RESEARCH ARTICLE OPEN ACCESS

A Cost Comparison for Open-Cut and Trenchless Method in City Natural Gas Pipeline Network

Alok Kumar Giri (M.tech, HBTU, Kanpur)
(Student, Department Of Mechanical Engineering, HBTU, Kanpur, Uttar Pradesh, India

ABSTRACT : The present work aims at cost comparison of open cut method with the trenchless method that uses Horizontal Direction Drilling. The use of trenchless method is significantly increasing over open cut method. The execution cost of laying network is sum of cost of laying pipeline and cost of restoration of surface. Due to reducing cost of laying network by trenchless method, the reduction in cost of laying has gone down by 50 percent in last six years 2011 -2017 by trenchless method.There are five type of surfaces viz Normal Soil, Brick on edged soling, Cement concrete road, Interlocking tile road and Bituminous road are found in city gas pipeline network . The restoration charge for all the surfaces remained unchanged for last six years i.e, 2011 to 2017. This work includes cost comparison of pipeline laying network for all five type of surfaces in both open cut and trenchless method.A small part of existing gas pipeline network of Kanpur city has been considered for cost comparison purposes. Results obtain suggest that trenchless method is less costly for all type of surfaces over the open cut method.

Keywords – Horizontal Directional Drilling (HDD), City Gas Distribution (CGD), Gas Authority of India Limited (GAIL), Medium-Density Poly Ethylene (MDPE)

Date Of Submission: 02-04-2019 Date Of Acceptance: 18-04-2019

I. INTRODUCTION

Technology is common thing that being used by mankind. The word technology covers machines, processes, methods, materials, tools, and devices applied to industrial and commercial objectives. Technology also encompasses the organization of knowledge for the achievement of practical purposes. The contemporary world is influenced by technology. The major technological changes can set population shifts in motion, determine development pattern, and create or solve pollution problems. Technology has been developed and being used in industries widely such as automotive, manufacturing, renewable energy, construction even in transportation systems.

Organizations must develop capabilities to utilize the existing knowledge and technologies for short-term profits. The new knowledge and technologies help to explore long term innovations. The proper selection of new technologies is made on the basis of these efficiency whether on efficiency, environmental friendliness, cost-effectiveness of method. An example in construction project, using prefabricated technology can shortened construction time, lower overall construction cost and improve quality and durability in compression with conventional on-site construction method. However, the successful of applying the technology not only rely on the method but also the management team. Hence, project managers in today as construction industry must adapt the changes in industry environment to maintain competencies in practicing project manager by relying on skill, knowledge and experiences.

.

1.1. CROSS COUNTRY GAS NETWORK

Cross-country pipelines have separate ROW for laying of gas pipeline which runs straight for kilometers in open fields between different cities, state or country. With the exploration of gas in south basin of Mumbai, the first cross-country pipeline in India was commenced with Hazira in Gujarat. Gas Authority of India (GAIL) was created in 1984, to serve ONGC for its purpose of natural gas in India.

1.2 City Gas Distribution Network

City gas distribution network are more complex in laying. These pipeline are laid in densely populated areas and have large number of branches in the network to fulfill the need of peoples in different localities within a city. CGD network are much smaller in length and size than cross-country pipelines. GAIL started a pilot project of CGD (City Gas Distribution) Project and It was undertaken with the help of ONGC at Vadodara city in 1972.

1.3 MDPE Pipe

The use of PE's use in the form of piping material was first seen in the middle of 1950's. In the state of North America.

Medium-Density PE (MDPE) pipe was the first use for Natural gas distribution project.

1.4 Classification of MDPE Pipe

MDPE pipes conforming using PE 80 and PE 100 grades.
Sizes - 20mm to 315mm (OD)
Standard Dimension Ratio - SDR 7 to SDR 17.6
Application - City Gas Distribution, Domestic & Industrial CNG Distribution

1.5 SCOPE OF PRESENT WORK

The objectives for this research will resolve the stated problem. They are;
i. To identify the criteria to be considered in trenchless technology.
ii. To find out the better result of cost comparison between trenchless technology and open-cut method

1.6 Open Trenching Method

The traditional open trenching method has been utilized for pipeline replacement since the early 1900s. This method is suitable for all pipe materials and is most familiar to almost all contractors undertaking some sort of excavation project. Traditional open trenching is a disruptive method. Traditional open trenching is defined as the operation of excavating to the required pipe installation level and then backfilling.

1.7 Trenchless Method

A system for the laying of pipes, and cables using a surface launched drilling rig. HDD is applied conventionally to crossings of rivers and other similar works. Without rotating the drill string, fluid filled pilot bore is drilled and the drill dia increased by back reamer with respect to size required for the gas pipe.

1.8 Horizontal Directional Drilling (Hdd) [3]

In the decade of 1970s the Horizontal Directional Drilling (HDD) technology was developed in the petroleum industry and it came out along with the additional technology which was created in the utility sector industry and in the gas well installation. The slow processes used in the decade 1960s for the need of underground installation of cables and conduits in cities are mainly the predecessors of the present HDD technology.

1.9 The Advantages of Using HDD Method

- Drilling launches from the surface, small entry and exit pits thus no vertical shafts are required.
- Steering ability to avoid existing utilities or other obstacles either horizontally, vertically and even pulled back
- Little auxiliary equipment and short set up time is relatively required.
- With the use of HDD method it leads to the easy crossing of rivers, highways, rail tracks or airfield runaways.
- It reduces expensive restoration work and create a positivity on public.
- HDD is more eco friendly and causes less damage to the environment.
- There is no requirement of de-watering when the work is carried below the ground water table with reducing time and cost
- Where other methods cannot be used easily HDD method is useful in crowded utility area.
- Causes least traffic disruption and social cost among the people.
- It has the ability to accommodate large diameters.
- Pipes of different materials like HDPE, PVC, steel and ductile iron can also be installed.
- It is used for different type of soils loose sand or solid rock .
- This method follows environmental guidelines mostly in wet lands.
- In a single shot installation line can be laid for long distances.

1.10 Hindrance of HDD Works

- There is the chance of damages in other utilities from poor practices by other contractors.
- Lack of established good practices.
- Insufficient experienced drillers
- Availability of training for HDD operators.
- Before starting the HDD survey of land is very important.
- To establish through soil conditions
- When using toxic materials like bentonite there should be a arrangement of recycling.

II. SOLUTION METHODOLOGY

Thus total demand d_{total} comes out for 25 years from assessment of previous years gas consumption in kanpur and particular area.

From present gas consumption predicting the demand after *n* years,

using the formula given below

$$demand_{total} = Present\ consumption\ of\ gas\ (1+R)^n$$

where
R = Approximate growth rate of gas consumption

2.1 Gas Flow Estimation:
Let the Q be Flow of Gas in cubic meter per second, it is given by

$$Q = \frac{demand_{total}}{t} \quad m^3/sec$$

2.2 Requirement of Pipe Dimension in Gas Network [2]:
The execution cost of laying network requires cost of laying gas pipeline and cost of restoration.
The above equation 3.5 may be used to calculate area of pipe.

$$Q = A \times V$$

Where

Q = Flow of Gas in pipeline, m^3/sec
V = Velocity of Gas in pipeline, m/sec
A = Area of gas pipeline, m^2

Or,

$$A = \frac{Q}{V}$$

Keeping area in terms in pipe diameter D

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

The required diameter of Gas Pipeline is given by

$$D = \sqrt{\frac{A}{\frac{\pi}{4}}}$$

2.3 Thickness of Pipe:
In general SDR-11 is used in gas pipeline laying network. SDR is signifies the pipe thickness calculated by as

$$\text{Thickness of pipe (T)} = \frac{\text{Diameter of pipe}}{SDR}$$

Where,
T = Thickness of pipe, mm
D = Diameter of pipe, mm

2.4 Cost estimation for open cut method and trenchless method:
The rates used in laying of pipeline are taken from Schedule of Rates provided by Gas distribution company of Kanpur [1] and rates used for restoration of surfaces after laying of pipeline are taken from Schedule of Rates of Kanpur Nagar Nigam [2].
Five different type of surfaces are found during execution work of gas pipeline for both open cut and trenchless method. These are :

i. Normal Soil,
ii. Brick on edged Soling,
iii. Cement Concrete Road,
iv. Interlocking tile Road and
v. Bituminous Road

III. NUMERICAL RESULTS

According to collected data of five year Domestic and commercial connection are available in this area with approval of the gas company management. Domestic connection in this area is approximate 4000 Nos.
Average model and Moving Average model are not work in forecasting model. Our gas demand fore casting model work on average model. We are predicting for 25 years gas demand with growth rate of 16% per years.
Manufacturers tell the life of MDPE pipe is approximate 100 years. It is varying based on pipe service conditions, So we assume that network of gas pipeline will be safe for 50 years. 25 years recommended for the gas pipeline network. After that should be review the condition of pipeline in 5 years interval for another 25 years.

Table 3.1 Growth Rate of Domestic Connections in Kanpur and Different Areas

	Kanpur		Makdikheda		Moti jheel		Model Town	
Year	Cumulative No.	Growth (in %)	Cumulative No.	Growth (in %)	Cumulative No.	Growth (in %)	Cumulative No.	Growth (in %)
2014	7597		1575		2941	39	2214	29
2015	11163	47	2210	40	4082	37	2705	24
2016	14229	27	2680	21	4821	34	3078	22
2017	18607	31	3457	29	5186	28	4565	25
2018	21420	15	4000	16	5471	26	6310	29

Estimate the gas consumption for 25 years for the gas network of domestic connections with 16 % growth in makadikheda area.
Using Equation as below

$$d_{total} = Present\ domestic\ connection\ (1+R)^n$$
$$= 4000 \times (1+.16)^{25}$$
$$= 163497\ SCM$$

Considering the consumption of gas is 0.50 SCM per domestic connection per day the total expected gas demand after 25 years may be calculated.

3.1 Gas Quantity Estimation:
Let take domestic connection after 25 years will be approximate 160000 Nos.
Gas Consumption = 0.50 SCM X 160000 Nos.
= 80000 SCM

3.2 Estimation of Gas Flow:
Gas Flow required (Q) = Quantity required / Time

= 80000 SCM / (24 x 3600 seconds)

Or,

= 0.920 m³/sec

3.3 Requirement of Pipe Dimension in Gas Network:
Let value of velocity (V) in entry points of gas network be 20 m/sec as per PNG regulatory board standards.[3].
V = Velocity of Gas in pipeline (20 m/sec)
Q = Flow of Gas in pipeline
A = Area of Gas pipeline
Using equation
Q = A x V

0.920 = A x 20

A (Area of Gas Pipe) = 0.046 m²
Thus,

$A = \frac{\pi}{4}D^2 = (3.14/4)\ D^2 = .785\ D^2$

D = .058 m

D = 58 mm

Network is made for higher side of available standard pipe size ≈ 63 mm.

3.4 Thickness of Pipe:
It is standard that thickness of MDPE Gas pipeline is as per SDR-11. SDR is the 'Standard Dimension Ratio', which is the ration of diameter of pipeline and thickness of the MDPE pipe and it should be 11.

Pipe Diameter taken = 63 mm,

SDR for MDPE Gas pipe =11

$SDR = \frac{\text{Pipe Dia}}{\text{Thickness}}$
Where,

T = Thickness of Pipe

D = Pipe Diameter (mm)

Now Calculate
Thickness of pipe $T = \frac{\text{Pipe Dia}}{SDR}$

= 63/11

Or,

= 5.7 mm

Required thickness of Gas Pipe = 5.7 mm.

Considering the unit length of working gas pipeline is 100 Mtrs as shown in Fig 5.3 and this pipeline laid at the depth of 1 meter and 0.3 Mtrs width required for open cut method. Open trench method takes more time as comparison to trench less method.

Total Length of Trench (l)	100 M
Total Depth of Trench (d)	1 M
Total Width of Trench (w)	0.3 M

FIGURE 3.1 Working Pipe Length for Makdikheda Area [4]

The cost comparison tables 3.2(a) and (b) show total estimated cost of open cut method and trenchless method for normal soil and similarly for Brick on edged Soling, Cement concrete, Interlocking tile, Bituminous surfaces. The first column shows the serial no. of activity, second column shows description of activities and Third column is for unit of measurement (uom). Forth column describes quantity of activity, Fifth column shows rates of particular activity per working unit

and sixth column is for total expenditure for activity mentioned in second column.

The restoration rates used in this comparison are collected from Kanpur Nagar Nigam. Open Cut and Trenchless method used in pipeline laying for Gas networks rates are taken from city gas distribution company of Kanpur for November, 2017.

Area for restoration of trench by open cut method $(A_{ro}) = l \times w \times d$

= 100 x 0.3x1

= 30 sqm

Considering 2 Nos. of pit 1.5 Mtr. x 1 Mtr. Size excavated for laying of 100 m length gas pipeline by trenchless method.

Area for restoration of trench pit by trenchless method $(A_{rt}) = 2\ (l \times w \times d)$

= 2(1.5 x 1x 1)

= 3 sqm

For all tables made for five surfaces mentioned length of working pipeline in 4rth column, which are same for both method but restoration area are different due to very less area excavation required in trenchless method. The rate of pipeline laying in trenchless method is higher than open cut method. But total estimated cost of trenchless method is less as comparison to open cut method.

Cost comparison of both methods for normal soil are shown in Table 3.2 (a) and 3.2 (b) as total estimated cost of open cut method and trenchless method respectively. With this comparison approximate cost of laying method for trenchless is 15 % less per working length over open cut method.

Table 3.2 (a) Total Estimated Cost of Open Cut Method for Normal Soil

Sl No.	Description	Uom	Qty	Rate per unit (in Rs.)	Amount (in Rs.)
1	MDPE Pipe line laying in all type of surface by open trench method 63 mm PE pipe (Including Excavation, Jointing, Laying , compaction, Backfilling & as built drawing)	Mtrs.	100	282.41	28241
2	Restoration of Normal Soil	SQM	30	353	10590
	Total Estimated Cost of Open Cut Method				38831

Table 3.2 (b) Total Estimated Cost of Trenchless Method for Normal Soil

Sl No.	Description	Uom	Qty	Rate per unit (in Rs.)	Amount (in Rs.)
1	MDPE Pipe line laying by Trenchless Method , without casing. 63 mm PE pipe (Including Excavation, Jointing, Laying , compaction, Backfilling & as built drawing)	Mtrs.	100	318.85	31885
2	Restoration of Normal Soil	SQM	3	353	1059
	Total Estimated Cost of Trenchless Method				32944.0

Difference of Amount For Normal Soil (in Rs.)	5887.0
Cost save by use of trenchless method w.r.t. Open Cut Method per working length	15.2%

Numerical results for cost comparison of both methods, open cut and trench less methods along with five type of surfaces found that in year 2017.

Table 3.3 Predicted cost saving for trenchless method over open cut method for different Surfaces

Sr. No.	Type of Surface	Cost in open cut	Cost in trenchless	Cost save by use of trenchless method	Cost saved by use of trenchless method (In %)
1	Normal Soil	38831	32944	5887.00	15.16
2	Brick on edged Soling	57581	34819	22762.00	39.53
3	Cement Concrete Road	92681	38329	54352.00	58.64
4	Interlocking tile Road	107681	39829	67852.00	63.01
5	Bituminous Road	165761	45637	120124.00	72.47

As shown in Table 3.4, Maximum cost saving in year 2017 is for interlocking tile road and minimum cost is reduced for normal soil surface and due to development of cities the road surfaces is changing, It is different from pipeline laying year 2011. In year 2011, Maximum cost is saved in brick on edged soling surfaces and minimum cost reduced in cement concrete road surface.

Table 3.4 Weighted Average cost saving by use of trenchless method in year 2011 and 2017.

Sr. No.	Type of Surface	Cost save by use of trenchless method (In %)	Approx. percentage of used surface in year		Weighted Average cost saving by use of trench less in different surfaces	
			2011	2017	2011	2017
1	Normal Soil	15.16	20.00	10.00	8.62	6.03
2	Brick on edged Soling	39.53	50.00	20.00	22.08	13.28
3	Cement Concrete Road	58.64	2.00	10.00	1.93	8.54
4	Interlocking tile Road	63.01	20.00	50.00	15.18	27.88
5	Bituminious Road	72.47	8.00	10.00	7.20	8.79

IV. CONCLUSION

The case study taken in the present work done relates to small part of gas pipeline. It is expected to network of Kanpur. The laying network in year 2011 and for next 20 years. Meet demand the gas pipeline execution uses two type of methods, first is open cut and second is trenchless with HDD technology. Cost of trenchless is reducing significantly from year 2011 to 2017. This cost of expected technology reducing in future. In gas pipeline network execution five type of surfaces viz. Normal Surface, Brick on edge soling, Cement concrete road, Interlocking tiles road, Bituminous road are found, restoration charges increases from year 2011 to 2017.Thus reduces significantly in year 2011, if trenchless method is used in place of open cut method. The cost saving in five surfaces comes out to be 15% to 73 % less.

The cost of pipeline in trenchless technology is reduce i.e. 50 percent in last six years. It may be reduce further and therefore trenchless method will have as over open cut method, So it should be use as much as possible because of less cost and less time. The open cut method is labour intensive and therefore it should be minimize. The restoration charges remain unchanged up to 2017 for all type of surfaces.

4.1 Scope For Future Work

The present work has been done for gas pipeline network. Similar work may be performed to explore savings in laying electricity distribution network. Underground telecommunication networks are very common now days may be savings in cost determined laying these networks using trenchless method.

REFERENCES

[1]. Data collected from Kanpur Nagar Nigam.

[2]. Data collected from City Gas Distribution Company, Kanpur.
[3]. http://www.pngrb.gov.in/OurRegulation/pdf/Gazette-Regulation /English / GSR476 (E).pdf
[4]. https://www.google.co.in/maps/@26.5068964,80.2757519,16z

Alok Kumar Giri " A Cost Comparison for Open-Cut and Trenchless Method in City Natural Gas Pipeline Network" International Journal of Engineering Research and Applications (IJERA), Vol. 09, No.04, 2019, pp. 01-07