Engineering Excellence: Maha HDD (3.8 km) Crossing of the Mighty Mahanadi for Srikakulam Angul Pipeline (SAPL) (An Experience Sharing):

Overcoming Construction Challenges and Achieving Productivity & Safety Excellence through Innovative Execution Practices

Presence of SAPL across Odisha & Andra Pradesh

Srikakulam–Angul Natural Gas Pipeline

A new energy corridor connecting Odisha's industrial heartland with the national gas grid

744 km	6.65 MMSCMD	422 + 322 km	31	5	1 DT 1RT 3 Consumer terminals	165
Total pipeline length	Design capacity	Mainline + Spurline	SV Stations	IP Stations		HDD Crossings

- Route: Angul → Srikakulam, linking eastern & southern Odisha with the natural gas grid.
- Pipeline configuration: 166 km of 24-inch, 304 km of 18-inch and 274 km of 12-inch diameter pipeline.
- Gas sources: LNG from Dhamra; HVJ gas through the JHBDPL network; future connectivity to KG Basin gas through the Kakinada–Srikakulam network.
- Serves industrial, domestic, commercial and transport demand across 10 Odisha districts plus Srikakulam in Andhra Pradesh.
- Covering 10 Districts (Angul, Dhenkanal, Cuttack, Khordha, Nayagarh, Ganjam, Gajapati, Rayagada, Kalahandi & Koraput)
- No. of Crossings: ~1316

Anchor industrial demand

Vedanta, Utkal Alumina & NALCO	2.26 MMSCMD
Domestic/Commercial Transport	0.50 MMSCMD
CGD / Other markets	2.46 MMSCMD
Total	5.62 MMSCMD

Projected demand: ~5–7 MMSCMD over the long term

Natural gas vs. furnace oil: typically ~25–30% lower CO_2 per unit of energy

Building Through Challenging Terrain

The project is not only a pipeline—it is an engineering corridor through difficult geography

Hilly & Rocky Terrain

Alignment through the hill districts of Rayagada, Koraput and Kalahandi required careful route engineering, construction planning and slope/terrain management.

~1316 Crossings

Road, rail and water-body crossings demanded multiple construction methodologies, traffic / stakeholder coordination and stringent safety controls.

Forest & Remote Areas

Approximately 50 hectares of forest area and remote stretches increased access, RoU, environmental and logistics challenges.

31 SV stations • 5 IP stations • 1 DT • 1 RT • 3 consumer terminals | A high-reliability gas corridor for eastern India

Salient features of HDD

- **Name of the contractor** : M/s Trenchless Engineering Private Ltd
- **Length of the HDD** : 24” dia x 3822 mtrs with Intersection method
- **Name of the River** : Mahanadi River (900Kms long perennial river)
  : India’s sixth largest river
  : Originating from Raipur and opens into Bay of Bengal
- **Type of soil strata** : Very stiff clay sand & poorly graded sand
- **ROU area** : Forest patch on Angul side
  : Marshy land on Srikakulam side.
  : Flood prone area
  : Paddy & Vegetable fields
- **HDD Profile features** : Lowest river bed level = 28.5 MSL
  : River Scour level = 19.22 MSL
  : 24” Pipe laid level = 16.23 MSL

HDD across MAHANADI River

HDD is a trenchless method used for the installation of underground utilities, including gas pipelines and the sequence of steps are:

1) Route survey, site soil investigation, preparation of profile drawing
2) Site set up and placement of Rigs and associated equipment
3) Pilot hole drilling and Reaming
4) Pipeline string
5) Pullback of pipeline

1. Route survey & site soil investigation

- Geotechnical survey:

Soil sample collection done by creating 69 nos. of bore holes of 150mm dia using auger equipment

- Bathymetric survey:

To map the depths and shapes of underwater terrain

- Hydrological survey: To obtain Historical Local Data available for any bank erosion, scour observed at nearby bridges, change of river course etc.
- Hydrographic survey: To obtain nature of bed material, to establish accurate bed profiles, to map surface features in the river crossing and to obtain scour profiles at crossing location

HDD across MAHANADI River

TYPICAL HDD EQUIPMENT

Drill Rigs

- 2 Nos. Rigs of 500 ton capacity of M/s American Augers Ltd make

Mud Pumps

- 02 Nos 800 GPM of Continental Emsco F-800 & 1000 GPM Gardner Denver PZ-8 make
- 01 No 750 GPM of Gardner Denver make

Mud Recycling Unit

- 600 - 1000 GPM Recycling Systems

Mud Tanks

30 cum capacity of 02 Nos.

Powerpack

400 KVA & 250 KVA.

Control Cabin

HDD across MAHANADI River

2. Site setup with placement of Rigs and associated eqpt

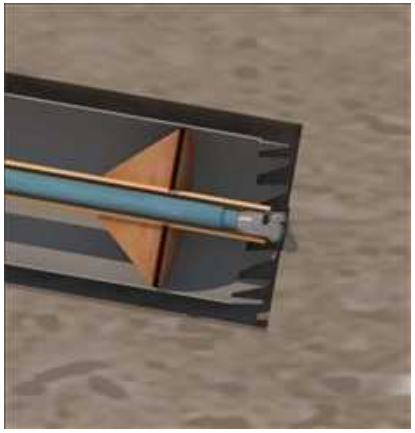
- Rig Setup with other equipment:
  - Positioning Rigs above the dead man (RCC foundation) along with power packs, drill pipe skid & supporting equipment
  - Control cabin for housing the controls & steering operations
  - Drilling fluid (bentonite) pumping & recycling setup
  - Entry pit excavation to collect drilling fluid return

HDD across MAHANADI River

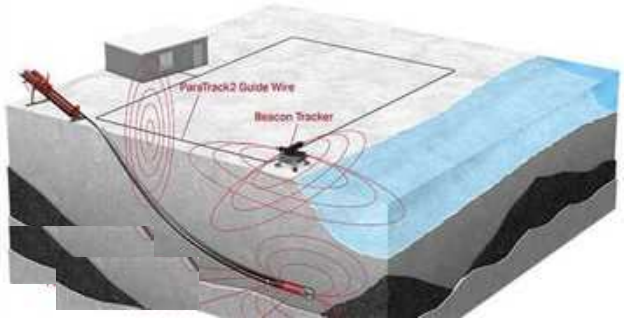
3. Pilot hole drilling and Reaming

Drilling process from both sides of river (Srikakulam side & Angul side):

- Drilling of pilot bore done by pushing and rotating the drill pipes (each one of 6-5/8" dia & 9.5 mtrs length).



- Para track 2 guidance system with surface coil tracking of vector magnetics make is used to locate the position and orientation of the drill bit



Intersection Method:

- Intersection of both the pilot drills performed accurately near to the middle of the HDD length, consuming a total of 395 Nos. drill rods covering the complete HDD bore followed by single pilot string using bulnose.

HDD across MAHANADI River

3. Pilot hole drilling and Reaming

- Drilling fluid management

➢ Drilling fluids (bentonite mixture)

- mixes with soil, silt & aids in its removal from bore
- stabilize the bore, cool the cutting tools, lubricates the drilling operation

➢ Drilling fluid travels through drill rods, exits out from drill bit/reamers & returns back to pits

➢ The collected bentonite mixture is sent to recycling unit for

- Separation of silt, sand
- mixing of fresh bentonite maintaining viscosity @ 50 centipoise (cP), for further reuse

- Enlarging of pilot bore with multiple Reamers :

1. 20" Reaming
2. 24" Reaming
3. 30" Reaming & Clean pass
4. 36" Reaming & Clean pass

4. Pipeline string

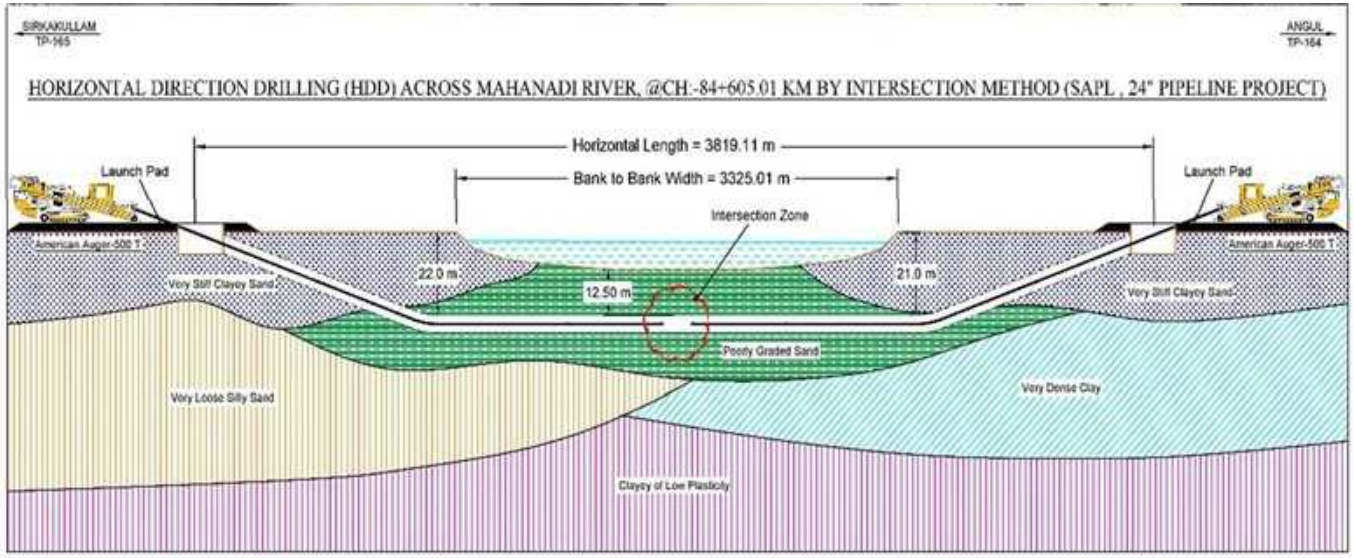
➢ String preparation of 3.8 Kms long 24" carrier pipeline done in two parts

- String 1 : 2.3Kms
- String 2: 1.5Kms

HDD across MAHANADI River

HDD works for 6″ Conduit pipe

- Pilot drilling followed by 6″ dia conduit pipe pulling of 3.8 Kms length for OFC.



HDD works for 24″ Carrier pipe

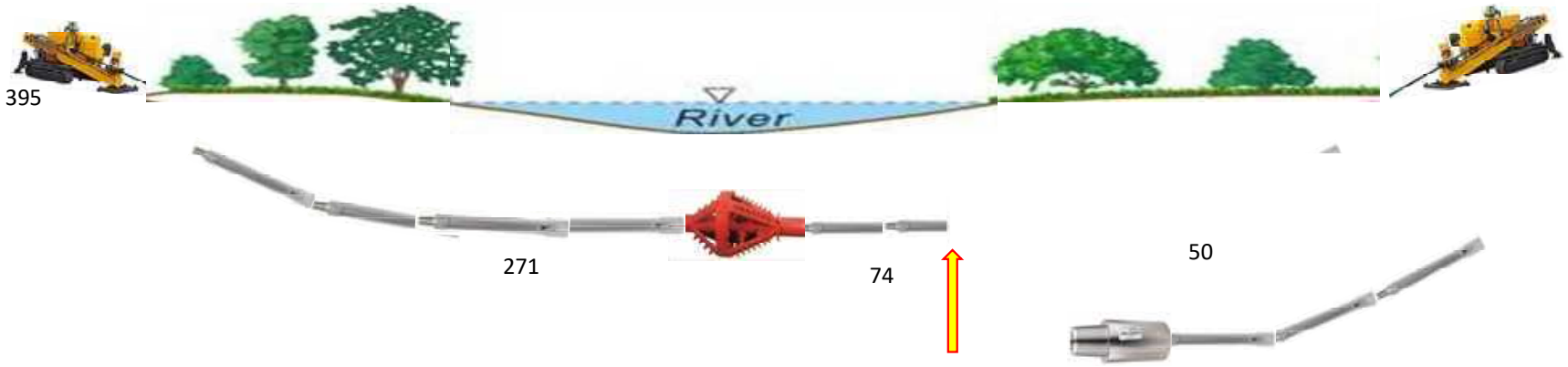
1) Pilot drilling done upto depths of 22 mtrs from NGL & at 12.5mtrs depth from lowest water bed level
2) Casing pipes of sizes 16″ during pilot drill & 40″ during reaming/clean pass, were used at entry & exit pits of HDD for guiding drill bit/reamers travel
3) Successfully performed the intersection of both pilot drill bits using the electromagnetic steering technology along with para-tracking guiding system fixed to pilot drills showcasing the accuracy
4) Weeper subs were fixed between drill rods at strategic locations to manage drilling fluid ejection
5) Consequently, multiple runs of reamers (20″, 24″, 30″ & 36″ dia) used for increasing bore size

Problem encountered – 36" Reamer stuck up during HDD

- During the final clean pass with 36" dia reamer,
  - Threading between weepersub & drill rod failed at 50th rod from Angul side
  - Resulted in disengaging of pilot rods portion on Angul side.
- Since the Rig at Srikakulam side was removed to fix Thruster, the balance pilot rods in the bore couldn't be pulled from there immediately
- By the time in fixing the Rig at Srikakulam side, the bentonite fluid inside the bore hole got hardened due to stoppage of mud recirculation process.
- This resulted in 36" Reamer stuck up

36" Reamer

Weeper sub



Efforts to retrieve stuck Reamer

Efforts from Angul side:

Pneumatic Hammering of 600 Tons capacity from Rig side was tried but the reamer didn't move from its stuck place

A separate customized fishing tool was fabricated at site and sent into the bore and engaged with the trapped weeper sub

Efforts from Srikakulam side:

10" DONUT tool pushed into the bore aligning with existing drill rods inorder to clear/ loosen the hardened mud around the reamer

In spite of all above efforts, the stuck reamer couldn't be retrieved and the process of HDD could not be completed.

Alternative solution

After brainstorming at site by M/s TESPL with GAIL & MECON team, for way forward:

- Finally decided to go for HDD with NEW BORE besides existing 6" OFC conduit within the ROU

Following are the modifications derived and implemented that aided in completion of HDD
• Forthcoming monsoon, also to deal with flood type situation • Revision of Profile drawing for new drill path • Effective mud management to avoid weeper subs. • Addition of new reaming steps i.e., 28" before 30" and 32" before 36" reaming • Making a single P/L string of 24" carrier pipe instead of two strings

Overcoming the challenges for successful completion of HDD

Pipeline string made single piece

- The two P/L strings (2.5Km & 1.3 Kms) were made as single P/L string by welding them prior to pipe pulling and achieved the Single Shot pulling thereby avoiding the chances of hardening of bentonite fluid

Reduction of torque to pull 3.8Kms single string

- Prepared trench (1.5 x 1.5 mts) with water for around 2.0 Kms length, allowing pipeline to float.
- This enabled in reduction of pipe pulling torque, thus aiding for effective managing of rotary & pipe pulling torques.

Effective mud (bentonite mixture) management

- Effectively used the high volume mud pumps maintaining flows @ 800-1000 GPM (3 to 3.8 m3/min)
- Thus avoided the use of weeper sub as the torque was maintained <60 KN-m during reaming
- Torque during final clean pass was further reduced to 45-50 KN-m

Overcoming the challenges for successful completion of HDD

Pulling of 3.8Kms pipeline single string through Meandering ROU

- Strategically placed adequate qty of rollers & backhoe machines with cradles, along the route of pipeline string ensuring smooth pulling of single string

Pipeline pulling through 42″casing at road crossing

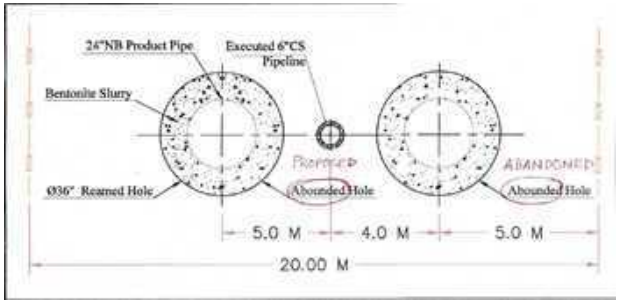
- Ensured safe pulling of single string through casing using cradles & with continuous monitoring on both sides of the casing

Overcoming the challenges for successful completion of HDD

Flood prone Area

- Meticulous planning targeting to complete reattempting of HDD before monsoon
- Ensured round the clock execution with 04 crews in shifts

Re-attempting HDD in a new bore



- Utmost care taken in reattempting HDD in a new hole beside existing 2 holes with effective utilization of paratrack system and better coordination between rig operators on both sides of the river

Enhancing productivity through safety & innovation

1) STRETCH ARRESTOR:

During pulling of 24" carrier pipe, encountered the problem of pulling back of the drill rods at Rig due to the pipeline load acting on drill rods.

- This was mitigated by instant design & engineering of stretch arrestor at site, which arrested the back pulling movement.

2. SCISSOR LIFTS:

Because of heavy load associated with pulling the complete 3.8Kms single pipeline string, it became difficult in handling the backhoe for adjusting the over bend at entry point with desired entry angle

- This was addressed by fixing the scissor lifts in the place of backhoe for smooth pipeline pulling

Milestones

- GAIL successfully completed a 3.8 km Horizontal Directional Drilling (HDD) crossing beneath the Mahanadi River
- GAIL's longest HDD crossing
- 24" pipeline by intersection method in just 66 days for its Srikakulam Angul Pipeline
- Achieved a major milestone through a continuous single-shot pipe pull completed in only 39 hours.

Lessons learnt

- Use new weeper subs only when unavoidable; handle with caution.
- Multiple P/L strings shall be eliminated for pipe
- Mud management shall be carefully monitored, and its viscosity shall be consistently maintained, as this directly impacts pulling loads and can lead to associated failures.

GAIL's Longest HDD (24"dia) across Mahanadi River

through intersection method

CONCLUSION

Finally, to conclude, the Mahanadi HDD crossing is more than just a construction achievement—

- It is a story of **Resilience**
- It is a story of **Innovation**
- It is a story of **Engineering Excellence under Extreme Conditions**

THANK you