Tools for Improved Decision Making in Project Delivery

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U.S. Federal Highway Administration
Washington, DC

www.GeoTechTools.org
Did you know...

...That up to half of all construction claims in highway works are related to geotechnical issues.

www.GeoTechTools.org
Log-In Screen
Geotech Tools: Geo-construction Information & Technology Selection Guidance for Geotechnical, Structural, & Pavement Engineers was developed by a SHRP 2 project with the goal of making geotechnical solutions more accessible to public agencies in the United States. This website is a toolkit of geotechnical information to address all phases of decision making from planning to design to construction. Transportation projects can be designed to be built faster, to be less expensive, and/or to last longer with use of these tools. Anyone involved in planning, design, and construction of transportation infrastructure will benefit from the information and resources available here. The information in the system is also applicable to non-transportation works and beyond the United States. We invite your comments and feedback on any aspect of the system. A Users’ Guide to the Information and Guidance System is available. First time users are encouraged to review the User’s Guide.

What’s New
Click here to download an icon for GeoTechTools.

Catalog of Technologies
The Catalog of Technologies provides a listing of all the technologies. For each technology, the following information is available:
- Technology Fact Sheet
- Photos
- Case Histories
- Design Guidance
- QC/QA Procedures
- Cost Estimating
- Specifications
- Bibliography

Technology Selection
Technology Selection is an interactive tool to identify candidate technologies for specific geoconstruction applications using project information and constraints. Final technology selection requires project-specific engineering. Technologies can also be accessed by classification or through a catalog of specific technologies.

Contribute
This is a living system; it is updated based upon your input. Users are strongly encouraged to contribute technical updates/corrections, case histories, cost information, photographs, and references to enhance and expand this web-based system. Users are also encouraged to report any bugs or glitches. All issues can be submitted through the Submit a Comment link.

A case history template is available in MS Word format.
Deep Mixing Methods
Aggregate Columns

Light Weight Fill
Column Supported Embankments
Catalog of Technologies

About the Technologies Listed

Included are ground improvement and geoconstruction technologies that are used for the following elements of construction:

- New embankment and roadway construction over unstable soils
- Roadway and embankment widening
- Geotechnical pavement components (base, subbase, and subgrade)
- Working platforms

An exception is that two traditional technologies—excavation and replacement, and traditional compaction—are included as often used "base" technologies, to which ground improvement and geoconstruction methods are often compared.

Click here to view Catalog of Technologies with SHRP 2 R02 ratings that also allows comparison of selected technologies.
See the SHRP 2 R02 Technology Ratings Summary for a legend and description of rating development.

**Rating Scale:** 1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high

## Ratings Catalog

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<tr>
<th>Technology</th>
<th>Degree of Establishment</th>
<th>Rapid Renewal</th>
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Prefabricated Vertical Drains and Fill Preloading

PVDs are band shaped (rectangular cross-section) products consisting of a geotextile filter material surrounding a plastic core that allow water flow. PVDs are used to accelerate the consolidation rate and strength gain of saturated, soft foundation soils by reducing drainage path lengths. Fill loading consists of a temporary surcharge load placed on the top of embankment to accelerate settlement in foundation soils. Advantages include reduced construction time, low cost, no spoil, durable and extensive experience. This technique is applicable to new embankments on unstable soils and embankment widening.
Case Histories

COLUMN SUPPORTED EMBANKMENT
MINNESOTA TRUNK HIGHWAY 241 WIDENING
– PROJECT CASE HISTORY –

Location: TH 241 near St. Michael, MN, southwest of I-94/TH 241 interchange
Owner: Minnesota Department of Transportation
Contractor: Mn/DOT and The Collin Group
Year Constructed: 2006

Project Summary/Scope:
A pile supported embankment was constructed on Trunk Highway (TH) 241 near St. Michael, MN, about 2,000 feet southwest of the I-94/TH 241 interchange. This project involved the widening of a highway from two to four lanes. The new embankment was a widening of an existing embankment. Differential settlement between the new embankment section and the old section was a concern.

Subsurface Conditions: 30 feet of highly organic silt loams and peats underlain by 20 feet of silty organic soils. Below that is 12 feet of loamy sand underlain by 35 feet of gravelly sand. A well-cemented sandstone lay 100 feet below the ground surface. The section of highway is bordered on the northwest by a small pond and on the southeast by marshy terrain.

Pile spacing was 7 feet on-center and the diameter of pile caps was 2 feet. The Load Transfer Platform (LTP) embankment was designed using the beam design method. Piles consisted of steel pipes filled with concrete. Four layers of geosynthetic reinforcement were used with granular fill. The total thickness of the LTP was 3 feet (~1 meter). Backfilling of the embankment was completed on October 10, 2006. Instrumentation data is presented through June 4, 2007.

Complementary Technologies Used:
Geofoam lightweight fill, reinforced soil slope, and geosynthetic construction platform stabilization technologies were also used for this embankment widening.

Performance Monitoring:
The embankment was instrumented with 48 sensors including strain gages, earth pressure cells, and settlement systems. Settlements, geosynthetic strains, and pile strains/loads are presented in the technical paper for an approximately 18-month period following construction. A finite element analysis was performed using STRAND7. Instrumentation results are compared with the finite element analysis.

Case History
Author/Submitter: Rich Lamb, P.E., Foundations Engineer
Mn/DOT Office of Materials, Mailstop 645
1400 Gervais Avenue
Maplewood, MN 55109
Rich.Lamb@dot.state.mn.us
(651) 366 - 5595


Date Case History Prepared: November 2012
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### SHRP 2 Ratings for Rapid Impact Compaction

#### Degree of Technology Establishment

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*(Rating Scale: 1 = not established or low applicability, 5 = well established or high applicability)*

See the [SHRP 2 R02 Technology Ratings Summary](#) for a legend and description of rating development.
Research & Vetting Process

1,000s pages Tech Docs

100s page Summaries

38 Post-Doc & Grad Students

38 Post-Doc & Grad Students & 12 Principal Investigators & Advisory Board & Peer Reviewers

8 Tools – 2 to 40 pages each
Value Added

The system *collects, synthesizes, integrates, and organizes* a vast amount of *critically important information* about geotechnical solutions on a *readily accessible* website.
Okay, So It Is WikiGeotech?
www.GeoTechTools.org

A Comprehensive Web-Based Information & Guidance System for

• Embankment, Ground Improvement & Pavement Applications

• Project Development and Delivery Options
Delivery/Contracting Methods

• Methods:
  – Design-Bid-Build (D-B-B)
  – Design-Build (D-B)
  – Public-Private Partnership (P3)
  – Construction Manager – General Contractor (CMGC)
  – Value Engineering (VE)
  – Change Orders

• How are risks (geo-construction related) allocated?
Construction over Unstable Soils

Construction over Stable/Stabilized Soils

Geotechnical Pavement Components (Base, Subbase, and Subgrade)

Working Platforms
Example Guide Illustration:

1. Initiate and Align
2. Plan the Work
3. Endorse the Plan
4. Work the Plan
5. Transition and Closure

Manage Change

After: http://www.wsdot.wa.gov/Projects/ProjectMgmt/PMOG.htm
Constraints & Risks Similarities

Examples

• Constraint: 3-inch Settlement Limit
• Risk: Settlement exceeds 3 inches

• Constraint: 90% Settlement by 3 months
• Risk: 90% Settlement takes more than 3 months
## Typical Constraints

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Typical Risks?

General
• Schedule/Delays
• Cost Overruns
• Underestimating Disruption
• Quality
• Errors & Omissions

Geo-Related
• Change of conditions
• Excessive Moisture
• Slope Instability
• Excessive Settlements
• Damage to Adjacent Structures
• Subsurface Investigation
Technology Selection System Disclaimer

By accessing the Technology Selection System, the user understands, accepts responsibility for, and agrees to the following conditions and limitations:

- The user has read User's Guide to the Information and Guidance System and acknowledges the system constraints and limitations.
- TRB, SHRP 2, FHWA, and AASHTO do not provide user assistance or support for this system.
- The application of this system is the responsibility of the user. It is imperative that the responsible engineer understand the potential accuracy limitations of the program results, independently cross checks those results with other methods, and examines the reasonableness of the results with engineering knowledge and experience.
- There are no expressed or implied warranties as outlined in the disclaimer.

[Agree] Continue to Technology Selection System

[Disagree] Return to Home Page
Technology Selection

Technology Selection

From this page, a user can narrow potential technologies by choosing to view a list of technologies by classification or by using the interactive selection system.

**View technologies by classification**

This option is designed for users who already know the general project geoconstruction methodology to be used (e.g., lateral earth support). Selecting this option will list applicable technologies according to classification.

**Access the interactive selection system**

This option leads to an interactive selection system that has been developed to aid the user in identifying a candidate list of technologies for any application. By selecting this option, the user will enter a dynamic system that narrows the potential technologies through a series of questions. Initially, technologies are divided into four applications: Construction over Unstable Soils, Construction over Stable/Stabilized Soils, Geotechnical Pavement Components, and Working Platforms.

*Refer to the document User's Guide to the Information and Guidance System for the constraints, intended uses, and limitations of the Technology Selection portion of this website.

ALWAYS remember these "take-home messages" concerning technology selection, geotechnical engineering, and judgment:

1. Engineering judgment without relevant experience is weak.
2. Engineering judgment without relevant data is foolish.
3. Good judgment needs good data and evaluated experience.
4. Good judgment is essential for the effective use of information technology tools.
5. Good judgment is central to geotechnical engineering, even in the information age.

From Allen Marr, Ph.D., P.E., F.ASCE, NAE. "Geotechnical engineering and judgment in the information age," GeoCongress 2006, Geotechnical Engineering in the Information Technology Age.
Technologies by Classification

Geotechnical Solutions for Earthwork Construction
- Bio-Treatment for Subgrade Stabilization
- Chemical Stabilization of Subgrades and Bases
- Excavation and Replacement
- Geocell Confinement in Pavement Systems
- Geosynthetic Reinforced Construction Platforms
- High-Energy Impact Rollers
- Intelligent Compaction
- Mechanical Stabilization of Subgrades and Bases
- Rapid Impact Compaction
- Traditional Compaction

Geotechnical Solutions for Soft Ground Drainage and Consolidation
- Electro-Osmosis
- Excavation and Replacement
- Hydraulic Fill with Geocomposite and Vacuum Consolidation
- Prefabricated Vertical Drains and Fill Preloading
- Vacuum Preloading with and without Prefabricated Vertical Drains

Geotechnical Solutions for Densification of Cohesionless Soils
- Aggregate Columns
- Blasting Densification
- Deep Dynamic Compaction
- Excavation and Replacement
- High-Energy Impact Rollers
- Intelligent Compaction
- Rapid Impact Compaction
- Sand Compaction Piles
- Vibrocompaction
Access the interactive selection system

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Interactive Selection System

Select an Application

Begin the interactive selection system by selecting one of the applications to the right. These inputs are the basic information required for screening potential technologies.

The technologies shown in the far right-hand column are all the potential solutions available in this system. After selecting one of the applications below, a short list of potential solutions for the selected application will appear in the right hand column. As additional inputs are entered, potential technologies are highlighted and eliminated technologies are faded.

- embankment
- unstable soils
- solutions at or below grade
- Construction over Unstable Soils
- solutions above grade
- embankment
- stable soils
- Construction over Stable or Stabilized Soils
- pavement surface
- base
- subbase
- subgrade soils
- Geotechnical Pavement Components (Base, Subbase, and Subgrade)
- ground surface
- unstable soils
- Working Platforms

FAQ are found throughout the interactive selection system to provide additional information regarding each selection.

Technologies

- Aggregate Columns
- Beneficial Reuse of Waste Materials
- Bio-Treatment for Subgrade Stabilization
- Blasting Densification
- Bulk-Infill Grouting
- Chemical Grouting/Injection Systems
- Chemical Stabilization of Subgrades and Bases
- Column-Supported Embankments
- Combined Soil Stabilization with Vertical Columns
- Compaction Grouting
- Continuous Flight Auger Piles
- Deep Dynamic Compaction
- Deep Mixing Methods
- Drilled/Grouted and Hollow Bar Soil Nailing
- Electro-Osmosis
- Excavation and Replacement
- Fiber Reinforcement in Pavement Systems
- Geocell Confinement in Pavement Systems
- Geosynthetic Reinforced Construction Platforms
Construction Over Unstable Soils

Interactive Selection System

Each screen will prompt for an input. These inputs are the basic information required for screening potential technologies. The technologies shown in the right-hand column are potential solutions for the selected application. As additional inputs are entered, potential technologies are highlighted and eliminated technologies are faded.

Your selections so far

Click on an item to return to a previous selection.

Selected Application: Construction over Unstable Soils

Select a response that best represents project conditions

- Wet and Weak, Fine Grained Soils
- Unsaturated, Loose Granular Soils
- Saturated, Loose Granular Soils
- Voids – Sinkholes, Abandoned Mines, etc.
- Problem Soils and Sites – Expansive, Collapsible, Dispersive, Organic, Existing Fill, Landfills

*For guidance on combining technologies, see White Paper on Integrated Technologies for Embankments on Unstable Ground.
Wet and Weak, Fine Grained Soils

Interactive Selection System

Each screen will prompt for an input. These inputs are the basic information required for screening potential technologies. The technologies shown in the right-hand column are potential solutions for the selected application. As additional inputs are entered, potential technologies are highlighted and eliminated technologies are faded.

Your selections so far

Click on an item to return to a previous selection.

- Selected Application: Construction over Unstable Soils
- Unstable Soil Condition: Wet and Weak, Fine Grained Soils

Select a response that best represents project conditions

Depth below ground surface requiring treatment. This depth could be full-depth treatment of unstable soils or partial-depth treatment of unstable soils.

- 0 - 5 ft
- 5 - 10 ft
- 10 - 30 ft
- 30 - 50 ft
- Greater than 50 ft

*For guidance on combining technologies, see White Paper on Integrated Technologies for Embankments on Unstable Ground.

are found throughout the interactive selection system to provide additional information regarding each selection.
30 – 50 ft

Interactive Selection System

Each screen will prompt for an input. These inputs are the basic information required for screening potential technologies. The technologies shown in the right-hand column are potential solutions for the selected application. As additional inputs are entered, potential technologies are highlighted and eliminated technologies are faded.

Select a response that best represents project conditions

This completes the screening process. The highlighted technologies on the right are the candidate technologies based on these selected inputs.

For guidance on combining technologies, see White Paper on Integrated Technologies for Embankments on Unstable Ground.
Project-Specific Selection

Project-Specific Technology Selection for Construction over Unstable Soils

Selections Made
The following selections have been made so far. Click on an item to return to a previous selection.

- **Selected Application**: Construction over unstable soils
- **Unstable Soil Condition**: Wet and Weak, Fine Grained Soils
- **Depth Below Ground Surface**: 30 - 50 ft

Select Project-Specific Characteristics
Answer the following questions that best describe the site conditions. Leave questions blank when the information is unknown (at this time) or inapplicable. The list on the right will update as selections are made. Click on the ? for additional information regarding each selection.

- **Purpose of Improvement**: Make your selection
- **Additional Purpose of Improvement**: Make your selection
- **Select Project Type**: Make your selection
- **Site Characteristics**: Make your selection

Right Panel:
- Aggregate Columns
- Blasting Densification
- Chemical Grouting/Injection Systems
- Column-Supported Embankments
- Combined Soil Stabilization with Vertical Columns
- Compaction Grouting
- Continuous Flight Auger Piles
- Deep Dynamic Compaction
- Deep Mixing Methods
- Electro-Osmosis
- Excavation and Replacement
- Geosynthetic Reinforced Embankments
- Geotextile Encased Columns
- High-Energy Impact Rollers
- Jet Grouting
- Lightweight Fill
- Micropiles
- Prefabricated Vertical Drains and Fill Preloading
- Rapid Impact Compaction
- Sand Compaction Piles
- Vacuum Preloading with and without Prefabricated Vertical Drains
- Vibrocompaction
- Vibro-Concrete Columns
Purpose of Improvement:

- Increase Resistance to Liquefaction
- Increase Strength
- Increase Bearing Capacity
- Bypass Soft Ground
- Reduce Immediate Settlement
- Seepage Barrier (cutoff wall)
- Reduce Consolidation Settlement
- Increase Rate of Consolidation
Making Decisions with GeoTechTools

• Options by identifying candidate technologies, and providing a ranking of technologies. Relative rankings for:
  – Degree of establishment
  – Rapidity of construction
  – Minimize disruption
  – Longevity of constructed works

• Relative costs of geotechnologies to compare alternatives
Making Decisions

General Ground Characteristics
The project and site information input into the selection system is summarized below.

Selected Application: Construction over unstable soils
Unstable Soil Condition: Wet and Weak, Fine Grained Soils
Depth Below Ground Surface: 30 - 50 ft

Project-Specific Characteristics
Purpose of Improvement: Reduce Consolidation Settlement
Additional Purpose of Improvement: Increase Strength
Project Type: New Embankment/New Construction
Site Characteristics: Constrained, developed sites
Size of Area to be Improved: Less than 10,000 ft² (930 m²)
Project Constraints:
Secondary Project Constraints:
Best description of the construction or implementation schedule:
Unstable soil condition that best describes site:
Are sufficiently thick peat layers present that will affect construction and settlement?
If unstable fine grained soils are present, do the unstable soils have a shear strength less than 500 psf?
Are water bearing sands present in the soil to be improved?
Are any subsurface obstructions present which would cause drilling difficulty, such as cobbles, boulders, buried tree trunks, or construction debris?

Potential Technologies
The potential technologies as a result of the project and site information are shown below.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Degree of Establishment*</th>
<th>Potential Contribution to SHRP 2 Renewal Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Columns</td>
<td>4</td>
<td>3 1 1 4</td>
</tr>
<tr>
<td>Combined Soil Stabilization with Vertical Columns</td>
<td>2</td>
<td>3 1 1 4</td>
</tr>
<tr>
<td>Jet Grouting</td>
<td>4</td>
<td>4 2 4 4</td>
</tr>
<tr>
<td>Prefabricated Vertical Drains and Fill Preloading</td>
<td>5</td>
<td>3 1 1 4</td>
</tr>
<tr>
<td>Sand Compaction Piles</td>
<td>2</td>
<td>4 1 3 3</td>
</tr>
<tr>
<td>Vacuum Preloading with and without Prefabricated Vertical Drains</td>
<td>2</td>
<td>3 1 1 4</td>
</tr>
</tbody>
</table>
Implementation Goal

Integration of GeoTechTools into Practice – both program delivery and project development
Primary Audience

• Public agency personnel at Local, State and Federal levels
  – Geotechnical Engineers
  – Civil/Structural/Bridge Design & Construction Engineers, Pavement Design & Construction Engineers
  – Project Planners/Managers, Research, Maintenance, District Engineers

• Consultants, Contractors, A/Ess

• Academics/Students
Home Page

What's New

Click here to download an icon for GeoTechTools.

Catalog of Technologies

The Catalog of Technologies provides a listing of all the technologies. For each technology, the following information is available:
- Technology Fact Sheet
- Photos
- Case Histories
- Design Guidance
- QC/QA Procedures
- Cost Estimating
- Specifications
- Bibliography

Technology Selection

Technology Selection is an interactive tool to identify candidate technologies for specific geosynthetic applications using project information and constraints. Final technology selection requires project-specific engineering. Technologies can also be accessed by classification or through a catalog of specific technologies.

Contribute

This is a living system; it is updated based upon your input. Users are strongly encouraged to contribute technical updates/corrections, case histories, cost information, photographs, and references to enhance and expand the web-based system. Users are also encouraged to report any bugs or glitches. All issues can be submitted through the Submit a Comment link.

A case history template is available in MS Word format.

Technical Revision Log

1. Intelligent Compaction
   101 video added
Thank You!

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