Hooghly river bed.
- The length of the tunnels below Hooghly river bed is 520 meter.

Approach of Tunnel under Hooghly River

- Howrah Metro Station is the deepest metro stations in India
- Deepest Metro Escape shaft at Strand Road
- Corridor connects major terminals Howrah & Sealdah with combined footfall of 22 lakh passengers.
- The live feed of CCTV inside all the rakes is available at the Operation Control Centre which is also a unique feature of East West Metro.
- Institution of Civil Engineers, UK/ICE had recognized this project among 200 global projects which had significant impacts in making people lives better.

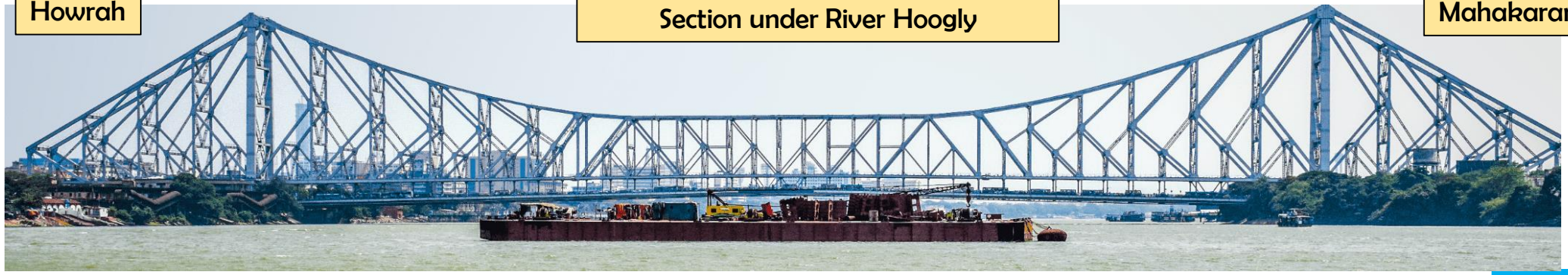
Tunnel under Hooghly River

RISK ASSESSMENT & MITIGATION DURING TUNNELING UNDER HOOGHLY RIVER

Howrah

Section under River Hoogly

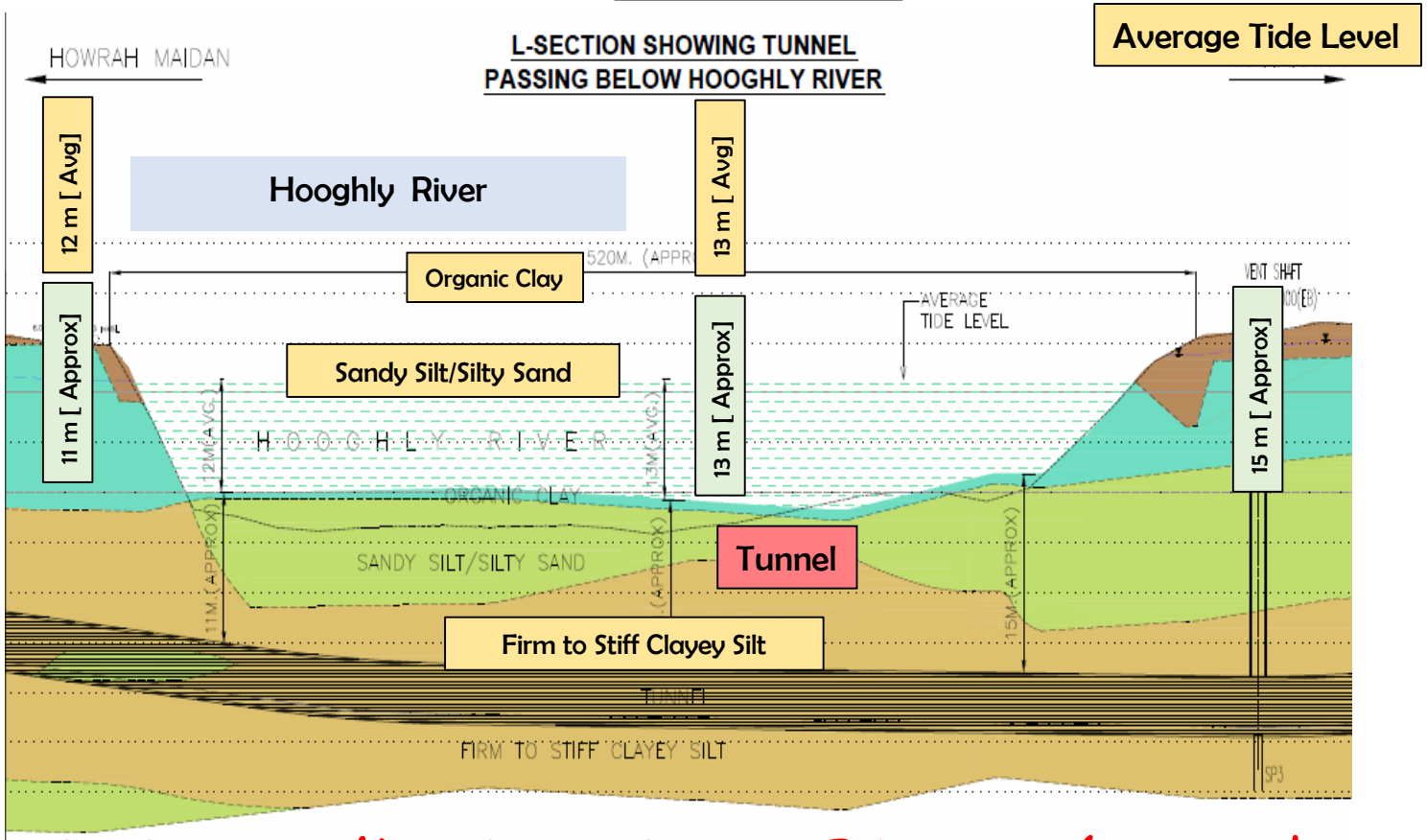
Mahakaran



520 m [Approx]

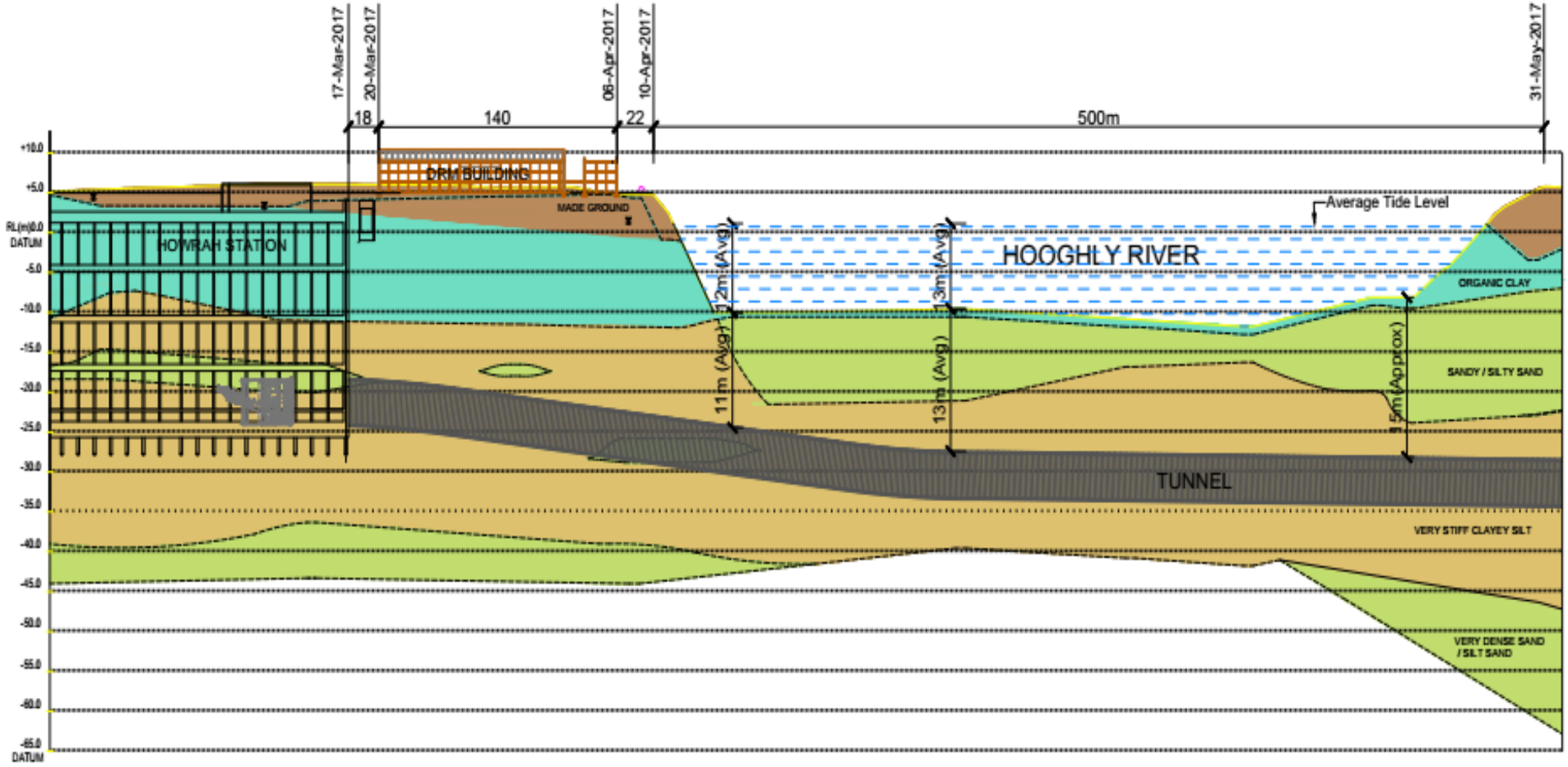
Vent Shaft

Average Tide Level



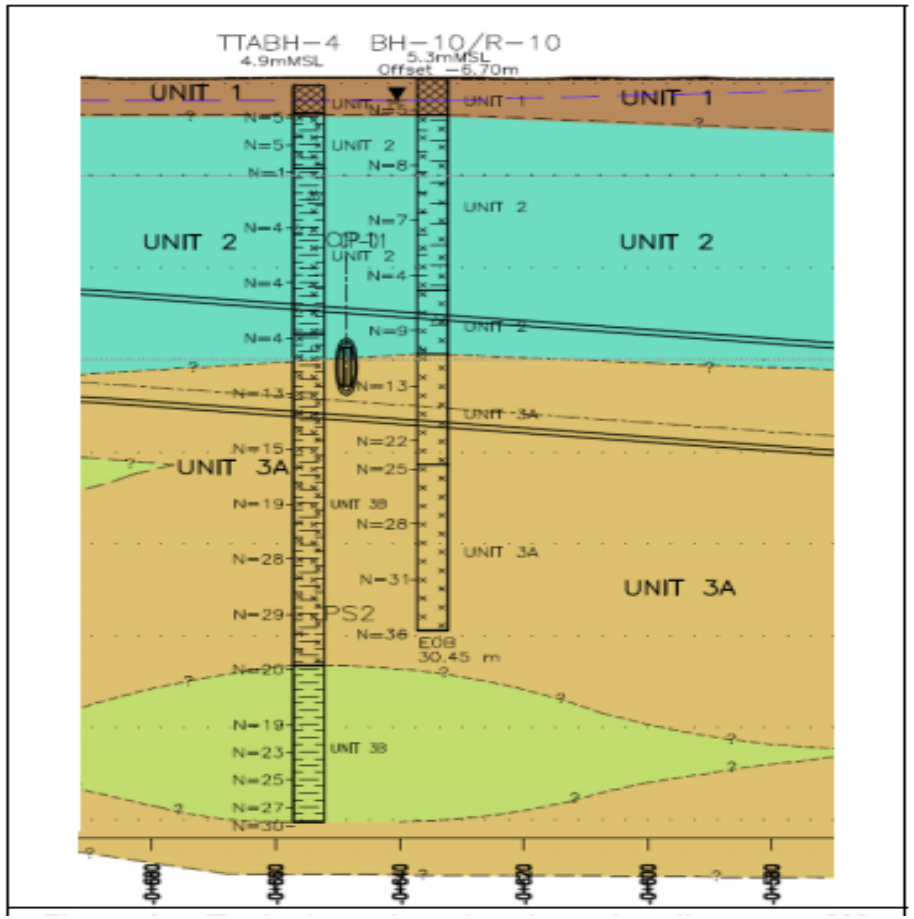
Tunnel below river Hooghly completed in July 2017 (66 days)

Geological Profile at Hooghly River



Typical soil profile along the tunnelling from Howrah Maidan to Esplanade

- Unit 1 – Made Ground.
  Fill ranges from fine to coarse-grained soils containing fragments of construction debris and trash in varying amounts.
- Unit 2 – Organic Clay (clayey silt/silty clay).
  This unit is formed by clayey silt / silty clay of intermediate to high plasticity (CI, CH, MI, MH). Taking into account the description provided in [2] , observed Nspt values range between 4 – 18 and 2 - 7 along the initial (-1+095 to 0+255) and final (upon chainage 0+705) stretches respectively.
- Unit 3a – Clayey silt/silty clay.
  This unit is formed by medium-high stiff silty clay with occasionally some gravel. Taking into account the description provided in [2] , observed Nspt values range between 12 - 40 and 12 - 27 along the initial (-1+095 to 0+255) and final (upon chainage 0+705) stretches respectively. Under the Hooghly River this unit shows an average Nspt value of around 25-31.
- Unit 3b – Sandy silt / silty sand.
  This unit consists of grey sandy silt, silty fine sand and fine sand (SM, SP-SM). Taking into account



Salient features of working

General:

- Bore wells for soil investigation drilled outside Tunnel area and plugged
- Expected production while crossing the river will be 8 rings / day
- Total rings = 357 = 45 days

TBM Operation:

- TBM operator in cabin at all times, shift handover in TBM.
- TBM face pressure maintained all times, bentonite pumping in case of face pressure
- Strict muck skip count to ensure no over-excavation.
- In over excavation Tunnel Manager to be informed immediately.
- Injected grout volume approx 4.32 cum per ring.

- Four grout ports used. In the event one becomes blocked mining to be completed and port to be cleaned immediately and back grouting to be done on the ring through the grout sockets.
- Secondary Grouting to be done every third ring from behind the shield.
- There will always be a minimum crew for pumping bentonite, water, grout etc. on the TBM.

Shift Change:

- Under normal conditions shift change will be every fortnight, with the Saturday night and Sunday being maintenance shifts.
- Required personal will be on the TBM
- On Shift Change weekends the ring is to be built before end of last shift, the tail-skin should never be left empty so that if it is needed the TBM can be pushed forward to ensure proper earth pressure.

In the event of leakage into shield from articulation joint:

- Sufficient tail-skin grease, foam, HBW and EP 2 grease to be on the TBM.
- Screw gate emergency closing accumulator pressure to be checked and recorded each shift by the shift engineer. Minimum pressure 100 bars.
- The articulation joint is to be inspected each shift, for contamination, leakage or any other related problem, also to be recorded.
- Articulation should be kept closed to approx 30mm on any one measuring group.
- Dewatering pumps to be checked and recorded every shift, to be changed immediately if not working
- Spare pump to be available.
- Tighten the double lip seal by adjusting the tensioning bolts
- If required pump tail-skin grease into the joint via the grease ports
- If required inflate the emergency seal, stop all TBM activity and inform the Tunnel Manager / Project Manager immediately.

In the event of intervention : -

- Doctor to be onsite during intervention
- Air pressure to be set as required
- Maximum three persons at a time inside
- Communication system to be tested hourly
- No materials or equipment to obstruct the bulkhead entry door.
- No shift change to take place while intervention in progress.

Tunnel flooding	• Prior Cutter Head Intervention • Man lock doors kept unobstructed • Screw conveyor gate closure
Leakages scenario	• Articulation Joint [TSG charge, tightening lip seal] • Screw conveyor gate [testing, emergency tank is charged, check tank press in each shift] • Hyperbaric chamber
Geology	• Stiff Clayey Silt • N- Value 20-30 • Under river N value 25-30
Obstruction	• Geologically nothing was unexpected • Expect the unexpected
Steady Pace	• Continuous pace • Adequate inventory feed • Equipment on standby • Continuous disposal from muck bin • Tunneling completed in 67 days against planned 127 days
TBM Crew Management	• No shift change below river • TBM Operator round the clock • Check screw conveyor gate press. [100bar] • Strict muck counting

RESILIENCE TO MONSOON

UNDER GROUND SECTION OF BLUE LINE

- BULIT IN 1970s M-20 concrete was available not M-35.
- Ground water allowed to pass through porous tunnel & collected in a sump pit and then pumped out through high capacity centrifugal pumps.
- For 40 yrs this arrangement ensured Metro services even in monsoon flooded in city when other transports failed.
- Because of this reason it is called lifeline of the city.

RESILIENCE to NATIONAL POWER GRID FAILURE

- Only Metro without DG set in Stations, Depot for 40 years of service.
- National Grid Failure 31.7.2012, trains stranded in mid section for 1 hr.
- First Metro, First Rly Zone to have 4 Mega Watt Hour Battery Energy Storage System (BESS) with (LFP/LTO) battery. Tender Opening November 2023 @Rs. 25 Cr
- BESS shall haul 4 trains at a time to nearest station
- Total 60 trains (of 8 Car each) can be hauled
- The speed of the train shall be 10-20 kmph
- Limited no of Train can run with 50 km/h

RESILIENCE FOR SUB-SOIL TEMPERATURE

- Concern for maintaining sub-soil temperature in 80s spell bound us. .
- Hong Kong and Kolkata Metro pioneers in metro air conditioning and tunnel ventilation for a tropical country using separate methodologies.
- IIT Kharagpur designed air-conditioning and TVS in 70s with manual calculation as no CFD analysis software available.
- Station temperature was set at 27-28 °C and station cooled air were taken out from midpoint exhaust as sub-soil temperature of Kolkata is 27.5 °C
- Under Platform Exhaust provided to throw heat from braking resister to atmosphere so that tunnel soil do not get heated.

RESILIENCE IN FIRE CONDITION

- Mid-point shaft ventilation used for TVS .
- 70's design ensures by default 2 ventilation zones between all 2 adjacent stations which shall ensure resilience against fire even 90 sec headway.
- Fire hydrant fed through gravitational method from overhead tank to ensure water availability without electrical power.
- In Blue Line tunnel UP&DN tracks are placed without any barrier ensuring every inch as cross passage instead of cross passage after 250 m.

RESILIENCE IN FIRE CONDITION

- Dry type traction transformer since 1970s.
- In 7O's when FRLS (Fire Retardant Low Smoke Cable) was not available in India but all cables in Metro Rly Tunnel laid are FRLS.
- Use of fire alarm using radio active element on all electrical pannels and CO2 gas flooding system above transformer in 70 's surprised us
- First Metro in India to switch over to Lithium Iron Phosphate (LFP) Battery in substation and Emergency Lighting to reduce the risk of fire from battery and as compliance to Govt of India's policy on Advance Chemical Cell (ACC) .

RESILIENCE IN FIRE CONDITION

- Blue Line underground tunnel survived 40 years
- Upcoming corridors of Blue Line, Purple Line, Green Line, Pink Line are designed for Zone IV as defined in IEC.
- Electrical panels are designed to withstand Zone IV.
- With one button press all trains shall stop in Green Line

RESILIENCE BEING EXECUTED

- To reduce restoration time after untoward incident mini-ART equipment shall be provided at every 3-5 stations .
- Video communication directly with passenger & OCC during any untoward incident.
- Rs. 400 Cr shall be spent for further strengthening and effective & energy efficient TVS system.
- Artificial Intelligence enabled CCTV surveillance for crowd management.


Thanks For Attention