

Geotechnical Frontiers 2025

GSP 365

Emerging Topics and Geotechnologies

Selected Papers from Geotechnical Frontiers 2025
Louisville, Kentucky • March 2–5, 2025

Edited by
Melissa S. Beauregard, Ph.D., P.E., ENV SP
Aaron S. Budge, Ph.D., P.E., BC.GE

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EMERGING TOPICS AND GEOTECHNOLOGIES

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March 2–5, 2025
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Geosynthetic Materials Association
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of the American Society of Civil Engineers

EDITED BY
Melissa S. Beauregard, Ph.D., P.E., ENV SP
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Preface

This is the third volume of six Geotechnical Special Publications (GSPs) containing papers from the Geotechnical Frontiers 2025 Conference held in Louisville, Kentucky on March 2-5, 2025. Geotechnical Frontiers occurs every six years and is the merging of the Geosynthetics Conference and the annual Geo-Congress replacing both events in 2025. This popular event is where the geotechnical, civil and geo-professional communities unite to share developments in geotechnical engineering and technologies. The four-day event featured more than 200 exhibits, plus a comprehensive program of short courses, panel discussions, round table discussions, technical paper lectures and posters presented by top industry experts as well as the industry's most influential plenary speakers. Geotechnical Frontiers 2025 was organized by the Advanced Textile Association's Geosynthetic Materials Association and the American Society of Civil Engineer's Geo-Institute. The congress was attended by a wide range of geo-professionals including engineers, contractors, academicians, equipment manufacturers, geo-technologists, researchers, and service, material and tooling suppliers.

This publication culminates two years of effort by the technical planning committee whose focus has been to continue the success of the previous meetings in the Geotechnical Frontiers conference series. Many individuals are responsible for the content of this volume, all of whom served in the efforts to maintain the standard set by previous proceedings. An international call for papers and a rigorous peer review process yielded nearly 300 accepted technical papers that were presented in 37 technical and special sessions, in addition to invited keynote presentations. Papers were reviewed in accordance with ASCE GSP standards. Accordingly, each paper was subjected to technical review by two or more independent peer reviewers. Publication requires concurrence by at least two peer reviewers.

The Editors would like to express their appreciation for having been provided the opportunity to be a part of this Congress' organization along with their sincere thanks to the numerous session chairs and reviewers. We hope that these proceedings will be of use to the geotechnical engineering community for many years to come.

The Editors,

Melissa S. Beauregard, Ph.D., PE, ENV-SP, M.ASCE, U.S. Army Corps of Engineers

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Large Language Model for Geotechnical Engineering Applications Using Retrieval Augmented Generation

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ABSTRACT

The application of Natural Language Processing (NLP) in the field of Civil and geotechnical engineering presents unique challenges with the complexity of the calculations and the necessity for engineering judgment. Large Language Models (LLM) have been successfully presented to be one of the most effective solutions in many specific fields such as arts and literature, finance, and even software development. However, the use of LLM in the field of Civil Engineering and specifically in Geotechnical Engineering has not been widely discussed often compared to the other fields. This paper aims to cover the details with the framework and breakdown of how LLMs can be used to retrieve information from domain-specific data set specifically related to geotechnical engineering. The paper covers topics ranging from settlement analysis, ground improvements, to scripting features with the Rocscience platform. Data sources include research papers, technical documents from geotechnical engineers, and documentation for online help from the relevant geotechnical software. The paper is structured into three main sections: an introduction to LLM models with a focus on pre-trained models and model selection; a discussion of the data retrieval process using domain-specific database using Retrieval Augmented Generation (RAG); and an evaluation of the model's performance. Performance benchmarks are established with vector embedding to trace context retrieval, and validation is performed using methods such as Recall-Oriented Understudy for Gisting Evaluation (ROGUE), Bidirectional Encoder Representations From Transformer (BERT), and Bilingual Evaluation Understudy (BLEU) score to compare the result with prompt-completion pairs. The study demonstrates that an LLM with sufficient geotechnical domain-specific data source produces superior responses compared to LLM trained on a generic public data set. The paper concludes with a discussion on the comparative results and the future potential of the LLM in geotechnical engineering.

Key words: Large Language Models (LLM), Retrieval Augmented Generation (RAG), ChatGPT, Civil Engineering, RS2, Settle3, settlement analysis, fine-tuned models, APIs with OpenAI.

1.0 INTRODUCTION

The use of ChatGPT (Generative Pre-trained Transformer) and Artificial Intelligence (AI) spans many professional fields, including the field of civil engineering. Applications with Natural-language Processing (NLP) in Civil Engineering include reviewing documentation,

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