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A Comparative Study of Top-Down and Cut-and-Cover Methods in Tunnel Construction

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Jakarta MRT Phase II; Top-down method; Cut and cover method; Tunnel construction; Excavation volume.

Abstract
This study compared the top-down and cut-and-cover construction methods for tunnel construction in the Jakarta MRT Phase II project. The objective was to evaluate the differences in excavation volume, construction duration, and labor efficiency between the two methods. This study employed a descriptive-analytical case study approach using secondary data, including project drawings, work quantities, equipment productivity data, and construction schedules. The analysis involved calculations of excavation volume, duration of each construction phase, and labor efficiency for both construction methods. The results showed that the top-down method required an excavation volume of approximately 179,162.15 m^3 with a construction duration of approximately 2,007.5 days (±66 months), whereas the cut-and-cover method required an excavation volume of approximately 9,714.62 m^3 with a duration of approximately 562 days (±18.5 months). The difference in construction duration between the two methods was 1,445.5 days, indicating that the cut-and-cover method enabled faster completion. However, the cut-and-cover method requires a larger construction area and may cause greater environmental disturbances, whereas the top-down method provides better excavation stability and is more suitable for densely populated urban areas. In conclusion, neither method can be considered universally superior; instead, the selection of a construction method should be based on site conditions and project requirements. The top-down method is more appropriate for dense urban environments where structural stability and limited surface disruption are priorities, while the cut-and-cover method is more suitable when rapid construction is required and sufficient working space is available.

INTRODUCTION

The development of urban transportation infrastructure, particularly the Jakarta MRT, represents a strategic solution for addressing congestion and improving public mobility in urban areas (Hasibuan & Mulyani, 2022; Suartika, 2025; Sumabrata et al., n.d.; Syafruddin, 2025; Yudhistira & Putra, 2024). MRT projects, especially underground construction phases, require optimal and efficient implementation strategies to minimize social, economic, and environmental impacts (Barma et al., 2024; Li et al., 2024; T.-Y. Liu et al., 2026; Shinde et al., 2024). The CP 203 MRT project, which includes the construction of underground stations and tunnels, involves complex engineering challenges that require accurate construction planning and appropriate methodological selection.

Two primary methods are commonly applied in underground tunnel construction: the top-down method and the cut-and-cover method (Damiani et al., 2025; Huang et al., 2026; Kara et al., 2023; Y. Liu et al., 2025; Yamchoo et al., 2025). The top-down method

enables construction activities to proceed progressively from the surface downward, allowing work on the upper and lower structural components to be carried out concurrently. Research by Lalic et al. (2021) indicates that the top-down method allows simultaneous construction progress from the surface level to underground structures, thereby reducing disruption to the surrounding environment. Furthermore, Zhang et al. (2020) found that the application of the top-down method can reduce environmental impacts and improve construction efficiency, particularly in densely populated urban areas. These findings demonstrate that this method can optimize space utilization and minimize disturbances to community activities surrounding the project site (Chen & Xu, 2022; Hegazy & Kamarah, 2022; Mohsen, 2024; Pan & Zhang, 2023).

In contrast, the cut-and-cover method is a conventional construction technique that begins with surface excavation before tunnel construction activities are carried out. This method is generally considered simpler to implement and requires lower initial investment. However, Chen et al. (2022) explained that the cut-and-cover method requires open excavation from the surface, which may cause significant disruptions to traffic flow and surrounding activities during construction. Additionally, Zhang et al. (2023) stated that the cut-and-cover method is commonly applied for shallow tunnel construction due to its relatively straightforward implementation and reduced risk of damage to adjacent infrastructure.

Several previous studies have reported varying findings regarding the effectiveness of these two construction methods. Wang et al. (2021) argued that the top-down method is more effective in accelerating construction processes in densely populated urban environments. Conversely, Tan and Lim (2022) emphasized the importance of considering social and environmental factors when selecting construction methods. Furthermore, Sari and Prabowo (2023) highlighted the necessity of comprehensive cost-benefit analyses to determine the most efficient and sustainable construction approach.

The urgency of this research is driven by Jakarta's rapid urbanization and the increasing demand for efficient underground transportation infrastructure. According to the Jakarta Transportation Agency (2023), Jakarta's population exceeds 10.5 million, with approximately 4.5 million vehicles operating daily, contributing to severe congestion levels among the highest in Southeast Asia. The Jakarta MRT Phase II project represents a major investment in urban transportation infrastructure, requiring careful selection of construction methods to minimize disruption to urban activities and ensure project effectiveness. The choice between the top-down and cut-and-cover methods has significant implications for construction duration, cost efficiency, environmental impacts, and community acceptance.

The novelty of this research lies in its comprehensive comparative evaluation of the top-down and cut-and-cover methods by examining excavation volume, construction duration, and resource efficiency within the context of Jakarta's urban environment. Unlike previous studies that generally analyze these parameters separately, this research integrates multiple analytical dimensions to provide a more holistic assessment of underground construction methods. Furthermore, this study contributes to the limited knowledge base regarding underground construction practices in Indonesia by providing empirical analysis that can support future infrastructure development projects in similar urban environments across Southeast Asia.

Considering the current conditions, selecting an appropriate construction method is essential, particularly in a densely populated city such as Jakarta where land availability is limited. Therefore, this study was conducted to compare the top-down and cut-and-cover methods in terms of construction duration and implementation characteristics. The findings are expected to provide valuable recommendations for planning underground construction projects and serve as a reference for future urban transportation infrastructure development.

METHOD

Data Collection Methods

The study used primary and secondary data. Primary data were obtained through field observations and interviews with relevant stakeholders to determine the appropriate construction methods. Secondary data were collected from project documents and supporting literature, including work plan drawings, to calculate work volumes, productivity, and activity durations.

Type of Research Approach

Activities undertaken in the preparation stage included a literature review to obtain as many references and basic theories as possible regarding the research being conducted and to obtain information supporting the implementation of this study. These references will also serve as guidelines for solving the research questions raised in this study.

Data Collection Stage

This activity aims to obtain data and information related to the research being conducted. The data used in the analysis in this study are secondary data obtained from the MRT Phase II tunnel construction project and data on the time and cost of implementing the cut and cover method for the Simpang Mandai underpass construction. The influencing variables in this study are as follows:

1. Type of activities carried out on the project.
2. Project shop drawings.
3. The total volume of each project.
4. The productivity of the resources used in the project.

Data Analysis

Cut and Cover Construction Method Analysis

This method involves excavating the soil from above, then constructing a concrete structure at the base of the excavation, and then covering the area once all work is completed. According to Tri Wahyuni (2025), this approach can significantly shorten the project's duration. However, during the construction process, the main road must be completely closed, resulting in congestion and complaints from local residents.

Top-Down Construction Method Analysis

The top-down construction method is a basement construction method in which structural work and excavation are carried out simultaneously and in stages until the planned depth is reached.

In this method, soil reinforcement generally uses a diaphragm wall, which not only functions as a retaining wall but also forms part of the permanent structure of the basement wall.

The construction process begins with the construction of the diaphragm wall and

initial support elements such as king posts (vertical steel columns). After that, the ground floor slab is cast first as a support. Subsequently, excavation is carried out under the slab in stages.

During the excavation process, each level of the basement slab is cast sequentially from top to bottom. This slab serves as additional lateral support against ground pressure. During this process, the basement slab is temporarily supported by king posts, which act as temporary columns until the permanent structure is formed.

Casting of the raft foundation is carried out after the excavation reaches the planned deepest elevation. Once the raft foundation is complete, the main structural elements, such as columns and core walls, are continued until they are connected to the superstructure.

Duration Analysis

The work duration is calculated for each activity item by dividing the work volume by the productivity level of the available resources. This analysis also explains the interrelationships between tasks according to the construction method used.

The duration of each task is greatly influenced by the amount of resources allocated and the volume of work to be completed. The higher the productivity or the more resources used, the shorter the duration, and vice versa.

Comparative Analysis

After analyzing the methods and durations, the results of the two methods are then compared to determine the most effective duration or time for the work.

Research Location

This research took place in the Jakarta MRT Phase II project area, specifically CP 203. The selection of this location is based on the characteristics of a densely populated area.

Figure 1 Location project area

RESULTS AND DISCUSSION

Top-Down Construction Method Analysis

This section explains the top-down construction method, which is carried out in stages from top to bottom.

a. King Post

King post construction begins with pre-drilling, followed by temporary casing installation, and then casting and backfilling. The purpose of this process is to create the initial structural support elements that will support the construction throughout the process.

b. Retaining Wall (D-Wall)

Diaphragm walls act as soil support during excavation. This process includes panel excavation, application of slurry (polymer), and monitoring the stability of the excavation wall to prevent landslides.

c. Excavation

Excavation is carried out in stages while maintaining the stability of the structure above. The use of large machinery such as excavators and slurry control systems is crucial to the success of this project.

d. Top-Down Work Volume Analysis

Work capacity and equipment effectiveness are calculated to determine the time required for each task. This approach tends to result in a smaller excavation volume, but with a longer implementation time due to the gradual and complex process.

Cut and Cover Method Analysis

This method is implemented by excavating on the surface, making the process easier and more direct.

a. Excavation Work

This is the initial work involving measuring and determining construction points in the field as a reference for implementation.

b. Earthwork

This involves excavating the earth using heavy equipment such as excavators and dump trucks. Equipment productivity calculations are used to determine the duration of the work based on the excavation volume.

c. Cut and Cover Method Calculation Analysis

Production capacity, work duration, and equipment requirements are calculated. This method produces a much larger excavation volume than the top-down method, but the process is faster because it is not phased.

d. Comparative Effectiveness Analysis and Implementation

Time The analysis results show that:

The Top-Down method has a duration of approximately 2,007.5 days (approximately 66 months).

The Cut and Cover method has a duration of approximately 562 days (approximately 18.5 months).

The difference in duration is approximately 1,445.5 days, with the Cut and Cover method being faster. However, this method requires a larger workspace and has the potential to cause greater environmental impacts.

Table 1 Comparison Table

No	Parameter	Cut and Cover	Top Down
1	Implementation Method	Excavation is carried out openly from the ground surface to the planned depth. After excavation is completed, the tunnel structure is constructed and the excavation is backfilled.	The top slab is constructed first, followed by staged excavation beneath the slab while the remaining structural elements are built progressively downward.

2	Work Sequence	1. Site Preparation2. Excavation3. Retaining Wall Work4. Substructure Work5. Backfilling6. Finishing	1. Site Preparation2. Top Slab Construction3. Phased Excavation4. Substructure Work5. Finishing
3	Total Excavation Volume	9,714.62 m³	179,162.15 m³
4	Project Duration	562 days (approximately 1 year 6 months)	2,007.5 days (approximately 5 years 6 months / 66 months)
5	Implementation Characteristics	Construction is performed using an open excavation method and progresses sequentially from the bottom upward.	Construction is performed in stages from the top downward while excavation and structural works proceed simultaneously.
6	Construction System	Conventional construction method.	Integrated construction system with staged excavation and structural work.

CONCLUSION

Based on the analysis and discussion comparing the top-down and cut-and-cover construction methods for tunnel construction in the Jakarta MRT Phase II project, several conclusions can be drawn. The top-down and cut-and-cover methods demonstrated significant differences in their implementation sequences and construction characteristics. The top-down method involved constructing the upper structure first, followed by gradual excavation and construction of the underground structure, allowing surface activities to continue during the construction process. In contrast, the cut-and-cover method involved open excavation from the ground surface to the required tunnel depth, followed by structural construction and backfilling, resulting in greater disruption to surrounding activities and the environment. In terms of excavation volume, the top-down method required 179,162.15 m³ of excavation over a project length of 406.5 m, whereas the cut-and-cover method required 9,714.62 m³ over a project length of 120 m. The construction duration of the top-down method was 2,007.5 days (approximately 66 months), which was significantly longer than the cut-and-cover method's 562 days (approximately 18.5 months), resulting in a difference of 1,445.5 days.

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