RESEARCH ARTICLE OPEN ACCESS

A Comparative Study of Cost in Trenchless Technology over Traditional Open-Cut Method in Laying Water Supply Pipeline for Mota Varachha, Surat City

[1]Nishith A. Kakadiya, [2]Rahul S. Dhameliya, [3]Kaushal J. Badreshiya
[4]Satish H. Lakkad, [5]Prof. Hasmukh M. Shah (M. Tech, IIT Bombay)
[1,2,3,4]U.G. student, civil engineering department, ITM universe, Vadodara, Gujarat, India
[5]Visiting professor, civil engineering department, ITM universe, Vadodara, Gujarat, India
Corresponding Author: [1]Nishith A. Kakadiya

ABSTRACT:
As communities and regulators place build up demand on maintaining and make better infrastructure in cost effective and socially acceptable ways, there is an improve trend in the development and usage of trenchless technologies to provide the alternate solutions with advancement of technology for pipeline laying. At the present it brings different method that can be used in installing the underground pipeline which is able to decrease the cost of project. Today, Open excavation is most common method used to install underground pipeline involving surface disruption and brings negative effect to communities and environment. Trenchless technology offers viable alternative with innovative method with cost-effectiveness. Trenchless technologies are used to repair, upgrade, replace, or install underground infrastructure systems with least surface disruption and offer a viable alternative to existing open-cut methods. Therefore, this research aims to compare the cost effectiveness and viability of trenchless technology over traditional open-excavation method. In this paper analysis of the existing water supply system is evaluated and new method of trenchless technology for the water supply system for forecasted population of Mota Varachha area of Surat city is evaluated and Compared the total estimated cost of the project over traditional method of water pipeline installed by Trenchless technique.
Keywords: Horizontal Directional Drilling (H.D.D.), Micro-Tunnelling (M.T.), Pipe Ramming (P.R.), Trenchless Technology (T.T.), Water Supply System

---

Date of Submission: 20-11-2017 Date of acceptance: 21-12-2017

I. INTRODUCTION

1.1 Present Scenario and Demand for Trenchless Technology in Underground Utilities:

- Open-trench laying of pipeline has been for a long time, the single conventional method used to install, repair and remove underground utilities. This method involves the installation of utilities by performing excavations and removing soil to lay pipelines for utilities.
- It requires digging a trench along the alignment of the proposed pipeline and placing the pipe in the trench on an adequate bedding material and then backfilling.
- Many times, the construction try to focus on activities like diversion roads, traffic flow management, trench excavation, shoring, dewatering, backfilling and many other operations that are not adding value of the job but are actually increasing construction, social costs and environmental costs.
- Main problem in the open-cut method is it generates the noise pollution, air pollution, traffic congestion and road traffic disturbance.
- Because of the drawbacks of open-cut methods, new technologies admit of underground utilities and pipeline installation without digging trench has been investigated and developed. These technologies are mostly known as Trenchless Technology.

1.2 Trenchless Technology – An Alternate Method:

- Trenchless technology is the science of installing, repairing and renewing underground Pipes, ducts and cables using techniques which minimize or eliminate the need for excavation.
- It can minimize environmental damage, Social costs and produce another to open trench method of installation, renewal and repair it includes in, development of all kinds of underground napping techniques, tunnelling devices and specialised materials and equipment's.

- Trenchless technology is basically a making of a tunnel below the surface and installing service lines like water or gas pipes, electric or telecommunication cables etc. without any disturbance to the public and traffic.
- It also makes it possible to install the utilities under rivers, canals, roads, railways and other obstacles with no disruption of flow of water and traffic with minimize or no damage to the environment.
- Demand for installation of new underground utility systems in crowded areas with existing utility lines has improve the necessity for innovative and economic systems to go underneath and alongside in-place facilities.
- Environmental concerns, social (indirect) costs, new and strict safety regulations, difficult underground conditions (containing natural or artificial obstructions, high water table, etc.) and new evolution in equipment have increased demand for trenchless technology.

1.3 Trenchless Technology in India:

- Currently, trenchless technology has become one of the preferred construction methodologies for utility & other subsurface infrastructures. Today we are looking at an unparalleled growth of urban settlement and facing equally a problem to cater the demand for water supply. This additional demand for water supply is to be met through new pipelines or existing old lines.
- India is highly dense in terms of population. As the population continues to grow, it is estimated that almost half of India's 626 districts will require upgrades in utility infrastructures. Considering this population growth, the trenchless market in India is theoretically around 50,000 km of infrastructure across a total urban area of 77,370km^2. Around 63 cities identified in JNNURM are considered to be a priority for development.
- In an effort to decrease the environmental impact of developing and operating existing water supply networks, underground interceptors constructed using trenchless methods are being viewed as a positive solution in densely populated cities, especially those located along river banks. According to the JNNURM plan, the total value of trenchless projects being developed in the 63 priority cities is around USD 23 billion.

1.4 Aim and Objective:

- Development of technology for water supply pipeline installation today brings alternative method that can be used in installing the underground pipeline which is able to decrease the cost and time of the project.
- The primary objective of this paper is to develop a better understanding of the parameters affecting the direct costs of trenchless projects in the India for installing water pipelines. Today, there are not many detailed studies available, related to HDD project costs. It is important for bidders to have a rates of the main component cost of trenchless technology for the Indian market.
- Therefore, this research paper aims to compare the cost-effectiveness of trenchless technology over open-cut method. An analysis of the present water supply system and new method of laying pipeline for the water supply system for forecasted population by trenchless technology at Mota Varachha area, Surat city. Cost Comparison with the traditional open cut method and also estimated cost of the project is presented.

II. LIMITATIONS OF TRADITIONAL OPEN-CUT METHOD

2.1 Limitations:

- Extra excavation and backfilling is required compared to trenchless methods and may require to remove street and side pavements which increase
  the expense of restoration and risks of damage to other under around service utilities.
- The method does not provide safety to workers and road users and this method is more costly, time consuming and unsafe as compare to trenchless technique.
- Creates road closures, unnecessary detours, traffic disruptions, delays and Impact on the environment such as dust, noise and general disruption.
- Business disruptions and loss of access to nearly by dwellers. As a result, customers/consumers turn away from the shops if duration of work is relatively long.
- Costs to reinstate the integrity of pavement layer works and surfaces to their original state are high and these reinstatements are not always done properly (does not look or feel as it was).
- Open trenching is more expensive when digging around existing service utilities.
- From an environmental point of view, construction activities cause extensive damage existing to flora especially in dense urban areas.
- Roadside trees in particular area repeatedly harmed due to trenching activities.

III. ADVANTAGES OF TRENCHLESS TECHNOLOGY

3.1 Advantages:

- Less soil is disturbed so impacts on adjacent habitats and water bodies can be reduced significantly.
- Traffic delays are reduced or eliminated as is heavy truck traffic associated with culvert excavation deep below the roadway.
- Construction often takes less time regardless of the road fill depth.
- Many safety concerns associated with steep-excavation slopes, work inside trench boxes, and worker exposure to traffic may be eliminated or reduced.
- Less surveying, fewer design calculations, and fewer drawings and specifications may be required.
- Minimize ground disturbance results in fewer contingencies associated with subsurface conditions with pipe lining options.
- It reduces damages to valuable surface and it reduces the danger of improperly compacted excavations.
- It saves resources and it is accident-free.
- It avoids traffic jam and it saves underground space (pipe busting).
- It is possible to lay service lines across the railway track, narrow lanes etc. When open trenching is impossible.
- Presence of a canal, pond, river etc. across the root poses possible by trenchless technology systems.
- Without disturbing the traffic and life on the surface, the lines can be laid below ground in a much shorter time by using this technology.
- For replacement, repair, and rehabilitation of old water supply lines in cities, it is very helpful to use trench less technology without disturbing the normal life on the surface.

IV. DESIGN OF WATER SUPPLY SYSTEM IN MOTA VARACHHA AREA, SURAT CUTY FOR FORECASTED POPULATION OF YEAR-2041

4.1 Data of Water Supply system at Mota Varachha area – Surat:

- Data on water supply system in Mota Varachha area from Surat Municipal Corporation are collected.
- This data is used to design water supply system data collected are as shown in the table below:

Location	Mota Varachha, Surat city, Gujarat
Department	Hydraulic Department, SMC
Zone	New North Zone
Type of area	Residential area
Total area	19.55 km^2
Total Population of Mota Varachha area	6.54 lacs (in year of 2026) 10.47 lacs (in year of 2041)
Population of Selected area of Mota Varachha	84,000 (in year of 2041)
Total Liters of Water Supply	122 MLD
Total Cost of Water supply Scheme	167.43 Crores
Total length of Water Pipeline	250 km
Soil Type	Black cotton soil and Yellow soil

[Table 1: Data of water supply system *[1]***]**

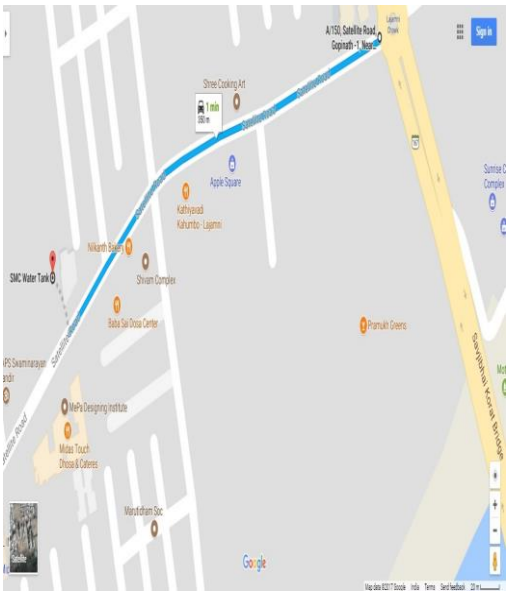
Site	**Water Table (m)**	**Soil depth below G.L. (m)**	**Moisture Content (%)**	**Soil Bearing Capacity (T/m^2)**	**Density (g/cc)**		**Type of Soil**
					Bulk	**Dry**	
Mota Varachha	12.50	00.00-01.40	21.78	5 - 20	-	-	Black plastic silty clay
		01.40-03.00	22.89		1.86	1.51	Blackish yellow high plastic clay

		03.00-06.00	23.96		1.88	1.52	Yellow plastic silty clay
		06.00-12.50	22.31		1.91	1.56	Yellow plastic silty clay with low kankar

[Table 2: Surat Site Soil Data]

4.2 Design for Water Supply System in the Mota Varachha, Surat City:

- In Mota Varachha area for analysis of laying pipeline along road using trenchless technology a small road portion area of 2.5km serving forecasted population of 84,000 persons has been selected and the design and estimated cost of the whole project using open cut and trenchless technology.



[Fig. 1: Roadmap of Mota Varachha, Surat *[2]*]

- Selected road portion is shown in above map:
  - Total area covered by Water tank is carried out = 2.5 km^2
  - Total Population of selected area of Mota Varachha considered = 84,000 (in year of 2041)
  - Per capita demand = 135 Lit/capita/day

4.2.1 Water Quantity Estimation:

- Assume, peak demand as 2 times, So Per capita demand = 270 lit/capita/day

Total Quantity Required = Per capita demand x Population
= 270 x 84000 Litres

Total Quantity Required = 22680 $\boldsymbol{m^3}$

4.2.2 Water Discharge calculation:

$$\text{Discharge Required} = \frac{Quantity\ Required}{\text{Time}} = \frac{22680\ \ m^3}{24\ x\ 3600\ Seconds}$$

Discharge Required = 0.26 m^3/sec

4.2.3 *[3]***Required Diameter of Pipe to be laid:**

- Assume, Velocity in pipeline = 1 $\frac{m}{Sec}$

Q = A x V
0.26 = A x 1.00.26
A = 0.26 m^2

A = $\frac{\pi}{4}D^2$
= $\frac{3.14}{4}D^2$
= 0.574 m

D = 574 mm

- Required diameter of pipe ≈ 600 mm.

4.2.4 *[4]***Thickness of Pipe:**

Internal Dia = 600 mm, External Dia = 620 mm, Design Pressure = 0.017 PSI, Nominal Pipe Diameter = 600 mm, Allowable stress = 20000 PSI, Quality Factor = 0.85, Material Factor = 0.4, Mechanical Allowances in Corrosion = 3.175 mm

$$t = \frac{P(d + 2c)}{2(SE - P(1 - Y))}$$

Where,

T = Thickness of Pipe
P = Design Pressure (PSI)
D = Nominal Pipe Diameter (mm)
S = Allowable Stress
E = Quality Factor
Y = Material Factor
C = Mechanical Allowances inch Corrosion Allowance

- Now Calculate

Thickness of pipe t = 0.017 x (600 + 2 x 3.175) / 2(20000 x 0.85 – 0.017(1-0.4))
t = 0.3281 in
t = 8.3 mm

- Required thickness of D.I. Pipe = 10 mm

V. Cost Comparison Water Supply System in Open-Cut Method and Trenchless Technology

5.1 *[5]* **Estimated cost of Water Supply System by Open-cut Method:**

Total Length of Laying Pipeline = 350 m Total Depth of Excavation = 1.5 m
Total Width of Excavation = 0.8 m Total Duration of Work = 1 Month

A. Total Estimated Cost of Water Supply Pipe Laying :

Item No.	Description	As per GWSSB, Surat SOR 2014-15			
		QTY	Rate (Rs.)	Unit	Amount (Rs.)
1.	Excavation for pipeline trenches (A) depth 0.00 to 1.50 mt.	420	115	m^3	48,300
2.	D.I. pipe(600mm Dia. D.I. Pipe)	350	7855	R.M.	27,49,250
3.	Conveying, lowering, laying and jointing D.I. Pipes	350	404.80	R.M.	1,41,680
4.	Making lead joint	58	1470	NOS	85,260
5.	Providing and fixing M.S manhole frame and a cover	250	60.39	KG	15,097
6.	Providing and laying C.C 1:3:6	20	2850	m^3	57,000
7.	Providing and constructing brickwork	50	2725	m^3	1,36,250
8.	Providing and applying 10 mm thick cement plaster in a single coat	30	109	m^2	3,270
9.	Providing and laying M-20 nominal mix concrete	12	5421.75	m^3	65,061
				Total Amount (Rs.)	33,01,168

Add10% Contractor's Profit = + 3, 30,116
Total amount (Rs.) = 36, 31,284

- Total estimated cost of laying water supply pipeline by the open cut method is Rs. 36,31,284 + Water charges, Extra materials, labours charges, transportation charges, etc.

B. Total Estimated Cost of Bitumen Road to be resurfaced:

Item No.	Description	As per R&B, Surat SOR 2014-15			
		Qty.	Rates (Rs.)	Unit	Amount (Rs.)
1.	Box cutting the road surface in all sorts of soil, Murrum to proper slope & camber for making a base for road work	35	64.74	m^3	2,266
2.	Conveyance charge of earth, lime, Murrum, building rubbish, manure, garbage, sludge, excavated rock, fly ash, aggregates of any kind Including spreading & leveling etc. complete	35	111.81	m^3	3,913
3.	Rolling of Earth Work in layers with power roller including filling in depressions which occurs during the process.	35	11.89	m^3	416
4.	Watering of Earth as Directed	35	5.66	m^3	198
5.	Providing, laying, spreading	35	1271.86	m^3	44,515

	and compacting graded stone aggregate				
6.	Providing and applying primer coat with cationic bitumen emulsion SS1 grade. The primer shall be sprayed uniformly at the rate of 0.70-1.0 kg/Sqm.	350	30.82	m^2	10,787
7.	Dense Graded Bituminous Macadam (Providing and laying dense bituminous macadam with 100120 TPH batch type HMP producing an average output of 75 tons per hour using crushed aggregates of specified grading, premixed with bituminous binder @ min 4.5% by weight.	78.75	2628.59	m	2,07,001
8.	2.5Cm. thick open graded premix carpet surfacing with0.36 Cmt. Stone chipping (20mm. size profit 5 Cmt. & 10 mm size Profit 2 Cmt. And 6 mm Size 0.06 Cmt.) Mixed with 19.5 Kg. of bitumen per 10 Smt. Of road surface excluding rolling and consolidation etc. complete.	35	396	m^3	13,860
9.	Providing and laying Asphalt painting on B.T. surface with bitumen grade 60/70 (VG-30) @ a rate of 5 kg/10 Sqm by Mechanical sprayer.	350	27.91	m^2	9,768
10.	Consolidation of surface dressing in one coat with power roller including cost of fuel, hire charges of roller etc.	350	14	m^2	4,900
11.	Painting lines, dashes, arrows, etc., on roads in two coats with readily mixed road marking paint.	7	89.20	m^2	624
				Total Amount (Rs.)	2,98,248

Add 10% Contractor's Profit = + 29,824
Total amount (Rs.) = 3, 28,072

- Total estimated cost of Bitumen Road to be resurfaced is Rs. 3, 28,072 + Extra materials, transportation charges, etc.
- Here, road warning signboard charges, if traffic congestion is there then vehicles fuel cost, loss of space for shops and buildings charges, etc. all charges are considered in the Open cut method.
- So, If water supply pipeline laying by Open cut method then the total cost A + B = Rs. 36,31,284 + 3,28,072 + extra cost ≅40 lacs and cost of work is Rs. 11,428 per meter.

5.2Total estimated cost of Water supply System by Trenchless Technology:
Total Length of pipeline = 350 m
Total Duration of Work = 5 Days

Item No.	Description	As per GWSSB, Surat SOR2014-15			
		QTY	Rate (Rs.)	Unit	Amount (Rs.)
1.	Drilling of the Horizontal borehole for water main pipeline under the Road tracks in all strata with required length including fixing of D.I. (as specified by Railway, Road authority) casing pipe to sailable size and Thickness. For DI pipe and Making lead joint perfectly watertight. Etc. complete.	350	2700	R.M.	9,45,000
2.	D.I. pipe(600mm Dia. D.I. Pipe)	350	7855	R.M.	27,49,250
3.	Providing and fixing M.S manhole frame and a cover	250	60.39	KG	15,097
4.	Providing and laying C.C 1:3:6	10	2850	m^3	28,500
5.	Providing and constructing brickwork	45	2725	m^3	1,22,625
6.	Providing and applying 10 mm thick cement plaster	30	109	m^2	3,270
7.	Providing and laying M-20 nominal mix concrete	12	5421.75	m^3	65,061
				Total Amount (Rs.)	39,28,803
				Add 10% Contractor's Profit =	+ 3, 92,880
				Total amount (Rs.) =	43, 21,683

- Total estimated cost of laying water supply pipeline by Trenchless Technology method is Rs. 43.3 lacs (Round off) and cost of work Rs.12, 300 per meter.

VI. CONCLUSION

- As per study it is observed that if pipeline for water supply system is installed by open cut method the total cost of laying is margining low as compared to water supply system installed by trenchless technology however in open cut method many problems are faced by road users, contractor, and Municipal Corporation. However time saving in project completion is very much beneficial to users. Also as compared to open cut method there are many benefits as water supply pipeline is easily installed by trenchless Technology and more beneficial to road users and government. Also in open cut method, there are more limitations as compared to trenchless technique and more advantages using the trenchless technique. And their cost difference is not more compared to Trenchless technology in Construction.
- And as such considering overall benefits from construction, traffic diversion and disturbances to existing underground facilities, trenchless technology for laying water supply line in the urban area of Mota Varachha, Surat is economical, safe and suggested for Trenchless Technology.
- Time duration for Open cut laying of pipeline in selected area is 1 month compared to 5 days for trenchless technology which settles the cost benefits by open cut method.
- For small scale project work of laying pipeline by trenchless technology is costly but for large area of work trenchless technology is beneficial both in project cost and time as compared to open cut method.

REFERENCES

[1]. https://www.suratmunicipal.gov.in/Departments/HydraulicWaterSupplyMasterPlan

[2]. https://www.google.co.in/maps/dir/Lajamani+fastfood/SMC+Water+Tank,+SMC+WATER+TANK,+Savji+Korat+Bridge,+Ram+Krishana+Society,+Mota+Varachha,+Surat,+Gujarat+394101/@21.2383316,72.8881915,18.75z/data=!4m13!4m12!1m5!1m1!1s0x3be04f5ae9c09ea7:0x93b9ab66020008ee!2m2!1d72.888686!2d21.2387581!1m5!1m1!1s0x3be04f5acd748879:0x728dda4fbe904090!2m2!1d72.8854144!2d21.2378024

[3]. http://nptel.ac.in/courses/105104102/Lecture%202.htm
[4]. http://petrowiki.org/Pipeline_design_consideration_and_standards
[5]. Gujarat Water Supply & Sewerage Board, Schedule of rates 2014-15 (Gandhinagar-382 010)
[6]. Road and Building Schedule of rate 2014-15 (Government of Gujarat)

International Journal of Engineering Research and Applications (IJERA) is **UGC approved** Journal with Sl. No. 4525, Journal no. 47088. Indexed in Cross Ref, Index Copernicus (ICV 80.82), NASA, Ads, Researcher Id Thomson Reuters, DOAJ.

Nishith A. Kakadiya "A Comparative Study of Cost In trenchless Technology over Traditional open-Cut Method in Laying Water Supply Pipeline for Mota Varachha, Surat City." International Journal of Engineering Research and Applications (IJERA), vol. 7, no. 12, 2017, pp. 31-38.