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Feasibility Analysis of Application of Diaphragm Wall Method against Piling Method in Construction of Permanent Structure– Case Study of Budwar Peth underground Metro Station

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ABSTRACT: As India is currently second largest populated country in the world, it is the need of decade to provide better transport facility to the citizens of the country. Metro Transportation is one of the most popular transport in the urban cities these days. However the Metro projects are more complex especially when underground construction is involved and it is critical to complete the project at definite time interval which helps the people of city to use the transport and avoid the mobility time loss problems. Therefore this paper deals with feasibility comparison of Diaphragm Wall method against piling method for permanent structure in Underground construction of Budhwar peth Metro Station

KEYWORDS: Metro Transportation, underground construction, feasibility comparison, Diaphragm Wall method, piling method, Budhwar peth Metro Station.

I. INTRODUCTION

Metro is one of the rapid urban mass transit system operational in more than 200 cities all over the globe it is also in conformity with the principle of sustainable development. At global level Shanghai city in China has the largest network of metro rail serving around 10.63 million people per day. This network is spread 803 km under 19 lines and more than 500 stations operational. While in India Delhi Metro Network is one of the largest network in India & 4th largest across the globe. Delhi metro has a network of 390.14 km spread across 255 Stations. India being the second largest populated country in the world, it is very important to have proper flow of traffic throughout the country especially in the urban cities. India has 15 cities with at least 1 metro line operational for public transport whereas 7 metro projects in 7 cities is under construction & 3 are under proposal stage.

Pune metro has 3 metro lines in total of which one metro line i.e. line 2 between Vanaz to Ramwadi (Aqua line – 15.7 Km) is operational from 06th March 2022 consists of 16 Elevated stations. Pune metro also consists of underground patch between Shivaji Nagar to Swargate under purple line consists of 5 stations for 5.019Km (Shivaji Nagar, Civil Court, Budwar Peth, Mandai & Swargate) whereas 9 stations are in Elevated form. Metro Rails are set up in two ways i) Elevated & ii) Underground, both methods has its own advantages and one of them is selected based on congested areas where surrounding infrastructure does not provides sufficient place for setting up metro rail underground metro construction is been considered in these areas especially in older parts of urban cities.

Metro Constructions serves as one of leading transport service in urban cities in India. As per the past census of 2011 nearly 32% while in 2021 it was reported with 3.39% increase leading to 35.39% as per the World Bank collection of



development indicators. As per various studies it is predicted that this population will rise up to 50% population contributing to 850 million people in urban areas. Therefore it is very important to get better connectivity in this areas which contributes to major percentage of our National GDP. To serve this rising need it is very important to complete the big infrastructure projects with greater quality and economical methods. Also the major problems of urban cities is traffic Jams which leads to reduce in optimum utilization of fuels and human productivity hours. Therefore this paper deals with feasibility analysis of Diaphragm wall method against piling method required for live case of Kasbapeth Underground Metro Station.

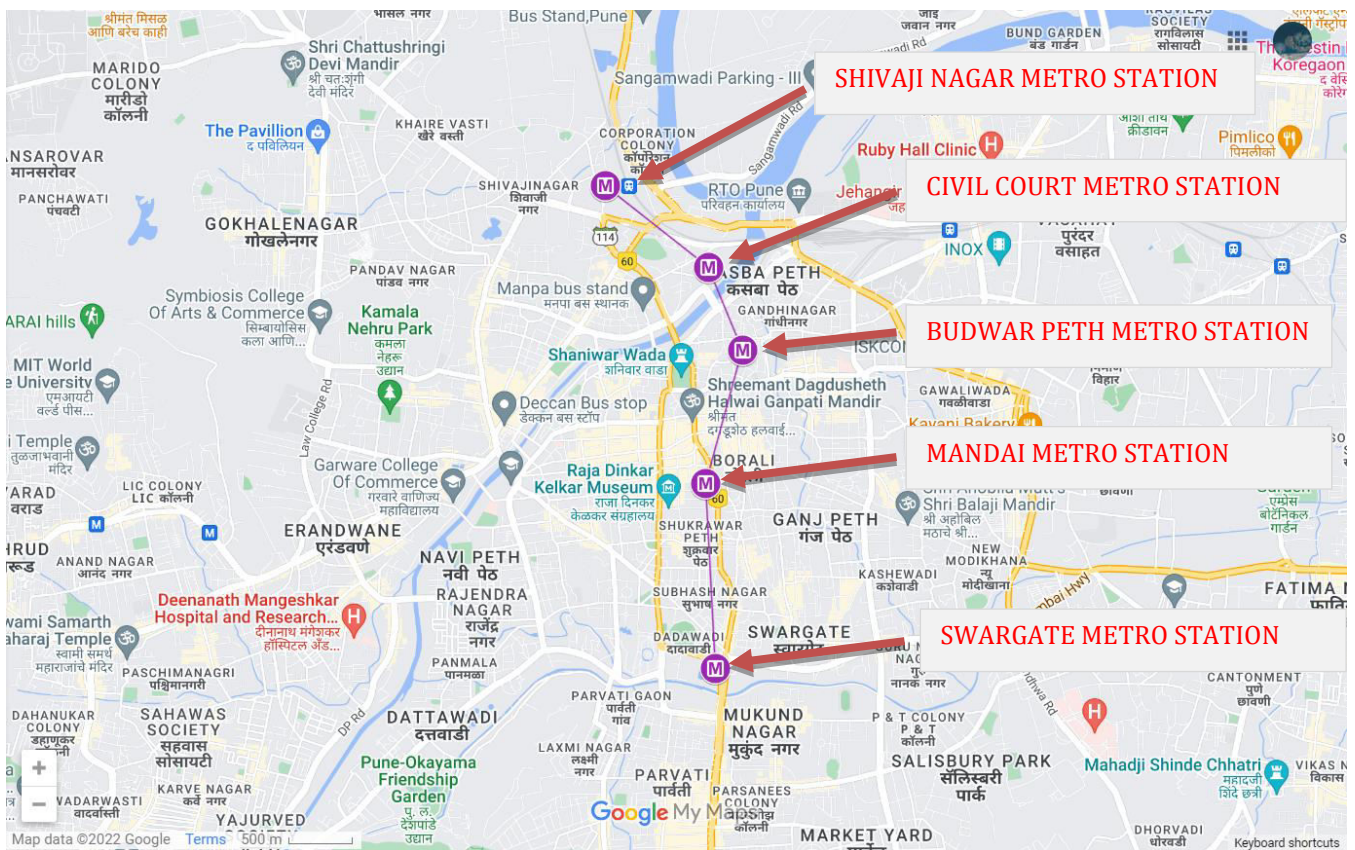


Figure 1 - MAP OF UNDERGROUND METRO STATIONS IN PUNE

II. LITERATURE REVIEW

- **Virendra Kumar Paul¹, Salman Khursheed², Rohit Singh³** published a paper titled “Comparative Study of Construction Technologies for Underground Metro Stations in India in IJRET Vol 6 Issue 03.

MRTS (Mass Rapid Transit System) in India is an arising idea and need of great importance. The development innovation is new to the nation and there are numerous regions with respect to development and arranging which should be comprehend. It is inescapable truth that continuously MRTS will be the foundation of each and every metropolitan city of the world with perspective on its development. Subsequently, from the framework previously built under this plan of development we want to learn and devise the standard elements and information sources that can be utilized for future preparation and productive development. Metro Rail being the foundation of Delhi transportation arrangement of Delhi's framework, it has numerous basic element due to: a) Area of the MRTS course arrangement b) Particular site, plan and development limitation c) Strain on the public authority to commission the vehicle course lines to smoothen the vehicle necessity and so forth c) To begin utilization of the office to produce income and pay back credits taken from worldwide banks and so on. Hence, through this paper an endeavour has been made to comprehend



the fundamental ideas with respect to the development system and innovation principally utilized in for "Underground Metro Development" as per geology and site imperatives. Different mechanical headways have occurred and slowly new imaginative and proficient varieties have been presented in the development rationale for underground metro stations. Subsequent to laying out a conventional comprehension of the station idiosyncrasies and development systems, data in regards to two development philosophy of underground development for example Cut and Cover (Base Up and Top Down) and Box Pushing Procedure will be dissected.

- **Shravika Birwadkar¹, Gayatri Korse², Swaranjali Teli³, Tanuja Taur⁴, Dr. Shruti Wadalkar⁵ published a paper titled "PARAMETRIC STUDY OF DIAPHRAGM WALL" in IRJMETS Vol 04 Issue 07 22.**

Infrastructure assumes an imperative part in a metropolis. Because of Hazardous development of cities in agricultural nations and, expansion popular for further developed reasonableness and environmental security has encouraged areas of strength for a new underground development. The number of inhabitants in India in metropolitan regions continues to increment step by step due to urbanization. In 1950 357 million individuals lived in metropolitan regions and the number expanded to 1009 million in 2000 (UN 2002 Report). It is normal that the number will reach 1409 million in 2030. As numerous mega cities show, there is a constraint of how far cities can spread. One approach to managing the issues of metropolitan space shortage is by building upwards. For sure, elevated structures have for a really long time been the showing illustration of how to make more space on a restricted measure of land. Nonetheless, office space or it isn't the just to live space requested space in cities. Underground space alludes to a space that is arranged underneath the ground level. Underground land can likewise be characterized as land which lies underneath the outer layer of the earth. It matters underneath the surface land can be considered as underground land. Underground development will make more space over the ground for some purposes particularly for entertainment and social exercises and development of new green fields and private regions. Thinking back, the underground space has been taken advantage of for millennia, for key and military purposes, for strict structure, for water and sterilization transport and military purposes. It is as it were later that the underground has been profoundly utilized for transportation, business building and other infrastructure, for example, burrowing and incorporated railroad transport. India is likewise not avoided from urbanization issues. In view of the quantity of metropolitan thickness and urbanization, metropolitan development in India is developing quickly. It implies the thought for involving metropolitan underground space for development should be really focused. Underground usage designs change in various metropolitan settings, contingent upon the nearby culture, topographical circumstance, social climate and monetary necessities. In underground development profound uncovering is required furthermore, for profound uncovering earth holding structure is required. Diaphragm wall is the most well-known earth holding structure in profound removal/establishment powerless/unfortunate soil conditions. In this work various kinds of Diaphragm wall have been completed. Additionally the parametric investigation of diaphragm wall has been finished through case study.

- **Mahesh Tandon¹, published a paper titled "LARGE UNDERGROUND CONSTRUCTION FOR METRO STATIONS" in Journal of Research in Engineering and Applied Sciences Vol 04 Issue 04 Oct 2019.**

Metro Transport is one of the popular ease and economical transport for people in the country. It provides a decent form of communication channels in the city areas as well as adjacent areas of metro cities. Author highlights the major features of metro construction with consideration of environmental aspects involved, with a short review of construction technology and innovative planning ideas. In this paper the author discuss the necessities of metro and the types of construction methods involved majorly D-wall and Piling work method. Author concludes with the important of Underground metro construction in urban cities and its minimal impact on environmental aspects.

- **Makarand G. Khare¹, Varun, M¹, published a paper titled Effect of Diaphragm Wall - Slab Joint Rigidity on Design of Underground Metro Station in academia education web portal.**

This paper discusses the impact of rigidity of the diaphragm wall and slab connection with design of underground metro station. Cases of bottom-up (BU) and top-down (TD) development successions for a metro station are modelled in this review. A two dimensional limited element analysis was utilized to model the collaboration between soil/rock and diaphragm wall during different uncovering stages to acquire the wall minutes. Diaphragm wall and the slab (the roof, concourse and base slabs) joints are modelled as inflexible and then as hinged with turn springs (with ability to model partial fixity). The review shows that for allpractical purposes a spring stiffness of 4EI/L addresses nearly



unbending association between wall and slab. The decrease in spring stiffness generally lessens the wall moments. However, the influence of spring stiffness on „retained side“ wall second was negligible below the concourse slab level. The wall second on „excavated side“ (for example strain on uncovered face) decreased with decrease in spring stiffness notably at base slab level. The wall-slab joint rigidity has critical effect on wall second particularly at roof slab level. The review shows that the rigidity of slab-diaphragm wall intersection has tremendous impact on plan minutes during development stage which thus could administer plans during the long-lasting stage.

III. OBJECTIVE OF THE PAPER

The Objective of the research paper is as mention in the following points

- To conduct feasibility analysis between applications of Diaphragm Wall Method Vs Piling Method with live case study application in Budhwar peth Metro station.

IV. METHODOLOGY



V. EXPERIMENTAL RESULTS

Considering 215m area is in scope of work at congested site of Budhwar peth metro station. Now feasibility analysis is been conducted based on various parameters to involve the most safest & economical method in the project.

Sr.No	Inputs	DIAPHRAGM WALL	PILING METHOD
1	Scope of Work = 215 m	43 Panels of D-wall are required considering 5 m each with average depth of 9m	307 piles in span of 215m considering 450mm diameter piles and 2piles in 1m span. Also additional retaining wall construction in required as well.
2	Required Time	Day & Night Shift = 20hrs, 43 Days required i.e. 1 day for 1 D-wall panel	Day & Night Shift = 20hrs, 102 Days required considering 3 piles per day. Also additional retaining wall construction in required as well.
3	Cost of Machinery	Required machinery = Grabber, Crane, Bar Bending & Cutting & Power Jack. Cost per day of machinery : <ul style="list-style-type: none"> • Grabber = Rs 40000/- per day • Crane = Rs 20,000/- per day • Bar Bending & Cutting = Rs 3,00,000/- purchased machinery • Power Jack = Rs 2,50,000/- purchased Total Cost per day = 60,000 + 11,000 = 71,000/- Rs per day	Required machinery = Grabber, Crane, Bar Bending & Cutting. Cost per day of machinery : <ul style="list-style-type: none"> • Grabber = Rs 40000/- per day • Crane = Rs 20,000/- per day • Bar Bending & Cutting = Rs 3,00,000/- purchased machinery Total Cost per day = 60,000 + 3,334 = Rs 63,333/- Rs per day Cost of Machinery to Cast 307 piles for



		<p>Cost of Machinery to Cast 43 D-Wall panels for considering durations as 43+7 = 50 Days. 7 Days considered as free float.</p> <p>50 days cost of Machinery = Rs35,50,000/-</p>	<p>considering durations as 102+3days = 105 Days. 3 Days considered as free float.</p> <p>105 days cost of Machinery = Rs66,49,965/-</p>
4	Resource Required with their wages	<p>7 Fitter, 5 Concrete team members, 5 Helpers.</p> <p><i>Per Day & Night Shift Cost of 1 Fitter = Rs 2165/- (per hour cost = 108.25)</i> <i>Per Day Cost of 1 CT member = Rs 1970/- (per hour cost = 98.5)</i> <i>Per Day Cost of 1 Helper = Rs 1,777.5/- (per hour cost = 88.87)</i></p> <p>Total Cost of a Day = Rs 33,892.5/- Total Cost of 50 Days = Rs 16,94,625/-</p>	<p>7 Fitter, 5 Concrete team members, 5 Helpers.</p> <p><i>Per Day & Night Shift Cost of 1 Fitter = Rs 2165/- (per hour cost = 108.25)</i> <i>Per Day Cost of 1 CT member = Rs 1970/- (per hour cost = 98.5)</i> <i>Per Day Cost of 1 Helper = Rs 1,777.5/- (per hour cost = 88.87)</i></p> <p>Total Cost of a Day = Rs 33,892.5/- Total Cost of 105 Days = Rs 35,58,712.5/-</p>
6	Cost of Materials required for 1 Panel	<ol style="list-style-type: none"> 1. Steel Req. in one Panel = 3 MT 2. Steel cost for 1 panel = Rs 2,10,000/- 3. Concrete Req. in 1 Panel = 36 Cum 4. Transit Mixer req. for 1 Panel = 6 Nos 5. Cost of 1 TM = Rs 42000/- 6. Cost of 6 TM = Rs 2,52,000/- 	<ul style="list-style-type: none"> • Steel Req. in one Pile = 1MT • Steel Cost for 1 Pile = Rs 70,000/- • Concrete Req. in 1 pile = 6 Cum • Transit Mixer req. for 1 Pile = 1 Nos • Cost of 1 TM = Rs 42000/-
8	Total Cost	<p>Cost required for Casting</p> <ul style="list-style-type: none"> • Total Labour Cost of 50 Days = Rs 16,94,625/- • Total Steel Cost for 43 Panels = Rs 90,30,000/- • Total Cost of Concrete for 43 Panels = Rs 1,08,36,000/- • Total Cost of Machinery = Rs35,50,000/- • Total cost = 2,51,10,625/- 	<p>Cost required for Casting</p> <ul style="list-style-type: none"> • Total Labour Cost of 105 Days = Rs 35,58,712.5/- • Total Steel Cost for 307 Piles = Rs 2,14,90,000/- • Total Cost of Concrete for 307 Piles = Rs1,28,94,000 • Total Cost of Machinery = Rs 66,49,965/- • Total cost = 4,45,92,677.50/-
9	Extra Works in Method Application	No extra works is required	The Piles are temporary structures that needs to be evicted after certain point of time. The addition of tie beams and all are always required. Also Retaining wall is required.

➤ Therefore as per the above calculation it is very clear that the D- Wall construction method is the most economical method when compared to the piling method as explained below -

- Compared in terms of **Labour cost** Piling method requires total cost of **Rs 35,58,712.5/-** whereas labour cost for D-Wall method = **Rs 16,94,625/-**.
- Compared in terms of **Duration** the Piling method requires **105 Days** whereas the D-wall method requires **50 Days**.

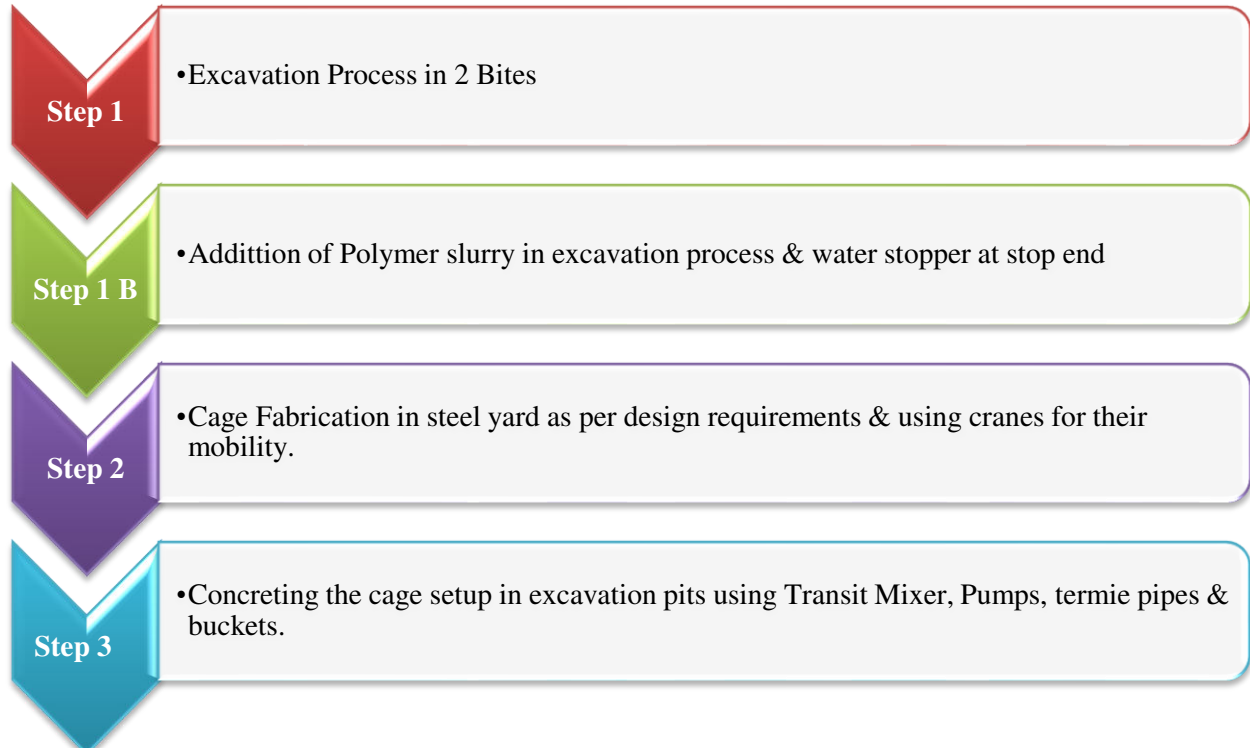
- Compared in terms of *Steel Cost* the Piling method requires **Rs2,14,90,000/-** whereas the D-wall method requires = **Rs 90,30,000/-**
- Compared in terms of *Concrete Cost* the Piling method requires **Rs 1,28,94,000** whereas the D-wall method requires = **1,08,36,000/-**
- Compared in terms of *Machinery Cost* the Piling method requires **Rs 66, 49,965/-** whereas the D-wall method requires = **Rs35, 50,000.**

VI. BUDHWAR PETH UNDERGROUND METRO STATION – CASE STUDY

Methodology for D-wall Construction at Budhwar Peth Site



Figure 2 - D-Wall Construction at Budhwar Peth Site



VII. CONCLUSION

As per the feasibility study conducted for both the methods it is found that Diaphragm Wall Construction is the feasible option rather than go with Pile work and Retaining Wall Construction due to following conclusion points

- A. As compared in terms of **Duration** the **D-wall method** requires less amount of time to complete the work
- B. As compared in terms of **labour cost** the **D- Wall method** requires less amount of cost to complete the work.
- C. As compared in terms of **Machinery cost** the **D- Wall method** requires less amount of cost to complete the work.
- D. As compared in terms of **Material cost** the **D- Wall method** requires less amount of cost to complete the work.

Also in Piling method the Retaining wall is to be constructed separately resulting to additional element and additional cost to the project where as in D- Wall method it itself satisfies the requirement of Retaining Wall.

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