ADVANCE ". TOP-DOWN" CONSTRUCTION SEQUENCES USED IN HIGHLY TRAFFIC AREAS TO IMPROVE PRODUCTIVITY

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Dedicated To:

My Father: NABIN CHANDRA JHA

My Mother: MIRA JHA

My better half: SADHANA KUMARI

Abstract: Top-Down method is totally opposite of bottom-up method. In this our permanent structure are built from top to bottom with the help of deep excavation. The layers of slabs are constructed accordingly to the excavation techniques. A cutout holes are left to allow excavation of the same level at which slabs casted. It also provides strength and bracing to the Diaphragm wall. This wall is rapid solution for underground construction. Top-down method is generally used in traffic areas where bottom-up method is not feasible and there is problem of land and space as well. In this thesis Top - Down Construction project in Delhi (Vinobapuri Station) done by Delhi Metro Rail Corporation is selected as the case study in this research. All information regarding project is taken physically or with the help of Project Manager to obtain in-depth knowledge and understanding of method / sequence used in this construction. Deep surveying technics also shows that Top-down method is quite safer than the bottom up which may less affect to the nearby and surround buildings in Delhi.

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LIST OF ACRONYMS

TBM	**Tunnel Boaring Machine**
JV	**Joint Venture**
P	**Penetration**
Pa	**Active Pressure**
Pp	**Passive Pressure**
EPB	**Earth Pressure Balance**
ABM	**Auger Boring Machine**
TD	**Tunnel Design**
STN	**Station**
UG	**Under Ground**
GW	**Guide Wall**
DW	**Diaphragm Wall**
RS	**Roof slab**
SA	**Station Area**
BS	**Base Slab**
BI	**Boreability Index**
In	**Inch**
M	**Meter**

DEFINITIONS

Rock Quality Designation (RQD): It is a index by which we asses rock quality. whether the quality of rock is (1^{st}, 2^{nd},3^{rd} …. etc.).

Small Boring Unit (SBU): It has rock cutting head used in the top of Auger Machine.

Specific Energy: The Energy required to excavate a quantity of rock.

Tensile Strength: To measure the force applied to pull material. for example, rope, beam, structural steel, The strength is maximum stress subject till failure.

Tunneling: this process is similar to the Micro tunnel process except the tunneling method which is used as a temporary support of structure.

Micro tunneling Process: It includes the construction method used at site. For installation of pipe lines. Micro tunneling have so many features in it:

1) Remote control – In this Micro tunneling machine is operated through control panels which placed on the surface. The process installs pipes after spoil is excavated and material removed from it.

2) Guided- This system has a taken a reference from the laser beam focused on the target in Micro tunnel, It is capable to install sewers or other type of pipelines to require tolerance for line.

(4) Continuous supported - Continuous pressure is given on the face of excavated portion to move out the ground water and earth pressure.

(5) Penetration Rate (TBM) : Tunnel Boring Machine speed calculate without consider time require for supports and maintenance.

Joint: Joint represent the weakness mass in a tunnel.

1. INTRODUCTION

1.1 DELHI METRO

Delhi metro is itself a proud for all of us. It stands for Delhi metro rail Corporation. which comes under central government.

1.2 NETWORK

Delhi Metro plan to construct in so many sequences & phases as lot of stations is not possible to construct at same time. There are many Phases completed and construct by DMRC which is as follows. The Delhi Metro is being built in phases.

S.NO	DESCRIPTION	LENGTH	REMARK
1	DMRC PHASE-I	65.11 KM	TOTAL
	UNDERGROUND	13.01 KM	
	ELEVATED	52.10 KM	
2	DMRC PHASE-II	128 KM	TOTAL
3	DMRC PHASE-III	112 KM	COMPLETED
4	DMRC PHASE IV	108.5 KM	IN PROGRESS

1.3 Existing routes of Delhi metro

As of now during project duration DMRC already completed his Phase I, II,III and now Phase IV is in Progress . The DMRC is having 5 colored lines with 1 special Airport Express line which is in total of 148 stations.

Red Line

The first line (Red line) of DMRC line connects with Rithale to Dilshad garden in west side which totally covers a distance of 25.09 km. This line is divided in two sections i.e (Elevated or partially Elevated) some where it may also cross Yamuna River between cashmere Gate station and shastri station.

YELLOW LINE OF DMRC

Yellow Line of DMRC was the second line of the Metro which is started just after red line. It is first started with the Underground stations for the public. It is of 44.36 km total from north – south. This line also connects through Jahangir Puri with Huda city in Gurgaon.

BLUE LINE OF DMRC

The Blue Line of DMRC is the third line of Delhi Metro which is opened and construction has been started for public convenience. First this was started as elevated to connect with another line and then plan to be opened. First it may connect local areas or mainly outer periphery.

Violet Line

This 23.2 Km line connects the Badarpur to ITO station with 9 km overhead and rest is of Underground station. The first section is Inaugurated on 3-10-2010.

Phase III

The deadline for completion of Phase 3 Metro Project in Delhi was 2016. But due to the extension of new stations which is introduced in last of 2016. So, the deliver time is extended and it may finished in 2019 end.

Phase I,Phase II & Phase III DMRC network

Line	Stations	Length (km)	Terminals		No. of interchanges planned
Yellow Line extension	3	4.49	Jahangirpuri	Samaypur Badli	0
Violet Line extension	7	9.37	Central Secretariat	Kashmere Gate	2
	9	13.875	Badarpur	YMCA Chowk	0
Blue Line extension	3	4.295	Dwarka	Najafgarh	1
	6	6.675	Noida City Centre	Noida Electronic City	1
Green Line extension	6	11.182	Mundka	Bahadurgarh	0
Pink Line also called Inner Ring Road Line (Line 7)[84]	38	58.59	Mukundpur	Shiv Vihar	11
Magenta Line also called Outer Ring Road Line (Line 8)	25	38.24	Janakpuri West	Botanical Garden	4
Red Line extension	6	9.6	Dilshad Garden	New Bus Stand, Ghaziabad	0
Brown Line (Noida-Greater Noida Line)	20	21	Sector 52 Noida (Blue Line)	Depot Station	1
Total	**102**	**156.12**			**18**

1.4 PROJECT DETAIL

The Delhi Metro Rail Project Contract CC-24 is comprised of construction of twin 3.4 km bored tunnels, 0.39 km cut & cover tunnels, 12 cross passages and 4 stations.The TBM-EPB (Earth Pressure Balanced) shield machine will be utilized for excavating the twin bored tunnel from the Hazarat Nizamuddin Cut & Cover Shaft to the Ashram Station. From the Lajpat Nagar Cut & Cover Shaft to the Vinoba Puri Station, and from the Vinoba Puri Station to the Ashram Station.Two units of Earth Pressure Balance type TBMs will be used to construct the twin bored tunnels from the Hazrat Nizamuddin Shaft (Cut & Cover) to the Ashram Station (East

Shaft), the Lajpat Nagar Cut & Cover to the Vinoba Puri Station (West) and from the Vinoba Puri Station (East) to the Ashram Station (West) for the Delhi Metro RailProject Contact CC-24. The TBM is 6610 mm in diameter and is manufactured by TERRATEC.

SUMMARY OF PROJECT

Contract Period : 23-Jul-2012 to 23-Jan-2016

Proposed Completion : 23-Dec-2016 (Excluding Ashram)

Contract Amount : INR 1011 Crores (INR 9,091,917,288 + US$ 19,094,233)

Elapsed Time so far : 33 Months till 30-April-2015

Physical Progress : 100 %

Financial Progress : 100 %

Length of Route : 5490.942 Meters

Total Length

a) Tunnel : 6966.952 m

b) Ramp : 240.030 Meters

c) Cut & Cover : 879.024 Meters

d) Stations(4Nos.) : 888.413 Meters

e) Cross Passages : 16 Nos.

ACTUAL VIEW OF THE SITE

2. ENVIRONMENT, HEALTH & SAFETY

The contractor before starting of work or entering into the site premises must ensure that all workers must receive a safety induction & Health, safety and environment training by the Qualified Safety Officers. They must have a full knowledge about the hazards which may be encountered at site during the working hours. All workers must have their own ID card signed by the Authorized Representative of the contractor before they start any work. Safety is the prime Responsibility of all the staff and workers. shall ensure that all the personnel. All workers going to the site must have PPE before entering in the PPE zone. Other important aspect of safety is to ensure that every personnel at the site are in PPE's as they reduce hazards both fatal and non-fatal to minimum. The earthen pots for the laborer's should be filled with potable and clean water. First aid kits should be available easily to tend towards non-fatal injuries. Proper barricading needs to be done to mark out the area under construction from the area the general public uses for commotion so that hazard to the general public is minimized. People from SHE should always be present to ensure proper safety during the construction period. They should initiate good habits to save/protect the environment. They have a duty to provide with economical solution to reduction in pollutant output at the site during the entire duration of the construction. Penalty may be levied upon the contractor if the safety standards are not being met at the site.

2.1 PPE ZONE REQUIRED BEFORE ENTERING INTO SITE (personal protective equipment)

Personal protective equipment (PPE) refers to the protective dress/ cloths which may protect our body from harmful hazards at site. It also protects ourself from the injury or any other infections.

The Aim of personal protective equipment is to minimize the hazards which is not feasible or to reduce the risk which may come Unannounced. In construction work many of the work are most hazardous which may also lead to death so it is very necessary to cover ourself my protective kits.

2.2 Types of PPE for site construction

A) Eye Hazards

B) Neck & Head Hazards

C) Arm & Hand Hazards

D) Leg & feet Hazards

3. BUILDING SURVEY METHODOLOGY

The building for which pre-condition survey is required will be along the proposed alignment of Metro Corridor for a width of 35m on either side of centre line.

i) Necessary permissions shall be obtained from the owner of the buildings to facilitate closure inspection of the buildings. The permissions may be with some restrictions like no digging, no hammering/chiseling/drilling, etc.

ii) The requisite details of buildings including general lay out plan, age of structure, foundation type and condition, and all other such details shall be collected from the owner of the buildings.

iii) The overview of the buildings such as location, area and other land mark will be recorded; these locations will be located on the drawings.

iv) The outline plan of the buildings shall be incorporated in the general layout drawing. The drawing will also include the location of the nearby tunnel alignment providing the distances from the nearest tunnel's external face, so that an idea can be obtained weather the buildings is coming within the normal influence zone i.e. 35 m on either side of centre line.

v) For pre-condition survey of the buildings the general procedure shall be as follows:

a) After obtaining the necessary permissions from the owner of the building, the initial preliminary inspection will be made so as to broadly determine the visible distresses and plan the inspection schedule.

b) Wherever necessary help of the Client will be sought so that the inspection team can enter the premises with proper equipment.

c) Afterwards, a detailed inspection will be made along with the necessary equipment/tools so that most of the defects can be identified and recorded for further use. The inspection shall be carried out on all accessible areas including:
- External areas like footpath, walkway.
- Internal areas (whichever are accessible).
-Foundations (to the extent possible without digging).
-Nearest landmarks shall also be recorded.

d) All the premises in the building that are available and accessible would be inspected and sufficient information would be gathered to determine the present conditions and structural integrity of the building.

e) The portion of the buildings which are inaccessible and which could not be surveyed, shall be identified and specified in the report.

f) Existing damage shall be identified & classified using Burland Classification system .

g) Special emphasis shall be made on the existing cracks. The crack width and estimated length along with their orientations with respect to their nearest wall or columns will be recorded. In case if the cracks are inaccessible to measure then engineering judgment will be made and the tentative crack length and width will be mentioned.

h) The plan of the structure shall be prepared in the drawings (not to scale) and all the walls/columns and other members shall be given a unique identification number.

i)All the defects shall also be given a unique identification number with respect to the identification number of the structural members and shall be presented in a tabular form.

j) Wherever required, necessary elevation of the structural members shall also be prepared in drawings (not to scale) and the defects shall be marked accordingly.

k) The photographs of all the defects shall be recorded in the report and necessary comments on all the defects shall also be specified along with all the photographs.

l) Identification of location for crack gauges, settlement points and location where any real time monitoring is required shall depend upon a number of factors including:

- Distance of the building from proposed tunnel alignment.
-The damage category of building.
- Importance of structure etc.

Proposed instruments plan suitable for monitoring of cracks, settlement points and locations for special monitoring shall be specified in the pre-condition reports.

vi) Based on the records of the visual inspection and the analysis of the information recorded; any structural defects shall be highlighted.

vii) Once the survey for the buildings is completed, the report will be generated and submitted to the DMRC for approval.

4. CONSTRUCTION METHODOLOGY

The construction methodology adopted for this project is cut and cover(top to bottom), a prevalent technique for underground projects. It is a technique which is being used for a number of projects all around the world.

The basic construction includes:

- Guide wall:It gives proper alignment for excavation of D wall.
- D wall:It is a box like stucture in which whole construction takes place.
- Roof Slab: It is that part of metro station which acts as the roof of the metro station.
- Concourse Slab: The points of entry, exit, transit through staircase and the place where we place our cards and tokens.
- Base Slab: It is that level of metro station where the metro runs

4.1 GUIDE WALL METHODOLOGY:

Guide wall construction shall be performed according to the following description.

a) Survey: Surveyor shall mark the layout from approved drawing. Layout may be further developed powder or other visible markings.

b) Guide Wall Corner: One side of each Guide Wall corner shall be extended by 200 mm as under:

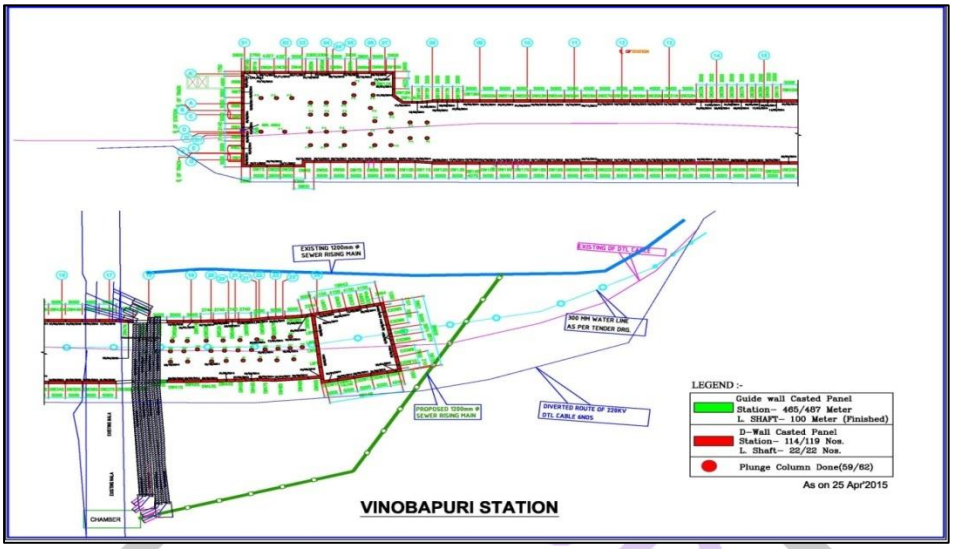
c) Excavation: Excavation in vertical portion shall be done using mechanical excavator. Final profile shall be by manual excavation. Top Level of Trench Soffit shall be bottom level of Guide Wall RCC. If due to any reason extra excavation has been done, same shall be filled up Concrete only. No filling of soil shall be carried out .

c) Reinforcement: Reinforcement shall be cut and Bent to the shapes Fabrication Yard. Same shall be transported to site and tied in Place using tying wire.

d) Formwork: Steel shutters shall be used. Cover blocks, U bars & chairs of required sizes shall be used to maintain cover to reinforcement.

Only one side of Guide wall shall be formed. The other side (soil side) shall be directly placed on earth.

e) Concreting :Top level of concrete shall be marked on shutters if the shutter top is not fixed accurately. Top Ievel of Guide wall shall be same for the Shaft/Station. Concreting shall be done in layers and precaution need to be taken to ensure that the both sides are concreted simultaneously. This will avoid movement of shutters or bulging during concreting. Top level shall be marked using rebar pegs to maintain finished Concrete level. Props jacks shall be removed after 12 hrs of Concreting. De shuttering shall be done after 24 hrs of Concreting. Curing shall be done for 07 days. Curing shall be done using wet Hessian cloth.



4.2 DIAPHGRAM WALL METHODOLOGY:

Diaphragm wall construction shall be performed according to the following Sequence:

- Marking of Primary/ Secondary Panels on Constructed Guide Wall.
- Installation of monitoring instruments.
- Trenching for Diaphragm Wall.
- Lowering of Reinforcement Cage.
- Concreting.

4.3 Installation of Plunge column

• The pile of required diameter (1200 mm in our case) will be bored with Hydraulic rig upto 6m.

• Then temporary steel casing of dia 1200mm shall be installed upto to·6m depth.

• Boring of piles will go till required depth with the help of polymer.

• Sounding shall be checked.

• After Proper lapping and welding cage shall be lowered and kept hanging by projection 2m above the ground.

• Now prefabricated Plunge column shall be inserted in the cage by 1.5 m and connected with cage as per approved drawing.

• Now entire assembly shall be lowered slowly inside the bore to the required level.

• Then tremie pipe shall be inserted inside the plunge column to pour the concrete.

• After concreting rest of the pile shall be filled with soil/sand upto top level.

4.4 ROOF SLAB CASTING

This includes the following.

• **Breaking and removal of Guide walls :** After the casting of Roof slab the Guide wall must be break with the help of Hydraulic breaker without damaging the casted couplers.

• **Breaking and removal of roads and hard standing** : It is also ensure that the extra debris or road part which merge with the existing guide wall must be beak into pieces.

• **Excavation upto soffit of roof slab:** Excavate the soil down to the formation level using bachoe. Adjust the formation level (lower), where the lower couplers slightly out of position (lower than the designed level) but within the allowable limits.

• **Preparation of D'wall and exposure of coupler:** Couplers shall be exposed by chipping off the concrete surface using electric chipping machine (Hilti or equivalent). The surface of diaphragm wall shall be in contact with roof slab shall then be roughened to provide a good joint between the old and new concrete. Beside recess shall be made in the D'wall along the coupler location.

• **Placing of PCC:** PCC concrete must be placed of minimum 75mm thickness shall with the help of concrete pump. Concrete shall be finished Properly to ensure uniformity. The blinding concrete shall be extended minimum 500mm beyond construction joint of structural slab.

Application of ply wood: After hardening of the PCC, the structure must be covered by Ply {4mm thick) and nailed to PCC.

Exacavation work at vinobapuri station

EXCAVATION IN PROGRESS ON GRID 08 TO 10

Exposed couplers

• **Concreting :** Approved grade of concrete need to place as per concrete pouring plan. Concrete pump with pipeline shall be used for pouring of concrete to pour area.

• **Curing**

Reinforcement work in Progress for roof slab

Reinforcement Work of the roof slab

4.5 CONCOURSE SLAB CASTING

Concourse slab construction shall be performed according to the following Sequence:

1. Instrumentation and monitoring

Monitoring of ground water levels and settlements must be record till completion of Project by continuing reading at the installed piezometers, inclinometer and standpipes (If required).

2. Excavation works: Permit to dig shall be obtained from the designer prior to carrying the excavation works.

a) The soil must be excavate till the formation level is attained.

b) Excavate the soil level wise with the help of bachoe attached with long boom.

c) Use dumpers to clean the excavated soil coming out from the excavation.

d) Survey levels must be checked to confirm the excavation level.

e) Excavate the area close to diaphgram wall and is shown in the drawings too.

f) Adjust the slab level (lower), where the lower couplers slightly out of position (lower than the designed level) but within the allowable limits.

3. Preparation of diaphragm wall surface and exposure of couplers:

Currently with the excavation for the concourse slab, the surface must be prepared accordingly as mentioned under:

Couplers must be exposed by chipping off the concrete surface using electric chipping machine (Hilti or equivalent).

Following points should be noted while doing this operation

a) It is to be ensure that the rebars shall not be exposed unnecessarily.

b) Chipping shall be limited to exposing the sound concrete surface only.

c) Chipping should be carried out in a manner that cracks are not formed/propagated.

• All loose and unsuitable material/concrete shall be removed using water/air pressure wash. The blackouts in the diaphragm wall for the concourse slab must be removed and the casted couplers shall be located in the diaphragm wall. In the event of cement grout found in the inner threads of couplers, it shall be cleaned by wire brushes and compressed air. A threader may be used if required.

• In case of missing couplers or couplers out of position beyond tolerance, guideline shall be sought from the designer.

• The surface of diaphragm wall shall be in contact with concourse slab shall then be roughened to provide a good joint between, the old and new concrete. Beside recess c shall be made in the D'wall along the coupler location.

5. Preparation of Formation

After the excavation once reach the desired level, relevant marking of Grid lines must be set out and the area for the PCC shall be levelled and compacted

6. Placing of PCC concrete

PCC must be placed on the compacted area which is of 50mm thick. it shall be placed manually.

7. Application of Ply wood

After placing of concrete once concrete gets hard it should be covered by 3mm Ply and it must be nailed from the top.

8. Formwork

Formwork shall be required for following:

• Open all the wholes around the starter bar in the formwork.

• To form sides of the slabs around the main access openings and other smaller openings.

• Formwork shall be externally supported by suitable bracing & will be strutted all along the length of formwork.

9. Compaction of concrete

Concrete must be compact during concreting with the help of needle & vibrators which is of 60mm dia penetration vibrators shall be used at grid of 300mm c/c.

Vibration must be done in continuous manner until the expulsion of air has practically ceased. The vibrator shall be removed slowly to remove all the voids from the concrete. During the compaction it should be ensure that reinforcement may not be displaced, formwork, pre-fixed pipes, block outs, thermocouples, etc. care should be taken while working.

10. Surface Finishing

Surface finish for the PCC/blinding concrete and concourse slab concrete shall be done at the required level.

11. Curing of concrete

The following procedures shall be followed in curing the slab concrete:

• Curing shall be done with water which is found 'suitable to be used as mixing water (for concrete (As per IS 456: 2000).

• Wet hession cloth shall be spread over the concrete surface or curing shall be done by ponding.

12. Removal of Formwork

Roof Slab

Concourse slab

COLUMNS WORK IN PROGRESS IN FULL SWING

4.6 BASE SLAB CASTING

Base slab construction shall be performed according to the following Sequence:

1. Instrumentation and monitoring

continuing reading at the installed piezometers, inclinometer and standpipes (If required). For monitoring till end.

2. Excavation works:

Permit to dig shall be obtained from the designer prior to carrying the excavation works.

• Excavation of soil must be till the formation level

a) Excavate the soil till the desired level may not achieved by the help of long boom and mechanical excavators.

b) Dumpers must be used to throw the excavated earth from the site premises to dumping yard location.

c) Progressively take the survey levels to ensure that required level is achieved or not.

d) Excavate from the corner of the Dwall or which may be shown in the drawings according to the level is mentioned.

e) Adjust the desired level (lower), where the lower couplers slightly out of position (lower than the designed level) but within the allowable limits.

f) Water table will always be maintained below final excavation level.

3. Preparation of diaphragm wall surface and exposure of couplers:

Currently with the excavation for the base slab, the surface may be ready/Prepare as mentioned below:

• Couplers will be exposed by chipping off concrete surface using electric chipping machine.

Following points should be noted while doing this operation.

a) Chipping shall be limited to exposing the sound concrete surface only.
b) Chipping should be carried out in a manner that cracks are not formed/propagated.

• All loose and unsuitable material/concrete shall be removed using water/air pressure wash. The blackouts in the diaphragm wall for the base slab will be removed and the cast in couplers shall be located in the diaphragm wall. In the event of cement grout found in the inner threads of couplers, it shall be cleaned by wire brushes and compressed air. A threader may be used if required.
• In case of missing couplers or couplers out of position beyond tolerance, the same shall be treated as per guideline given by designer.

• The surface of diaphragm wall shall be in contact with base slab shall then be roughened to provide a good joint between the old and new concrete. Beside recess shall be made in the D'wall along the coupler location.

4. Preparation of Desired Level.

After we complete the excavation till the desired / formation level , relevant grid lines should be marked for PCC.

5. Placing of Plane cement concrete (PCC)

PCC of required thickness shall be placed manually or by mechanical means.

6. Application of waterproofing

Method statement for application of waterproofing shall be followed.

7. Formwork

Formwork shall be required for following:

• cover all the holes (opening around starter bars) in the formwork.

• To form sides of the slabs around the main access openings and other smaller openings.

• Formwork shall be externally supported by suitable bracing & will be strutted all along the length of formwork.

8. Compaction of concrete

Concrete may be compacted during placing by immersion vibrator needle 60mm dia penetration vibrator should be used at grid upto 300mm c/c. Immersion vibrator should be handled in near vertical position .Vibration should be applied continuously until the deformation of air has practically ceased. The vibrator shall be switch off slowly to avoid the formation of voids. During the compaction, one should care to avoid the displacement of reinforcement, formwork, pre-fixed pipes, thermocouples, etc.

9. Surface Finishing

Surface finish for the PCC concrete and base slab concrete shall be done at the required level.

10. Curing of concrete

The following procedures shall be followed in curing the slab concrete:

• Curing shall be done with water which is found suitable to be used as mixing water for concrete (As per IS 456: 2000).

• Wet hession cloth shall be spread over the concrete surface or curing shall be done by ponding.

11. Removal of Formwork:

The side forms at construction joints shall be struck after 24hrs

BASE SLAB (ASS-01) GRID 01 TO 04

5. SHEAR PIN METHODOLOGY:

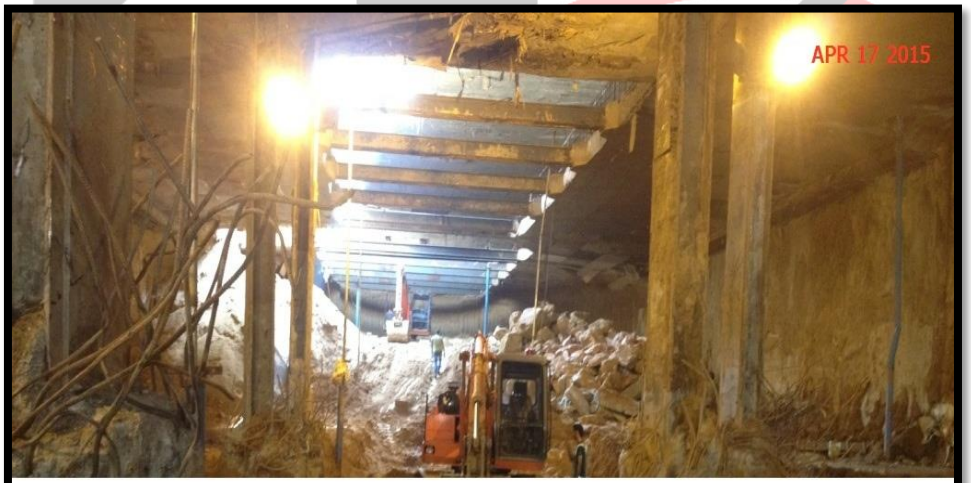
Erection of Shear Pin shall be performed according to the following Sequence: Leave the HDPE Pipe in D-Wall. During casting of D-wall, the 10 mm thick HDPE pipe of 250 mm dia (110) should be provided.

Levels of shear pin: It varies according to rock level.

Boring for pile: Boring for pile shall be done by means of DOWN THE HOLE "DTH".

Lowering of Inbuilt steel section: Inbuilt steel section shall be fabricated and lowered till the required level.

Grouting: Grout the hole using grade 40 non shrink grout.



ROCK ENCOUNTERED DURING EXCAVATION FROM GRID 08 ONWARDS AT BASE LEVEL OF VNP STATION

6. INSTRUMENTATION & MONITORING

6.1 Soil / Pavement settlement point

The instrument soil settlement point self-explained that it may be used to monitor the vertical settlement of any of the horizontal member like road, slab etc. This instrument consists of a plastic tapered (disc) around 100mm in diameter which is to be placed by a special retaining nail.

PAVEMENT SETTLEMENT POINT *BUILDING SETTLEMENT POINT*

6.2 Building settlement

This second instrument is to used be fixed the vertical member which may monitor the vertical movement and any other settlements if any in the structure. It may consist a male anchor fitted into the anchor socket which in place is usually fixed in a wall of thickness greater than 80 mm.

6.3 Tilt Meter

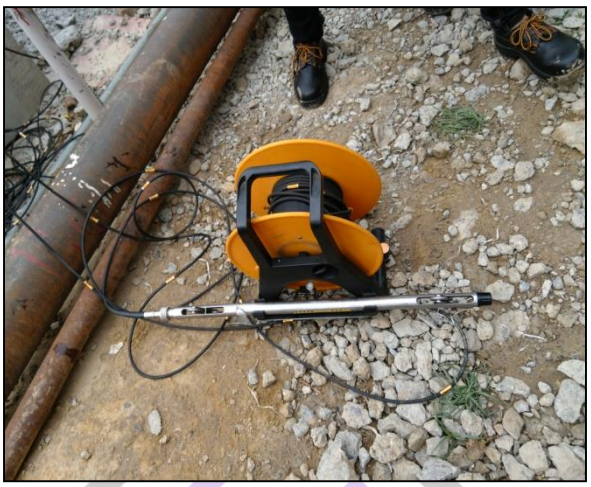
Tilt meter is generally used to monitor utilities, building etc. it may also observe the inclination and rotation or movement in retaining wall, dam, pile, piers etc

TILT METER

6.4 Inclinometer

This instrument is used to measure the angles of slopes, elevation of an object with respect to gravitational forces. It may cast in D-wall at the interval of 5 Mtr.

INCLINOMETER



7. TESTS AT SITE

7.1 Slump test

It ensure the uniformity of the concrete prepared from the different batches for the same work of same grade. It also ensures the effects of Plasticizers in new batched. This test is very useful at site during concrete as we can check the variation if any and variation in material while batched at plant. Sudden increase in slump means that there is unexpectedly increase in moisture content of aggregate.

7.2 PULLOUT TEST

1) Fix the rebar.

2) Leave the rebar till full cure time.

3) Place the load cell and pass the rod through the load cell.

4) Place the coupler over the load cell. The jaws should clamp the rebar lightly. Light hammering can be done for the same.

5) Fix the dial gauge on the hydraulic pump and connect the hose of the hydraulic pump to the load cell.

6) Close the pressure release valve.

7) Bring the black dial to 0.

8) Start applying the pressure slowly through the hydraulic pump. 9) Note the reading till the required limit. In case of failure, take the reading until the black dial starts returning.

10) Taking the reading in the dial gauge. The reading taken would be in terms of force (KN or Kgf)

11) Release the pressure valve.

12) Disassemble the setup. Repeat the process for further testings.

8. WATERPROOFING

Waterproofing shall be performed according to the following Sequence:

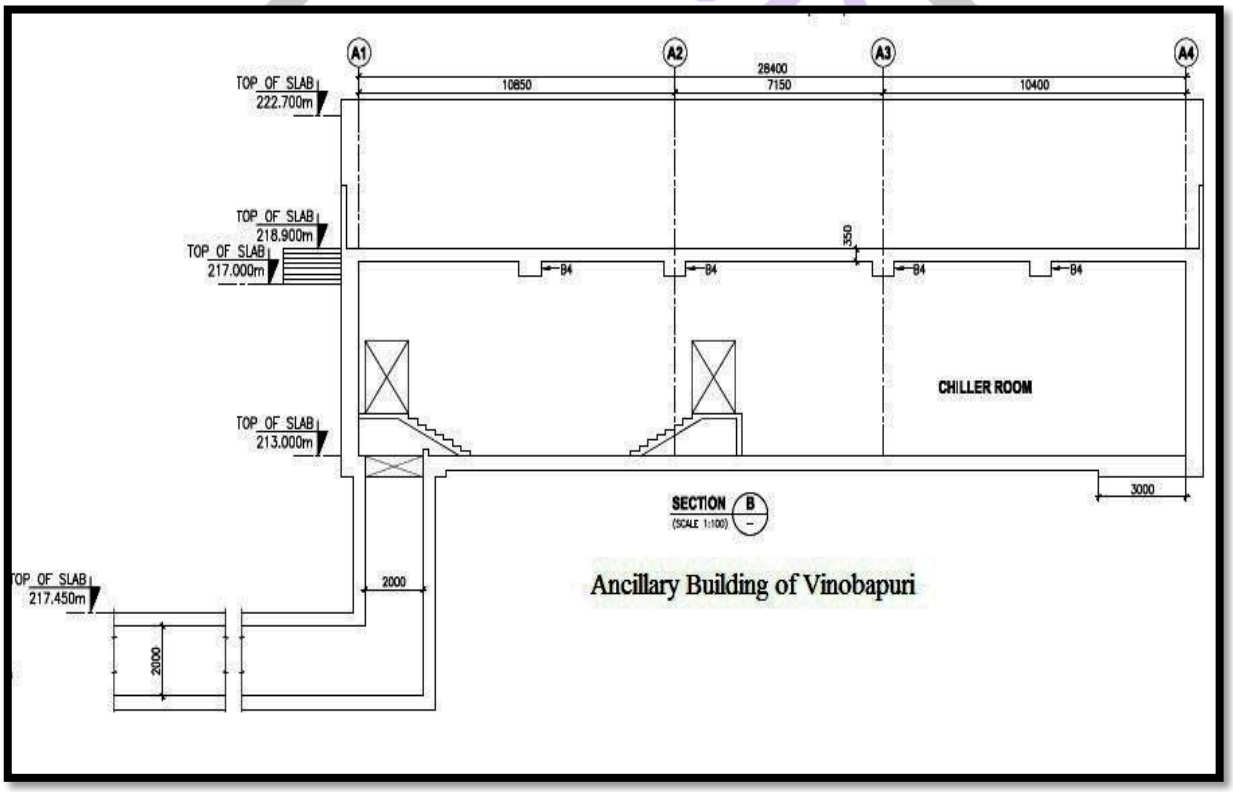
1)Cleaning and Preparation: The area must be well cleaned and prepared before applying of CONIROOF. The area should have free from all loose particles and have fully sound proof.

2) Surface Preparation: New construction must require the high strength to withstand the load of structures. So concrete needs to be well coated, mixed , designed in accordance to match the quality standards.

3) Preparation for primer coat: This chemical (CONIROOF) may be applied in various places from dense to light weight metals. So, installation of CONIROOF is essential before proceed.

4) Application Waterproofing coat: CONIPUR M 800 chemical is solvent free, it comes with two components, once we applied through SPRAY waterproofing membrane which is highly reactive and can only be applied by , two component spray equipments.

Waterproofing work is carrying out



ANCILLARY BUILDING AT VNP STATION

9. TUNNEL BORING MACHINE (TBM)

Modern tunnel construction is done with the **tunnel boring machines**. These machines have a boring head called Mole which can excavate tunnels of only circular cross sections. These machines can work in different type of strata – from hard rock to soft soil. The TBM also produces smooth surface there by reducing the cost of tunnel lining significantly. The TBM consists of a rotating wheel, which is called cutter head. There is an opening in the cutter head which allows the muck to drop to the mucking system; generally, a belt conveyer delivers the muck to a following truck or a muck car. TBM is generally a machine which depends on the geology, amount of ground water and many other factors on which it depends.

9.1 TBM COMPONENTS

Each TBM is not complete and has been dismantled following testing and commissioning in the factory. The TBMs are divided into separated body sections with other equipment packed and loaded based on appropriate size and weight for efficient shipping, transportation, lifting, lowering and assembly.

The TBMs consist of the following main parts for shipping, transportation and identification.

A. TBM Shield Body : The TBM's body is divided in an axial direction and into 4 sections. These are the A-ring, the B-ring, the CD-ring and the EF-ring sections. The cutter head and the cutter driving unit are mounted on the A-ring section. The shield jacks and the articulation jacks are mounted in the B-ring and CD-ring sections. The tail seal brushes are mounted on the EF-ring section.

B. Cutter Head Drive Motors - 10 numbers.

D. Screw Conveyor- 1 number.

E. Erector -1 number.

F. Rear Scaffolding -1 set. The rear scaffolding is divided into left and right sections.

G. Segment Hoist.

H. Belt conveyor - Divided into 3 sections.

I. Segment Feeder Unit.

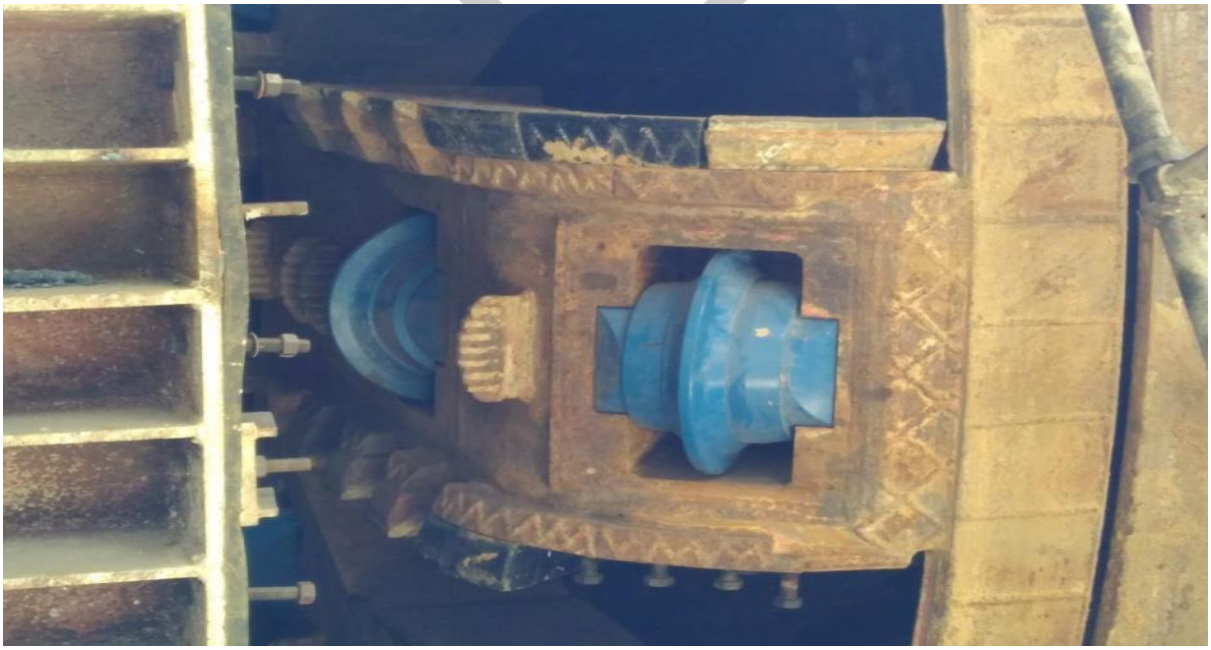
J. Bridge Gantry.

K. Back Up Gantry - 6 numbers.

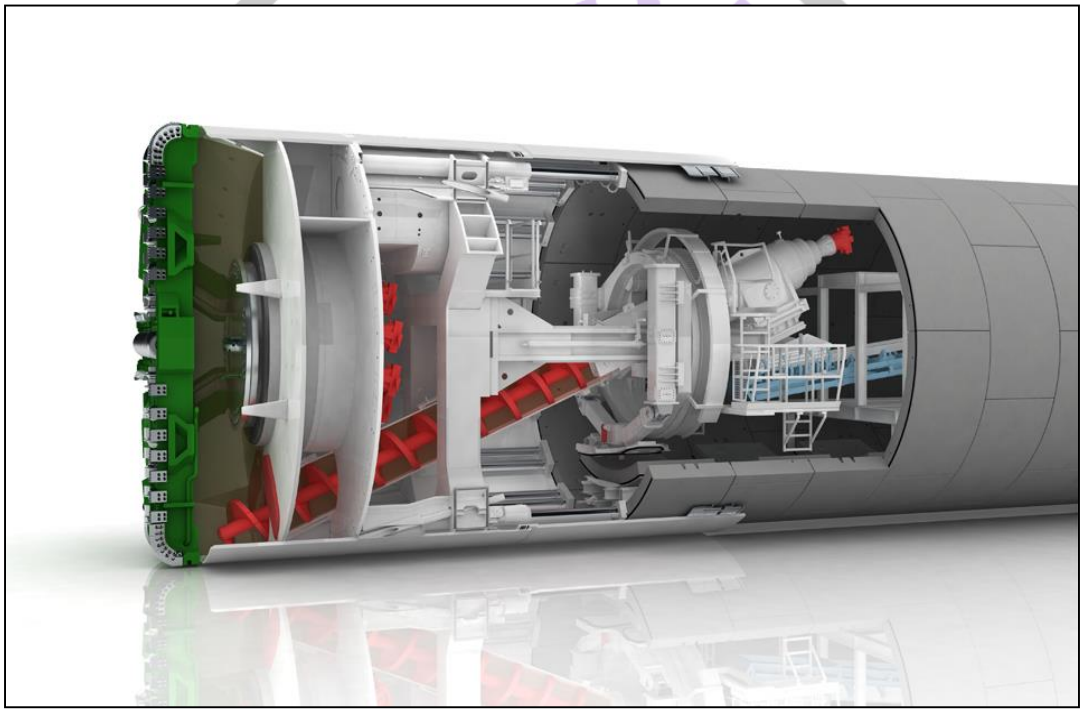
Our Tunneling Method is, in principle, the repetition of excavation and lining construction at every 1.4m. The TBM-EPB moves forward rotating the cutterhead in order to cut the ground ahead. The thrust force will be obtained by pushing against the erected segmental rings. Once the advance of 1.4m is completed, several rams (Shield jacks) will be retracted for a new segmental lining erection. Six numbers of segment pieces (5 + 1) will be placed at the scheduled positions, one by one, using the segment erector to make a complete ring. Bored tunnel construction involves various works. The next part will provide a brief description of the activities which are implemented on the ground surface, at the service shaft and inside the TBM-EPB back-up cars. The TBM-EPB advancement process utilizing an EPB tunnel boring machine will be described in the next section.

TBM at Vinobapuri site

Rock cutter



Tunnel at the site



A TBM Model

10. PURPOSE.

Two units of Earth Pressure Balance type TBMs will be used to construct the twin bored tunnels from the Hazrat Nizamuddin Shaft (Cut & Cover) to the Ashram Station (East Shaft), the Lajpat Nagar Cut & Cover to the Vinoba Puri Station (West) and from the Vinoba Puri Station (East) to the Ashram Station (West) for the Delhi Metro Rail Project Contact CC-24. The TBM is 6610 mm in diameter and is manufactured by TERRATEC.

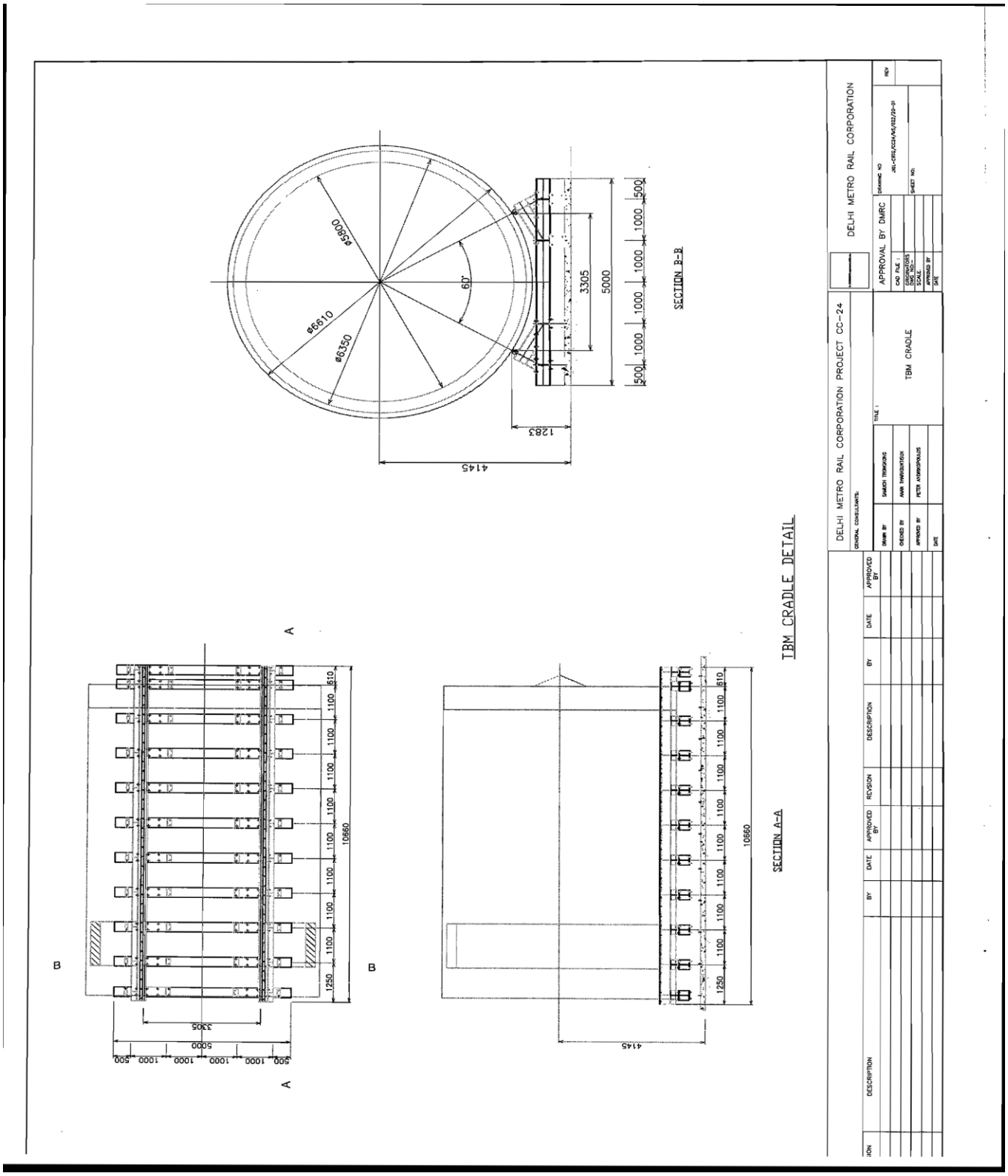
This document outlines the work method and procedures for the lifting, the lowering and the first phase of the TBM's assembly in preparation for the TBM's initial drives.

11.SCOPE

The scope of work involves the following:

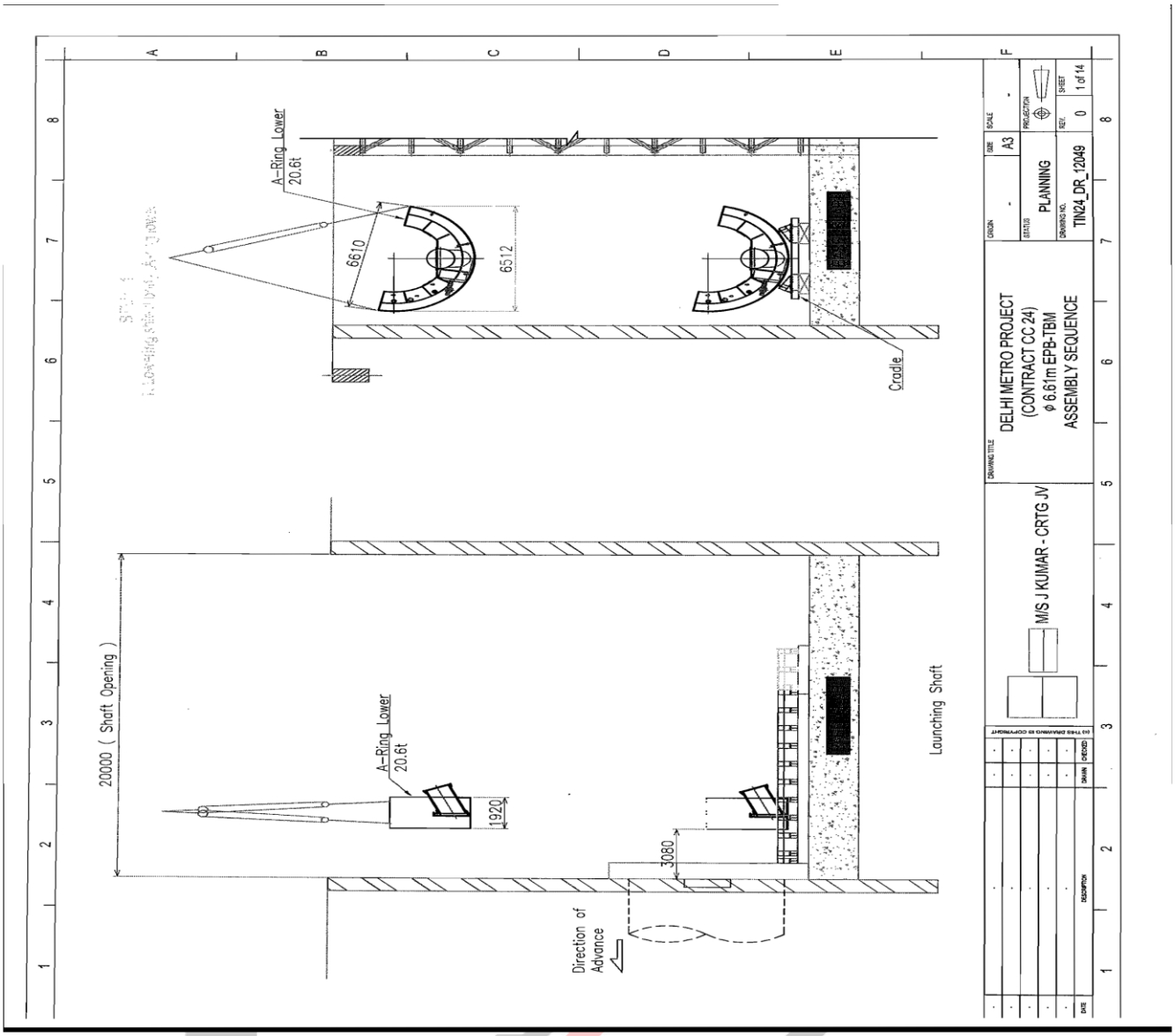
- Preparation.
- The Lowering of the TBM parts into the launch shaft.
- The Assembly of the TBM at the shaft bottom.

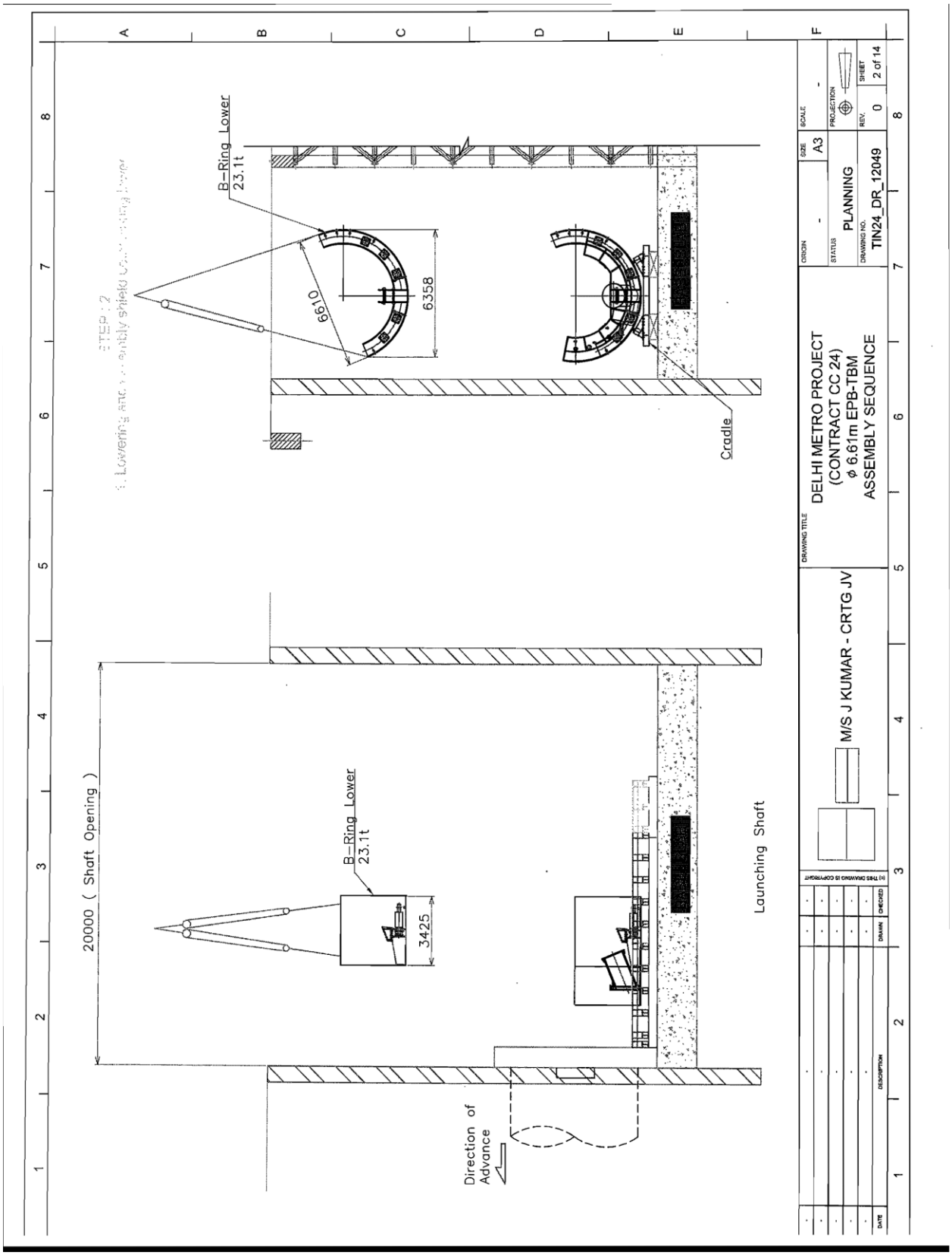
12. TBM CRADLE FIXING SEQUENCE BEFORE LOWERING OF TBM

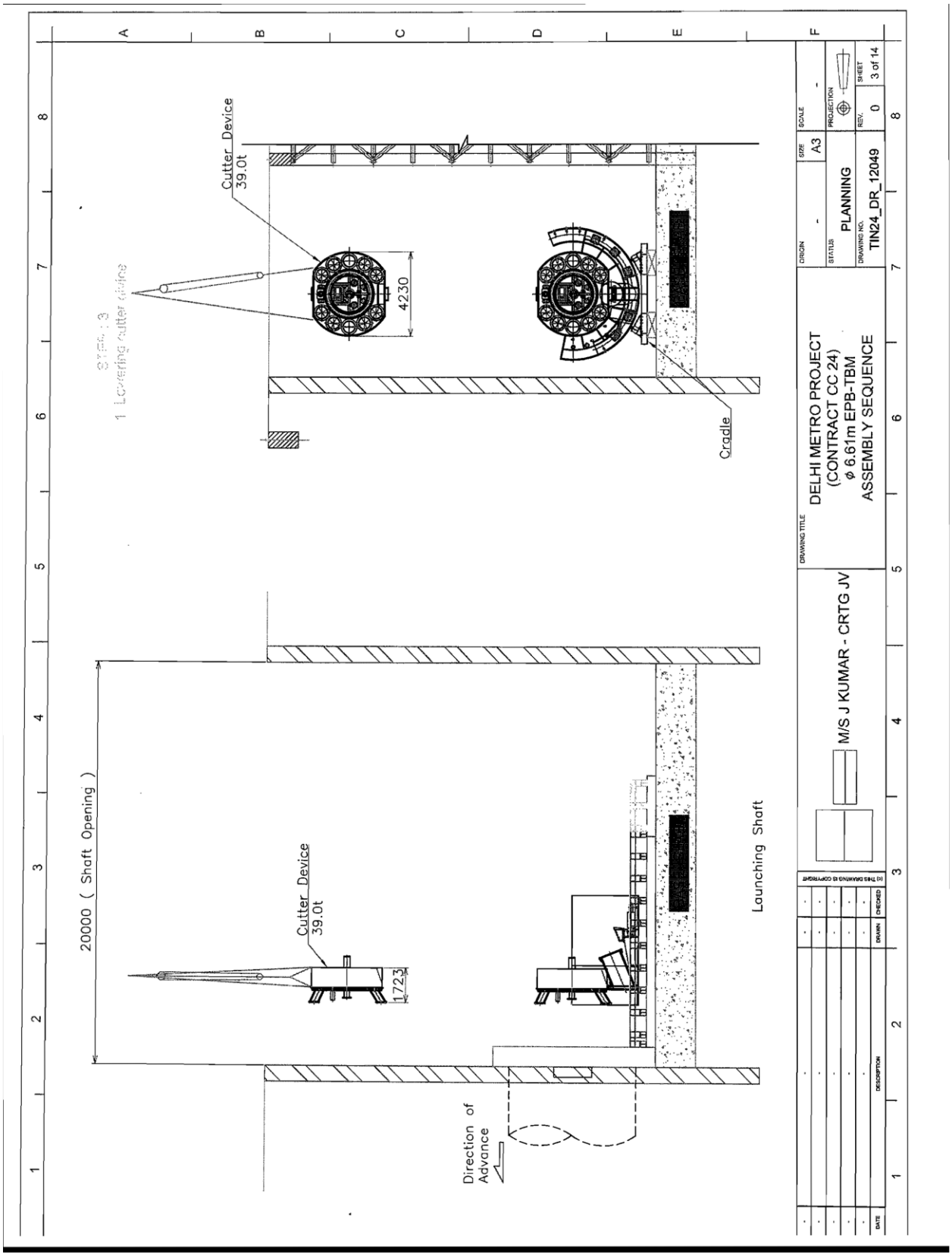


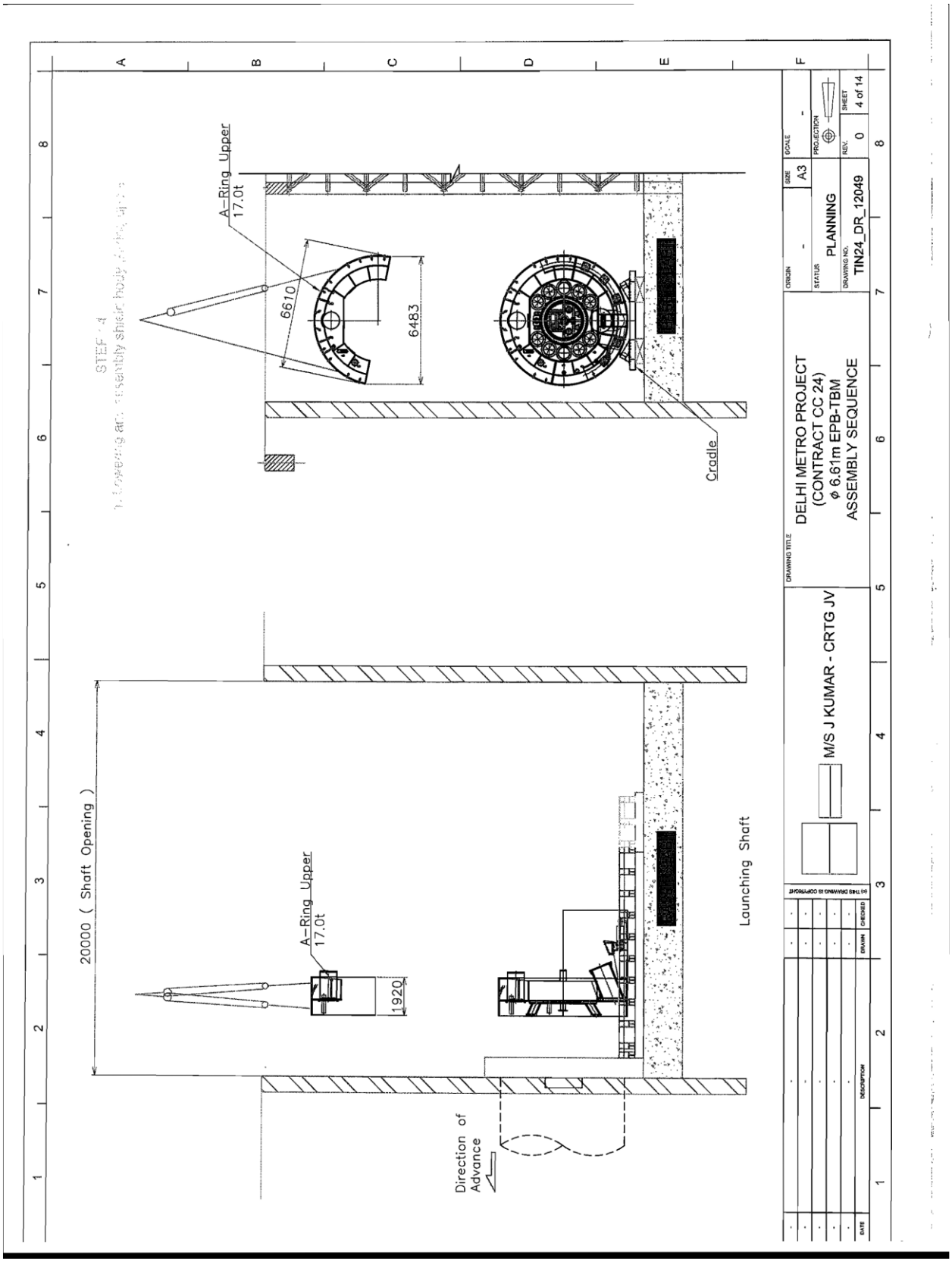
TBM ASSEMBLY SEQUENCE PART WISE

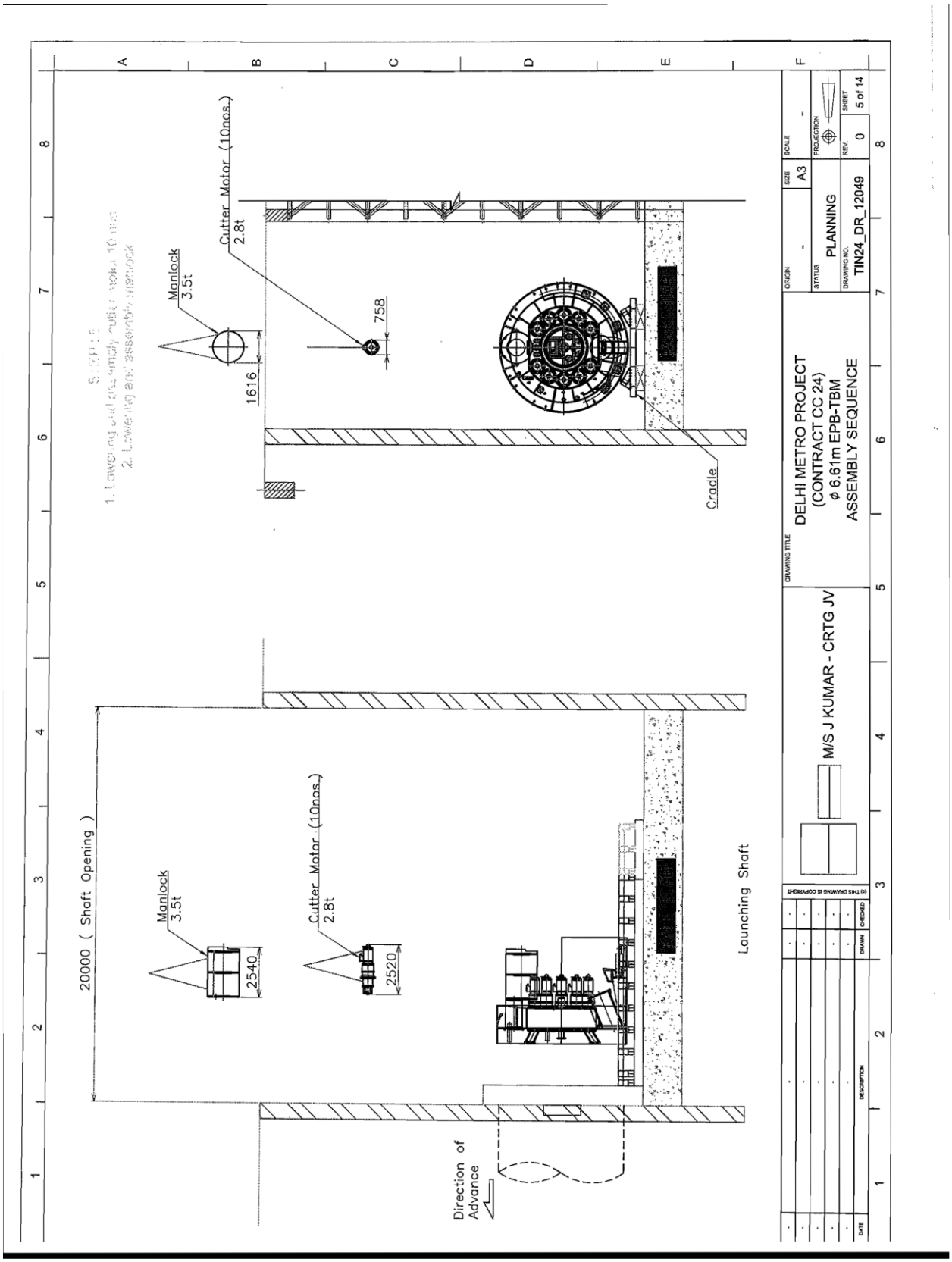
Tbm needs to assemble at Base slab so it may lower part wise from the temporary cutout and once it may lower all parts is welded at Base slab and it is started to proceed for the tunnel. TBM is so big in nature hence it is not possible to lower full TBM at ground.

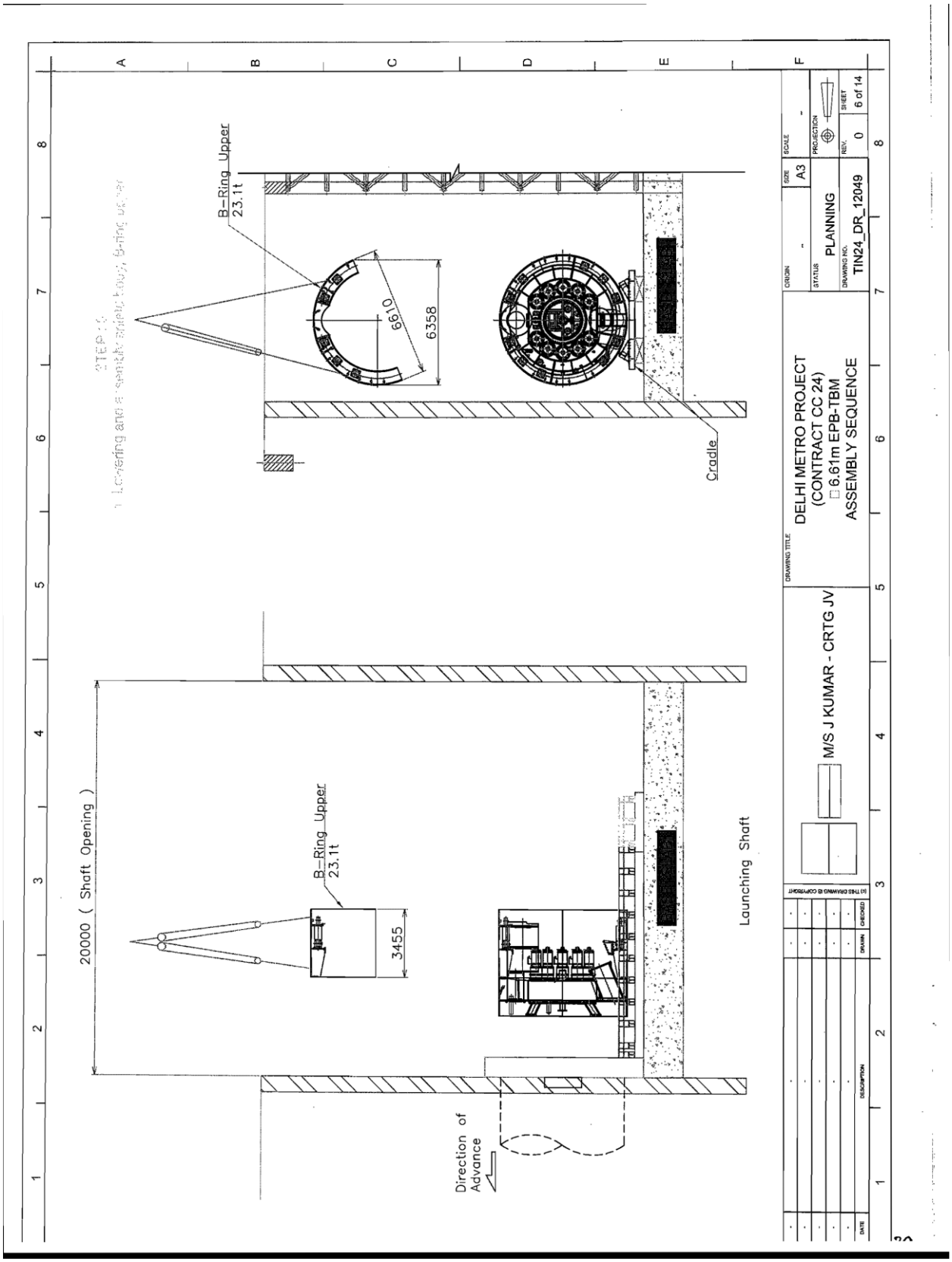

A–Ring Lower
20.6t
6610
6512
Cradle
20000 (Shaft Opening)
A–Ring Lower
20.6t
1920
3080
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
ϕ 6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
1 of 14

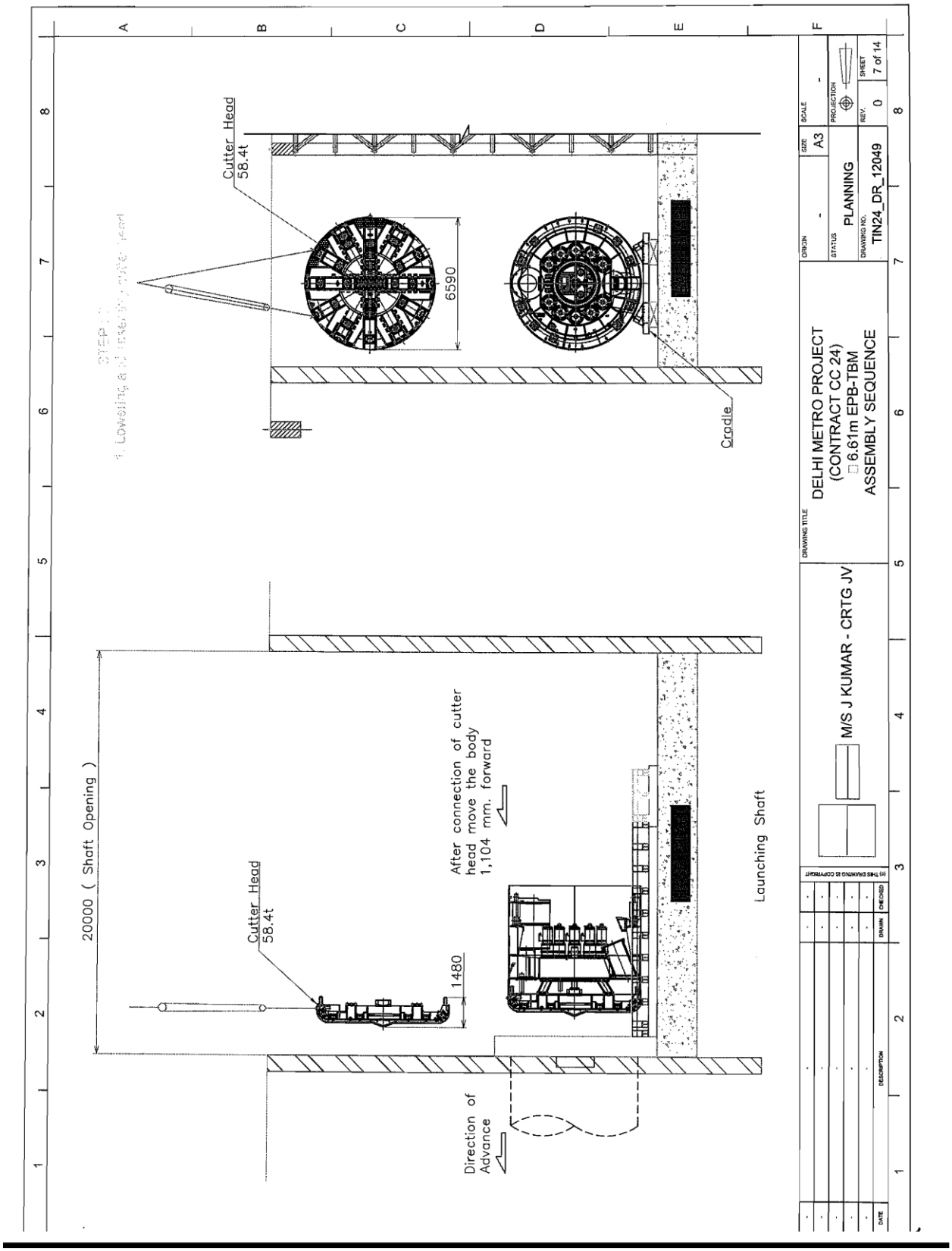

B-Ring Lower
23.1t
6610
6358
Cradle
20000 (Shaft Opening)
B-Ring Lower
23.1t
3425
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
ϕ 6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
2 of 14


Cutter Device
39.0t
4230
Cradle
Launching Shaft
20000 (Shaft Opening)
Cutter Device
39.0t
1723
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
ø 6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
3 of 14


A
B
C
D
E
F
1
2
3
4
5
6
7
8
A-Ring Upper
17.0t
6610
6483
Cradle
20000 (Shaft Opening)
A-Ring Upper
17.0t
1920
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
ϕ 6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
SIZE
A3
SCALE
-
PROJECTION
REV.
0
SHEET
4 of 14
STATUS
ORIGIN
DRAWING NO.
DRAWING TITLE
DESCRIPTION
DRAWN
CHECKED
DATE


Cutter Motor (10nos.)
2.8t
Manlock
3.5t
758
1616
Cradle
20000 (Shaft Opening)
Manlock
3.5t
2540
Cutter Motor (10nos.)
2.8t
2520
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
ϕ 6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
5 of 14


B-Ring Upper
23.1t
6610
6358
Cradle
20000 (Shaft Opening)
B-Ring Upper
23.1t
3455
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
6 of 14


Cutter Head
58.4t
6590
Cradle
20000 (Shaft Opening)
Cutter Head
58.4t
1480
After connection of cutter
head move the body
1,104 mm. forward
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
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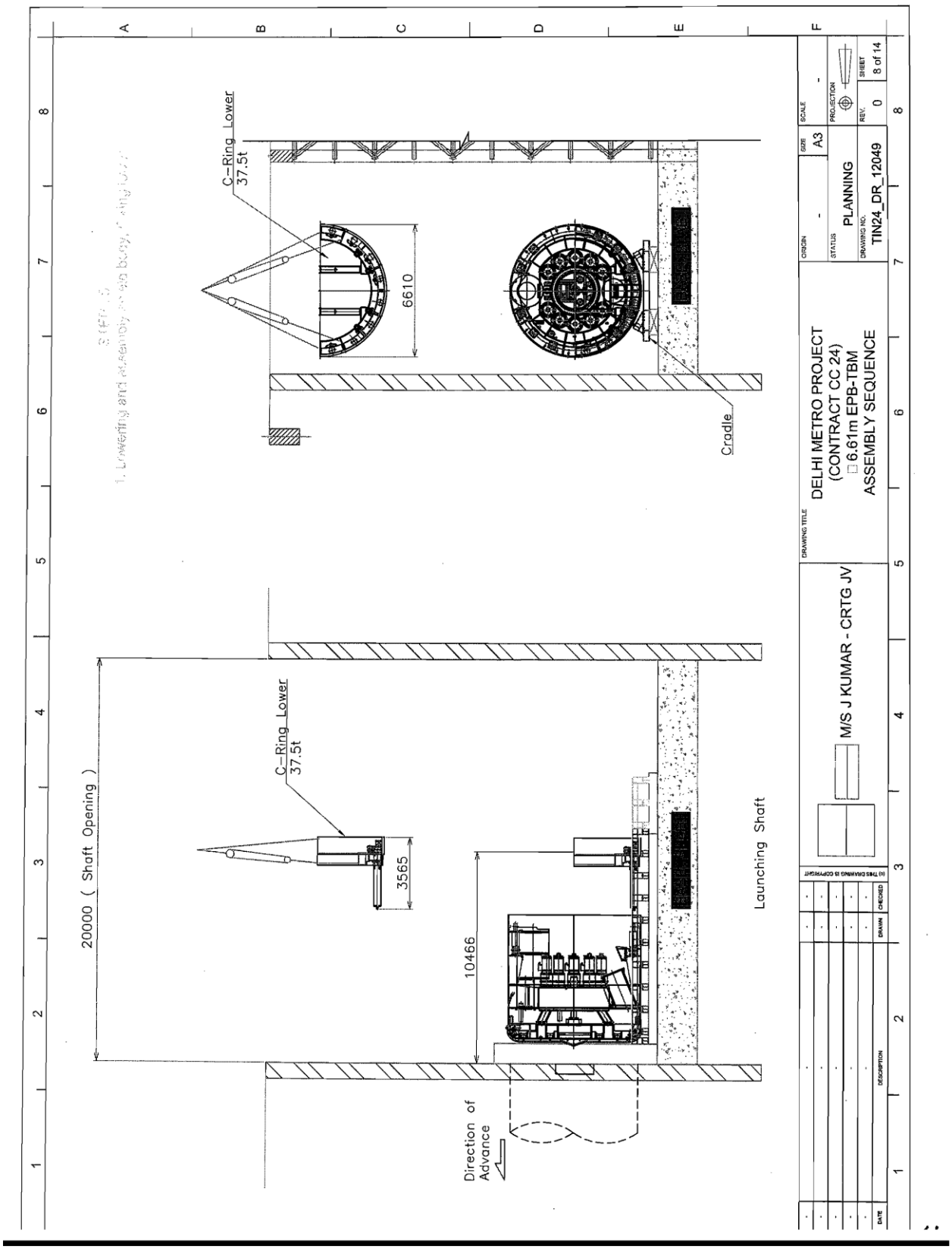
C-Ring Lower
37.5t
6610
Cradle
C-Ring Lower
37.5t
3565
20000 (Shaft Opening)
10466
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
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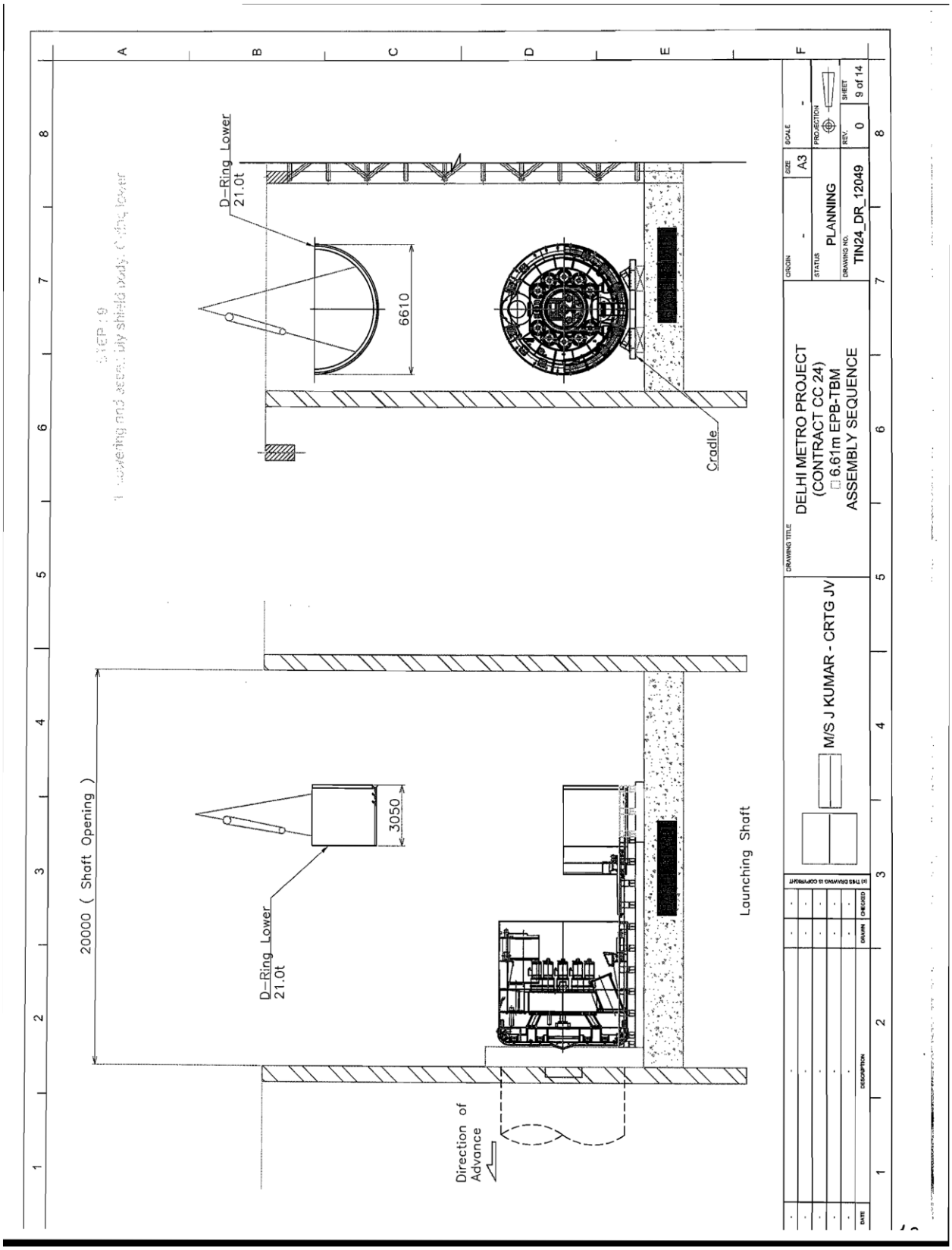
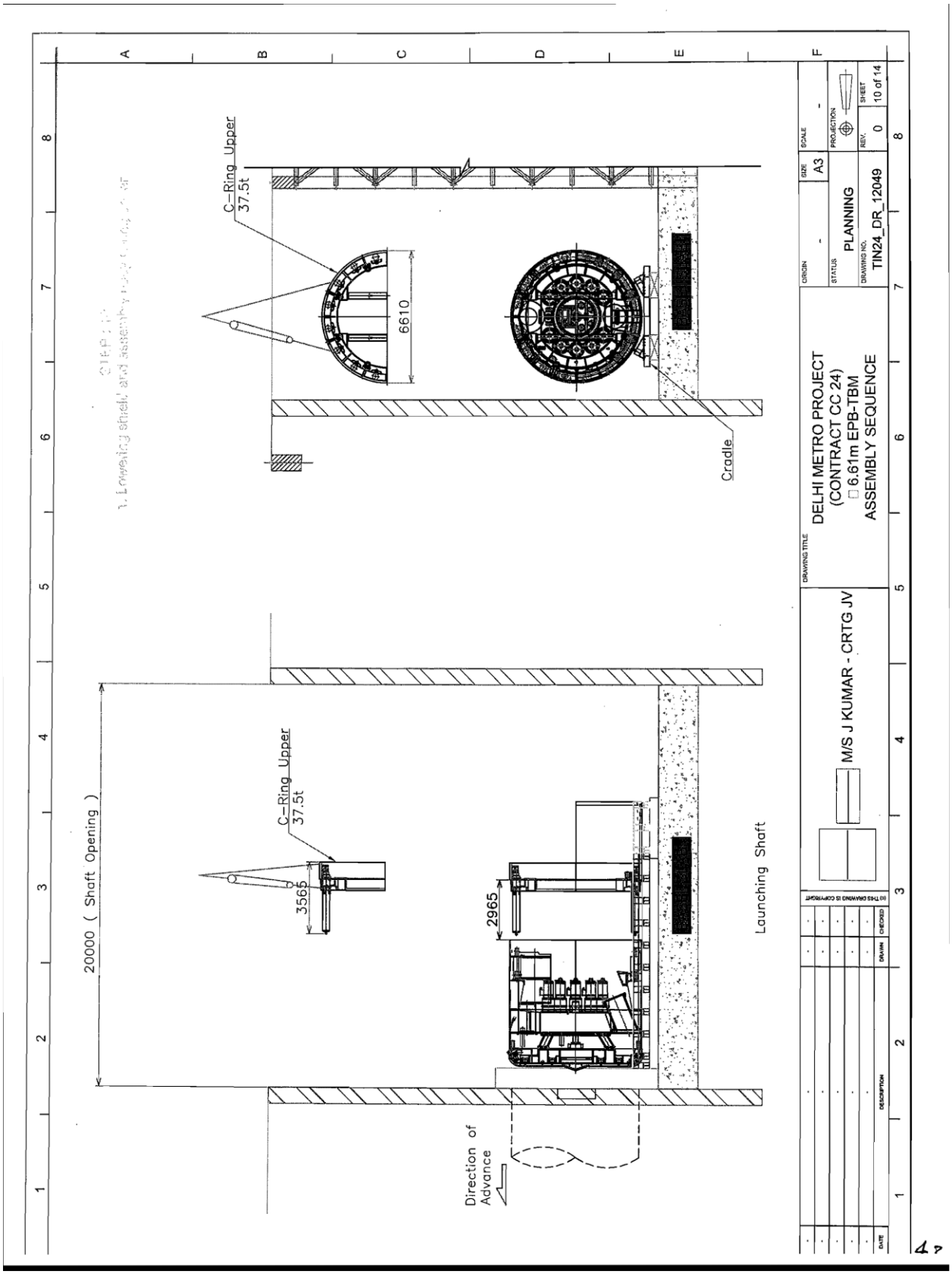

D-Ring Lower
21.0t
6610
Cradle
20000 (Shaft Opening)
3050
D-Ring Lower
21.0t
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
SHEET
9 of 14


C-Ring Upper
37.5t
6610
Cradle
20000 (Shaft Opening)
C-Ring Upper
37.5t
3565
2965
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
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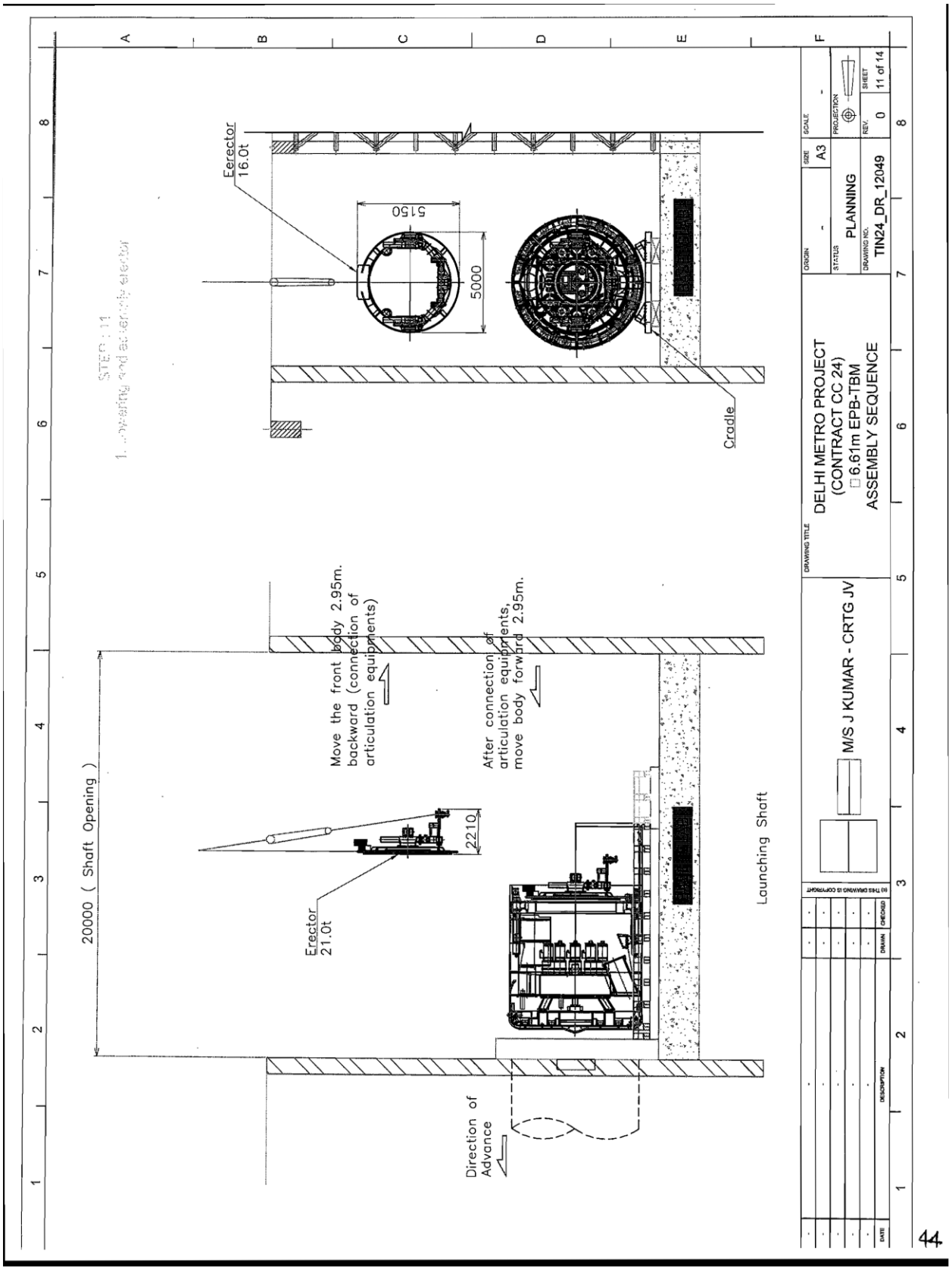
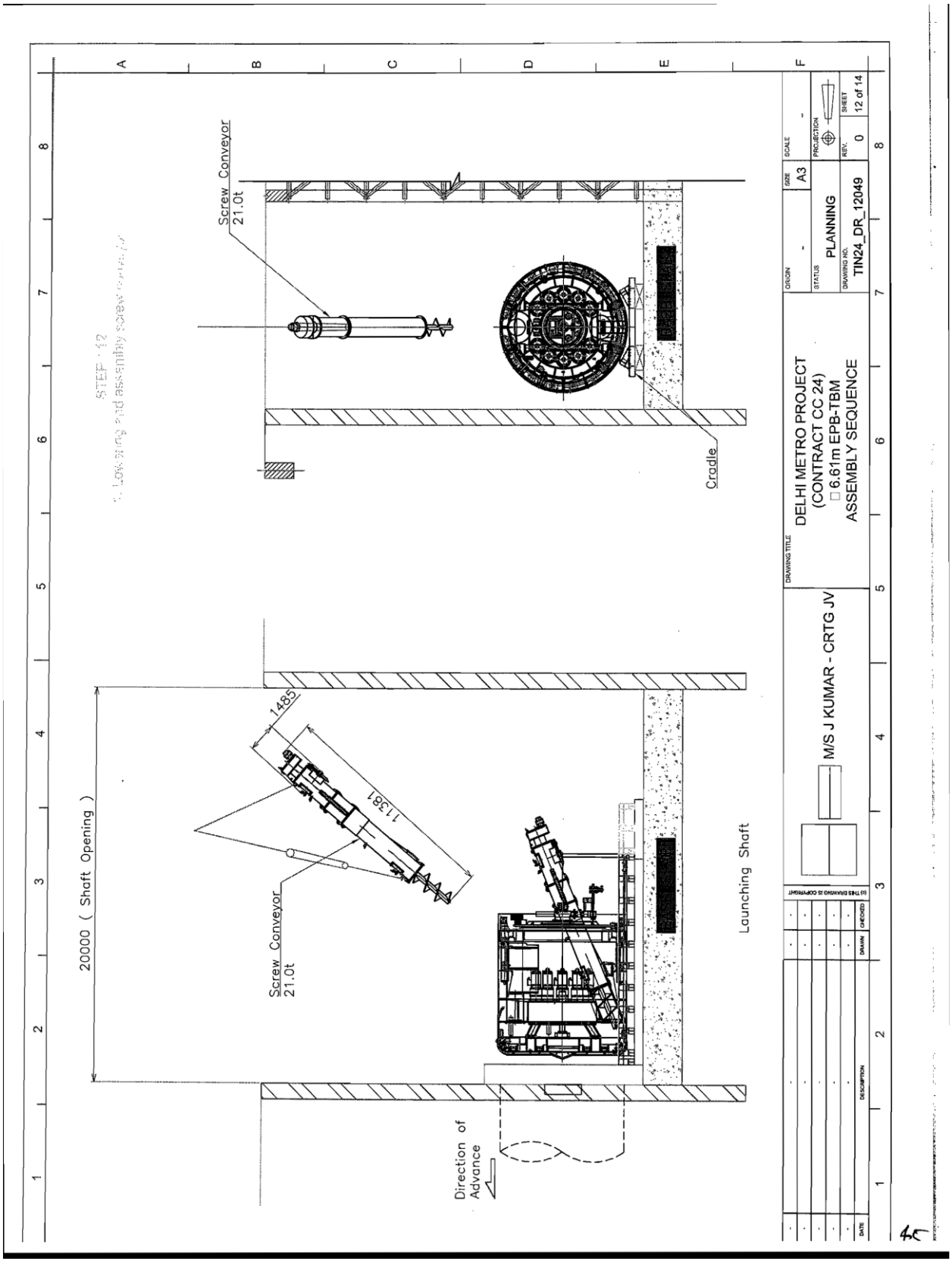
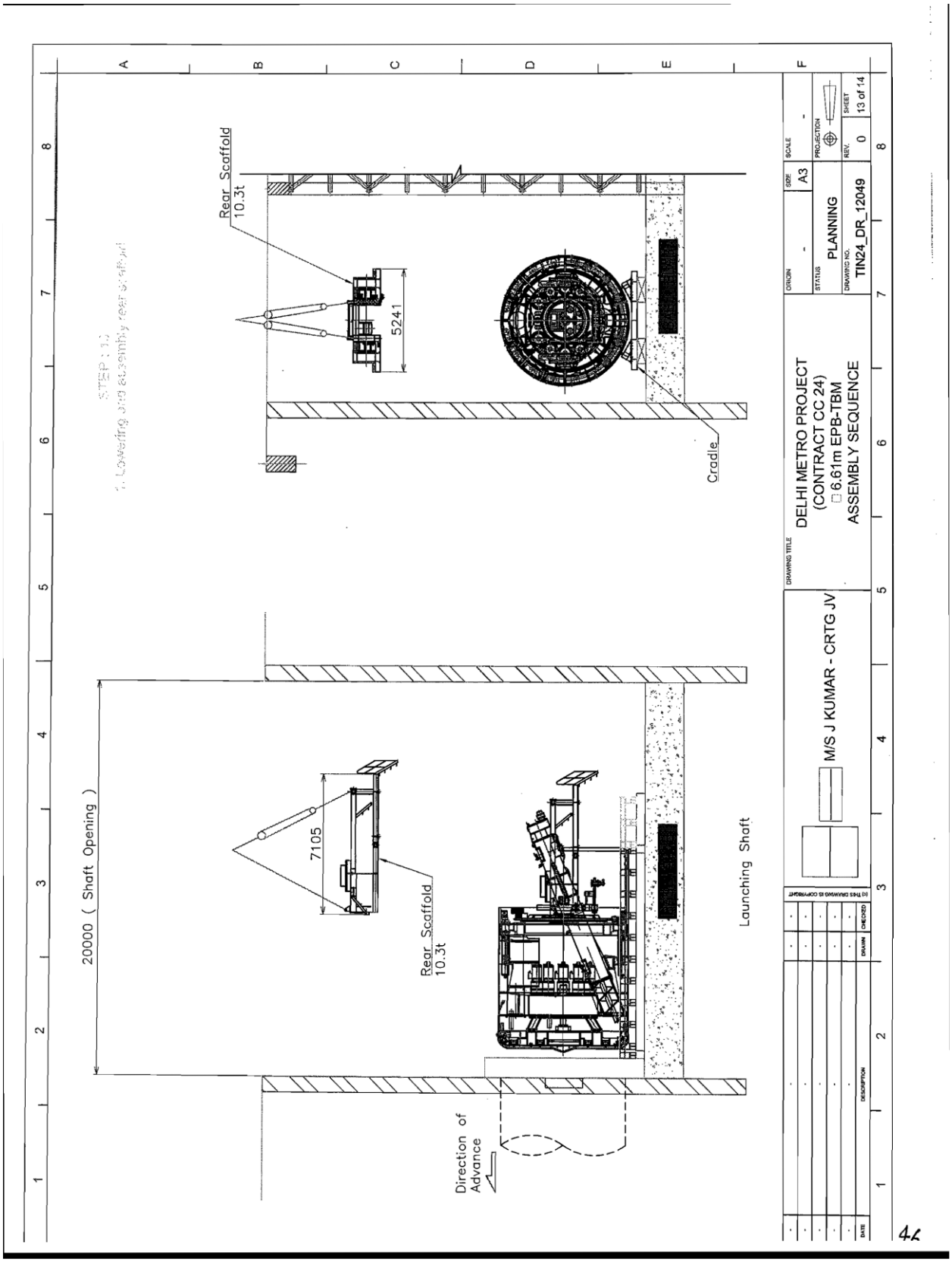

Erector
16.0t
5150
5000
Cradle
Move the front body 2.95m.
backward (connection of
articulation equipments)
After connection of
articulation equipments,
move body forward 2.95m.
20000 (Shaft Opening)
2210
Erector
21.0t
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
A3
11 of 14
44


Screw Conveyor
21.0t
Cradle
1485
1138t
Screw Conveyor
21.0t
20000 (Shaft Opening)
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
TIN24_DR_12049
SCALE -
SIZE A3
SHEET 12 of 14
REV. 0


Rear Scaffold
10.3t
5241
Cradle
20000 (Shaft Opening)
7105
Rear Scaffold
10.3t
Launching Shaft
Direction of
Advance
DELHI METRO PROJECT
(CONTRACT CC 24)
6.61m EPB-TBM
ASSEMBLY SEQUENCE
M/S J KUMAR - CRTG JV
PLANNING
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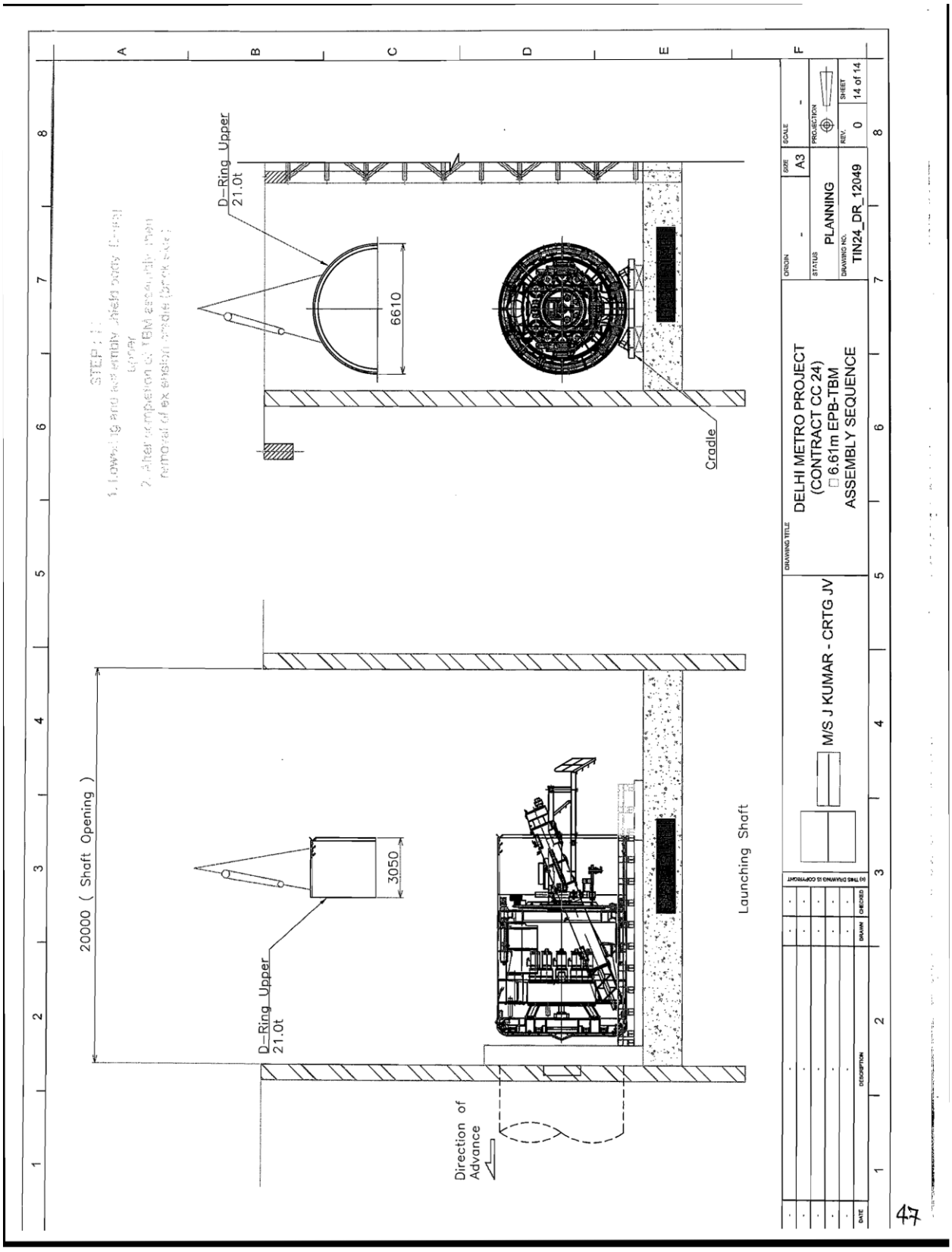
13 of 14



Recommendation to Colleague Researchers

Due to insufficient time and lot of Pressure of work at site. This thesis did not include a brief details of TBM.

study of TBM production as per the capacity and geological conditions. Therefore, I recommend to my colleagues for doing the future research in the same topic can be

summarized as follow:

1. To collect the original data from the ongoing projects (WIP)

2. Analysis of TBM modelling and know about the actual productivity.

3. Brief Cost analysis to finalize the TBM for the specific project.

CONCLUSION

- With the available data it is concluded that varieties of TBM is available with different types of soil Nature.
- The TBM machines have no limitation of work in soil conditions so correct choice of machine and experienced operator is required to success.
- During construction it is also required a brief study of Traffic areas is necessary to finalize the underground method of construction.

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