

ASSEMBLING AND DISMANTLING OF TBM IN HSUEHSHAN TUNNEL

Yao-Tung Leng¹

ABSTRACT

Taiwan, Taipei-I lan Expressway Hsuehshan Tunnel, in length of 12.9Km, the full face TBM (Tunnel Boring Machine) with a 11.74m boring diameter will be applied for tunnel excavation for both the East Bound and West Bound main tunnels. Since, it is the first time contract specifications called for the largest diameter of Double Shielded hard rock TBM in the world use in domestic tunnel project, therefore, prior to its arrival, serious and proper planning for all necessary procedures such as transportation, storage arrangement, assembling at portal...etc. have to be made in advance so that could effectively control the progress of TBM and Back-up systems assembling in order to proceed commissioning and launching to the mining face in accordance with the Contract schedule. This paper presents our methodology and experience of assembling the huge diameter TBMs at portal which were used in Hsuehshan main tunnels construction as well as the dismantling after the completion of tunnel mining operation, provide to Tunneling and underground construction fields expert for reference.

1.INTRODUCTION

The Hsuehshan main tunnels are among the most difficult TBM projects in the world in terms of adverse geology, water inrushes, tunnel size and tunnel length. The Hsuehshan Tunnel, with a maximum overburden of 700 meters, is located on the convergent boundary between the Eurasian plate and the Philippine Sea plate. The entire zone heavily affected by tectonically movement is very much faulted and bears a great amount of water. In addition to six identified water-bearing fault, there are many problematic and unanticipated shear zones. The approx. 12.9 Km long Hsuehshan main tunnels are designed as a twin tunnels of 11.74m boring diameter for both the East and West Bound double lanes. Between the main tunnels, the service pilot tunnel of 4.8m boring diameter is located, and which is excavating as well as by TBM in ahead of main tunnels TBMs for the purpose of water drainage, gathering precise geological information to feed back to the main tunnels construction, ground pretreatment to the main tunnels if necessary, service line for the emergency.

The Client, Taiwan Area National Expressway Engineering Bureau (TANEEB), signed with RSEA

Engineering Corporation for the construction of the Hsuehshan main tunnels and associated structures on July 23,1993. Project management is held by Sinotech Engineering Consultants Inc.

2.TBM

The Contract specifications of Hsuehshan main tunnels called for two virtually identical and with the same specifications of Double Shielded hard rock TBMs for each of East and West Bound main tunnel. The two Double Shielded TBMs, Type TB 1172 H/TS with a boring diameter of 11.74m are weighing complete with Back-up approx.2300 tons each and are the largest Double Shielded hard rock machines ever built by the TBM manufacturer, Wirth Company. The machines are equipped with 7550KW of which 4000KW are for the fully hydraulic cutter head drive, will generate a maximum torque of 36000KNm at 0.25rpm speed and are designed to achieve a penetration rate of 4.5m/h. The general specifications of TBM are shown in table 1.

In addition, many features such as cutter head drive, cutter mounts, cutter head profile, bucket closure doors, movable cutter head with over cutters assemblies, muck gate, trough chain conveyor, injection system...etc.

1. RSEA Engineering Corporation, Deputy Manager of 2nd site PEI-I Construction Office



Figure 1. Wirth TBM Type TB 1172H/TS.

Table 1. The general specification of Wirth TBM Type TB1172H/TS.

Item	Description	Spec. and Q'ty	Item	Description	Spec. and Q'ty
1	Cutter Head boring diameter	11.74m	13	Total thrust of 18 ea telescope cylinder	50600KN
2	Center Cutter	6ea	14	Total thrust of 28 ea segment cylinder	78700KN
3	Face Cutter	71ea	15	Total thrust of 2ea gripper cylinder	65000KN
4	Gauge Cutter	3ea	16	Gripping Type	T (Three points gripping)
5	Reamer Cutter	3ea	17	Hydraulic system pressure (Max.)	405Bar
6	Cutter Disc. diameter	432mm	18	Total power of TBM and B/U	7550KW
7	Cutter Head drive power	4000KW	19	Transformer (690V)	2x3150KVA
8	Cutter Head speed	0~4rpm	20	Transformer (440V)	1x1250KVA
9	75% efficiency rate of torque at 4rpm speed	7200KNm	21	Mucking Capacity	1200t/hr
10	Max. torque at 0.95rpm speed	30000KNm	22	Length in one stroke of mining	1.5m
11	Max. torque at 0.25 rpm speed of break out mode	36000KNm	23	Length of TBM and B/U	250m
12	Cutter head drive motor	18Set	24	Weight of TBM and B/U	2300t



Figure 2. TBM Packages during the transportation by vessel and heavy duty trucks.

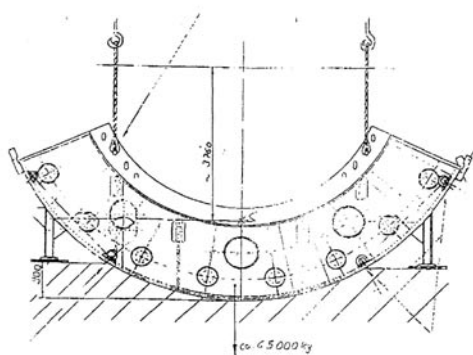


Figure 3. Place lower part of cutter head shield.

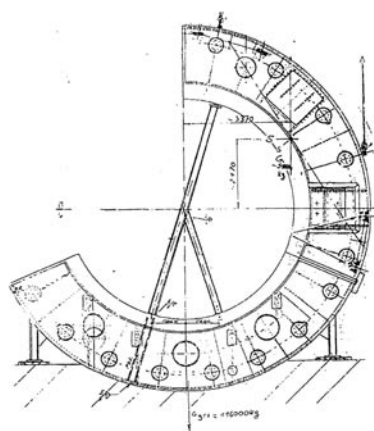


Figure 4. Assemble right cutter head shield and torque beam.

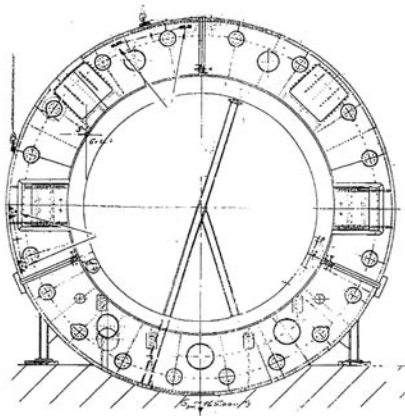


Figure 5. Assemble left cutter head shield and torque beam.

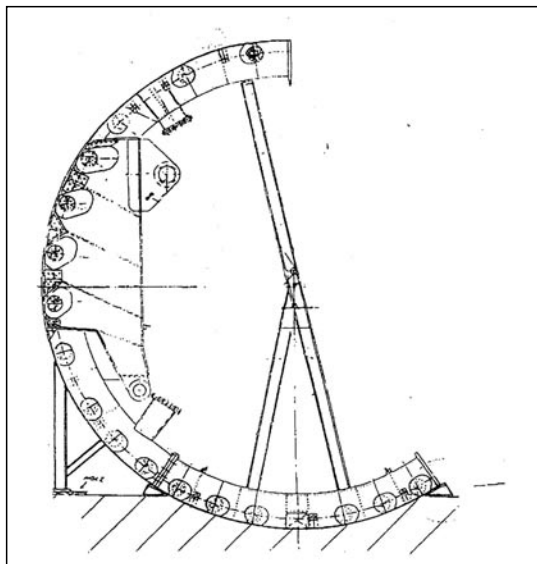


Figure 6. Place the bottom and left segments of gripper shield.

are especially incorporated in design of the TBM in order to improve the performance in adverse ground condition, e.g. high water inflow, fracture and blocky rock, squeezing rock, high overburden load, soft and/or sticky soil, running type ground.

3. ASSEMBLING OF TBM AND BACK-UP AT THE HSUEHSHAN TUNNEL PORTAL

The 1st TBM for East Bound Tunnel was shipped from Antwerp port to Suao harbour by vessel, and

inland transportation was carried by heavy duty trucks from Suao harbour to project site on May 10, 1995. To avoid the disturbance of traffic, some of the oversize and overweight packages were especially transported during the mid night and guided by Traffic polices. As for the storage, all of the packages were unloaded and positioned in the area already planed. The 2nd TBM for West Bound tunnel was arrived to the project site later on July 19, 1995. Assembling of TBM and back-up at the portal were begun since.

Due to the tight schedule of Hsuehshan Tunnel project, the plan/schedule of assembly and commissioning is set-up with only ten and half weeks for each machine. Therefore, all the work items for assembly and erection of the front part and secondary back-up have to be well organized and parallel arranged.

The assembly procedure of Wirth TBM TB1172 H/TS will be described as below;

1. Assembly of Cutter head Shield.

Prior to the assembly works, unload TBM main basic bodies and structures of all relative cutter head, shields, main bearing, muck chute...etc. on the assembly area in sequent as prearranged storage plan.

- 1.1 Place lower part of cutter head shield in the assembly cradle and support from the side.
- 1.2 Assemble main bearing flange and bolt to lower part of the shield.
- 1.3 Assemble right cutter head shield and torque beam and bolt to main bearing flange.
- 1.4 Assemble left cutter head shield and torque beam

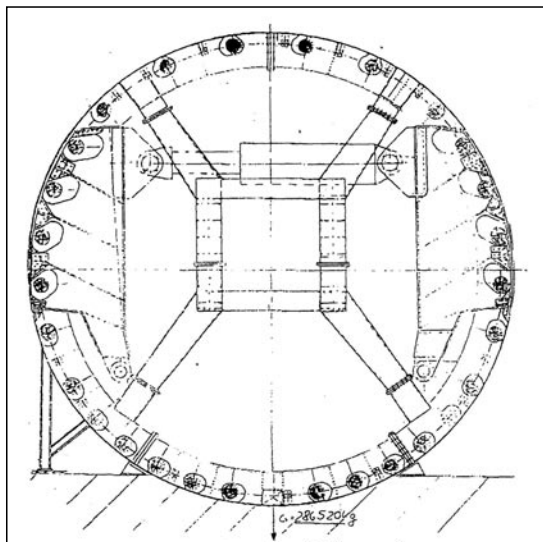


Figure 7. Install the gripper shield complete with gripper cylinder and erector support.

- and bolt to main bearing flange.
- 1.5 Align complete cutter head shield and bolt to main bearing flange using the stud tensioner device.
- 1.6 Weld cutter head shield joints together.
- 1.7 Assembly bottom segment of cutter head shield extension.
- 2. Assembly of Telescope Shield.
 - 2.1 Lay complete telescope shield on the ground and bolt the flange connections together.
 - 2.2 Install telescope shield seal.
 - 2.3 Lift complete telescope shield with portal crane and place into the assembly shell.
- 3. Assembly of Gripper Shield and Tail Shield.
 - 3.1 Install segment cylinders in the bottom segment of shield and place into cradle.
 - 3.2 Tack-weld both bottom segments of the tail shield and gripper shield together in the cradle.
 - 3.3 Side supports into position and assemble mid-auxiliary supports.
 - 3.4 Welding and steel beam imbedded in concrete will act as an anti-torsion support for the bottom segment of the gripper shield.
 - 3.5 Install segment cylinder into gripper shield

- segments.
- 3.6 Connect left gripper shield segment to bottom segment.
- 3.7 Install gripper cylinder into left gripper shield segment. The gripper cylinder will be held in the horizontal position using the mid-auxiliary supports.
- 3.8 Assemble right gripper shield.
- 3.9 Bolt complete gripper shield together.
- 3.10 Finalize installation of gripper cylinder.
- 3.11 Remove mid-auxiliary supports.
- 3.12 Lift complete telescope shield and bolt to gripper shield using the stud tensioning device.
- 3.13 Assemble erector support (steel sheet stuffing).
- 3.14 Assemble 4-part pressure ring in horizontal position and mount it vertically in the tail shield. The pressure ring is supported against tipping.
- 3.15 Assemble complete tail shield and prepare for welding.
- 3.16 Finalize welding of tail shield and gripper shield.
- 3.17 Assemble segment cylinders to pressure ring.

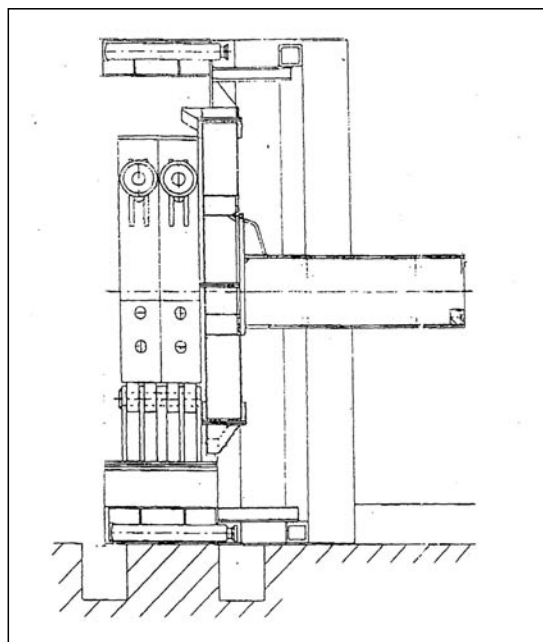


Figure 8. Assemble 4-part pressure ring and tail shield.

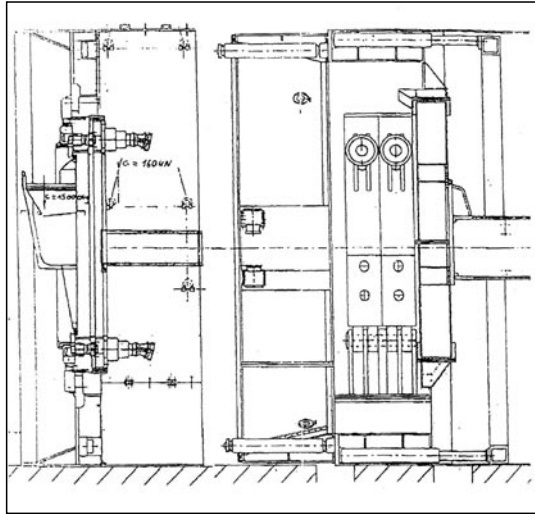


Figure 9. Assemble segment cylinders to pressure ring.

4. Assembly of Main Bearing and Muck Chute.

- 4.1 Lift main bearing and gearing into the vertical position, using the portal crane.
- 4.2 Dismantle hook from main bearing and loosen one side of the turning device so that the main bearing flange can be attached.
- 4.3 Lay main bearing flange horizontally, assemble seal, lift main bearing flange into the vertical position and turn using the portal crane. Then bolt the main bearing flange to the main bearing using the stud tensioning device.
- 4.4 Lay cross beam on torque supports and fix.
- 4.5 Using an extra intermediate piece connect 4 No. thrust cylinders to the cutter head shield. It may be necessary to connect the upper area of the cutter head shield and gripper shield using 2 No. steel beams to prevent tipping during assembly of the main bearing.
- 4.6 Bring assembly beam for main bearing into position using the crane.
- 4.7 Using hydraulic cylinder push the main bearing into the cutter head shield until the main bearing flange butts up against the shield.
- 4.8 Bolt main bearing flange to cutter head shield using the stud tensioning device.
- 4.9 Dismantle assembly beam and cross beam.
- 4.10 Place the muck chute between the gripper

shield and cutter head shield in the vertical position. Install assembly beam. Lift assembly beam and muck chute and position it on to the gearing using the main portal crane and auxiliary crane. Bolt the muck chute to the gearing. Dismantle assembly beam.

5. Assembly of Cutter head Shield Tail.

- 5.1 All necessary parts, e.g. pipe work, water pumps, hydraulic power packs and scrapers to be connected to the shield and gearing.
- 5.2 Completely assemble cutter head shield tail.
- 5.3 Weld tail to cutter head shield.
- 5.4 Pull cutter head shield and telescope shield together. Remove intermediate pieces (see 4, 5). Extend all thrust cylinders and connect to cutter head shield. Then connect both shields together.

6. Assembly of Cutter head.

- 6.1 Assemble cutter head basic bodies i.e. center piece together and bolt.
- 6.2 Assemble center piece to machine and bolt.
- 6.3 Assemble segments 1-4.
- 6.4 Mount cutters to cutter head.

7. Assembly of Erector and Equipment Bridge 1.

- 7.1 Lay machine conveyor in erector bridge.
- 7.2 Assemble erector and erector platforms.
- 7.3 Lay crane supports and 8 lateral trusses into position.
- 7.4 Assemble rear wheel set to rear cross support and lay into position.
- 7.5 Connect bridge frame to erector bridge, lie on rear lateral truss and bolt together.
- 7.6 Connect 8 lateral trusses with bracing and crane gantry under the bridge frame.
- 7.7 Fix E-motors to pumps and install on equipment bridge 1.
- 7.8 Install all switchgear, hydraulic components and control cabin on equipment bridge 1.
- 7.9 Assemble supports and platforms to equipment bridge 1.
- 7.10 Install probe drill with guide frame on working platform.
- 7.11 Install parts of belt No.2.

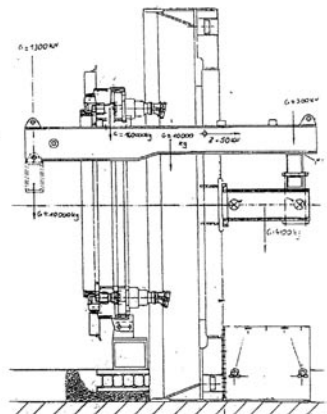


Figure 10. Assemble main bearing.

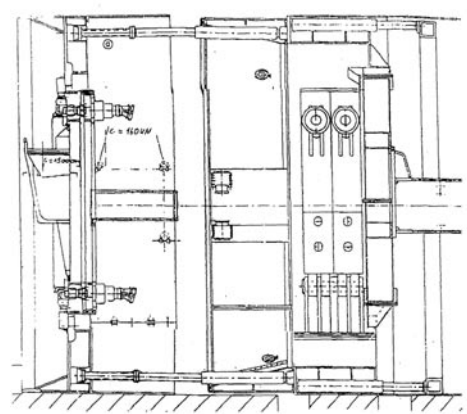


Figure 11. Connect the cutter head shield and gripper shield.

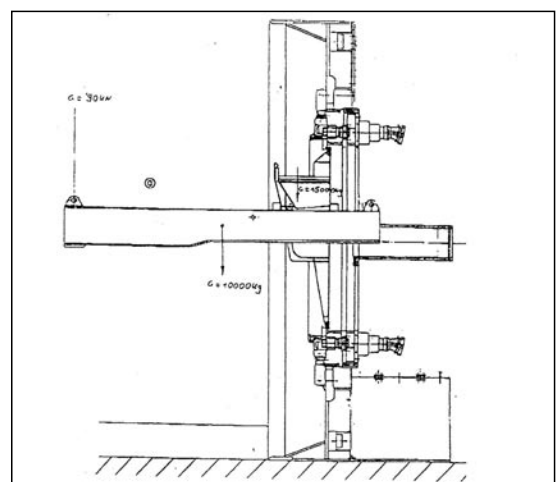


Figure 12. Install the main bearing into the cutter head shield.

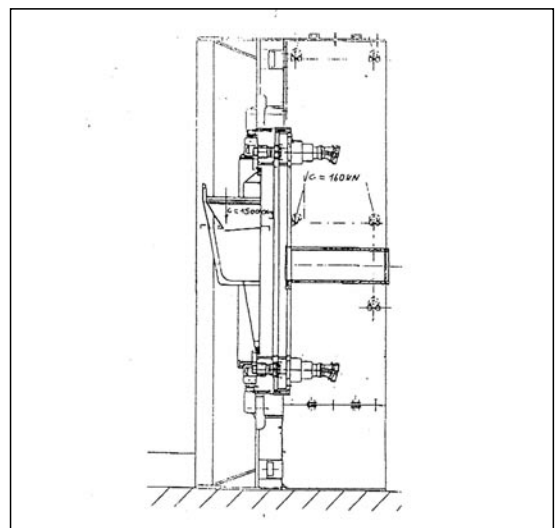


Figure 13. Assemble cutter head shield tail.

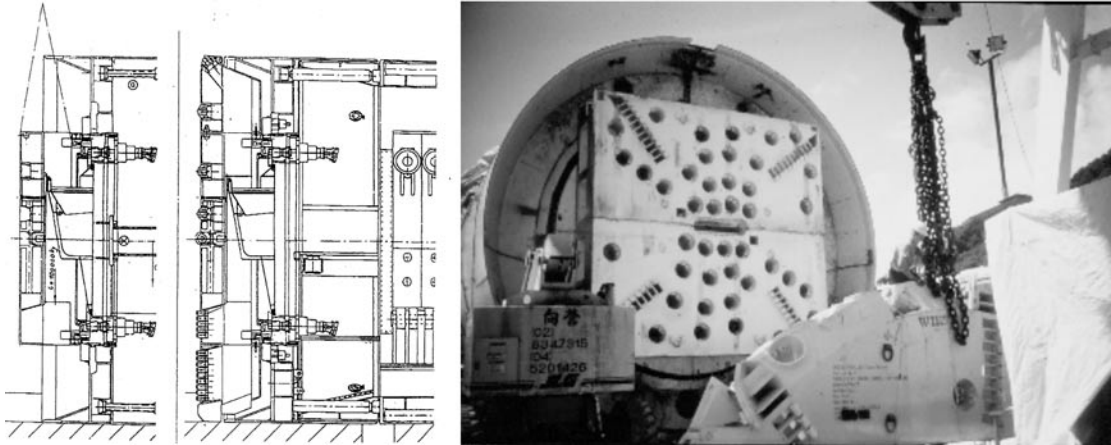


Figure 14. Assemble the cutter head.

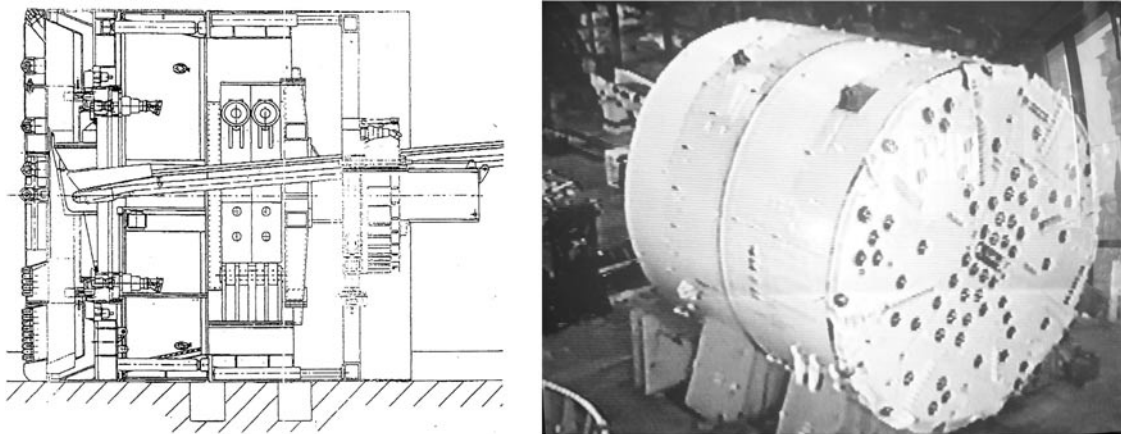


Figure 15. Assemble the machine conveyor.

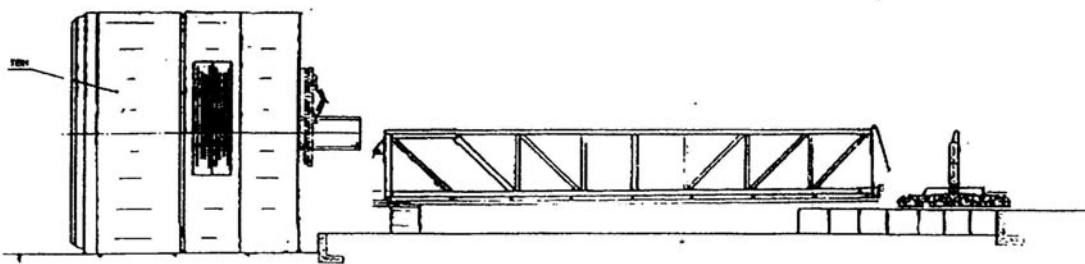


Figure 16. Assemble the erector and lateral trusses for crane supports.

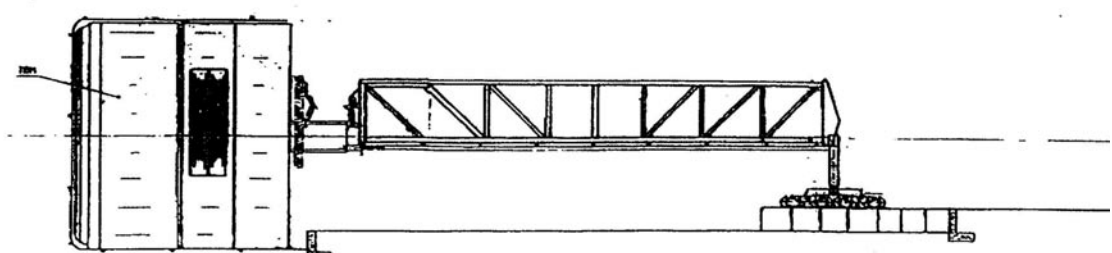


Figure 17. Connect the bridge frame to erector bridge.

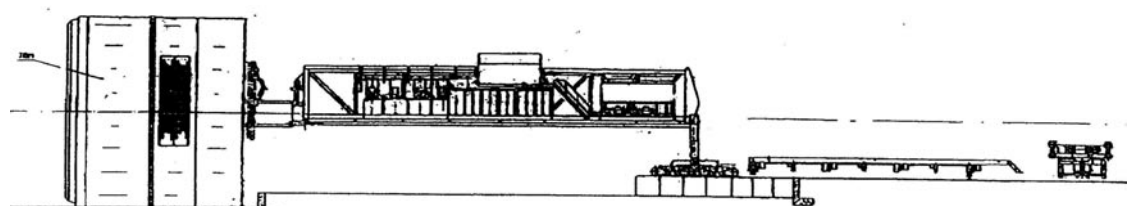


Figure 18. Install the E-motors and all relevant equipments on equipment bridge 1.

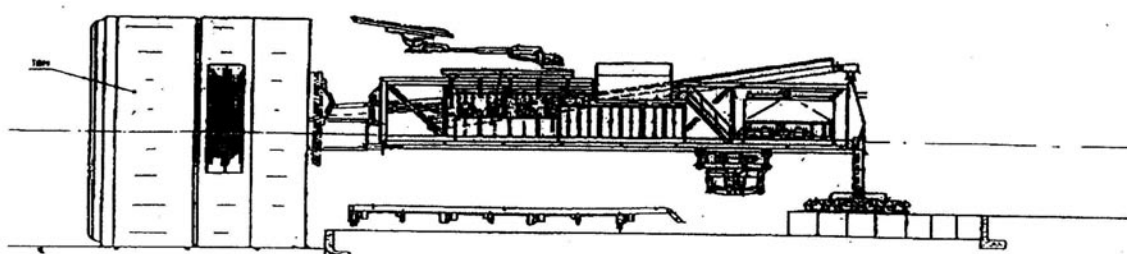


Figure 19. Install the probe drill and all relevant equipments.

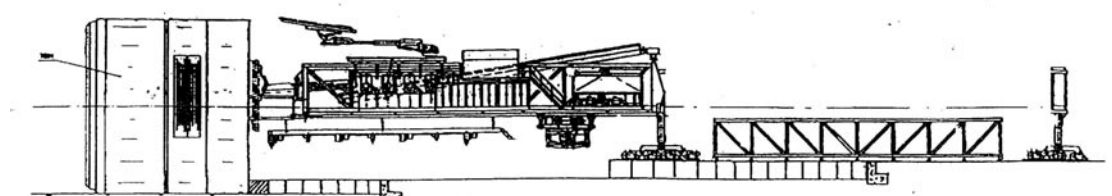


Figure 20. Assemble the equipment bridge 2.

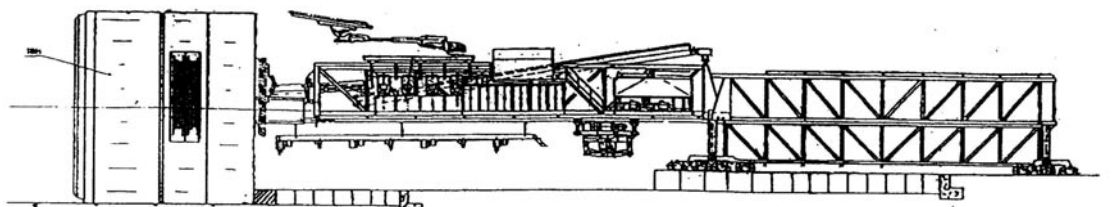


Figure 21. Connect the equipment bridge 2 to bridge 1.

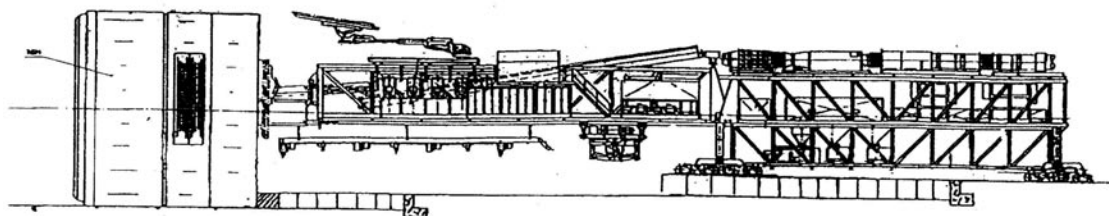


Figure 22. Install the transformers and all relevant equipments on equipment bridge 2.

- 7.12 Assemble segment magazine behind equipment bridge 1. Thereafter it can move forward independently.
- 7.13 Assemble segment crane behind equipment bridge 1 and position in the crane gantry.
- 8. Assembly Equipment Bridge 2.
 - 8.1 Push machine forward until cutter head has reached Sta. 40k+250.100.
 - 8.2 Lay lower lateral truss on the ground in the right position together with the main beams and bolt together.
 - 8.3 Lay crane gantry in the middle.
 - 8.4 Assemble mid-deck including all beams and bracings.
 - 8.5 Assemble wheel sets to rear lateral truss and move into position.
 - 8.6 Connect front cross-frame with main beams.
 - 8.7 Mount side-main beams onto mid-deck.
 - 8.8 Lift complete bridge at front, lie on equipment bridge 1 and secure against sliding.
 - 8.9 Lift rear section of bridge, lateral truss with wheel sets and connect together.
 - 8.10 Install all equipment such as transformers, MV switchgear, silos, wagons, tipper cable channels etc.
 - 8.11 Mount upper crane with cabin and gantry on mid-deck.
 - 8.12 Completely assemble upper cross-bracing.
 - 8.13 Assemble crane and gantry to the underside of the upper deck.
 - 8.14 Assemble working platforms on upper deck.
 - 8.15 Assemble all equipment on upper deck such as dust scrubber , piping etc.

9. Assemble Track Laying Bridge.

- 9.1 Using portal crane for one side and a mobile crane for the other side, the bridge is lifted and connected to equipment bridge 2.
- 9.2 Assemble all relevant equipment on track laying bridge.
- 9.3 Connect secondary back-up (platforms 1 to 21) to track laying bridge.
- 9.4 Fix all necessary connections between the machine and back-up.
- 9.5 Commissioning.

10. Assemble platform wagons 1to 21.

The process of bolting the platform wagons 21-1 together and installing the equipment will be done parallel to the assembly procedures 1-9.

4. DISMANTLING OF TBM AND BACK-UP

Hsuehshan Tunnel, the West Bound main tunnel TBM and Back-up was crushed and buried 100 meters long in the tunnel collapsing on December 15,1997 due to huge water inrushes with 750~800 l/sec and 18 bar water pressure. After a long discussion and revaluation of the cost of re-built TBM and Back-up and project time schedule, the Client TANEEB decided to remove the damaged TBM and change to conventional Drill & Blast construction method for the rest of West Bound main tunnel.

Dismantling of West Bound tunnel TBM and Back-up inside the tunnel was started on November 9,1999. It took only 70 calendar days and completed on January 17,2000. Dismantling was mainly done by cut in pieces as shown in Figure 26.

As for East Bound tunnel TBM, after completed its mining operation on 2nd of February 2005, dismantled by direct cutting in pieces same as West Bound TBM and removed out from tunnel within 39 days in order to provide unhindered access for follow-on construction

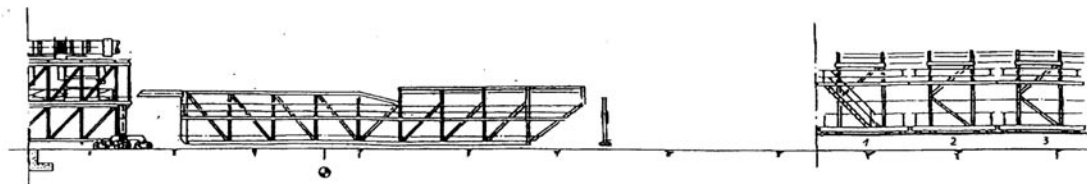


Figure 23. Assemble the track laying bridge.

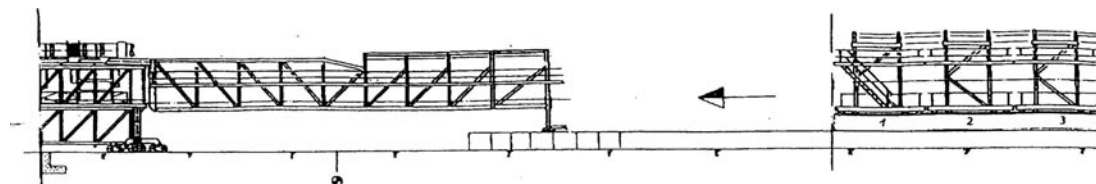


Figure 24. Connect the track laying bridge to equipment bridge 2.

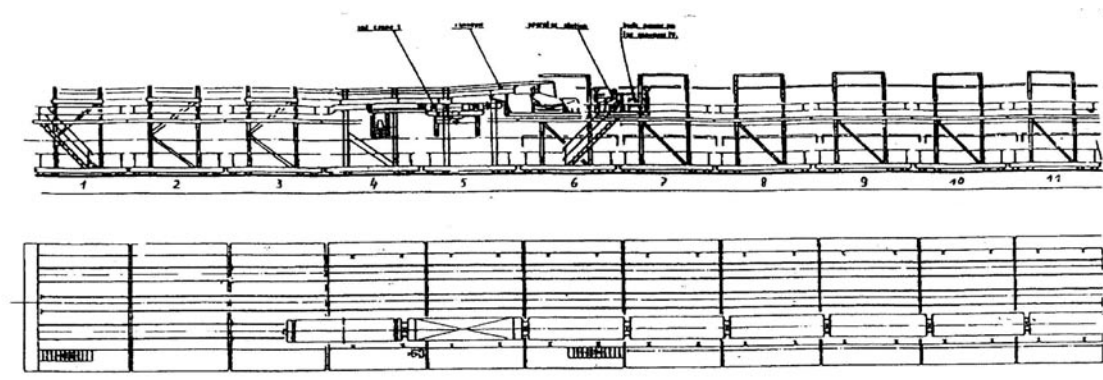


Figure 25. Assemble and connect the secondary back-up to track laying bridge.



Figure 26. Dismantling of West Bound tunnel TBM by cutting.

activities such as secondary lining of tunnel, structure construction of ventilation and interchange stations, corresponding hydrant and telephone niches excavation ... etc.

5. CONCLUSION

Hsuehshan Tunnel, the two TBMs for the both of West Bound and East Bound main tunnels were properly assembled and completed the commissioning within the time schedule by means of well pre-arrangement and good coordination. However, taking this opportunity, TBM working crews of RSEA Engineering Corporation have learned the technique and technical know-how in connection with assembling the huge diameter of TBM and its Back-up systems at portal.

6. REFERENCES

- * Technical documentation of Wirth Maschinen und Bohrgerate Fabrik GmbH.