Jurnal Teknik Sipil & Perencanaan 26 (1) (2024) p 15 - 21

JURNAL TEKNIK SIPIL & PERENCANAAN

http://journal.unnes.ac.id/nju/index.php/jtsp/index

Analysis of the Finite Element Method in Reinforcing Soft Soil using Geotextiles

Pranadya Krida Palgunadi[1 a)], Togani C U[2]

Civil Engineering, Faculty of Engineering, Semarang State University, Semarang City, Indonesia; pranadya27@students.unnes.ac.id

[a)]Correspondence: pranadya27@students.unnes.ac.id

SUBMITTED March 24, 2025 **REVISED** March 24, 2025 **ACCEPTED** March 24, 2025

Abstract. This study focuses on the analysis of the finite element method for soft soil reinforcement using geotextiles in the Tambak Lorok area, Tanjung Emas Village, Semarang Utara District, Central Java. The research location was selected because this area is experiencing rapid economic and infrastructure development, but faces significant soil subsidence issues due to the high swelling-shrinking potential of clay soil. This subsidence negatively impacts building stability as well as the social and economic lives of the community. This study aims to evaluate the stability of fill soil with and without geotextile reinforcement using Plaxis 2D software. The research method used is quantitative, with analysis using Plaxis 2D to evaluate the stability of the original fill soil with and without geotextile reinforcement. The data used includes secondary data from government agencies and primary data from standard penetration tests (SPT) as well as interviews with local residents. This study is limited to the location on Tambak Mulyo Road, with aspects reviewed including the extent of soil subsidence and the safety factor of the fill. The software used is PLAXIS 2D, and Google Maps historical data and interview results are used for data validation. The analysis results show that the stability level of the original fill soil without geotextile tends to be lower, with significant soil settlement at the measurement point. Before the application of geotextile, the safety factor value of the fill soil was 1.407. After the application of geotextile with a tensile strength of 200 kN/m², the safety factor increased to 1.507. These results indicate that the use of geotextile is effective in enhancing the stability of fill soil in the Tambak Lorok area, North Semarang.

Keywords: Soil settlement, geotextile, safety factor, Plaxis 2D, Tambak Lorok

BACKGROUND

In every civil engineering project, soil is an important element that cannot be ignored. Many problems that often arise in civil engineering structures in the field are caused by poor soil properties, such as high water content, high compressibility, and low bearing capacity. Some types of soil with these poor characteristics tend to undergo significant volume changes due to swelling and shrinkage. As the capital of Central Java, Semarang has experienced rapid development in the fields of economy, industry, and infrastructure. However, this development poses challenges, particularly regarding environmental sustainability. Some soil types with high potential for swelling and shrinkage are those that undergo significant volume changes when their moisture content varies. Such soils are typically clay soils containing minerals with high swelling capacity. Soil with these characteristics is often referred to as clay soil. Soil subsidence in Semarang affects the stability of infrastructure buildings and has widespread impacts on the social and economic lives of the community. Residents in areas prone to soil subsidence face risks of house damage, cracked roads, and disruptions to drainage and sanitation systems. This leads to increased repair and maintenance costs and

can hinder regional economic growth. One of the common causes of building construction failure is land subsidence resulting from consolidation processes. This subsidence is caused by loads acting on the soil. If the subsidence occurs uniformly and is not excessive, it typically does not cause damage to buildings. However, if the subsidence occurs unevenly and excessively, it can lead to structural damage, disrupt building stability, and impair the aesthetics and comfort of building users. Research on land subsidence in Semarang is crucial for understanding the causes and mechanisms of land subsidence, as well as formulating effective strategies to mitigate its impacts. It is hoped that this research will contribute to the formulation of policies and practical steps to ensure environmental sustainability and improve the quality of life for the people of Semarang.

LITERATUR REVIEW

1) Land Subsidence
   Land subsidence is the phenomenon of a decrease in ground elevation due to natural factors or human activities. Natural factors causing land subsidence include natural sediment compaction, soil consolidation, and tectonic and volcanic activity. Anthropogenic factors contributing to this phenomenon include excessive groundwater exploitation, infrastructure loads, and land use changes such as reclamation and agriculture. Land subsidence can be classified into two main types: immediate settlement and consolidation settlement. Immediate settlement occurs due to direct loads on elastic soil and is difficult to predict, while consolidation settlement is caused by changes in soil volume due to the release of pore water over a certain period of time.

2) Safety Factor
   The safety factor in geotechnical engineering is an important parameter used to assess the stability of soil embankments against potential failure. This factor is calculated as the ratio between the available shear strength of the soil and the shear stress acting on the embankment. In this study, the safety factor was analyzed using the finite element method with PLAXIS 2D software. Calculations were performed by identifying weak planes in the soil layers, then gradually reducing the cohesion and friction angle values until reaching critical conditions.kritis.

TABLE 1. Recommended Safety Factor Values for Rock Slopes
(Source: SNI 8460:2017)

Rock Slope Conditions	Recommended Safety Factor Values
Long-Term Conditions	1,5
Short-Term Conditions	1,3

3) Geotextile
   Geotextile is a geosynthetic material in the form of textile made from synthetic fibers, with high flexibility, and resistant to chemical reactions and weather conditions. In civil engineering, geotextile functions as a separation layer, filtration layer, drainage layer, soil reinforcement, and moisture barrier. The use of geotextiles in civil engineering projects offers several key benefits, such as improving soil stability in high embankments or slopes, reducing the risk of landslides, and enhancing infrastructure resistance to deformation caused by dynamic loads. Additionally, geotextiles aid in soil compaction and reduce erosion in soft soil layers.

FIGURE 1. Non-woven geotextile
(Source : Polyfabrics.com.au)

RESEARCH LOCATION

This research was conducted in Tambak Lorok Village, Tanjung Emas Subdistrict, Semarang Utara District, Central Java, which is a coastal area with a high rate of land subsidence. Land subsidence in Tambak Lorok has serious impacts on the lives of the community, including increased frequency of tidal flooding, damage to buildings, and disruptions to drainage and sanitation systems. Therefore, this study focuses on analyzing the stability of fill soil reinforced with geotextiles using PLAXIS 2D software to mitigate the negative impacts of land subsidence and enhance the safety factor of the fill.

FIGURE 2. Research Location

METHOD

This study uses quantitative methods, which focus on processing numerical data with statistical analysis to obtain objective and measurable results. The data used consists of primary and secondary data.

1. Data Collection Method
   a) Primary data was obtained through standard penetration tests (SPT) to analyze the geotechnical characteristics of the soil at the research site.
   b) Secondary data was obtained from government agencies, including geological maps, land subsidence data, and information related to geotechnical conditions in the research area.
2. Data Analysis Method
   This study uses PLAXIS 2D software, based on the finite element method, to simulate the stability of soil fill with and without geotextile reinforcement. The analysis includes:
   a) Determination of soil subsidence values at various measurement points.
   b) Evaluation of the safety factor of soil fill before and after geotextile reinforcement.

RESARCH RESULTS

This section explains the results and analysis based on the data processing that has been carried out. Data analysis was performed to determine the settlement values and safety factors of the embankment before and after reinforcement with 200 kN/m tensile strength geotextile using PLAXIS 2D.

1. Settlement values before geotextile reinforcement

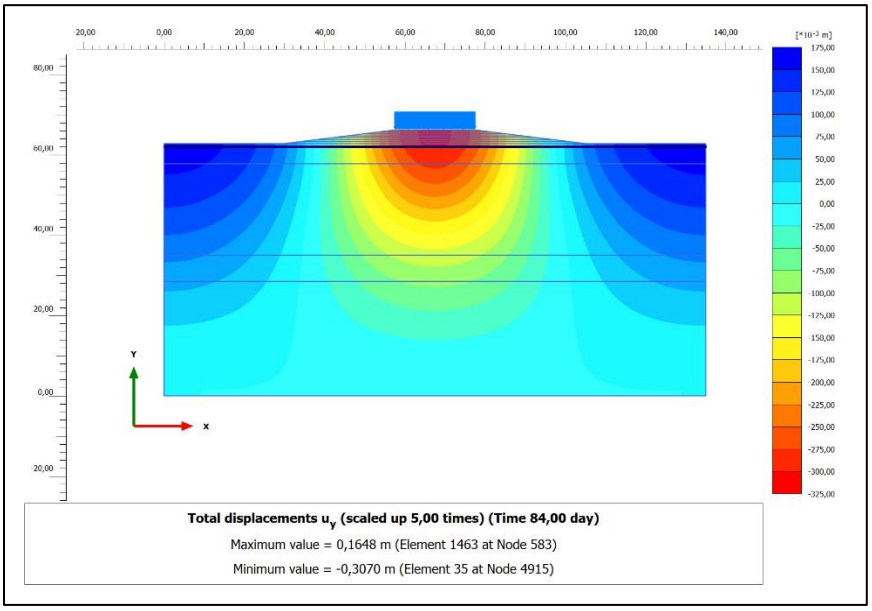

FIGURE 3. Value of the heap reduction before being given geotextile reinforcement

2. Safety factors before being given geotextile reinforcement

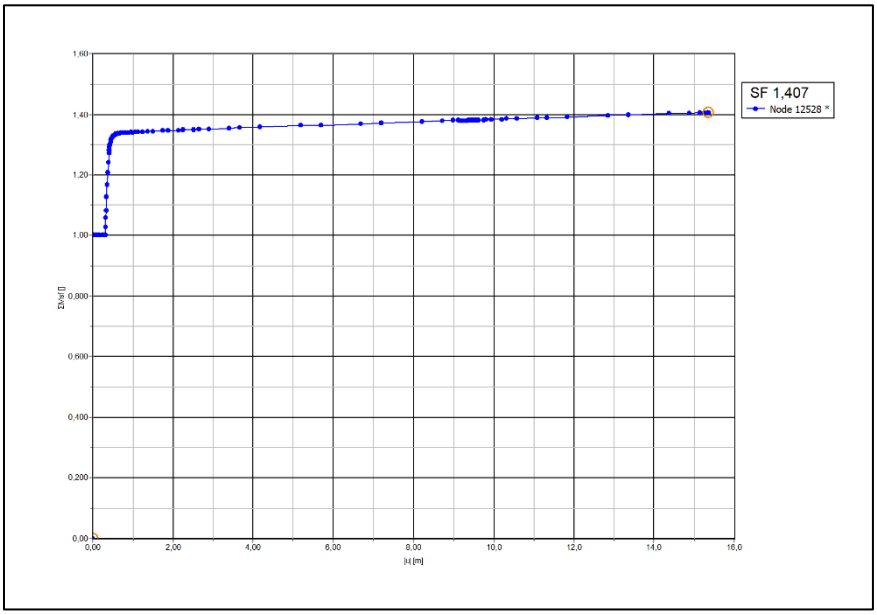

FIGURE 4. Graph of the safety of the stockpile factor before being reinforced with geotextiles

From the results of the analysis of the soil pile before being given the above geotextile reinforcement, a decrease value of 0.3070 m and a safety factor value of 1.407 were obtained. Then a stockpile analysis was carried out with geotextile reinforcement with a tensile strength specification of 200 kN/m.

3. Degradation value after being reinforced with 200 kN/m geotextile reinforcement

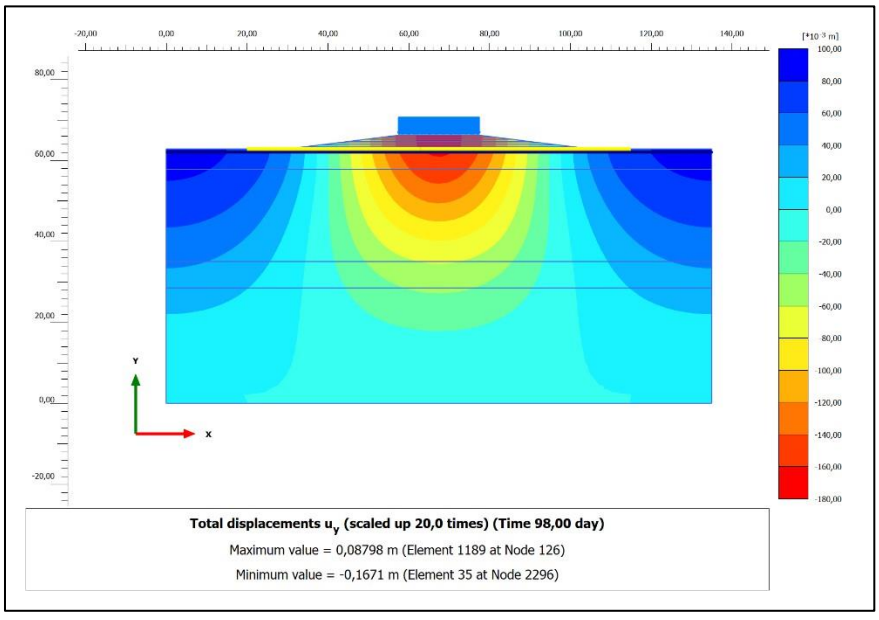

FIGURE 5. The value of the downfill after being reinforced with 200 kN/m geotextiles.

4. Safety factor after being reinforced with 200 kN/m geotextile

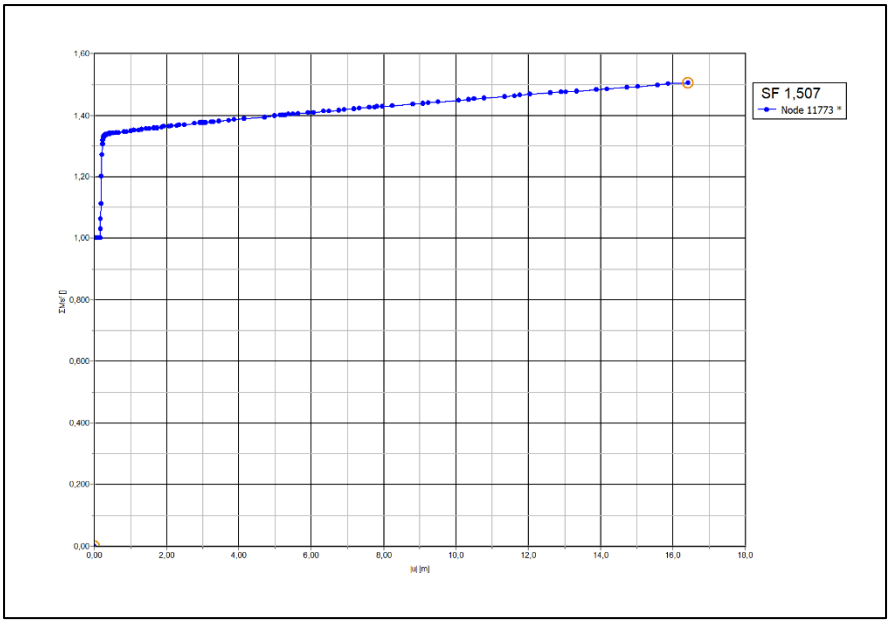

FIGURE 6. Graph of the safety of the stockpile factor after being reinforced with 200 kN/m geotextile

In the analysis of the heaps after being given geotextile reinforcement with a tensile strength specification of 200 kN/m, a decrease value of 0.1671 m and a safety factor value of 1.507 were obtained.

CONCLUSION

Based on the analysis of the value of the decline and safety factors that have been carried out on the soft soil of Kampung Tambak Lorok, North Semarang, Semarang City, Central Java, it can be concluded that in the heap before being given geotectile reinforcement there was a decrease of 0.3070 meters in the vertical direction and a safety factor of 1.407 was obtained, referring to SNI 8460:2017 for long-term construction safety factors the value above is not qualified or it can be said that the heapland is unstable. Then for the stockpile after being strengthened with a geotextile with a tensile strength of 200 kN/m, a decrease value of 0.1671 m was obtained in the vertical direction and a safety factor value of 1.507, referring to SNI 8460:2017 for long-term construction in the analysis of the stockpile after being given the reinforcement of the geotextile of 200 kN/m can be said to be stable.

PENAFIAN

This article aims to provide general information about civil engineering and is not professional advice. The author and publisher are not responsible for any errors, omissions, or repercussions of the use of this information. Always consult with the relevant engineer or expert before implementing the concepts discussed.

AVAILABILITY OF DATA AND MATERIALS

The data and materials used in this article are obtained from relevant and accountable sources. However, the author does not guarantee the accuracy, completeness, or novelty of the information presented. Fully use of the data and materials in this article be the responsibility of the reader If required, the reader may contact the author for further information regarding the availability of data and related materials.

THANKS

With great respect, I would like to thank Prof. Dr. Rini Kusumawardani, S.T., M.T., M.Sc., for the guidance, knowledge, and direction that has been given during the process of compiling this article. The support and insight that you provide are very helpful in understanding and developing the topics discussed. Hopefully the knowledge that has been taught will be a valuable provision for me and other colleagues.

Thank you also to friends who have provided support, discussion, and enthusiasm in completing this article. The togetherness and cooperation that has been established is very meaningful in this academic journey.

REFERENCES

[1] Abidin, HZ, Andreas, H, Gumilar, I, Sidiq, TP, & ... (2013). Land subsidence in coastal city of Semarang (Indonesia): characteristics, impacts and causes. *... , Natural Hazards and i...*, Taylor &Francis, https://doi.org/10.1080/19475705.2012.692336

[2] Abidin, HZ, Djaja, R, Darmawan, D, Hadi, S, Akbar, A, & ... (2001). Land subsidence of Jakarta (Indonesia) and its geodetic monitoring system. Natural Hazards, Springer, https://doi.org/10.1023/A:1011144602064

[3] Holzer, TL, & Galloway, DL (2005). Impacts of land subsidence caused by withdrawal of underground fluids in the United States., pubs.geoscienceworld.org, https://pubs.geoscienceworld.org/gsa/books/edited-volume/921/chapter/4847138

[4] Kasfari, R., Yuwono, B. D., & Awaluddin, M. (2018). Pengamatan Penurunan Muka Tanah Kota Semarang Tahun 2017. Jurnal Geodesi Undip, 7(1), 120-130.

[5] Melle, D. A., & Jatmiko, P. (1999). Pemakaian Geotekstil sebagai Perkuatan Tanah Lunak pada Badan Jalan.

[6] Siswanto, A. B., Wijaya, U., & Widawati, E. (2023). Perbaikan Tanah Lunak Untuk Konstruksi Jalan Pada Proyek Jalan Lingkar Utara Brebes Tegal. Journal Of Civil Engineering And Technology Sciences, 2(1), 31-43.

[7] Umum, K. P., & Rakyat, P. (2017). Manual Perkerasan Jalan. Direktorat Jenderal Bina Marga. Jakarta.