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STATE OF THE ART/PRACTICE PAPER

A Bibliometric Review of Reinforced Soil Wall Research Topics

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Abstract

Reinforced soil or mechanically stabilized earth (MSE) wall structures offer straightforward construction techniques as an alternative to conventional retaining earth walls. The benefits of MSE wall structures are their low cost, rapid construction, minimal ground occupation, and high tolerance for differential settlements. In the past, a vast amount of research has been conducted on this specific topic, but there is no state-of-the-art overview on the general reinforced soil walls subject. In this paper, a bibliometric review of MSE walls literature is carried out to provide multiple data points regarding the state-of-the-art in MSE wall publications. To present/demonstrate the main traditional applications, current utility, and last developments of MSE walls, a thematic/keyword cluster categorization is performed to catalog and organize the numerous applications analyzed and published in the last 4 decades. Furthermore, a discussion of MSE wall characteristics is conducted to assist researchers in expanding their understanding of potential future research areas.

Keywords Bibliometric analysis · Geosynthetic reinforcement · MSE walls · Reinforced soil structures

Introduction

Retaining earth structures are routinely used in highways and roads, bridges, railways, industrial and mining, dams, embankments, protection measures on slopes, basement walls in buildings, etc. For many years, nearly all retaining structures were constructed from reinforced concrete and designed as gravity or cantilever walls, which are essentially immobile structures that are unable to meet significant differential settlements unless they are supported by deep foundations. The resistance of soil to compressive stresses is greater than its resistance to shear stresses. Therefore, tensile elements are frequently used to compensate for this flaw. The MSE systems are utilized in the construction of a variety of geotechnical structures and can be incorporated into the category of flexible or semi-flexible walls, which include, at least, the following two structural components:

- Reinforced backfill: properly compacted well-graded granular fills with high frictional properties are typically used in MSE wall systems. Suitable backfill features, in conjunction with the reinforcement elements type and layout, must satisfy external and internal stability requirements as well as durability requirements. Marginal or lower-quality fills could also be used, subjected to specific studies [1].
- Reinforcement: performing inextensible or extensible behavior in relation to backfill strains, metallic or nonmetallic reinforcements are generally used. Reinforcement geometry can be very different according to the system and connection to the facing. Inextensible metallic reinforcements, like steel strips, provide high stiffness and resistance to deformation, effectively distributing the forces within the MSE wall structure. In contrast, metallic reinforcements that are extensible, such as steel thin wire grids or meshes, are able to accommodate larger strains by expanding without compromising structural integrity. This flexibility allows the MSE wall structure to dissipate energy and reduce concentrations of stress. Nonmetallic reinforcements, which are frequently made from geosynthetic materials, also offer versatility and performance benefits. Because of their low weight, high tensile strength, and corrosion resistance, geosynthetics, such as geogrids and geotextiles, are commonly

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conducted for the period from 1985 to 2023 to extract the essence of the past and present condition of MSE walls. In this procedure, the Science Citation Index Expanded (SCIE) and the Social Sciences Citation Index (SSCI) were utilized to extract documents with the language set to "English" and the document type restricted to journal papers.

The International Collaboration Index accounts for the articles that have been produced by researchers from several countries. This index shows the ratio of a journal's documents signed by researchers from more than one country, that is, including more than one country's address. The influence of a journal is a measure of the scientific influence of journals that accounts for both the number of citations

Table 2 Most productive Q1 Journals of the MSE walls research

Rank	Name of Journal	Country	Editorial	Number of publications (NP)	Total citations (TC)
1	Geotextiles and Geomembranes	Netherlands	Elsevier	64	3578
2	Journal of Geotechnical and Geoenvironmental Engineering	United States	ASCE	24	2397
3	Geosynthetics International	United Kingdom	ICE	29	2355
4	Canadian Geotechnical Journal	Canada	National Research Council of Canada	14	1664

Table 3 Highest-cited papers (TC > 200) to the date in the MSE walls bibliometrics research

Rank	Authors	Source	Citations				Main keywords
			Total	2023	2013–2022	2008–2012	
1	Hatami and Bathurst [41]	Canadian Geotechnical Journal	408	42	290	55	Numerical analysis, Model test study, Geosynthetic, Soil–structure interaction, Earth pressure
2	Bathurst and Hatami [16]	Geosynthetics International	353	38	180	72	Seismic, Numerical analysis, Geosynthetic
3	Hatami and Bathurst [111]	Journal of Geotechnical and Geoenvironmental engineering	340	30	234	61	Numerical analysis, Geosynthetic, Soil–structure interaction
4	El-Emam and Bathurst [83]	Geotextiles and Geomembranes	275	36	180	55	Failure, Seismic, Deformation, Facing, Model test study, Earth pressure, Geosynthetic
5	Leshchinsky and Boedeker [19]	Journal of Geotechnical Engineering	259	9	112	46	Numerical analysis, Geosynthetic, Earth pressure, Analytical analysis
6	Huang et al. [154]	Journal of Geotechnical and Geoenvironmental engineering	250	35	189	26	Failure, Numerical analysis, Deformation, Facing, Earth pressure, Geosynthetic
7	Ling et al. [91]	Journal of Geotechnical and Geoenvironmental Engineering	239	25	145	55	Failure, Seismic, Facing, Model test study, Earth pressure, Geosynthetic
8	Allen et al. [164]	Canadian Geotechnical Journal	232	25	114	58	Failure, Analytical analysis, Static stability, Steel reinforcement, Earth pressure, Geosynthetic
9	Bathurst et al. [174]	Geosynthetics International	216	16	157	43	Failure, Analytical analysis, Deformation, Facing, Earth pressure, Geosynthetic
10	Bathurst et al. [163]	Geotextiles and Geomembranes	215	22	120	52	Failure, Analytical analysis, Deformation, Facing, Earth pressure, Geosynthetic

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