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Evaluating the Impact of Secant Piles on Retaining Wall Safety at Lapangan Merdeka Medan

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Abstract:
This study investigates the effectiveness of integrating secant piles into retaining wall systems for basement construction, with a specific focus on the Medan Merdeka Square Revitalization Project. As part of a major redevelopment effort in a historically significant urban area, ensuring the structural stability of basement walls is essential to protect both the site and surrounding infrastructure. Secant pile walls, composed of overlapping reinforced concrete piles, offer enhanced lateral resistance and groundwater control compared to conventional retaining structures. The research evaluates wall performance before and after the application of secant piles through geotechnical analysis and engineering stability assessments. The methodology includes determining lateral earth pressure using Rankine's Theory and conducting stability checks against overturning, sliding, and bearing capacity failure. Soil characteristics, earth pressure coefficients, and relevant safety factors are analyzed to understand how the combined secant pile–reinforced concrete system distributes loads and improves structural performance. Construction methods and sequencing are also considered to ensure minimal disruption to the heritage environment. The results indicate that the retaining wall with added secant piles meets all required stability criteria: sliding resistance is safe, overturning potential is negligible, and bearing capacity is adequate to support the applied loads. Additionally, the recorded deflection value of 0.8 remains within acceptable limits, confirming the structural suitability of the design. Overall, the incorporation of secant piles significantly enhances the stability and reliability of the basement retaining wall, making it appropriate for long-term implementation in the revitalization project.

Keywords: Basement Construction; Lapangan Merdeka Medan; Retaining Wall; Secant Pile; Stability Analysis

Introduction

The revitalization project of Lapangan Merdeka Medan includes the construction of a public square, supporting facilities, and a basement. In addition to being a historical site, the revitalization is also aimed at developing green open space. According to the design plan, the revitalized area will feature a public stage and supporting infrastructure, incorporating the concept of preserving historical urban spaces with a contemporary design approach. This revitalization effort has gained significant support from various segments of the community.

The stability of the retaining wall structure in the Lapangan Merdeka Medan revitalization project is a critical aspect, as soil bearing capacity plays a fundamental role in the performance of building foundations. Therefore, the use of a retaining wall system combining secant pile and reinforced concrete walls is considered a suitable solution for this project. Secant pile walls function as rigid lateral support structures for excavations and underground facilities, constructed through a series of overlapping concrete piles that create a continuous barrier against soil and water infiltration. Recent experimental investigations (Basha et al., 2023) have demonstrated that secant pile walls possess both structural and overall stability characteristics necessary to withstand lateral earth pressures as well as applied axial loads, making them particularly suitable for urban construction projects with space limitations.

Advanced monitoring technologies using distributed fiber optic sensors have proven effective in tracking the behavior of secant pile walls during construction and excavation phases (Zhang et al., 2025), with studies showing minimal lateral displacement after excavation due to the high stiffness of properly designed secant pile walls. Furthermore, comprehensive investigations of deep excavations in layered stiff ground conditions (Christensen et al., 2025) have revealed that ground stiffness emerges as the critical factor affecting wall deflections during both cantilever and supported construction stages, emphasizing the importance of thorough geotechnical investigation prior to design.

The application of secant pile technology has gained considerable traction in urban construction due to its versatility and effectiveness in controlling both earth retention and groundwater. Secant pile walls can be constructed in various soil conditions, including challenging terrains with cobbles and boulders, and can be supported by anchor or strutting systems with waler beams to distribute loads and prevent structural failure. Recent parametric studies (Gowthaman & Anburaj, 2024) have also examined the performance of permanently anchored secant pile walls under earthquake loading conditions, providing valuable insights for seismic design considerations in urban areas.

In various cases involving the use of secant piles in the city of Medan, notable examples include the implementation of secondary secant pile techniques as retaining walls in the construction of a pump house for the wastewater pipeline network optimization project and the analysis of retaining wall stability in the pump house construction project on Jl. Sidorukun, Pulo Brayan Darat, Medan. These local applications demonstrate the growing confidence in secant pile technology for critical infrastructure projects in the region, providing valuable precedents for the Lapangan Merdeka revitalization project.

Literature Review

1. Basha et al. (2023) - Performance Analysis of Axially Loaded Secant Pile Wall

Penelitian yang dilakukan oleh Basha et al. (2023) mengkaji kinerja dinding secant pile yang dibebani secara aksial melalui pendekatan eksperimental pada tanah pasir. Studi ini menggunakan model skala laboratorium untuk menganalisis perilaku struktural dan stabilitas keseluruhan dari dinding secant pile ketika mengalami beban aksial dan tekanan lateral tanah secara bersamaan. Hasil penelitian menunjukkan bahwa dinding secant pile memiliki kapasitas daya dukung yang signifikan dan mampu mempertahankan stabilitasnya bahkan di bawah kondisi pembebanan kombinasi. Penelitian ini juga mengidentifikasi pola distribusi tegangan pada pile dan mekanisme transfer beban ke tanah di sekitarnya. Temuan ini memberikan kontribusi penting dalam memahami perilaku struktural secant pile, khususnya untuk aplikasi pada proyek konstruksi perkotaan dengan keterbatasan ruang. Relevansi penelitian ini terhadap proyek Lapangan Merdeka Medan terletak pada validasi kemampuan sistem secant pile dalam menahan beban vertikal dari struktur di atasnya sekaligus berfungsi sebagai dinding penahan tanah, yang merupakan kondisi serupa dengan kebutuhan proyek revitalisasi yang melibatkan konstruksi basement dan fasilitas pendukung.

2. Zhang et al. (2025) - Monitoring Excavation-Induced Deformation Using Distributed Fiber Optic Sensors

Zhang et al. (2025) melakukan penelitian tentang pemantauan deformasi dinding secant pile akibat galian menggunakan sensor serat optik terdistribusi (distributed fiber optic sensors). Penelitian ini mengaplikasikan teknologi monitoring canggih untuk melacak pergerakan dan deformasi dinding secant pile secara real-time selama proses konstruksi dan penggalian. Hasil monitoring menunjukkan bahwa

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dinding secant pile yang dirancang dengan baik mengalami perpindahan lateral yang minimal setelah penggalian, yang mengindikasikan kekakuan struktural yang tinggi. Studi ini juga berhasil mengidentifikasi zona kritis pada dinding yang mengalami tegangan maksimum, sehingga memungkinkan intervensi dini jika terjadi kondisi yang tidak diinginkan. Penggunaan teknologi fiber optic sensors memberikan data kontinu dan akurat sepanjang kedalaman dinding, yang tidak dapat dicapai dengan metode monitoring konvensional. Penelitian ini sangat relevan untuk proyek Lapangan Merdeka Medan karena menekankan pentingnya monitoring real-time untuk memastikan keamanan struktur penahan tanah, terutama mengingat lokasi proyek yang berada di area urban dengan tingkat aktivitas tinggi dan berdekatan dengan bangunan bersejarah yang harus dilindungi dari potensi settlement atau pergerakan tanah.

3. Christensen et al. (2025) - Deformation Behaviour in Layered Soil-Rock Profiles

Christensen et al. (2025) menginvestigasi perilaku deformasi dinding secant pile pada profil tanah berlapis yang terdiri dari kombinasi tanah dan batuan di Copenhagen. Penelitian ini menganalisis data dari beberapa proyek galian dalam (deep excavation) untuk memahami faktor-faktor yang mempengaruhi defleksi dinding selama tahap konstruksi kantilever maupun tahap dengan sistem penyangga. Temuan utama penelitian menunjukkan bahwa kekakuan tanah (ground stiffness) merupakan faktor kritis yang paling berpengaruh terhadap besarnya defleksi dinding, lebih signifikan dibandingkan faktor-faktor lain seperti panjang kantilever atau kedalaman galian. Studi ini juga mengungkapkan bahwa pada kondisi tanah berlapis dengan variasi kekakuan yang tinggi, diperlukan pemodelan yang lebih detail untuk memprediksi perilaku dinding secara akurat. Penelitian ini memberikan pelajaran penting tentang pentingnya investigasi geoteknik yang menyeluruh sebelum tahap desain, termasuk karakterisasi detail dari setiap lapisan tanah. Untuk proyek Lapangan Merdeka Medan, penelitian ini sangat relevan mengingat kondisi tanah di kota Medan yang umumnya bersifat heterogen dengan variasi jenis dan karakteristik tanah pada kedalaman yang berbeda, sehingga memerlukan perhatian khusus dalam desain dinding penahan tanah untuk mengantisipasi potensi deformasi yang dapat mempengaruhi keamanan struktur.

Research Method

This study employs a quantitative evaluative approach aimed at analyzing and comparing the safety factors of retaining wall structures before and after the installation of secant piles, utilizing geotechnical data obtained from field investigations. The analysis focuses on soil lateral pressure, slope stability, and structural deflection to assess the effectiveness of secant pile implementation in enhancing the safety and performance of the retaining wall system. Primary data, such as SPT and CPT test results, were unavailable due to time constraints and limited access to the project site. Therefore, this study relies on secondary data sourced from official planning reports of the Lapangan Merdeka Medan revitalization project prepared by the consulting engineers.

This study did not employ geotechnical software validation due to the following reasons the research focused on manual theoretical calculations, applying conventional theoretical methods such as Rankine’s theory and traditional stability equations, without the use of numerical modeling software. In addition, limited access to commercial geotechnical software licenses restricted the ability to conduct numerical validation within the scope of this study. Furthermore, due to time and resource constraints, software-based validation was not carried out and is recommended to be addressed in future research.

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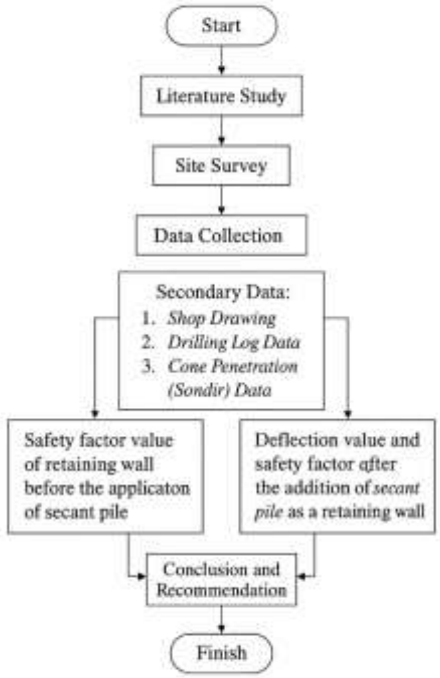

Figure 1 Research Flow Chart

This study relies exclusively on secondary data, which were obtained from documents and technical reports provided by the project stakeholders involved in the Revitalization of Lapangan Merdeka Medan. The data include:

- Standard Penetration Test (SPT) and Cone Penetration Test (CPT) results.
- Drilling logs from soil investigation
- Technical drawings (shop drawings) of the retaining wall structure.
- Soil parameter reports, such as cohesion, internal friction angle, and unit weight.
- Literature and technical references, including Indonesian National Standards (SNI), geotechnical engineering textbooks, and previous studies related to earth pressure and secant pile applications.

Techniques of Data Collection

- Document Review

  Collection of geotechnical data and technical reports from the Revitalization Project of Lapangan Merdeka Medan. The documents include Standard Penetration Test (SPT) results, Cone Penetration Test (CPT) data, drilling logs, soil parameter reports, and technical drawings related to the retaining wall and basement structure.

- Drawing Analysis

  Analysis of structural shop drawings and reinforcement details to understand the geometry, structural elements, and construction methods used in both the original retaining wall and the configuration after the addition of secant piles.

- Literature Study

Use of theoretical references, calculation standards, and design guidelines obtained from textbooks, scientific journals, and national regulations such as SNI. These references support the analysis of lateral earth pressure, wall deflection, and safety factor calculations.

Steps in Data Analysis:

1. Identification of Structural and Soil Parameters: Determine the geotechnical and structural parameters necessary for the analysis, including soil cohesion, internal friction angle, and unit weight. These parameters are derived from SPT and CPT data, as well as structural dimensions from shop drawings.
2. Safety Factor Calculation

   Calculate the safety factor of the retaining wall against three failure modes:

- **Sliding**, based on the balance of horizontal forces.
- **Overturning**, based on moment equilibrium.
- **Bearing capacity**, based on soil pressure and allowable bearing stress

3. Lateral Earth Pressure and Deflection Analysis

   Analyze lateral earth pressure using Rankine's Theory to determine the magnitude of force acting on the wall. Calculate the resulting wall deflection using appropriate structural beam theory to ensure the deformation remains within allowable limits.

4. Comparative Evaluation Before and After Secant Pile Installation

   Evaluate and compare all safety factor values and deflection results between two conditions:

- **Before** the application of secant pile (original condition).
- **After** the application of secant (improved condition) The comparison aims to assess the improvement in structural performance and determine the effectiveness of secant pile implementation.

Result

Based on the site investigation, drilling log data indicated five distinct soil layers:

1. Sandy clay with medium to stiff consistency
2. Silty fine sand and calcareous fine sand with medium density
3. Medium sand with pumice, classified as dense to very dense
4. Dense medium sand and
5. Dense fine sand.

Cone Penetration Testing (CPT) was performed following ASTM D3411 T75 using a 2.5-ton light-duty cone penetrometer. The test measured cone tip resistance (shear force per unit area) and sleeve adhesion (shear force per unit length).

Testing continued until reaching either hard soil (CR ≥ 150 kg/cm^2) or a depth of 20 meters. When CPT data alone was insufficient for soil classification, nearby borehole data was used as a reference.

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During the test, as the bicone penetrated into the soil, measurements were taken for both Cone Resistance (CR) and Total Resistance (TR) at 20 cm intervals, using a manometer. Based on the obtained CR and TR values, further analysis was conducted to derive soil strength parameters and interpret subsurface conditions.

The retaining wall design in the Revitalization Project of Lapangan Merdeka Medan initially followed a basic stability approach, where structural reinforcement was only considered after early signs of potential failure, such as excessive deflection or low safety factor values. As a result, no advanced soil-structure interaction method or preventive reinforcement, such as secant pile, was implemented in the initial design stage. Improvements were introduced only after the structural performance was reevaluated and found to be close to minimum safety thresholds.

6. FR = TR – CR

   FR (Friction Resistance) = 5 kg/cm²

   TR (Total Resistance) = 231 kg/cm²

   CR (Cone Resistance) = 226 kg/cm²

7. SF = FR x 20/10 (kg/cm)

   SF (Skin Friction) = 10 kg/cm

   20 = Reading interval (cm)

   10 = Equipment factor (Reduction Factor)

3. TSF (Total Skin Friction) = 714 kg/cm

4. LSF = FR / 10

   LSF (Local Skin Friction) = 0.50 kg/cm²

Discussion

Soil Strength Parameters

Cohesion and Internal Friction Angle of Soil

The calculation of soil cohesion and internal friction angle is based on data obtained from the Standard Penetration Test (SPT).

a. Determination of Cohesion Value

   The cohesion value represents the undrained shear strength of the soil. According to the chart proposed by K. Terzaghi, the cohesion (c) can generally be estimated as 0.6 times the SPT N-value, with the resulting cohesion expressed in ton/m³.

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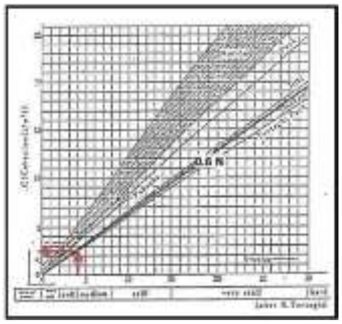

Figure 2 Relationship between cohesion value and SPT N-value in cohesive soils (Terzaghi, 1943)

Soil Profile Data (6,00 m – 10,45 m)

SPT N-value = 22

c = 0,6 . N

c = 0,6 x 22

c = 13,2 t/m3

Soil Profile Data (10,45 m – 14,00 m)

SPT N-value = 13

c = 0,6 . N

c = 0,6 x 13

c = 7,8 t/m3

Soil Profile Data (14,00 m – 18,45 m)

SPT N-value = 36

c = 0,6 . N

c = 0,6 x 36

c = 21,6 t/m3

Determination of Internal Friction Angle

In this case, the internal friction angle is determined based on the correlation between the friction angle and the type of soil.

Table 1. Relationship Between Internal Friction Angle and Soil Type

Soil Type	Internal Friction Angle (°)
Silty Gravel	35° – 40°
Coarse Gravel	35° – 40°
Dense Sand	35° – 40°

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Loose Sand	30°
Calcareous Clay	25° – 30°
Clay	20° – 25°

Source: Soil Mechanics, Braja M. Das, Volume 1

Depth Interval (6.00 m – 10.45 m)

- Identified soil type: Sandy clay
- Based on Table 4, sandy clay is categorized as clay, thus the highest internal friction angle for this category is selected, which is 25°.

Depth Interval (10.45 m – 14.00 m)

- Identified soil type: Silty fine sand
- According to Table 4, silty fine sand is most closely classified as dense sand, so the maximum internal friction angle of 35° is applied.

Depth Interval (14.00 m – 18.45 m)

- Identified soil type: Calcareous fine sand
- Referring to Table 4, this type of soil corresponds more closely to loose sand, hence the internal friction angle used is 30°.

Determining the Specific Gravity of Soil

The values of natural unit weight for various soil types recommended by Terzaghi (1947) are presented in Table 2.

Table 2. Specific Gravity

Soil Type	Specific Gravity of Soil (Gs)
Gravel	2.65 – 2.68
Sand	2.65 – 2.68
Inorganic silt	2.62 – 2.68
Organic clay	2.58 – 2.65
Inorganic clay	2.68 – 2.75
Humus	1.37
Peat	1.25 – 1.80

Source: Source: Soil Mechanics Book *1*, Hary Christady Hardiyatm

Soil Profile Data (6.00 m – 10.45 m)

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Based on the Standard Penetration Test (SPT) results, the soil at this depth is classified as sandy clay. Since this soil type is considered inorganic clay, the specific gravity

(Gs) = 2. 715, which is the average value between 2.68 and 2.75.

Soil Profile Data (10.45 m – 14.00 m)

According to the SPT data, the soil in this layer is identified as silty fine sand. This soil is also classified as inorganic, and therefore the specific gravity (Gs) = 2.715, the average between 2.68 and 2.75.

Soil Profile Data (14.00 m – 18.45 m)

Based on the Standard Penetration Test (SPT) results, the soil in this layer is classified as calcareous fine sand, which falls under the category of inorganic silt. Therefore, the specific gravity

(Gs) = 2.65, representing the average value between 2.62 and 2.68.

Determining the Unit Weight of Soil

The values of natural unit weight for various soil types recommended by Terzaghi (1947) are presented in Table 3**.**

Table 3. Values of Dry Unit Weight (γd) and Bulk Unit Weight (γb) for Natural Soils (Terzaghi, 1947)

Soil Type	Specific Gravity of Soil (Gs)
Gravel	2.65 – 2.68
Sand	2.65 – 2.68
Inorganic silt	2.62 – 2.68
Organic clay	2.58 – 2.65
Inorganic clay	2.68 – 2.75
Humus	1.37
Peat	1.25 – 1.80

Source: Soil Mechanics Volume 1, Hary Christady Hardiyatmo

Soil Profile Data

Soil Profile Depth (6.00 m – 10.45 m)

- Identified Soil Type: Sandy clay
- Sandy clay closely resembles the characteristics of dense well-graded sand.
- Therefore, the values are taken as: Dry unit weight (γd) = 18.6 kN/m³ Bulk unit weight (γb) = 21.6 kN/m³

Soil Profile Depth (10.45 m – 14.00 m)

- Identified Soil Type: Silty fine sand

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- Silty fine sand is also considered to resemble dense well-graded sand.
- Therefore, the values are assumed as: Dry unit weight (γd) = 18.6 kN/m³ Bulk unit weight (γb) = 21.6 kN/m³

Soil Profile Depth (14.00 m – 18.45 m)

- Identified Soil Type: Slightly silty fine sand
- Slightly silty fine sand is more comparable to loose uniform sand. This type of sand consists of uniform fine grains with relatively low density compared to dense uniform sand. This, it is generally classified as loose uniform sand.
- Therefore, the values are taken as: Dry unit weight (γd) = 14.3 kN/m³ Bulk unit weight (γb) = 18.9 kN/m³.

Structural Calculation of Basement Wall

To obtain the structural calculation of the basement wall, it is necessary to perform calculations that include: sliding stability, overturning stability, and bearing capacity stability.

Sliding Stability

The factor of safety (FK) for sliding stability of a retaining wall is calculated by comparing the resisting shear force to the driving shear force acting on the wall.

$$FK\ sliding = \frac{\mathrm{TR}}{TS}$$

Where,

- Tr is the resisting shear force provided by the weight of the wall and the frictional force between the base of the wall and the underlying soil.
- Ts is the driving shear force generated by lateral earth pressure and other external loads.

At a depth of (6.00 m to 10.45 m), the following data are given:

W = 150 kN

□ = 25°

c = 13,2 t/m³

A = 10 m

Resisting Shear Force

Tr = W tanφ + c′. A

Tr = 150 tan 25° + 13,2 x 10

Tr = 150 x 0,46631 + 132 Tr = 201,9456 kN

Driving Shear Force

Ts = Pa

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Pa = HγKa

$Ka = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 25°}{1+\sin 25°} = 0.405$

Pa = 8 x 21,6 x 0,405

Pa = 69,984 kN/m²

Ts = Pa

Ts = 69,984 kN

Sliding Factor of Safety

$$FK\ sliding = \frac{\mathrm{TR}}{TS}$$

$$FK\ sliding = \frac{201{,}9456}{69{,}984}$$

$FK\ sliding$ = 2,885 > 1,5 (safe / no sliding)

At a depth of (10,45 m – 14,00 m), the following data are given:

W = 150 kN

φ = 35°

c = 7,8 t/m³

A = 10 m

Resisting Shear Force

Tr = W tanφ + c′. A

Tr = 150 tan 35° + 7,8 x 10

Tr = 150 x 0,70021 + 78

Tr = 183,0315 kN

Driving Shear Force

Ts = Pa

Pa = HγKa

$Ka = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 35°}{1+\sin 35°} = 0.271$

Pa = 8 x 21,6 x 0,271

Pa = 46,83 kN/m²

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Ts = Pa

Ts = 46,83 kN

Sliding Factor of Safety

$$FK\ sliding = \frac{\text{TR}}{TS}$$

$$FK\ sliding = \frac{183{,}0315}{46{,}83}$$

$FK\ sliding$ = 3,91 > 1,5 (safe / no sliding)

At a depth of (14,00 m – 18,45 m), the following data are given:

W = 150 kN

□ = 30°

c = 13,2 t/m³

A = 10 m

Resisting Shear Force

Tr = W tanφ + c′. A

Tr = 150 tan 30° + 21,6 x 10

Tr = 150 x 0,57735 + 216

Tr = 302,6025 kN

Driving Shear Force

Ts = Pa

Pa = HγKa

$Ka = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 30°}{1+\sin 30°} = 0.33$

Pa = 8 x 18,9 x 0,33

Pa = 49,896 kN/m²

Ts = Pa

Ts = 49,896 kN/m²

Sliding Factor of Safety

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$$FK\ sliding = \frac{\text{TR}}{TS}$$

$$FK\ sliding = \frac{302{,}6025}{49{,}896}$$

$FK\ sliding$ = 6,06 > 1,5 (safe / no sliding)

Therefore, it can be concluded that the structure is safe against sliding.

Overturning Stability

The factor of safety (FK) for overturning stability of a retaining wall is calculated by comparing the resisting moment to the overturning moment.

$$FK\ Overturning = \frac{\text{Mr}}{Mo}$$

Where,

- Mr is the resisting moment, generated by the weight of the wall and other vertical loads.
- Mo is the overturning moment, caused by lateral earth pressure and other horizontal loads.

Resisting Moment

$$Mr = \text{W} \cdot \frac{\text{B}}{2}$$

$$Mr = 150 \cdot \frac{10}{2}$$

$$Mr = 750\ \text{kN. m}$$

Overturning Factor of Safety

$$Fk\ Overturning = \frac{\text{Mr}}{\text{Mo}}$$

$$Fk\ Overturning = \frac{750}{400}$$

$FK\ Overturning$ = 1,875 > 1,5 (safe / no sliding).

Bearing Capacity Stability

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Bearing capacity refers to the ability of the soil to support the loads applied to it. The factor of safety is calculated by comparing the ultimate bearing capacity with the applied load.

$$Fs = \frac{\mathrm{qu}}{\mathrm{qall}}$$

Where,

- qu is the ultimate bearing capacity
- qall is the applied load per unit area

Structural Analysis of the Basement Wall Reinforced with Secant Piles

γb = 18,9 kN/m3

□ = 30°

$Ka = \frac{1-\sin\varphi}{1+\sin\varphi} = \frac{1-\sin 30°}{1+\sin 30°} = 0.33$

Active Earth Pressure at the Base of the Wall:

Pa = HγbKa

= 8 x 18,9 x 0,33

= 49,896 kN/m2

Total Active Earth:

Pa = 1/2 H2γbKa = 1/2 x 82 x 18,9 x 0,33

= 199,584 kN/m’ ⟶ 22,434 t/m

Point of Application Pa :

y = H/3

= 8/3

= 2,67 m from the base of the wall.

$Kp = \tan^2(45 + \frac{30°}{2})$

= $(1,732)^2$

= 3

Passive Earth Pressure

Pp = HγbKp

= 8 x 18,9 x 3

= 453,6 kN/m2

Total Passive Earth Pressure

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Pp = 1/2 H2γbKp

= 1/2 x 82 x 18,9 x 3

= 1814,4 kN/m'

Ko = 1 − sinφ

= 1 − sin30

= 1 − 0,5

= 0,5

Coefficient of Earth Pressure at Rest:

Σh = Ko. σv

Where,

σv = γ.h

= 2,65 x 8

= 21,2 kN/m²

Therefore,

σh = 0,5 x 21,2

= 10,6 kN/m²

Calculation of the Resulting Deflection

$$\delta = \left(\frac{PaH.L^3}{3EI}\right)$$

Where,

E = 4700√f'c

E = 4700√31,2

E = 26252,771 MPa = 2625277,1 t/m

$I = \left(\frac{bh^3}{12}\right)$

$I = \left(\frac{0{,}6 \times 8^3}{12}\right)$

$I = 25{,}6\ m^4$, The moment of inertia (I) is normalized using a reference length, which is taken as the height of the wall,

$I/H^4 = 25{,}6/8^4 = 0{,}00625$

$$\delta = \frac{22{,}434 \text{ x } 2{,}67^3}{3 \times 2625277{,}1 \times 0{,}00625}$$

= 0,0080 m = 0,80 cm

The wall experiences a lateral deflection of 0.80 cm. In accordance with SNI 1726:2019, which regulates the maximum allowable lateral deflection for structures

calculated as:

Limit = 0,5% x H

= 0,5/100 x 800 cm

Limit = 4 cm > 0,80 cm …… (Safe

Conclusion

Based on the evaluation of the effect of secant pile addition on the safety factor of the retaining wall in the Revitalization Project of Merdeka Square, Medan, the following conclusions can be drawn:

1. The results of the analytical calculations indicate that the retaining wall meets the required stability criteria. Specifically, the structure satisfies the control checks for shear resistance (non-sliding condition), overturning moment (non-overturning condition), and bearing capacity (supportive and safe). Therefore, the retaining wall is considered structurally stable and suitable for use as a basement wall, in accordance with Coulomb's stability theory.
2. Furthermore, based on the unit load method, the resulting wall deflection is 0.8 cm. This deflection remains within the acceptable limits as specified by design standards, indicating that the structural deformation is still permissible and does not compromise the safety or functionality of the retaining wall.

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