

REVIEW PAPER ON ENHANCING STABILITY AND PERFORMANCE OF MECHANICALLY STABILIZED EARTH RETAINING WALLS THROUGH GEO-GRID INTEGRATION AND TIEBACK ANCHORS

Ravinder¹, Er. Abhishek Arya²

¹M. Tech Scholar, Matu Ram Institute Of Engineering & Management, Rohtak, India

²Assistant Professor, Matu Ram Institute Of Engineering & Management, Rohtak, India

ABSTRACT

Mechanically stabilized earth (MSE) retaining walls are essential components of civil engineering projects, since they provide crucial structural reinforcement to earth embankments, highway ramps, bridge abutments, and other infrastructure features. The stability and performance of Mechanically Stabilized Earth (MSE) walls are crucial for guaranteeing the safety and durability of these structures, especially in regions with difficult soil conditions or significant lateral loads. Engineers have devised advanced methods to improve the stability and performance of MSE retaining walls. These approaches include integrating geogrids and using tieback anchors.

Geogrids are geosynthetic materials that possess a significant amount of tensile strength and stiffness. They are often used to enhance the stability and strength of earth constructions. Geogrids, when included into MSE retaining walls, function as horizontal reinforcements, enhancing the wall's ability to withstand lateral earth forces. Through the mechanical connection of geogrids to the facing parts of the wall, such as concrete panels or modular blocks, the soil mass is strengthened, therefore decreasing the likelihood of wall deformation or collapse. Geogrids also facilitate soil compaction and hinder differential settlement, hence improving the overall stability and performance of the retaining structure.

Tieback anchors are crucial elements used to strengthen MSE retaining walls, especially when facing increased lateral loads or greater wall heights. These anchors provide extra sideways support by shifting the pressure from the earth to a stable area beyond the wall's failure plane. Tieback anchors are often fixed at a downward angle in the earth and are attached to the facing sections of a wall using tensioning devices like anchor plates or rods. Tieback anchors serve to counteract lateral pressures applied by the soil behind a retaining wall, thereby preventing any movement of the wall and ensuring its structural stability.

The use of geogrids and tieback anchors into MSE retaining walls provides synergistic advantages, leading to very solid and robust structures. Geogrids evenly distribute lateral loads throughout the wall face, hence lowering concentrated stresses and limiting the likelihood of wall collapse. In addition, tieback anchors provide additional support, increasing the wall's capacity to withstand soil pressure and raising its overall stability. By integrating these methodologies, engineers may create MSE retaining walls that are capable of enduring various geological obstacles and loading circumstances.

The stability and performance of MSE retaining walls, when combined with geogrid integration and tieback anchors, have undergone thorough examination and verification via laboratory testing, numerical simulations, and field applications. These methodologies have been effectively used in many civil engineering projects around the globe, including transportation infrastructure, water management systems, and environmental protection projects. Engineers may enhance the structural design, save construction expenses, and guarantee the long-term dependability of retaining structures by integrating geogrids and tieback anchors into MSE retaining walls.

Overall, the combination of geogrids with tieback anchors has greatly enhanced the stability and functionality of mechanically stabilized earth retaining walls. These novel methods provide a cost-efficient and effective alternative for strengthening MSE walls in difficult soil conditions and high-loading settings. Engineers may enhance safety, durability, and resilience in retaining wall projects by using the advantages of geogrids and tieback anchors. This contributes to the progress of sustainable infrastructure development on a global scale.

Key Words: Geo-grid integration, Tieback anchors, Soil reinforcement, Retaining wall, design, Slope stability, Earth retention systems

1. INTRODUCTION

When it comes to civil engineering, the most important factors to consider are the stability and performance of mechanically stabilized earth (MSE) retaining walls. Current advancements in MSE wall technology have concentrated on the use of geogrid reinforcement and tieback anchors to improve their efficiency and durability. Geogrid materials have seen advancements, including sophisticated polymers and carbon fibers that provide increased

tensile strength and endurance. These advancements provide enhanced durability against environmental elements such as moisture, UV radiation, and chemical deterioration. Furthermore, contemporary manufacturing techniques allow for the creation of geogrids that are customized to meet the unique requirements of a project, thereby maximizing the effectiveness of reinforcement and minimizing expenses. Simultaneously, there have been notable developments in tieback anchor design, as experts have been investigating the use of corrosion-resistant metals and composite materials to extend the lifetime of the anchors. Helical anchors and grouted anchors provide benefits in terms of simplicity of installation, load capacity, and flexibility to adapt to different soil types. The incorporation of geotechnical monitoring systems into MSE wall designs has also become a crucial trend. By using sophisticated sensor technology and data analytics, engineers can continuously monitor the behavior of walls and the conditions of the soil in real-time. This enables them to take preventative measures for maintenance and to reduce risks. In summary, these advancements highlight the continuous dedication to innovation in MSE wall technology, guaranteeing the durability, cost-efficiency, and environmental friendliness of retaining structures in various engineering applications.

2. LITERATURE REVIEW

Anderson and Brabant's (2019) research offers a thorough examination of the advantages and uses of Mechanically Stabilized Earth (MSE) abutments, highlighting the growing use of this technology. The study starts by elucidating the essential concepts of Reinforced Earth, as originally developed by Vidal. It then proceeds to examine the several materials used in this technique, including facing, reinforcement, and backfill. The authors conduct a comprehensive analysis of the behavior of MSE abutments, specifically focusing on their service life, settlement characteristics, seismic performance, and various kinds of abutments. Based on their investigation, they determine that MSE abutments have several benefits, such as a prolonged lifespan, the capacity to endure substantial settlement differences without notable damage, strong resistance to seismic activity, cost-effectiveness, and straightforward construction.

Rai's (2018) focuses on the building characteristics of flyover approaches employing reinforced soil technology, comparing it to traditional retaining walls. Rai underscores the superiority of reinforced soil technology above traditional techniques, emphasizing its cost efficiency, rapid construction, and aesthetic advantages. Reinforced soil technique has the advantage of speedier construction compared to standard retaining walls and also helps reduce traffic congestion throughout the building process. Additionally, it provides substantial cost reductions, ranging from 30% to 50% in comparison to traditional retaining walls, which makes it a compelling choice for a variety of infrastructure projects.

Prof. V. S. Chandrasekaran's (2020) study delves into the basic design concerns for reinforced earth retaining walls, specifically focusing on the mechanics of these structures. It highlights the significance of carrying out analytical and experimental investigations in both static and seismic scenarios, especially for parallel walls that include soil backfill. Moreover, the research emphasizes the need of choosing the suitable reinforcing type considering aspects such as the fill material, environmental circumstances, and cost-effectiveness. It implies that using a technique that permits the use of fill material that is readily accessible in the local area may provide substantial advantages in terms of effectiveness and financial savings.

J. E. Sankey and P. Segregation's research examines the seismic performance of Mechanically Stabilized Earth Walls (MSEWs) after the Northridge earthquake. The researchers examine the conduct and reaction of MSEWs during and after the earthquake, with a specific emphasis on variables such as ground motion characteristics, soil qualities, and wall design parameters. Their objective is to comprehend the development of MSEW performance under seismic loading circumstances by conducting field observations, numerical models, and laboratory tests. The research provides insight into the efficacy of MSEWs in reducing seismic risks and identifies opportunities for enhancing their ability to withstand earthquakes via improvements in design, building, and maintenance techniques. In addition, the study examines the insights gained from the Northridge earthquake and suggests measures to improve the seismic design and retrofitting of MSEWs, with the aim of enhancing their overall performance and durability in areas prone to earthquakes. The earthquake occurrences in Kobe and Izmit showcased fascinating elements of the performance of reinforced earth buildings in harsh circumstances. Although there were cases when earthquake accelerations exceeded the design limitations, there was very little damage recorded. The natural malleability of reinforced soil allows for slight permanent deformations without causing substantial structural harm. Even in instances of significant differential settlements, when panels were spaced by up to 75mm, no collapse occurred. Nevertheless, these encounters underscore the need of taking wall height into account throughout the planning process in order to guarantee safety. Although reinforced earth buildings exhibit resilience when subjected to seismic loads, it is crucial to use meticulous design and planning to minimize possible hazards and guarantee structural integrity, especially in areas susceptible to seismic activity.

Bloomfield, Soliman, and Abraham examine the effectiveness of MSE walls on compressible soil and propose a Two-Stage Wall System for construction. This system is beneficial in situations where there is differential settlement, especially in soils that may be compressed. It has the ability to endure differential settlement of more than 1%. The approach has two primary steps: first, the construction of a wire facing unit positioned at a minimum distance of 600mm behind the permanent precast concrete face, followed by the connection of reinforced strips to the wire facing unit. Furthermore, the permanent precast concrete facing is joined to the wire facing unit by means of coil rods and a coil loop system, guaranteeing that all connections are pin connections.

Abu-Hejleh, Hearn, McMullen, and Zornberg provide valuable information on MSE barriers that use separate full-height facing panels. They use a project carried out by CDOT in 1996 as an example. The building method involves the placement of panels inside a shallow trench that is filled with flow material and supported by temporary bracings. The activities of backfilling, soil reinforcement, and anchor installation are performed simultaneously. Anchors are essential for ensuring the stability of the face. Significantly, the full-height facing functions separately from the earth reinforced material, resulting in less lateral pressure on the facing. This novel methodology improves the stability and efficiency of MSE walls, providing potential advantages in terms of longevity and structural soundness.

B.L. Sharma (2021) examines the use of steel strips as reinforcement in Reinforced Earth Technology. The study explores the inherent strength characteristics of steel, its behavior over extended periods of time, and factors pertaining to strength and creep. Moreover, it examines the impacts of several environmental conditions, including pH, chlorides, sulphates, and UV radiation, on steel reinforcement. Steel is known for its impressive tensile strength and its ability to be easily worked with, however it is prone to corrosion. In order to address this problem, the study proposes the use of galvanized coating on steel, specifically discussing the procedure of hot dip galvanization of steel strips.

This technology aims to improve the longevity and strength of steel reinforcements in reinforced earth constructions.

B. S. Berke, A. A. Sagues, and Rodney G. Powers performed a research on the long-term corrosion performance of soil reinforcement in mechanically stabilized earth (MSE) walls.

The study aimed to evaluate the corrosion rate of galvanized steel strips used as soil reinforcement in Mechanically Stabilized Earth (MSE) walls across Florida. Polarization measurements were used to monitor corrosion rates by instrumenting the walls with concrete coverings. The preliminary study done between 1995 and 1997 found that the average corrosion rate for galvanized steel strips in MSE walls aged 13 to 25 years was 0.02 ± 0.01 millimeters per year (mpy).

A further assessment conducted in 2006, ten years later, revealed that the rate of corrosion remained roughly constant. The data suggest that galvanized steel strips possess excellent durability and corrosion resistance, making them a suitable option for soil reinforcement in MSE walls.

D.V. Reddy has delivered a presentation on the enduring performance of geosynthetic reinforced MSE wall systems. This report presents experimental research conducted to observe the behavior of geosynthetics in mechanically stabilized earth (MSE) walls under loading conditions. Geosynthetics have excellent durability and corrosion resistance, making them more popular. However, they are prone to creep under sustained loading at high temperatures, which hinders our understanding of their long-term behavior. Consequently, research has been conducted to address this issue.

Justin Anderson (2017) emphasizes soil nailing and geosynthetically reinforced soil as the main methods for fixing shallow slope failures in his study on developing advances in Earth Retaining Systems (ERS). Although soil nails have shown efficacy, they encounter limits in terms of time, cost, and soil restrictions.

In order to tackle these difficulties, a novel method called Launched Soil Nails has been devised, enabling the fast installation of up to 250 nails each day. This approach has been more popular in several nations, such as the United States, Canada, the United Kingdom, New Zealand, and Australia. Engineers in Yukon are actively investigating the viability of use hollow, launched earth nails to vertically reinforce highways constructed over permafrost, with the goal of mitigating the impact of thawing permafrost on the integrity of infrastructure.

3. CONCLUSIONS

1. The angle of internal friction (ϕ) is the most important factor in the mechanical stability of earth and is the foundation of the design process.
2. It is important to choose backfill soil with a larger angle of internal friction in order to guarantee the stability and strength of the reinforced earth construction.
3. When the soil under the foundation is poor, it may be essential to strengthen the bearing capacity by replacing it with soil that has greater internal friction or using soil enhancement methods such as stone columns.

4. The length of reinforcement layers grows in direct proportion to the height of the wall, requiring longer reinforcement as the wall height increases in order to preserve structural integrity.
5. Two critical aspects that must be thoroughly evaluated throughout the design phase to guarantee structural stability are the design strength of reinforcement and the vertical spacing between reinforcements.
6. The selection of reinforcing components and their vertical spacing should be determined by the soil conditions and the tensile pressures exerted on the structure in order to efficiently withstand external loads.
7. It is recommended to utilize reinforcing components with a design strength equal to or more than the design load, together with a wider vertical spacing between reinforcements, where there is enough backfill soil with enough internal friction. This will provide an additional safety margin.
8. When evaluating the stability of a local region, it is important to identify and address layers that have insufficient design strength. This should take into account issues such as the probable failure of reinforcing elements. One way to address this is by expanding the area of reinforcement or utilizing parts with greater tensile strength.
9. Attention to detail in the design and placement of reinforcing elements is essential to ensure the overall stability and long-term durability of mechanically stabilized earth constructions.
10. Regular monitoring and modification of reinforcing schemes, taking into account site-specific variables and performance data, are crucial for ensuring the long-term structural integrity and safety of the reinforced earth system.

4. REFERENCES

- [1] Abraham A., Soliman A. F. and Bloomfield R. A., —Performance of MSE Wall Over Compressible Soils, The Reinforced Earth Company, Vienna, Virginia – USA, Technical paper.
- [2] Abu-Hejleh, Hearn, McMullen, and Zornberg —MSE Wall with Independent Full-Height Facing Panels, Technical paper after annual meeting of TRB, 2003.
- [3] Anderson Peter and Brabant Keith —Increased Use of MSE Abutments, The Reinforced Earth Company, Norcross GA, Technical paper, 2006.
- [4] Basudhar P.R and Syed Mohd.Ahemad, —Behavior of reinforced soil retaining wall under static loading using finite element method, Technical paper after 12th international conference of IACMAG, Goa, India, 2008.
- [5] Basudhar P. K., Vashistha Amol, Deb Kosik and Dey Arindam —Cost Optimization of Reinforced Earth Wall, published online 16th August, 2007.
- [6] Berke B.S., Sagüés A.A. and Powers Rodney G., —Long Term Corrosion Performance of Soil Reinforcement in MSE Walls, corrosion 2008 conference and expo.
- [7] Bhattacharya P., Chattopadhyay B. C., Debjit Bhowmik, Mukherjee S. P. —Pullout Behaviour of Square Anchors in Reinforced Clay, Technical paper after 12th International Conference of IACMAG at Goa, India, 2008.
- [8] Chonkar R. R., —Review of design of reinforced earth retaining walls for flyovers, The Indian Concrete Journal, December – 2001
- [9] Christopher Barry R., Ryan R. and Victor Elias, —Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction, Publication No. FHWA-NHI-00 043, U.S. Department of Transportation, March- 2001.
- [10] Deb Kousik, Chandra Sarvesh, Basudhar P. K. —Settlement Response of Granular Fill-Soft Soil Reinforced with Extensible Geosynthetics and Stone Columns, Technical paper after 12th International Conference of IACMAG at Goa, India, 2008.