Earthquake drains – Liquefaction mitigation technique for loose cohesionless soils.

One of the most destructive effects of earthquakes is their effect on deposits of saturated, loose, fine sand or silty-sand, causing a phenomenon known as liquefaction. When liquefaction occurs, the soil mass loses all shear strength and acts temporarily as a liquid. Such temporary loss of shear strength can have catastrophic effects on earthworks or structures founded on these deposits. Major landslides, lateral movement of bridge supports, settling or tilting of buildings, and failure of waterfront structures may result.

HB Wick Drains has applied its innovation and decades of experience in the wick drain and geosynthetics industry to the mitigation of liquefaction in loose cohesionless soils.

Earthquake drains are large-flow capacity synthetic vertical drains, installed with a vibrating mandrel into loose sands and silty sands. The vibratory installation achieves some densification of the soils, increasing their cyclic shear resistance, while the drain provides a path for the rapid dissipation of earthquake-generated excess pore pressures. The combination of drainage and densification is the most conservative approach to liquefaction mitigation.

Earthquake Drain Applications
- Highway Embankments
- Bridge Approaches and Overpasses
- Dams and Dikes
- Railway Embankments
- Airports, Seaports
- Commercial & Residential Developments
- Seismic Retrofit of Existing Buildings and Bridge Foundations
Earthquake Drains – The Concept

To avoid serious and potentially expensive problems due to liquefaction, it is desirable to densify loose soils and to provide drainage for the dissipation of the excess pore pressures before they reach dangerous levels. In most cases earthquake drains (alone or in combination with other treatment methods) are the most effective and economical solution available for the mitigation of liquefaction in loose, saturated, cohesionless soils.

During an earthquake base rock movements generate shear waves that propagate upward through overlying soils. These shear waves lead to the generation of excess pore pressure in loose cohesionless soils. If the pore pressure exceeds the total stress, the soil loses all shear strength and behaves as a heavy fluid, a “quick” condition, or quicksand. Evidence of liquefaction often takes the form of surface “sand boils” as excess water pressure vents to the surface during or shortly after an earthquake.

Historically, methods such as jet/compaction grouting, dynamic compaction and vibro replacement have been used to densify/stabilize potentially liquefiable soils. They offer alternative approaches, without the drainage capacity of earthquake drains, but can in combination offer cost-effective solutions to mitigate liquefaction and support the loads.

Earthquake Drains

Earthquake drains are high flow capacity prefabricated vertical drains wrapped with a geotextile filter fabric. Typical nominal diameters range from 75 mm – 200 mm (3.0 in – 8.0 in). Earthquake drains are installed by vibrating the insertion mandrel during penetration and withdrawal. Typically, the insertion mandrel consists of a heavy-gauge steel pipe with three equally spaced fins to aid in transmission of vibrations to the soil deposit.

Research using drainage elements for liquefaction remediation initially centered on the use of sand drains, but sand drains suffer from inefficiency of pore pressure drainage due to friction loss through the drain (porous media governed by Darcy’s Law). Flow through earthquake drains is governed by open pipe flow equations (Manning’s Equation). The discharge capacity and flow rates available in a 100 mm (4 in) earthquake drain are far greater than in a traditional sand drain.

Typical spacing for earthquake drains ranges from 1 m – 2 m (3.0 ft – 6.0 ft) center to center, depending on the earthquake magnitude and the soil’s permeability and relative density. The tight spacings result in uniformly denser deposit and the rapid dissipation of earthquake-generated excess pore pressures.

Earthquake drains consist of a polyethylene pipe extruded into a highly flexible configuration. The pipe is tightly wrapped with a proven durable geotextile filter fabric, selected for its excellent filtration properties, allowing free access of pore water into the drain, while preventing the movement of fines from adjacent soils. The geotextile wrap is also very durable, and able to withstand the handling and abrasion that occurs during installation. Several pipe designs and fabric types can be utilized to suit a variety of drainage applications and soil classifications.
Earthquake Drain Installation and Comparative Cost

HB Wick Drains Earthquake drains are installed using patented, proprietary installation methods. The equipment is attached to cranes or excavators, and is usually hydraulically powered. The drain is installed by inserting a tubular steel mandrel containing the drain into the ground, using static force and large vibrations. For retrofitting projects, earthquake drains can be installed using low-overhead, restricted-access equipment. In those cases where vibration would be detrimental to existing structures and foundations, earthquake drains are installed with drilling equipment or static down pressure.

Once the design depth of treatment has been reached, the earthquake drain is anchored with a specially designed anchor plate. Earthquake drains can be installed to depths over 25 m (85 ft).

Installation rates depend on the general resistance of the soils being improved, but can reach 2,500 m (8,250 ft) for each machine, per working shift. Several machines can be mobilized to increase production.

Technical Support Services

The underlying principles of densification and vertical drainage are fairly simple, but the design procedures and operating mechanism can be quite complex. The information in this publication does not contain design data.

HB Wick Drains has extensive information available to assist the client in the determination of the correct spacing and depths of earthquake drains, together with the level of densification required to achieve the desired safety factor for a given seismic event. Several options can be presented to allow the client to select the most cost-effective design to suit the project’s requirements. If desired, HB Wick Drains can furnish a value engineered design-build ground improvement system to meet your performance requirements.
Earthquake Drain System Design

The effective design of an earthquake drain project involves the compilation of soils and geotechnical earthquake data, which is utilized to determine the depth and spacing of the drains, as well as the level of densification required to obtain the appropriate safety factor.

Earthquake drain systems can be designed using the program FEQDrain: A finite element computer program for the analysis of the earthquake generation and dissipation of pore water pressure in layered sand deposits with vertical drains.

This program was developed and is distributed by the Earthquake Engineering Research Center, College of Engineering, University of California at Berkeley.

HB Wick Drains Construction Services

The HB Wick Drains division of Hayward Baker is capable of managing any earthquake drain project, regardless of the size, or location. Our crews have installed earthquake drains in North America and internationally.

Why Should You Choose HB Wick Drains?

As a division of North America’s leader in geotechnical construction, HB Wick Drains has the resources to build your project. Our network of offices and full-service equipment yards means fast mobilization and reduced start-up costs.

From job start-up to installation of the last drain, our attention to quality control helps to ensure that project specifications are achieved. We customize and design our equipment and tooling, helping to ensure that performance and reliability are the best in the industry.

HB Wick Drains has the experience and innovation to assist engineers, contractors, and owners with identifying, developing, and implementing the best drain solution.