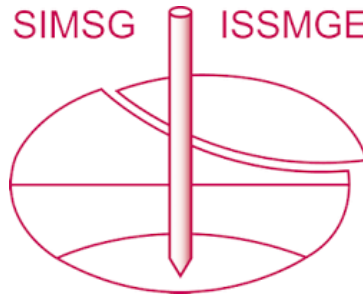


INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



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GeoTechTools: development, implementation, and future

GeoTechTools: développement, implémentation et avenir

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ABSTRACT: *GeoTechTools* (GTT) is a collection of geotechnic tools for anyone involved in geoconstruction and ground improvement design and construction. GTT is a readily accessible web-based system with a catalog of more than 50 geoconstruction and ground improvement technologies. For each technology, product/tool documents provide background, photos, case histories, design guidance, quality assurance guidance, cost information and guide specifications. The value of GTT is that it collects, synthesizes, integrates, and organizes a vast amount of critically important information in one easy to use location. The system allows users to find technically feasible solutions to vexing geotechnical problems as an aid in planning, developing, and executing projects in challenging ground conditions. This paper traces the development of the system since 2007 and its implementation within USA and worldwide. The future of GTT as an integrated geotechnical platform under the auspices of the ASCE Geo-Institute is explored.

RÉSUMÉ: *GeoTechTools* (GTT) est une collection d'outils géotechniques pour toute personne impliquée dans la conception et la construction de géoconstruction et d'amélioration des sols. GTT est un système Web facilement accessible avec un catalogue de plus de 50 technologies de géoconstruction et d'amélioration des sols. Pour chaque technologie, les documents produits/outils fournissent des informations contextuelles, des photos, des études de cas, des conseils de conception, des conseils d'assurance qualité, des informations sur les coûts et des spécifications de guide. La valeur de GTT est qu'il collecte, synthétise, intègre et organise une grande quantité d'informations d'importance critique dans un emplacement facile à utiliser. Le système permet aux utilisateurs de trouver des solutions techniquement réalisables à des problèmes géotechniques épineux afin d'aider à planifier, développer et exécuter des projets dans des conditions de terrain difficiles. Cet article retrace le développement du système depuis 2007 et sa mise en œuvre aux États-Unis et dans le monde. L'avenir de GTT en tant que plate-forme géotechnique intégrée sous les auspices du Géo-Institut de l'ASCE est exploré.

KEYWORDS: Ground improvement, geoconstruction, transportation infrastructure

1 INTRODUCTION.

GeoTechTools is a collection of geotechnic tools for anyone involved in geoconstruction and ground improvement design and construction. *GeoTechTools* (GTT) was developed under the auspices of the second Strategic Highway Research Program (SHRP2), which was created by the U.S. Congress in 2006 to address challenges of moving people and goods efficiently and safely on the nation's highways. Although in existence for several decades, many geoconstruction technologies face both technical and non-technical obstacles preventing broader and effective utilization in transportation infrastructure projects. The SHRP2 R02 project, *Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform*, was conceived to investigate the state of practices of transportation project engineering, geotechnical engineering, and earthwork construction to identify and assess methods to advance the use of these geoconstruction technologies. The research team created the following vision to drive development of the system and meet the goals of the SHRP2 program:

To make geotechnical solutions more accessible to public agencies in the United States for rapid renewal and improvement of the transportation infrastructure.

Research and development of the system began in the fall of 2007. A beta version of the website was launched in the spring of 2012, with the system opened to the public in November 2012. Continued development and updating occurred under SHRP2 through 2014. Subsequently, the U.S. Federal Highway Administration (FHWA) began an implementation effort to roll the system out to U.S. state departments of transportation (DOTs). A long-term goal of the developers was to create a living system, one that would outlast the research/development/implementation efforts funded by the federal government. In June of 2019, GTT was transferred to the American Society of Civil Engineers (ASCE) Geo-Institute (G-I) to manage and continue upgrades and expansion.

GeoTechTools is in reality two products in one. First, it is a Technology Catalog with detailed information on more than 50 geoconstruction and ground improvement techniques. In addition, the website contains a Technology Selection system to aid engineers and contractors in identifying potential technologies based on user defined project conditions, constraints and risks.

GeoTechTools is accessible at <https://www.geoinstitute.org/>. There is no cost to use this system. First time users must register and set up a log-in and password for future access. Upon

registration users are asked to identify their field of practice, organization type, title, and years of experience. This information helps to keep the system responsive to its users.

This paper traces the various phases of GTT from research and development, implementation and marketing, updating, to G-I's management and vision of the future of GTT.

2 RESEARCH & DEVELOPMENT

2.1 Early development

At its conception in 2007, this project was envisioned to address both technical and non-technical obstacles inhibiting the use of traditional, new, and emerging geoconstruction technologies in the practice of public agencies. New and emerging geoconstruction technologies were often underutilized in current USA practice, and they offered significant potential to achieve one or more of the objectives of: rapid renewal of transportation facilities; minimal disruption of traffic; and production of long-lived facilities. This project encompassed a broad spectrum of materials, processes, and technologies within geotechnical engineering and geoconstruction that were applicable to one or more of the following elements of construction: (1) new embankment and roadway construction over unstable soils; (2) roadway and embankment widening; and (3) stabilization of pavement working platforms.

The first phase of the project consisted of tasks focused on identifying those geotechnical materials, systems, and technologies that best achieve the strategic objectives for the three elements. Explicit in these tasks was the identification and evaluation of technical issues, project development/delivery methods, performance criteria and quality control and quality assurance (QC/QA) procedures, and non-technical issues that constrain full utilization of geotechnical materials, systems and technologies. Through identification of these obstacles that constrain usage of geoconstruction methods, and mitigation strategies to overcome the obstacles, the research team developed an approach to identify existing and innovative technologies to enhance geotechnical solutions for transportation infrastructure. This work was discussed in detail in the Phase 1 report (Schaefer and Filz 2008) and Schaefer et al. (2009).

During the first phase 46 technologies that best achieved the stated objectives were considered and evaluated and included in the system. These identified technologies included long-existing ones such as traditional compaction, emerging technologies such as bio-treatment of subgrades, many densification and consolidation technologies, aggregate columns, and 16 geosynthetic related technologies for drainage, reinforcement, and separation. The complete list is available on the *GeoTechTools* website. Phase 2 included development of a catalog of materials, processes, and systems for rapid renewal geoconstruction projects; and the evaluation and listing of design guidance and QC/QA procedures; methods for estimating costs; and sample specifications. A directory was developed which detailed the requirements for guidance on design, QC/QA, costs, and specifications into an integrated catalog and technology selection system.

The scope of this information, guidance and selection system was limited to technologies applicable to one of more of the three defined project elements: (1) new embankment and roadway construction over unstable soils, (2) roadway and embankment widening, and (3) stabilization of pavement working platforms. The final applications were divided into four areas as element three was subdivided into permanent and temporary stabilization applications. The system was developed with input from the research team members, the project Advisory Board (i.e., Stakeholders), an Expert Contact Group, FHWA, and SHRP2. Comments from Stakeholder meetings assisted in developing the goals and strategies of the final system. Stakeholder meetings

were conducted throughout the project to bring together state DOT personnel, practitioners, contractors, and academics who work with the relevant geotechnical materials, systems, and technologies. These meetings provided valuable brainstorming sessions to identify technical and non-technical obstacles limiting widespread, effective use of these technologies; to identify the available best opportunities for advancing the state of practice of existing and emerging technologies; and future directions of these technologies in transportation works.

2.2 Framework for the system

The development of the information system required planning on several levels. The framework for development required defining (1) overall system characteristics, (2) the user, (3) the knowledge, (4) the operating system, and (5) the approach to the system. The details of this development are summarized in Schaefer et al. (2011) and contained in the web-based system development report (Douglas et al. 2012).

The overall system developed is termed an information and guidance system because this system is meant to guide the user in selecting appropriate geoconstruction technologies for the project at hand. The knowledge base is contained in tables and the inference engine was developed graphically through flow charts. The flow charts and tables were programmed into a web-based system for ease of use. The system is intended to be used by both technical and nontechnical personnel, although to different levels.

The knowledge for identifying potentially applicable technologies to a set of geotechnical and loading conditions came from an in-depth technology overview that included advantages, potential disadvantages, applicable soil types, depth/height limits, groundwater conditions, material properties, project specific constraints, equipment needs, and environmental considerations. Additionally, for each technology case histories, design procedures, QC/QA procedures, and specifications were collected. The assessment efforts then qualitatively and quantitatively assessed the present design and QC/QA methods.

Like most geotechnical analytical solutions, the results of the analysis must be measured against the opinion of an experienced geotechnical engineer practicing in the local area of the project. The system was developed with a "keep the system simple" philosophy, using two approaches. The first approach is that the system conservatively removes potentially inapplicable technologies during the process. The second approach, which will be a common theme throughout the selection procedure, is that the final selection of the appropriate technology will be the responsibility of the user. The system will lead the user to multiple technologies and provide all the means for technology explanation, design, and cost estimating. This system does not replace the project Geotechnical Engineer. The Geotechnical Engineer's "engineering judgment" is the final selection process, which takes into consideration: construction cost, maintenance cost, design and quality control issues, performance and safety, inconvenience (a tangible factor, especially for heavily traveled roadways or long detours); environmental aspects, and aesthetic aspects (appearance of completed work with respect to its surroundings) (Johnson 1975 and Holtz 1989).

2.3 The web-based information system

The original web-based system was titled 'Geotechnical Solutions for Transportation Infrastructure' and contained four main parts: Geotechnical Design Process, Catalog of Technologies, Technology Selection, and Glossary.

The Geotechnical Design Process page was included to alert the user to the basic background information needed to conduct geotechnical design such as project loading conditions and constraints, soil site conditions, and evaluation of alternatives. The page contains links to FHWA documents on review of

geotechnical reports, evaluation of soil and rock properties, subsurface investigation and instrumentation. Additionally, links to several state DOT geotechnical design manuals were provided. During the development of the system, it was realized that a large number of technical terms and abbreviations were used and that in some cases different technologies used terms in different ways. Thus, an Abbreviations and Glossary was included with the system so that system users are able to find definitions of terms used in the various documents.

The technologies can be accessed in several ways. The Catalog of Technologies page provides a listing of the ground improvement and geoconstruction technologies in the system that addresses the four application areas. Two traditional technologies—excavation and replacement, and traditional compaction—are included as they are often-used “base” technologies, to which ground improvement and geoconstruction methods are compared. The name of each technology is a hot-link button on the website that takes the user to a web page for that technology. The Technology Selection page provides two further means of accessing technologies: through a classification system or through an interactive selection system. In the classification system, the technologies are grouped into the following categories: Earthwork Construction, Soft Ground Drainage and Consolidation, Densification of Cohesionless Soils, Construction of Vertical Support Elements, Embankments Over Soft Soils, Lateral Earth Support, Cutoff Walls, Liquefaction Mitigation, Increased Pavement Performance, Void Filling, and Sustainability. Thus, an experienced engineer can access solutions according to particular categories of problems. The interactive selection system provides the user the opportunity to assess technologies based on several applications. An information and guidance procedure has been developed for each application area shown in Figure 1. In developing the system, the importance of properly identifying the potential applications was recognized. The Interactive Selection System is entered through the clicking on one of the applications shown in Figure 1, wherein the first decision in the process is to select the potential application. In the selection system the list of applicable technologies is shown on the web page, all of which are hot-linked to the respective technology pages. At the start of the selection all technologies will be shown, and as decisions are made, non-applicable technologies will be grayed out.

After clicking on one of the four application areas, the user will encounter a page requesting additional information to narrow the list of candidate technologies for the particular application. The number of possible queries for additional information is dependent upon the application selected. The requested input and order of queries to the user were selected after considering the effect of the requested information on the determination of the potential technologies list. The potential queries (in no particular order) generated during development of the system are:

- What type of project is being constructed?
- What is the size of the project being constructed?
- Are there any project constraints to be considered in selecting a possible technology?
- What is the soil type that needs to be improved?
- To what depth do the unstable soils extend?
- At what depth do the unstable soils start?
- Is there a “crust” or “rubble fill” at the ground surface?
- What is the depth to the water table?
- How does the water table fluctuate?
- What constraints exist? (i.e., utilities, material sources, existing adjacent structures, etc.)
- What is the desired outcome of the improvement? (i.e., decrease settlement, decrease construction time, increase bearing capacity, etc.)
- What technologies does the user already have experience with?

The questions used to narrow the technologies are dependent upon the application selected. Generally, three or four questions are used to develop a short-list, which can then be further defined with answering additional questions.

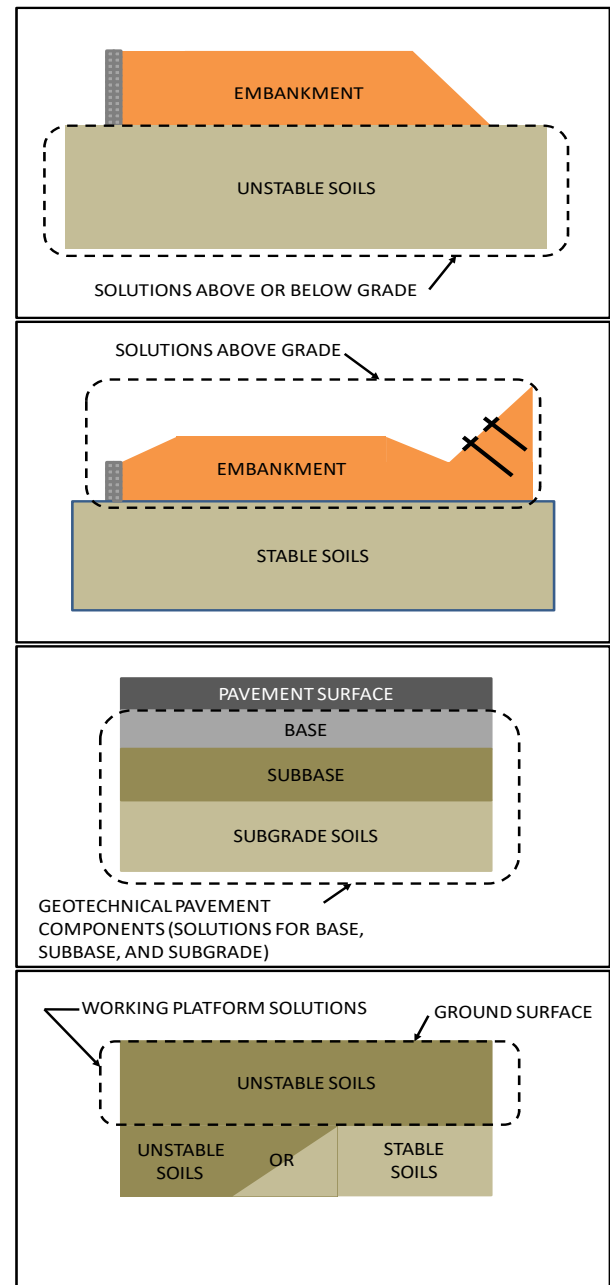


Figure 1. Illustrations showing the four application areas within the system, (a) Construction over stable soils, (b) Construction over stable-stabilized soil, (c) Geotechnical pavement components (base, subbase, subgrade) – permanent applications, and (d) Working platforms – temporary applications.

When a final list of candidate technologies has been determined, the user can further investigate the feasibility of each technology by accessing considerable information about each technology through information documents including Technology Fact Sheets, Photos, Case Histories, Design Procedures, QC/QA Procedures, Cost Estimation, Specifications, and Bibliography. The information documents are generally provided in Adobe pdf format. The Technology Fact Sheets are two-page, summary information sheets that provide basic information on the technology including basic function, general description, geologic applicability, construction

methods, applications, complementary technologies, alternate technologies, potential disadvantages, example successful applications, and key references. The Photos show pictorially the equipment or methods used in the technology and can be valuable to obtain a perspective on the technology. The Case Histories provide summaries of projects (generally conducted in the U.S. by a state DOT) and contain project location, owner, a project summary, performance, and contact information. The Design and QC/QA Procedures documents provide a summary of recommended procedures for the technology. The recommended design and QC/QA procedures come from an assessment of the current state of the practice of each technology. In cases where a well-established procedure (e.g., a FHWA manual) exists, that procedure is recommended. In cases of technologies with multiple design procedures, the assessment led to a recommendation of a procedure(s) to use. For a few technologies, design and/or QC/QA procedures were established based on additional research conducted during the project. For most technologies, there are two Cost Estimation documents available. The first provides an explanation of the cost item specific to the technology, generally emanating from the pay methods contained in specifications. Available regional cost numbers, generally from DOT bid tabs or national data bases, are compiled for each technology. The second document for Cost Estimation consists of an Excel spreadsheet developed to aid in estimating costs for use of the technology. The second document could not be prepared for some, emerging technologies due to insufficient information. The spreadsheet is unlocked and can be modified by the user to estimate specific project cost based on either a preliminary or final design. Guide specifications are provided for each technology in Adobe pdf and Microsoft (MS) Word (if available). The final document available for each technology is a bibliography compiled during the research project.

2.4 Going live

The system was beta tested in 2012. State DOT and FHWA personnel along with members of technical committees from the Geo-Institute and the Deep Foundations Institute were invited to try the system out and provide feedback to the team. During this time many bugs were discovered and fixed and numerous suggestions for improving technical documents were provided by beta users.

Among the key suggestions was that for a better name for the system. The team considered many options, with the result that *GeoTechTools* (GTT) was selected for the website name. The system went live in November 2012.

Registration was required to access the system to provide a contact for assistance and to track demographics of users. Information about years of experience, field of practice, organization type, country, and title were requested when registering. Within three months over one thousand users registered to use the system, which the developers considered a good accomplishment as its existence was disseminated primarily through emails and presentations at conferences. At the end of year one nearly two thousand users had registered on the system, from 59 countries. Registered users between opening in November 2012 and March of 2019 are shown in Figure 2 where the total users and public agency users registered are shown. The developers were uncertain how many users the system would attract, but with between 100 and 200 new users added every month during the first six years of the system, the developers felt that they were attracting the attention of the geotechnical community. The number of public agency users runs between 20 and 25% of the total registered users. As the vision of the project was to make geotechnical solutions more accessible to public agencies in the United States, having one-quarter of the users from public agencies was encouraging. As far as other organization types, about 40% of users are consultants (many of

whom do work for public agencies), 22% academic (students and faculty), 9% contractors (general and specialty), and about 7% as other. It was felt that the distribution of users across these organization types was good. About two-thirds of registrants list geotechnical engineering as their field of practice with remainder split among structural engineering, pavement engineering, management, and planning. The system is not meant only for geotechnical engineers and that one-third of users are not geotechnical engineers provides a positive indication of value to others wishing to learn about geoconstruction technologies. In March of 2018 GTT reached 100 countries with registered users, showing the breadth of reach of the system.

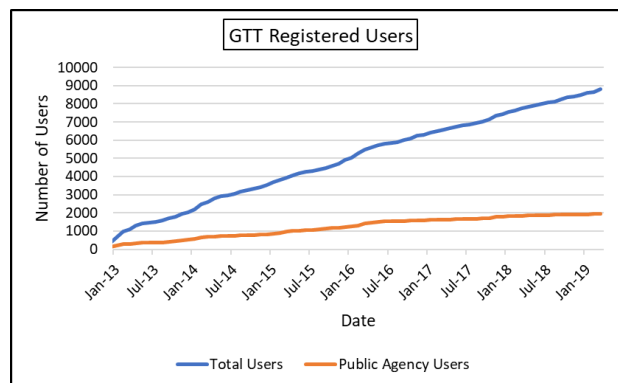


Figure 2. Plots of total users and public agency users between November 2012 and March 2019.

With 22% of GTT registrants being faculty or students, GTT has seen significant usage by academics. A number of faculty use GTT as part of their Soil/Ground Improvement and other courses and the first author has provided online lectures for such classes. At Iowa State University, the first author introduces the capstone design class to *GeoTechTools* for use in the geotechnical aspects of their projects.

Google Analytics is used to monitor usage of the system. Although the numbers fluctuate quite a bit month to month, the number of unique visitors to the system each month is typically between 400 and 600 with a few months having unique visitor numbers of over 1000. Visit durations typically range between 10 and 30 minutes, with a few visits as long as one to two hours.

The comment feature provided good and interesting feedback on the system, primarily on bugs related to document downloads. In response to a noted lack of discerning between methods for liquefaction mitigation, a separate liquefaction mitigation module was added in mid-2014. Also added in November 2014 was a Mass Mixing Methods technology which provides detailed information on shallow mass mixing and mass stabilization. This method was added as a separate technology from the existing Deep Mixing Method. The comment feature also provided good feedback on desired features users would like to see in the system such as a search function, ability to reorder lists at the click of a button, and an ability to access the system on tablets and smart phones.

3 IMPLEMENTATION

The initial project funding of the GTT concluded at the end of 2014. The FHWA, in partnership with the American Association of State Highway and Transportation Officials (AASHTO), was responsible for implementing the tools and products delivered by the Transportation Research Board (TRB) under the SHRP2 program. Hence, responsibility for the hosting, operation, and maintenance of the system was transferred to FHWA in early 2015 for the implementation phase of the system.

While GTT was originally developed for professionals in transportation infrastructure, the implementation team identified that GTT would be useful to a wider audience of engineers, geologists, planners, engineering consultants, and others to access critical information for ground modification and geoconstruction technologies. Iowa State University was selected to continue to provide hosting and technical support services for the implementation phase. Tasks included hosting the system, maintaining system functionality, providing technical content management, and updating, limited technical assistance to users, and usage tracking and reporting.

A key part of the implementation phase was outreach to state DOTs and other entities to promote the use of GTT. In support of this outreach a parallel effort was conducted to develop and deliver an FHWA one-day seminar on GTT. The resulting seminar was titled “Integrating GeoTechTools into Project Planning and Delivery” and was oriented to showing public agencies how GTT could be used to enhance their practice, in both program delivery and project development, while reducing risks due to geotechnical conditions. During 2015, 2016, and 2017, twenty-seven GTT seminars were conducted across the USA for state DOT personnel. The typical seminar had about 30 attendees and consisted of geotechnical engineers, geologists, structural engineers, planners, and administrators. Following the seminars Google Analytics was used to determine the number of users accessing GTT for the following four-week period. Usage numbers typically increased between 30 and 50 percent during that period. Subsequent surveys of the DOT personnel attending the seminars revealed that they found good value in the system and were using it in their work. A majority responded that GTT helped reduce the amount of time necessary to learn about potential geo-construction technologies. An interesting comment was made by one respondent: “GTT is a nice on-demand system, it is available when I need it.” The survey results and comments were taken as positive signs of usage within the DOT community. A number of states subsequently incorporated the use of GTT into their planning and geotechnical design guidance, including three states that required consultants to show that they had used GTT in scoping and design stages of a project.

Presentations were also made on GTT to geotechnical conferences throughout the U.S. and in Australia, Brazil, Canada, China, Crete, India, Malaysia, and Mexico.

In mid-2017 the implementation team desired to upgrade the GTT website platform from its original platform to one that included a content management system (CMS) that would allow non-webmasters to update web content, would improve the functionality and capabilities of the then-present system so users can better navigate the system, and would optimize the website for viewing and interaction experience across a full range of digital devices (desktops to mobile phones).

The updated website platform was built using open-source technology without any proprietary components thus allowing flexibility in future updates and enhancements with an CMS to allow administrators to update content, upload files, manage users, and modify the selection/workflow systems as technologies are added or updated. The upgraded site was designed and built to be a fully responsive interface Responsive Web Design (RWD) which means that the website was optimized for viewing and interaction experience across a full range of digital devices (desktops to mobile phones). RWD adapts the layout dynamically to the viewing environment using fluid, proportion-based grids for content. The upgraded website also contained site wide search capabilities. A key feature of the upgraded system was the updating of the system to meet ADA and Section 508 compliance requirements for the visually and hearing impaired. This accessibility was accomplished through the addition of appropriate Alt Tags to photographs, figures, graphs, and equations and appropriately configuring tables and charts. The updated website platform launched in March of 2019.

From the original conception of *GeoTechTools*, the developers had the goal of making it a living system that would be a continuing, updateable system for the geotechnical profession. To that end the final part of the implementation effort was to find a permanent home for GTT that would continue the updating efforts and expand the system.

Having been funded by federal programs for more than 10 years, continuation of *GeoTechTools* was contingent on finding non-federal sources of funding. The authors drafted a business plan to develop and present options for sustaining the life of the *GeoTechTools* system. First, the GTT product was summarized, the current business organization was described, and the current business financials were itemized. Next, the potential options for a new business organization or partnership were presented. Details of these options, including marketing and financials, were developed, and are compared to each other. A key item of the plan was the desire that access to GTT would continue to be free, particularly for public agency users.

The implementation team presented the plan and held discussions with several professional and trade organizations about the future of GTT and how to ensure its continuation. Out of these discussions the Geo-Institute of ASCE emerged as the future manager of GTT due to their strengths and their vision and commitment to GTT.

4 GEO-INSTITUTE MANAGEMENT AND FUTURE

A GTT task group comprised of the authors and Geo-Institute (G-I) stakeholders (the G-I director, G-I webmaster, and key G-I officers and committee chairs) reviewed and updated the business plan to meet G-I legal and management requirements. The updated G-I Business Plan was completed in October of 2018 and presented to the G-I Board of Governors for approval, which occurred in March of 2019. Key among the selling points for G-I to take on management of GTT was the fact that ASCE has the largest civil and geotechnical customer bases and that GTT has a tool that can bring the latest technology to them instantly, online. The GTT system was transferred to the Geo-Institute in June of 2019.

The G-I created two positions to implement GTT within the G-I. The Project Manager (PM) is tasked with overseeing program and management goals, which include marketing of GTT, technical services for management and response to technical inquiries, education and training, fundraising, and overall project management. The Technical Manager (TM) manages the review of all updates and changes to the GTT website and advises the G-I on new applications, technologies, and case histories to the GTT system. The first author is presently serving in this position. At present a GTT Administrative Committee consisting of these two positions, the G-I Executive Director, the G-I Webmaster and the G-I Board of Governors liaison to GTT oversee all aspects of the management of the system.

With the transfer of the GTT system to the Geo-Institute the original vision of the system is transforming from one centered on transportation issues to a more broad-based vision in support of all geotechnical related areas. In particular an emphasis on the technologies more specific to foundations of buildings is desired to be added to the system. Additionally, GTT is viewed as a location where information on ancillary topics such as geotechnical sustainability and instrumentation can be summarized and readily accessed. In short, GTT within the G-I is viewed as a one-stop location for geotechnical and geo-construction information.

The G-I Board of Governors has supported the updating of GTT through the allocation of significant special project funds to technical committees. A process was devised whereby G-I technical committees could propose specific tasks that would enhance the GTT system. In the 2019-2020 cycle, projects

approved included the Deep Foundations Committee developing drilled shaft technical materials to incorporate into GTT; the Embankment, Dams & Slopes Committee developing a strategic plan for GTT; the Rock Mechanics Committee developing rock slope stabilization technical materials for incorporation into GTT; and the Soil Improvement Committee developing a Roadmap for Updating GTT.

The Deep Foundations Committee developed materials for GTT that would identify projects conditions which would require geoconstruction information, identify or establish performance requirements, identify and assess any space or environmental constraints, assess subsurface conditions, provide preliminary selection of potentially applicable deep foundation technology(s), provide preliminary design methods, and allow comparison and selection considering performance, suitability, constructability, and cost. The Embankment, Dams & Slopes Committee's development of a strategic plan for GTT was delayed by Covid-19 and this effort is on-going. The Rock Mechanics Committee identified and summarized the relevant methods for rock slope stabilization, including rock bolts, rock bonding, tieback walls, and shotcrete. The Soil Improvement Committee conducted a thorough review of the technologies within GTT and prepared a roadmap for updating selected technologies. A need to update case histories, cost information, and expansion of technology applications from highway renewal to other applications such as buildings, industrial facilities, airports, and ports were noted.

The results of these efforts are presently being incorporated into GTT or helping to define the future of GTT. A second cycle of funding for 2020-2021 approved projects by the Sustainability Committee to develop a standalone sustainability module, by the Geosynthetics Committee to develop a minimum of 24 new case histories for the geosynthetic technologies in the system, and for the Soil Improvement Committee to update and combine the vacuum consolidation technologies in the system. Funding limitations did not allow all proposed projects to be funded and many good ideas remain for future enhancements to the GTT system including the expansion of elements to building foundations, the additional of more technologies, updating of liquefaction mitigation measures, a location/repository for geotechnical databases, and standalone modules on instrumentation and risk assessment.

During 2020 the G-I also merged the web platform on which GTT was developed to the same platform on which the G-I webpage was built, allowing access to GTT through either a direct login or by logging in through the Geo-Institute webpage. This effort creates efficiency in the hosting of the platform, and while in the background, the more direct linkage with the G-I webpage contributes to the enhancement of the GTT system and its future use by G-I members.

One of the first tasks of the GTT Administrative Committee was the development of a sponsorship program to provide funding to support updates to design tools, case histories, QC/QA procedures, cost estimates and adding new technologies and modules. This program began in early 2020 and has obtained the support of numerous contractors and consultants. The sponsors are listed on the GTT website (<https://www.geoinstitute.org/>).

The G-I management of the system continues the free use of GTT, and with the broadening of the system the future of GTT is very promising.

5 SUMMARY

This paper traces the development of the *GeoTechTools* web-based system from 2007 to the present time and discusses its future at Geo-Institute. The GTT system is a repository of knowledge and a selection system for geoconstruction and ground improvement technologies. The system is readily available on the internet for free. With the G-I assuming

management of GTT, enhancement and updating of the system is occurring and the system will continue to be available for use by geotechnical engineers, geologists, structural engineers, pavement engineers, transportation planners, transportation administrators, developers, owners, academics, and others, throughout the world.

6 ACKNOWLEDGEMENTS

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