XXII Congresso Brasileiro de Mecânica dos Solos e Engenharia Geotécnica
XI Simpósio Brasileiro de Engenheiros Geotécnicos Jovens
24 a 28 de agosto de 2026 – Brasília/DF
DOI: 10.47094/COBRAMSEG2026.6/41

Exploring the Feasibility of Cohesive Soils in Reinforced Walls: A Review of Performance and Environmental Implications

Gabriel da Silva Silverio
PhD Student, São Carlos School of Engineering - University of São Paulo, São Carlos, Brazil, gabrielsilverio@usp.br

Nicole Hansen
PhD Student, São Carlos School of Engineering - University of São Paulo, São Carlos, Brazil, nicolehansen@usp.br

Jefferson Lins da Silva
Associate professor, São Carlos School of Engineering - University of São Paulo, São Carlos, Brazil, jefferson@sc.usp.br

ABSTRACT: In the 1970s, geosynthetics began to be used as reinforcement elements, providing a viable alternative to concrete structures, mainly due to the lower costs of using soil as a construction material. However, for technical, geographical, and historical reasons, most studies on geosynthetic-reinforced walls have focused on using granular soils as backfill material. As a result, design guidelines and technical standards were developed with specific recommendations regarding the type of soil to be used, generally limiting the use of soils with fines. Often, however, in the areas where these structures are implemented, there is little or no availability of granular material, necessitating the transport of granular material—which increases costs and environmental impacts. In this context, the scarcity of granular materials due to increased demand from urban growth has highlighted the need for research on using cohesive soils in reinforced walls. Thus, this paper aims to review the technical literature to explore the performance of walls constructed with cohesive soils, the main environmental benefits of this usage, and the methods that consider soil cohesion in predicting the demand for reinforcements.

KEYWORDS: Geosynthetic-reinforced walls, cohesive soils, design methods, environmental benefits.

1 INTRODUCTION

Reinforced walls with geosynthetics (GRW) are defined as retaining solutions composed of compacted soil, facing elements, and drainage systems. The inclusion of passive geosynthetic reinforcements enhances stability through direct interaction with the soil. Since their inception, GRW have been recognised as efficient retaining solutions, offering economic and environmental benefits over the short, medium, and long term (Basu; Lee, 2021).

Over the past decades, the successful use of GRW in large-scale civil and infrastructure projects has spurred numerous studies comparing the economic viability of this solution with conventional systems involving concrete and steel. Results under various conditions have shown that GRW can be 25%–70% less expensive than traditional retaining walls, depending on factors such as foundation soil, backfill material, and wall height. A significant contributor to this cost efficiency is that geosynthetic reinforcements are more affordable than steel, accounting for only 15%–30% of the total structural cost (Christopher et al., 1990; Berg et al., 2009; Gupta et al., 2024).

As final decisions are often based on resource optimisation, many studies focus on highlighting the economic benefits of GRW while neglecting their environmental impact. However, with growing concerns about climate change and global climate agendas, sustainable development has become a key consideration in engineering projects (Damians et al., 2017; Zhu et al., 2022; Dąbrowska et al., 2023)

In this context, this paper aims to evaluate the use of geosynthetics combined with cohesive soils as an environmentally friendly alternative to conventional materials in retaining structures. The study explores and reviews the technical applicability of cohesive backfills, highlighting their environmental advantages, mechanical behavior, and the design methods required for reinforced walls using these materials.

2 APPLICABILITY OF COHESIVE SOILS AND ENVIRONMENTAL ADVANTAGES

To promote more sustainable and cost-effective practices, the use of local soils in the construction of geosynthetic-reinforced walls — even when these soils contain fine particles — has become a significant topic of discussion within the technical community. According to Malekmohammadi and Damians (2024), most of the published studies on reinforced walls originate from countries in the Northern Hemisphere, as shown in Figure 1, which illustrates the global distribution of research on geosynthetic-reinforced walls from 1990 to 2024.

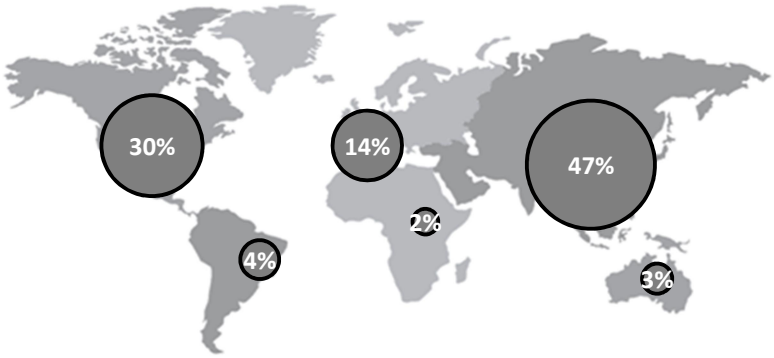


Figure 1. Distribution of scientific production about reinforced walls (1990-2024) according to Malekmohammadi and Damians (2024).

The figure shows that nearly all research has been conducted in regions with temperate climates and abundant granular soils. As a result, many countries have developed requirements for using soils as backfill materials, (Table 1. Standard recommendations for the backfill soil) presents some of these specifications drawn from design standards and guidelines.

Table 1. Standard recommendations for the backfill soil

Country	Material passing #200 (0.75mm)	Plasticity index	Reference
Australia	≤ 15%	≤ 12	(RTA, 2011)
Canada	≤ 12%	≤ 6	(CGS, 2023)
Hong Kong	≤ 10% (0.63mm)	≤ 20	(GEO, 2017)
UK	≤ 15% (0.63mm)	-	(BSI, 2010)
India	≤ 15%	≤ 6	(RTA, 2011)
	≤ 15%	≤ 6	(Berg et al., 2009)
USA	≤ 35%	≤ 20	(NCMA, 2010)
	≤ 15%	≤ 6	(FHWA, 2018)

However, in countries outside the Northern Hemisphere — especially tropical regions — the availability of clean, purely granular soils are more limited. As shown in Figure 2, there is a greater abundance of fine-grained or fine-granular soils. Thus, in many construction sites, whether in the Southern Hemisphere or even in some parts of the Northern Hemisphere, the soils encountered do not meet the specifications required by current design guidelines. Consequently, granular backfill often needs to be transported from distant locations, and in such cases, transportation costs can represent 50%–70% of the total

project cost. Therefore, using local marginal soils offers economic benefits and helps reduce greenhouse gas emissions associated with material transportation (Koerner; Koerner, 2011).

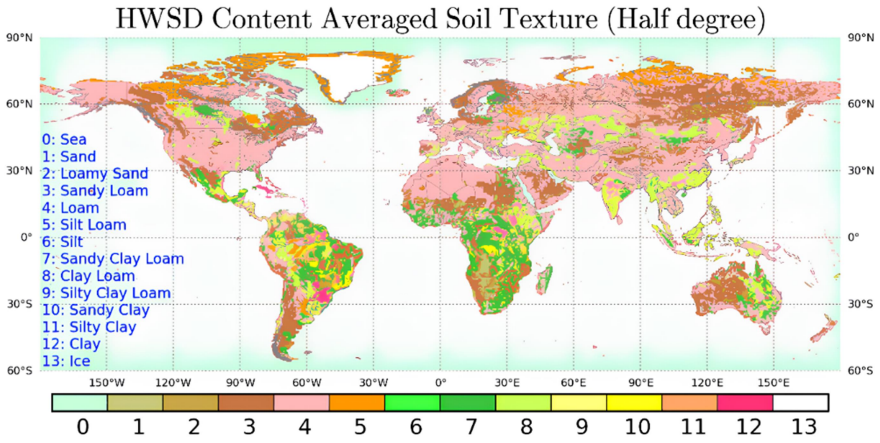


Figure 2. Global distribution of soil based on Harmonized World Soil Database (HWSD) estimated by averaging the contents of clay, sand, and silt (Koiral, 2013).

In light of growing concerns about climate change and the environmental impact of engineering projects, some authors have investigated how using marginal soils can make retaining structures more sustainable (Stucki et al., 2011; Koerner et al., 2019; Basu; Lee, 2021; Morsy; Thakeb, 2022; Zhu et al., 2022; Gupta et al., 2024). These studies concluded that geosynthetic-reinforced walls can contribute to 9 of the 17 United Nations Sustainable Development Goals (SDGs), as shown in Table 2. Relationship Between Geosynthetic-Reinforced Walls and Sustainability. Due to the use of local soils and the lower energy required for installation compared to conventional concrete structures, GRW can reduce carbon footprint by 24% to 69%.

Regarding the global distribution of soil types, some researchers have discussed why fine-grained soils are often overlooked in the literature. One key reason is their lower drainage capacity, which can reduce shear strength and lead to significant deformations. Additionally, reinforcements may offer limited advantages due to soil cohesion since the drained shear strength governs the soil-reinforcement interface behaviour. Another important factor is that geosynthetics were originally developed to interact with granular soils. Early studies were conducted mostly in regions where such soils were readily available, and the resulting design methods and standards have since focused primarily on granular materials as suitable backfill (Zornberg et al., 1994; Gofar; Hanafiah, 2018).

Table 2. Relationship Between Geosynthetic-Reinforced Walls and Sustainability (Morsy; Thakeb, 2022).

SDG Goal	Contributions
Goals 3 (Good Health and Well-Being)	Reducing air pollution by minimising photochemical ozone production, acidification and eutrophication.
Goal 6 (Water)	Contribute to reduce water depletion.
Goal 7 (Energy)	This solution requires low energy for installation.
Goal 9 (Industry, Innovation and Infrastructure)	Contributes to lower CO_2 emissions and ODP values, supporting sustainable development.
Goal 11 (Sustainable Cities and Communities)	It is the most sustainable retaining solution, contributing positively to economic, social, and environmental outcomes.
Goal 12 (Responsabile Consumption and Production)	Contributes to the sustainable use of natural resources.
Goal 13 (Climate Action)	Promotes green initiatives and raises awareness about the applicability of new technologies and policies in combating climate change.

Goal 14 (Life Below Water)	Reducing water eutrophication and acidification.
Goal 14 (Life on Land)	Reducing land eutrophication and acidification.

3 MECHANICAL BEHAVIOUR AND DESIGN METHODS OF REINFORCED WALLS WITH COHESIVE SOILS

With the growing emphasis on sustainability and circular economy principles in civil engineering, professionals have been encouraged to develop solutions that minimize environmental impacts and optimize available materials (Palmeira et al., 2021). Despite this shift, the existing literature on geosynthetic-reinforced structures still presents gaps, such as the mechanical behaviour of reinforced walls with cohesive soils and the incorporation of soil cohesion into design methodologies. These challenges highlight the need for advancements in design approaches, especially those capable of estimating reinforcement loads under non-standard soil conditions used as backfill material (Giglio et al., 2023; Miyata, 2023).

Studies on the mechanical behaviour of geosynthetic-reinforced walls using marginal soils as backfill have shown that the drainage system is the most critical component of the structure, particularly during the rainy season (Koerner; Koerner, 2011; Koerner et al., 2019). In this regard, Koerner and Koerner (2011) emphasized the importance of proper drainage control methods in structures with cohesive backfill soils. According to the authors, among 82 wall failure cases due to excessive deformation or collapse, 68% were attributed to problems with either the internal drainage system (46%) or the external drainage system (22%).

Similarly, an assessment by Koerner and Koerner (2013), which analyzed 171 walls in the United States that experienced significant deformations, found that nearly 60% of those that reached failure or serviceability limits exhibited issues related to drainage. As supported by Yang et al. (2018), water in the reinforced zone leads to two main effects: increased pore water pressure and soil thrust against the facing, and a reduction in soil-geosynthetic interface strength due to loss of matric suction. Both effects contribute to global and local deformations.

In this sense, walls with an efficient drainage system and a backfill compacted to at least 95% of the maximum dry unit weight benefit from the development of matric suction, which enhances performance, often making it comparable or even superior to walls constructed with granular materials (Benjamim et al., 2007; Vahedifard et al., 2016). Marginal cohesive soils can exhibit a wide range of properties. Those with lower fine content typically show greater shear strength than soils with higher fine content. According to international guidelines (Table 1), the ideal backfill material should have low plasticity and a low percentage of fines. Although these recommendations are common globally, they may not always reflect local soil distributions. For instance, tropical soils—characterized by high fine content and low plasticity—can perform well mechanically when properly compacted, in contrast to soils formed in temperate regions (Raja et al., 2012).

Regarding the role of compaction in wall performance, Vahedifard et al. (2016) and Raja et al. (2012) noted that well-compacted fine-grained soils placed near optimum moisture content generate suction, resulting in a relatively strong interaction between the fill and geosynthetic reinforcement. Besides increasing soil strength, compaction also influences service performance. A numerical study by Meireles et al. (2022) on cohesive reinforced walls showed that increasing the heavy compaction distance from the face reduces reinforcement stresses, shifts maximum reinforcement tension points inward, and decreases horizontal face deformations. On the same topic, Riccio et al. (2014) monitored a highly instrumented 4.2 m-high block-faced geogrid wall built with fine-grained tropical soils. The study assessed reinforcement tension induced by soil compaction, matric suction, and horizontal face displacements. Results revealed that induced stresses from compaction, soil cohesion, and stiffness should not be neglected.

The numerical study by Guler et al. (2007) investigated the influence of cohesion on reinforcement loads, showing reduced reinforcement demands without localized shear-induced deformations. Similarly, Anderson et al. (2018) found that typical cohesive strengths around 10 kPa can reduce reinforcement stresses by 50% to 75%. Another critical mechanism is crack formation in the backfill soil caused by tensile stresses. Cracks may result from low tensile resistance, wetting-drying cycles, desiccation, or weathering. While geosynthetics help limit crack development, the presence of cracks can significantly compromise stability (Utili, 2013).

These findings demonstrate the complex mechanical behaviour of geosynthetic-reinforced walls due to interactions between multiple materials. Several methods have been developed to verify internal stability and determine the required reinforcement load to prevent rupture and sufficient length to avoid pullout. However, early methods considered only granular backfill soils, excluding fine-cohesive soils. As noted by some authors (Allen et al., 2003; Raja et al., 2012; Mandloi; Hegde, 2022), this oversight can lead to overdesigned structures or less optimized economic and environmental alternatives and full-scale instrumented walls and numerical models support analytical developments to address this gap. These approaches include limit equilibrium, service limit stress methods, and plasticity-based limit analysis to incorporate the beneficial effects of soil cohesion and matric suction.

Based on the traditional limit equilibrium approach, Zhang et al. (2021) proposed a stability analysis for geosynthetic-reinforced soil walls with cohesive soils, determining reinforcement loads and connection strength at the limit state. A parametric study evaluated the influence of design parameters (e.g., cohesion, friction angle, wall inclination, reinforcement length) and validated results against experiments and simulations, showing good agreement. Findings indicate that cohesive soils as backfill reduce required reinforcement strength and horizontal displacements, thus alleviating bulging. A small wall inclination (about 10°) significantly reduces reinforcement demands but increases connection strength, particularly at the base. Extending reinforcement length helps prevent compound failure and reduces lateral deformations and reinforcement stress.

Still within the limit state framework, Vahedifard et al. (2016) observed that measured reinforcement loads in the field are lower than predicted, largely due to design conservatism. This is attributed to factors such as toe resistance, soil dilation, underestimated shear strength, and suction effects. The authors aimed to quantify this discrepancy by incorporating suction stress into active earth pressure coefficients under unsaturated steady flow. Using a limit equilibrium-based effective stress model, the study compared results for marginal and high-quality backfills under various rainfall events and surcharge conditions. Ignoring suction led to overestimations—up to threefold for marginal soils and sevenfold for high-quality soils. Thus, suction stress plays a key role in increasing interface strength and reducing mobilized reinforcement loads. Similarly, Vahedifard et al. (2014) included lateral earth pressure thrusts from unstable slopes composed of c-ϕ soils under pseudo-static seismic loading. Their formulation incorporated tensile cracks, slope inclination, and batter effects, assuming a log-spiral failure surface. Comparisons with alternative limit equilibrium and upper-bound limit analysis methods showed that cracks could significantly decrease stability, while cohesion helps reduce reinforcement loads.

Using a service limit state approach, Ehrlich and Mitchell (1994) presented an internal design method incorporating cohesion, reinforcement stiffness, compaction effects, and soil stress–strain behaviour. Another method, by Allen and Bathurst (2015), builds upon FHWA (2018) by introducing a normalized cohesion coefficient, calibrated with instrumented walls, to reduce reinforcement loads proportionally to cohesion and unit weight.

Limit analysis of plasticity is another widely used approach. It determines required reinforcement by equating external work (due to self-weight and surcharge) with internal energy dissipation from soil, reinforcement, and facing elements. Cohesion contributes by increasing dissipation, thus reducing the reinforcement demand. In slope stability analysis, Abd and Utili (2017), applied the kinematic limit analysis method to cohesive slopes with geosynthetic reinforcement and cracks from climatic or collapse mechanisms. The results highlight the benefit of cohesion in reducing reinforcement needs and the destabilizing impact of cracks. Using the same kinematic approach, Chen et al (2018) analyzed 3D reinforced structures accounting for pore water pressures and cohesion. Results showed that well-drained, narrow-width structures, or those with higher cohesion, exhibit more stable behaviour than 2D design assumptions. Similarly, Xu et al (2019) explored 3D analyses with fine-granular soils under seismic excitation, demonstrating that plane-strain designs are often conservative.

Addressing crack presence, Utili (2013) employed kinematic limit analysis to provide rigorous upper bounds on collapse, considering slope inclination, crack depth and location, and water presence. Rigid rotational failure mechanisms showed up to 85% reduction in stability factors compared to planar models. Porbaha et al (2000) applied a similar approach to centrifuge models of reinforced walls, optimizing critical heights using the Constrained Simplex method. In the context of design optimization, Franco et al (2023) incorporated cohesion and face elements in a semi-analytical method based on limit analysis. A parametric

study on cohesion, friction angle, face batter, reinforcement length, and interface properties revealed that accounting for cohesion and facing elements could reduce reinforcement needs by 57% to 82%. However, tension cracks in highly cohesive soils remain critical due to their negative impact on stability. The study also found that the adopting common reinforcement lengths employed in the design of reinforced soil walls (0.6H and 07.H), resulted mostly in two types of critical failure modes: internal failure with rupture of all layers of reinforcement and compound failure with the crossed layers failing in tensile rupture and pullout.

To assess unsaturated conditions and suction effects, Chehade et al. (2019) developed a method using the upper-bound theorem of limit analysis under pseudodynamic seismic loading. The parametric study showed that required reinforcement strength varies with friction angle, water table, suction distribution, and soil type. A comparison between saturated and unsaturated conditions revealed a significant decrease in reinforcement demand in unsaturated soils. In line with this, Chehade et al. (2020) proposed a method considering cracks under seismic action and evaluated their effect on reinforcement quantity.

3 CONCLUSIONS

The scarcity of granular material directly affects the construction of geosynthetic-reinforced walls since, even when this type of soil is available, the distance between the borrow site and the application location is generally large, resulting in additional costs and an increased carbon footprint due to transportation. Thus, the need arises to incorporate cohesive soils into constructing reinforced walls to maintain competitive advantages, which requires a revision of design practices.

Therefore, through the brief review proposed in this study, some conclusions regarding the use of cohesive soils in geosynthetic-reinforced walls are:

i. GRW demonstrate significant economic advantages, with costs up to 70% lower compared to conventional solutions. They also reduce the carbon footprint by up to 69%, aligning with the United Nations' sustainability goals.

ii. Using marginal and cohesive soils can reduce costs associated with material transportation and greenhouse gas emissions, provided they are properly designed and supported by an efficient drainage system.

iii. Existing methods, primarily developed for granular soils, do not adequately incorporate cohesive soil properties, such as cohesion and suction, creating opportunities for further optimization and improvement in design practices.

iv. The failure to ensure a robust drainage system is a key factor contributing to the collapse of GRWs using cohesive soils, emphasizing the importance of proper design and sufficient soil compaction.

v. Integrating analytical solutions, numerical studies, and full-scale wall monitoring is essential to validating the use of cohesive soils in GRWs and ensuring safe, cost-effective, and sustainable designs.

REFERENCES

Abd, A. H., Utili, S. (2017) Design of Geosynthetic-Reinforced Slopes in Cohesive Backfills. Geotextiles and Geomembranes, 45 (6), p. 627-641.

Allen, T. M., Bathurst, R. J. (2015) Improved Simplified Method for Prediction of Loads in Reinforced Soil Walls. Journal of Geotechnical and Geoenvironmental Engineering, 141 (11), p. 1-14.

Allen, T. M., et al. (2003) A New Working Stress Method for Prediction of Reinforcement Loads in Geosynthetic Walls. Canadian Geotechnical Journal, 40 (5), p. 976-994.

Anderson, D. G., et al. (2008) Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments. Transportation Research Board, Washington, D.C.

Basu, D., Lee, M. A. (2021) Sustainability Considerations in Geosynthetic Applications. In: Shukla, S. K. (ed.). ICE Handbook of Geosynthetic Engineering: Geosynthetics and Their Applications. 3rd ed., Ice Publishing, Fitchburg, USA, p. 427-457.

Benjamim, C. V. S., et al. (2007) Field Monitoring Evaluation of Geotextile-Reinforced Soil-Retaining Walls. Geosynthetics International, 14 (2), p. 100-118.

Berg, R. R., et al. (2009) Design of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume I. Federal Highway Administration, [S.l.], 306 p.

British Standards Institute (BSI) (2010). BS 8006-1:2010: Code of Practice for Strengthened/Reinforced Soils and Other Fills. UK.

Chehade, H., et al. (2019) Seismic Analysis of Geosynthetic-Reinforced Retaining Wall in Cohesive Soils. Geotextiles and Geomembranes, 47 (3), p. 315-326.

Chehade, H., et al. (2020) Upper Bound Seismic Limit Analysis of Geosynthetic-Reinforced Unsaturated Soil Walls. Geotextiles and Geomembranes, 48 (4), p. 419-430.

Chen, Y., et al. (2018) Required Unfactored Geosynthetic Strength of Three-Dimensional Reinforced Soil Structures Comprised of Cohesive Backfills. Geotextiles and Geomembranes, 46 (6), p. 860–868.

Christopher, B. R., et al. (1990) Reinforced Soil Structures: (Vol. 1: Design and Construction Guidelines). U.S. Department of Transportation, Federal Highway Administration, Springfield, USA, 306 p.

Dąbrowska, J., et al. (2023) Sustainability of Geosynthetics-Based Solutions. Environments, 10 (4), p. 64.

Damians, I. P., et al. (2017) Environmental Assessment of Earth Retaining Wall Structures. Environmental Geotechnics, 4 (6), p. 415-431.

Ehrlich, M., Mitchell, J. K. (1994) Working Stress Design Method for Reinforced Soil Walls. Journal of Geotechnical Engineering, 120 (4), p. 625–645.

Federal Highway Administration (FHWA) (2018). FHWA-HRT-17-080: Design and Construction Guidelines for Geosynthetic Reinforced Soil Abutments and Integrated Bridge Systems. USA.

Franco, Y. B., et al. (2023) Design of Reinforced Cohesive Soil Walls Accounting for Wall Facing Contribution to Stability. Géotechnique, 73 (8), p. 667-688.

Geotechnical Engineering Office (GEO) (2017). Geoguide 6: Guide to Reinforced Fill Structure and Slope Design. Civil Engineering and Development Department, Hong Kong.

Giglio, C., et al. (2023) A Scientometric Study of LCA-Based Industrialization and Commercialization of Geosynthetics in Infrastructures. Applied Sciences, 13 (4), p. 2328.

Gofar, N., Hanafiah (2018) Contribution of Suction on the Stability of Reinforced-Soil Retaining Wall. MATEC Web of Conferences, 195, p. 03004.

Guler, E., et al. (2007) Numerical Analysis of Reinforced Soil-Retaining Wall Structures with Cohesive and Granular Backfills. Geosynthetics International, 14 (6), p. 330-345.

Gupta, A. K., et al. (2024) Life Cycle Assessment (LCA) of MSE Wall vis-à-vis Conventional Retaining Wall: A Comparative Study. International Journal of Environmental Science and Technology, 21 (12), p. 8141-8156.

Koerner, R., et al. (2019) Relative Sustainability (i.e., Embodied Carbon) Calculations with Respect to Applications Using Traditional Materials Versus Geosynthetics. Geosynthetic Institute, Folsom, p. 1-16.

Koerner, R. M., Koerner, G. R. (2011) The Importance of Drainage Control for Geosynthetic Reinforced Mechanically Stabilized Earth Walls. Journal of Geoengineering, 6 (1), p. 3-13.

Koerner, R. M., Koerner, G. R. (2013) A Data Base, Statistics and Recommendations Regarding 171 Failed Geosynthetic Reinforced Mechanically Stabilized Earth (MSE) Walls. Geotextiles and Geomembranes, 40, p. 20-27.

Koiral, S. (2013) Soil Texture Map. Available at: http://hydro.iis.u-tokyo.ac.jp/~sujan/research/gswp3/soil-texture-map.html. Accessed at: 28 Nov. 2024.

Malekmohammadi, K., Damians, I. P. (2024) A Bibliometric Review of Reinforced Soil Wall Research Topics. International Journal of Geosynthetics and Ground Engineering, 10 (3), p. 1–16.

Mandloi, P., Hegde, A. (2022) Performance Evaluation of Reinforced Earth Walls with Sustainable Backfills Subjected to Railway Loading. Frontiers in Built Environment, 8, p. 1-13.

Meireles, L., et al. (2022) Numerical Evaluation of the Influence of Compaction and Soil Strength Parameters on GRSW. Soils and Rocks, 45 (4), p. 1–11.

Miyata, Y. (2023) Research and Practice on Geosynthetic MSE Walls: Past, Present and Future (Bathurst Lecture). In: Geosynthetics: Leading the Way to a Resilient Planet, CRC Press, p. 46-69.

Morsy, K. M., Thakeb, H. (2022) Comparative Evaluation of the Environmental Impacts of Geosynthetic Mechanically Stabilized Earth Walls. Journal of Cleaner Production, 374, p. 133912.

National Concrete Masonry Association (2010). Design Manual for Segmental Retaining Walls. Herndon, USA.

Palmeira, E. M., et al. (2021) Sustainable Solutions with Geosynthetics and Alternative Construction Materials—A Review. Sustainability, 13 (22), p. 12756.

Porbaha, A., et al. (2000) Upper Bound Estimate of Scaled Reinforced Soil Retaining Walls. Geotextiles and Geomembranes, 18 (6), p. 403-413.

Raja, J., et al. (2012) Designing with Marginal Fills: Understanding and Practice. In: European congress of Geosynthetics, 5., Valencia. Proceedings... International Geosynthetics Society (IGS), p. 1-7.

Riccio, M., et al. (2014) Field Monitoring and Analyses of the Response of a Block-Faced Geogrid Wall Using Fine-Grained Tropical Soils. Geotextiles and Geomembranes, 42 (2), p. 127-138.

Roads and Traffic Authority (RTA) (2011). R57: Design of Reinforced Soil Walls. 2nd ed., Roads and Traffic Authority, Australia.

Stucki, M., et al. (2011) Comparative Life Cycle Assessment of Geosynthetics versus Conventional Construction Materials. European Association for Geosynthetic Manufacturers (EAGM), Uster.

The Canadian Geotechnical Society (CGS) (2023). Canadian Foundation Engineering Manual. 5th ed., Canada.

Utili, S. (2013) Investigation by Limit Analysis on the Stability of Slopes with Cracks. Géotechnique, 63 (2), p. 140–154.

Vahedifard, F., et al. (2014) Impact of Cohesion on Seismic Design of Geosynthetic-Reinforced Earth Structures. Journal of Geotechnical and Geoenvironmental Engineering, 140 (6), p. 1–12.

Vahedifard, F., et al. (2016) Role of Suction Stress on Service State Behavior of Geosynthetic-Reinforced Soil Structures. Transportation Geotechnics, 8, p. 45-56.

Xu, J., et al. (2019) Stability Analysis of 3D Geosynthetic–Reinforced Earth Structures Composed of Nonhomogeneous Cohesive Backfills. Soil Dynamics and Earthquake Engineering, 126, p. 105768.

Yang, K.-H., et al. (2018) Numerical Evaluation of Reinforced Slopes with Various Backfill-Reinforcement-Drainage Systems Subject to Rainfall Infiltration. Computers and Geotechnics, 96, p. 25-39.

Zhang, F., et al. (2021) Analytical Method to determine reinforcement loads of geosynthetic-reinforced retaining wall. Jornal of Central South University, 52 (12), p. 4238-4251.

Zhu, Y., et al. (2022) Embodied Energy and Carbon Emissions Analysis of Geosynthetic Reinforced Soil Structures. Journal of Cleaner Production, 370, p. 133510.

Zornberg, J. G., et al. (1994) Reinforced Soil Structures with Poorly Draining Backfills. Part I: Reinforcement Interactions and Functions. Geosynthetics International, 1 (2), p. 103-147.