

Geotechnical Frontiers 2025

GSP 368

Soil Characterization and Improvement

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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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 sixth 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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Difference of Hammer Hanging Mechanisms on Standard Penetration Test Energy Transfer Ratio

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ABSTRACT

The Standard Penetration Test (SPT) has a long history of being used to estimate geotechnical soil parameters. The basis of the test relies on impacting a drill rod string with a hammer to advance a sampler, where the SPT N index is the number of hammer blows required to advance the sampler to a known distance. To reduce the variability of SPT N values between tests, several correction factors have been proposed to control for differences, including a correction for the energy transfer imparted from the hammer. A variant of the SPT, the Large Penetration Test (LPT), is sometimes used when gravels are anticipated, which may interfere with the penetration of the sampler in the SPT. The LPT test is conducted similarly to the SPT but uses a larger hammer and sampler. Within British Columbia, contractors typically use hydraulic automatic trip hammers from different manufacturers for both penetration tests. However, depending on the drill rig, the hammer may be affixed by a frame system to the drill mast or held by a winch line. This paper presents a case history where two nearby sites conducted instrumented SPTs and LPTs to obtain site-specific energy transfer ratios. At one site, the SPTs were conducted with the hammer affixed to the drill mast through a frame system; the other site conducted instrumented SPTs and LPTs with the hammer held up by a winch line system. The paper compares the inter-test and intra-test Energy Transfer Ratio (ETR) differences between the hammer suspension systems. Significant differences in ETR were observed between the two different hammer suspension systems. The average ETR within the test intervals varied from 79.4% to 93.9% in the SPTs and from 77.6% to 96.0% in the LPTs for different tests conducted with the hammer was suspended by the winch line. For the SPT tests conducted with the hammer affixed to the drill mast, the correlated ETR varied between 86.8% and 89.8% over the test intervals.

INTRODUCTION

As part of a recent geotechnical exploration program for a linear infrastructure project within southeastern British Columbia, Canada, subsurface information was obtained at two sites to advance the site characterization. As part of the work, Standard Penetration Tests (SPTs) and Large Penetration Tests (LPTs) were conducted to characterize the granular soils at the sites. One site made use of an SPT hammer affixed to the drill mast, whereas at the other site, the winch line of the drill rig suspended the SPT and LPT hammers. The energy transfer from the hammer to the drill rods was measured at both sites for the three hammer operation assemblies.

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This paper presents a case study reviewing differences in energy transfer considering different hammer suspension methods.

STANDARD PENETRATION TEST AND LARGE PENETRATION TEST APPARATUS

Different in situ testing methods to measure penetration resistance have long been conducted to infer geotechnical soil properties and inform geotechnical design. The Standard Penetration Test (SPT) is widely used as a relatively inexpensive and simple downhole in-situ test during borings. The SPT involves counting the number of hammer blows to advance a steel split spoon sampler through the test interval. The test uses a standard by a 63.5 kg (140 lb) hammer with a set drop height of 0.762 m (30 in), with the SPT N representing the number of hammer blows required to advance the sampler between 150 mm to 450 mm (6 in to 18 in) following an initial seating drive of 150 mm (6 in) (Idriss and Boulanger 2008, Miller 2022, Strasilla 2022). The SPT sampler itself has an outer diameter of 51 mm (2 in) and an inner diameter of 38 mm (1.5 in) (Daniel, Howie and Sy 2003). An inner liner is sometimes used within the SPT sampler reducing the inner diameter to 35 mm (1.38 in), however liners are seldomly used in practice (Canadian Geotechnical Society 2023). The length of the SPT sampler is typically 458 mm (18 in), however some samplers have an extended length of 610 mm (24 in) to obtain additional sample with a 4th 150 mm (6 in) interval.

The SPT apparatus was initially developed for sands and as a result larger sized particles, such as gravels, may affect the results of the test and lead to unrepresentative blow counts (Daniel, Howie and Sy 2003). To attempt to overcome the grain size effects other tests such as the Large Penetration Test (LPT) or Becker Penetration Test (BPT) are sometimes conducted when larger clasts are anticipated. A commonality of the three tests is the requirement to use a standardized hammer to advance a sampler a set distance, however the hammers and sampler dimensions are increased in the case of the LPT and BPT relative to those used within the SPT.

The LPT apparatus and test procedures are similar to that of the SPT; however, the dimensions of the sampler and hammer are both increased. There are several versions of LPTs in use throughout the world including variants in Japan, Italy, North America amongst others (Daniel, Howie and Sy 2003, Daniel 2008). The LPT sampler and test procedure used on the project discussed herein is consistent with the dimensions of the North American LPT (NALPT) described by Daniel, Howie, and Sy for the brevity it is referred to as the LPT herein (Daniel, Howie and Sy 2003). The LPT hammer drop height is the same as the SPT with a drop height of 0.762 m (30 in), however the weight of the hammer is increased by about a factor of 2 utilizing a 136.1 kg (300 lb) hammer. Similar to the SPT, the LPT N representing the number of hammer blows required to advance the sampler between 150 mm to 450 mm (6 in to 18 in) following a 150 mm (6 inch) seating drive. The LPT sampler size is also increased having an outer diameter and inner diameter of 76 mm (3 in) and 61 mm (2.4 in), respectively. A summary of the SPT and LPT test apparatuses are included in Table 1 below.

To complete either a SPT or LPT the hammer needs to be held above the drill rods that extend into the ground and ultimately advance the sampler in the borehole. Two common ways the hammer is suspended include having the hammer affixed to a frame system that is attached to the drill mast or being held by the drill rig's winch line. When the hammer is affixed to the frame system, it is typically affixed to the drill mast and has a hinge to move the hammer out of the way during drilling operations and affix it for the test. During the test, the hammer is prevented from swaying out of plumb by the frame and gradually lowered as the drill rods are advanced by

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