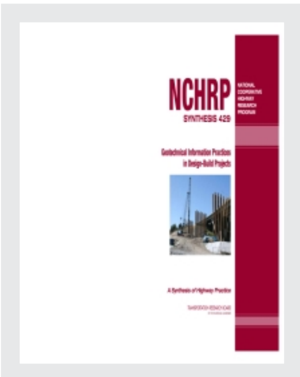

Geotechnical Information Practices in Design-Build Projects

DETAILS

112 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-22356-0 | DOI 10.17226/22793

AUTHORS

Gransberg, Douglas D.; and Loulakis, Michael C.

NCHRP SYNTHESIS 429

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Geotechnical Information Practices in Design-Build Projects

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 429

Geotechnical Information Practices in Design-Build Projects

A Synthesis of Highway Practice

CONSULTANTS
DOUGLAS D. GRANSBERG
Iowa State University
Ames, Iowa
and
MICHAEL C. LOULAKIS
Capital Project Strategies, LLC
Reston, Virginia

SUBSCRIBER CATEGORIES
Construction • Environment • Geotechnology • Highways

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2012
www.TRB.org

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communication and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NOTE: The Transportation Research Board of the National Academies, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, and the individual states participating in the National Cooperative Highway Research Program do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

NCHRP SYNTHESIS 429

Project 20-05 (Topic 42-01)
ISSN 0547-5570
ISBN 978-0-309-22356-0
Library of Congress Control No. 2012932146

NOTICE

The project that is the subject of this report was a part of the National Co-operative Highway Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the program concerned is of national importance and appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation Officials, or the Federal Highway Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at:
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Acad-emy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

TOPIC PANEL

DAN A. BROWN, *Dan A. Brown and Associates, Sequatchie, TN*
G.P. JAYAPRAKASH, *Transportation Research Board*
LAURA KRUSINSKI, *Maine Department of Transportation*
RICHARD A. LAMB, *Minnesota Department of Transportation*
BRIAN A. LIEBICH, *California Department of Transportation*
JAMES A. MORRISON, *Kiewit Engineering Company, Omaha, NE*
MOHAMMED A. MULLA, *North Carolina Department of Transportation*
JAMES M. SHEAHAN, *HDR Engineering, Inc., Pittsburgh, PA*
JOSEPH J. SQUIRE, *Oregon Department of Transportation*
SCOTT A. ANDERSON, *Federal Highway Administration, Lakewood, CO* (Liaison)
JENNIFER E. NICKS, *Federal Highway Administration, McLean, VA* (Liaison)

Cover photo: Washington State DOT bridge piles
(Courtesy: Washington State DOT).

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jo Allen Gauss
Senior Program Officer
Transportation Research Board

Use of the design-build project delivery method by state agencies for transportation projects is increasing each year. This study reviews how states use geotechnical information in solicitation documents and contracts for design-build highway projects. The report examines current practices regarding the allocation of geotechnical risk and the level of geotechnical information provided with bid documents, the scope of geotechnical information required after contract award, geotechnical-related performance testing during construction, and contract provisions related to geotechnical design and construction.

Information used in this study was gathered through a literature review, a survey of state departments of transportation (DOTs), analysis of design-build policy guidelines and solicitation documents from state DOTs, and interviews with design-build contractors. The report also provides case studies on legal and engineering geotechnical issues.

Douglas D. Gransberg, Iowa State University, and Michael C. Loulakis, Capital Project Strategies, LLC, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable with the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

GEOTECHNICAL INFORMATION PRACTICES IN DESIGN-BUILD PROJECTS

SUMMARY

Mitigating the risk of differing geotechnical site conditions is never simple, but risk mitigation is even more difficult in a design-build (DB) contract awarded before a complete subsurface investigation is completed. The FHWA's Special Experimental Projects No. 14—Alternative Contracting (SEP-14) was introduced in 1990 and by 2009 had authorized more than 400 DB highway projects. In June 2010, FHWA announced its "Every Day Counts" (EDC) initiative to address the rapid renewal of the nation's deteriorating infrastructure. The program is designed to accelerate the implementation of immediately available innovative practices.

Hence, the FHWA EDC focuses on innovations that have already been successfully employed by state departments of transportation (DOTs) and are no longer considered "experimental," as the SEP-14 label implies. "EDC is designed to identify and deploy innovation aimed at s*hortening project delivery*, enhancing the safety of our roadways, and protecting the environment… it's imperative we pursue better, faster, and *smarter ways of doing business*" [italics added]. It is worth noting that Administrator Mendez changed the "better, faster, cheaper" mantra to "better, faster, and smarter." This relieves the pressure on a state agency to find the cheapest solution to obtain federal-aid funding.

The EDC program identified DB project delivery as one of the tools to achieve its aims. Past research has shown that owners select DB primarily to accelerate a project's schedule, and that the major hurdle to achieving that goal is obtaining the owner's permission to release the design for construction. Because geotechnical investigation and design is usually the first design package that must be completed and geotechnical uncertainty is usually high at the time of DB contract award, the design-builder's geotechnical designers are under pressure to complete their work and enable foundation and other subsurface construction to commence. Successfully managing the geotechnical risk in a DB project is imperative to achieving the requisite level of quality in the finished product.

The purpose of this synthesis is to benchmark the state of the practice regarding the use of geotechnical information in DB solicitation documents and contracts. The high-level federal encouragement through EDC for state DOTs to accelerate project delivery by using DB elevates the need to manage geotechnical risk while expediting geotechnical design to a critical project success factor, and makes the results of this synthesis both timely and valuable.

The synthesis was based on a comprehensive literature review; a survey of U.S. DOTs, which received responses from 42 states (response rate = 84%); a content analysis of DB solicitation documents from 26 states; a content analysis of DB policy documents/guidelines from 12 state DOTs and 5 federal agencies; and interviews of 11 DB contractors whose markets encompass more than 30 states. The synthesis also furnishes three legal case studies (Colorado, Illinois, and Virginia) on cogent geotechnical issues and four geotechnical engineering case studies (Hawaii, Minnesota, Missouri, and Montana) that illustrate the methods transportation agencies use to deal with geotechnical issues on DB projects. Conclusions were drawn from the intersection of independent sources of informa-

tion from the survey, case studies, and literature. The major synthesis conclusions can be summarized as follows:

- DOTs typically select DB to accelerate project delivery.
- DOT design approval is a major hurdle to starting construction.
- Geotechnical uncertainty is always high until the post-award site investigation and geotechnical design report can be completed.
- Because geotechnical and site engineering is the first major design package and the one with the highest pre-award uncertainty—
  - It must be completed as expeditiously as possible.
  - The DOT needs to reduce the impact of geotechnical uncertainty as expeditiously as possible.

- The above leads DOTs to manage this risk by the following measures:
  - Requiring the design-builder's staff to include highly qualified and experienced geotechnical personnel;
  - Assigning the agency's most qualified geotechnical personnel to DB project oversight;
  - Mandating the use of geotechnical design solutions in which the agency is confident; and
  - Retaining most, if not all, of the traditional quality management (QM) roles and responsibilities for geotechnical features of work.

- These procedures are facilitated by the following effective practices:
  - Enhanced communication in the proposal preparation phase
    - √ Confidential one-on-one meetings to clarify request for proposal intent and to present potential alternative technical concepts (ATC).
    - √ Utilizing confidential pre-approved ATCs to enhance innovation in geotechnical design and subsurface construction means and methods.
    - √ Permitting design-builders to request/obtain additional site investigation before submitting a proposal.
  - Explicit differing site conditions clauses that:
    - √ Permit expeditious resolution of discrepancies between pre-award and post-award geotechnical conditions.
    - √ Risk sharing clauses that quantify the design-builder's exposure to geotechnical risks, with the DOT assuming everything above that threshold.
  - Expedited design review and acceptance procedures that may include one or more of the following techniques:
    - √ Restricting the DOT to a single interim design review before final release for construction review.
    - √ Maximizing the use of formal and informal over-the-shoulder design reviews.
    - √ Permitting release of geotechnical design packages for construction before the remainder of the design is complete.
  - The DOT treats the geotechnical and design QM program differently than the remainder of the project by increased agency involvement in the geotechnical aspects of quality assurance, quality control, verification, and acceptance (DOT survey results).

CHAPTER ONE

INTRODUCTION

The current ASCE *Report Card on America's Infrastructure* (ASCE 2010) rates the nation's highways as D− and bridges as C. This is just one of many reports that have documented the "urgent need to replace aging infrastructure" (Dowall and Whittington 2003). Design-build (DB) project delivery has proven to be one method to accelerate the construction, reconstruction, and rehabilitation of aging, structurally deficient infrastructure because it allows construction to begin before the design is 100% complete (FHWA 2006). DB also allows the department of transportation (DOT) to shift some of the responsibility for completing the geotechnical investigations necessary to support the geotechnical design to the design-builder after the award of the DB contract. This creates a different risk profile than when the project owner has full responsibility for design (and hence geotechnical investigations) in a traditional design-bid-build (DBB) project.

FHWA mandates the use of a differing site conditions (DSC) clause for DBB projects on federal-aid highway projects, unless the use of such a clause is contrary to state law (23 CFR 635.109). The DSC clause provides broad relief to a contractor for physical conditions that materially differ from those anticipated by the contract. FHWA does not, however, have the same mandate for DB projects. Instead, it encourages state DOTs to use this clause when appropriate for the risk and responsibilities that are shared with the design-builder.

On DBB projects, the risk of differing site conditions is almost always the responsibility of the owner (Tufenkjian 2007). Although this approach is largely the result of the DSC clause, it also results from the concept that prevailing case law and sound contract management principles require the owner to disclose to bidders virtually all geotechnical information in its control.

On DB projects, the risk of differing site conditions is not as clear (Clark and Borst 2002). The DB contract can be awarded before either the owner or the design-builder makes a full geotechnical site investigation (Smith 2001). This leads to a question of how to identify an appropriate baseline for the DSC clause, if one is included in the contract (Hatem 2011). The DOT must also consider the policy question of how much information it should furnish about the geotechnical site conditions (Blanchard 2007; Dwyre et al. 2010). The more information that is provided, the more likely it is that the design-builder will be able to reduce its contingencies and submit a competitive price proposal (Christiansen and Meeker 2002). Providing this information will also give the DOT a better sense of its program and expected costs. However, because the DB delivery process has proven to be an effective means of compressing project delivery periods to their shortest states (FHWA 2006), the DOT frequently has an incentive to start the procurement process before a robust geotechnical program has been performed (Higbee 2004; Kim et al. 2009). All of this creates some potential risks to both parties that are not present in a DBB delivery process (WSDOT 2004).

This synthesis will look at how state DOTs and other transportation agencies have dealt with the geotechnical conundrum described above and furnish information on commonly used practices for managing geotechnical risks in DB project.

SYNTHESIS OBJECTIVE

The objective of this synthesis is to identify and synthesize current effective practices that comprise the state of the practice on geotechnical engineering and constructability for DB highway projects, including bridges, other structures, embankments, and excavations. This report will help state DOTs develop effective procedures for delivering DB projects and managing geotechnical risks.

In addition to a rigorous literature review, the synthesis is based on new data from a survey, a set of structured interviews, four case studies, and content analyses of DB solicitation documents [requests for qualifications (RFQs) and requests for proposals (RFPs)] and policy documents/guidelines. A general survey on DB geotechnical practices yielded responses from 42 U.S. state DOTs. The content analysis included 46 DB solicitation documents from 26 U.S. states and DB policy documents/guidelines from 12 state DOTs and five federal agencies. Four case studies from different states also furnished specific information on different approaches to dealing with geotechnical requirements in DB projects. Two of the case studies examine completed DB projects to analyze the success or failure of the approaches used; the other two examine ongoing projects that are using innovative approaches that may complement the information gleaned from the survey and the solicitation document content analysis.

BACKGROUND

Many studies on the deteriorating condition of the nation's highway network conclude that public transportation agencies must find ways to deliver infrastructure projects "better, faster, cheaper" (Atzei et al. 1999; Avant 1999; Richmond et al. 2006). The FHWA's Special Experimental Projects No. 14—Alternative Contracting (SEP-14) was introduced in 1990, and by 2009 had authorized more than 400 DB highway projects (FHWA 2006, 2009). In June 2010, FHWA introduced its "Every Day Counts" (EDC) initiative to address this and other issues of similar import. The program is designed to accelerate the implementation of immediately available innovative practices, as described by the current FHWA Administrator, Victor Mendez.

> Our society and our industry face an unprecedented list of challenges. Because of our economy, we need to work more efficiently. The public wants greater accountability in how we spend their money. We need to find ways to make our roads safer. And we have an obligation to help preserve our planet for future generations. But it's not enough to simply address those challenges. *We need to do it with a new sense of urgency.* It's that quality—*urgency*—that I've tried to capture in our initiative, "Every Day Counts" (Mendez 2010, italics added).

Hence, the FHWA EDC focus is on innovations that have already been successfully employed by typical DOTs and are no longer considered "experimental," as the SEP-14 label implies. "EDC is designed to identify and deploy innovation aimed at *shortening project delivery*, enhancing the safety of our roadways, and protecting the environment… it's imperative we pursue better, faster, and *smarter ways of doing business*" (Mendez 2010, emphasis added). It is worth noting that Director Mendez changed the "better, faster, cheaper" mantra to "better, faster and smarter." This reduces the pressure on agencies because they no longer must use the cheapest solution to obtain federal-aid funding.

The EDC program identified DB project delivery as one of its potential tools to achieve its aims (Mendez 2010). The EDC program states, "In addition to the time savings, a DB contract provides savings in cost and improvement in quality" (Mendez 2010). The advent of this federal program demonstrates increasing encouragement from the federal level for state DOTs to use this project delivery method. Successfully managing the geotechnical risk in a DB project is imperative to achieving the requisite level of quality in the finished product.

The quality of transportation projects affects nearly every citizen in the United States on a daily basis. DB use has been advancing rapidly, and at this time more than 25 states have some experience using DB in their transportation projects (FHWA 2006). With the EDC program in action, one might expect to see more DOTs taking the plunge and selecting DB for critical projects. California and Vermont, for instance, adopted DB project delivery for the first time in 2010 (Caltrans 2010; VTrans 2010a).

In traditional DBB construction projects, the design and construction are performed under two separate contracts. In many cases, the DOT performs the design itself and then advertises for construction contractors to bid on the finished design. In DB, one entity is responsible for both design and construction; as a result the DOT has less direct control over the day-to-day details of design development, as both design and construction will have fixed obligations to meet a schedule and a price. Agencies that are new to DB fear that this loss of control will degrade the quality of the project (Ernzen and Feeney 2002).

The Florida DOT led the nation in implementing DB project delivery. By 2002, it had awarded 49 DB projects for nearly $500 million worth of work and estimated that DB cut the traditional project delivery period by 30% (Peters 2003). The success of Florida DOT and the rest of the SEP-14 DB projects confirms that DB accrues tangible benefits to the DOTs that implement it. FHWA articulates the motivation for implementing DB when it states, "The greatest motivation and realized benefit to a contracting agency of using design-build … is the ability to reduce the overall duration of the project development process by eliminating a second procurement process for the construction contract, *reducing the potential for design errors and omissions*, and allowing for more concurrent processing of design and construction activities..." (FHWA 2006, italics added).

The recent emphasis on speedy project delivery creates an environment where public engineers may adjust their focus from the project's technical requirements to expediting the procurement process. This includes evaluating the extent of the geotechnical engineering that the design-builder should perform after contract award. This geotechnical decision has a number of ramifications, including the level of liability for the underground conditions, which can be transferred along with the geotechnical investigation and design responsibility. This creates a situation where the primary risks to manage are post-award changes caused by design errors in the DB RFP and differing geotechnical site conditions.

A study of the causes of construction claims in DBB projects found that design errors accounted for 39% of the claims and differing site conditions made up another 15% (Diekmann and Nelson 1985). A more recent study found that 75% of DBB project change orders were the result of design errors or omissions, as opposed to 29% of DB project change orders. It also found that 25% and 21% of DBB and DB changes, respectively, were caused by differing site conditions (Perkins 2009). Therefore, Perkins' study agrees with the previously cited 2006 FHWA study finding that using DB project delivery appears to reduce the owner's liability for design errors.

As a consequence, explicitly distributing the risk of changed geotechnical conditions in DB projects is important. An FHWA technical manual on tunnel design and construction (Hung et al. 2009) outlines the essential information that should be contained in a typical contract with important geotechnical considerations, and recommends contractual mechanisms to coordinate the various aspects of geotechnical risk management, as follows:

- "Thorough geotechnical site investigations;
- Full disclosure of available geotechnical information to bidding contractors;
- Preparation of a Geotechnical Data Report (GDR) to present all the factual data for a project;
- Preparation of Geotechnical Design Memorandum (GDM) to present an interpretation of the available geotechnical information, document the assumptions and procedures used to develop the design, and facilitate communication within the design team during development of the design. GDMs are not intended to be incorporated into the Contract Documents and are subsequently superseded by the Geotechnical Baseline Report (GBR);
- Preparation of a Geotechnical Baseline Report (GBR) to define the baseline conditions on which contractors will base their bids and select their means, methods and equipment, and that will be used as a basis for determining the merits of contractor claims of differing site conditions during construction;
- Making the GDR and GBR contractually binding documents by incorporating them within the contract documents for the project, with the GBR taking precedence in the event of a conflict;
- Carefully coordinating the provisions of the contract specifications and drawings with the information presented in the GBR;
- Including a DSC clause that allows the contractor to seek compensation when ground conditions vary from those defined in the GBR, and that result in a corresponding increase in construction cost and/or delay in the construction schedule;
- Establishing a dispute resolution process to quickly and equitably resolve disagreements (particularly geotechnical problems) that may arise during construction without reverting to costly litigation procedures; and
- Providing escrow of bid documents" (Hung et al. 2009).

The specific use of the terms GDR and GBR is the key to effective implementation of these provisions. Thus, the next section furnishes detailed definitions that will be used in the synthesis report for these and other important technical terms.

KEY DEFINITIONS

The report uses a number of geotechnical terms in a precise sense. It is important for the reader to understand the specific definition of each term in order to gain a full understanding of this study. Differing usage of technology terminology in industry and public agencies continues to create unnecessary confusion and faulty interpretation of solicitation documents and contract specifications (Scott et al. 2006).

Geotechnical Terms

The definitions for the primary geotechnical reports referenced in the synthesis are drawn from the FHWA *Technical Manual for Design and Construction of Road Tunnels – Civil Elements*, which draws them in turn from an ASCE document that reports a consensus definition reached by the Underground Technical Research Council (Essex 2007).

- Geotechnical Design Memoranda (GDM): "interpretive reports are used to evaluate design alternatives, assess the impact of construction on adjacent structures and facilities, focus on individual elements of the project, and discuss construction issues… the GDM may be prepared at different stages of a project, and therefore may not accurately reflect the final design or final contract documents. Since GDMs are used internally within the design team and with the owner as part of the project development effort, it is not appropriate to include GDMs as part of the contract documents."
- Geotechnical Data Report (GDR): "a document that presents the factual subsurface data for the project without including an interpretation of these data. The purpose of the GDR is to compile all factual geological, geotechnical, groundwater, and other data obtained from the geotechnical investigations for use by the various participants in the project, including the owner, designers, contractors and third parties that may be impacted by the project. It serves as a single and comprehensive source of geotechnical information obtained for the project. The GDR should contain the following information (Essex 2007):
  - Descriptions of the geologic setting
  - Descriptions of the site exploration program(s)
  - Logs of all borings, trenches, and other site investigations
  - Descriptions/discussions of all field and laboratory test programs
  - Results of all field and laboratory testing" (Hung et al. 2009).
- Geotechnical Baseline Report (GBR): a document developed "to define the baseline conditions on which contractors will base their bids and select their means, methods and equipment, and that will be used as a basis for determining the merits of contractor claims of differing site conditions during construction" (Hung et

al. 2009). The GBR should contain the following information (Essex 2007):

– "The amounts and distribution of different materials along the selected alignment;
– Description, strength, compressibility, grain size, and permeability of the existing materials;
– Description, strength and permeability of the ground mass as a whole;
– Groundwater levels and expected groundwater conditions, including baseline estimates of inflows and pumping rates;
– Anticipated ground behavior, and the influence of groundwater, with regard to methods of excavation and installation of ground support;
– Construction impacts on adjacent facilities; and
– Potential geotechnical and man-made sources of potential difficulty or hazard that could impact construction, including the presence of faults, gas, boulders, solution cavities, existing foundation piles, and the like" (Hung et al. 2009).

In addition to these terms, the DOT survey used the following terms to describe commonly practiced methods furnished by the synthesis oversight panel for conveying geotechnical information in DB RFPs:

- Reconnaissance Report: A document that contains the results of a review of records and observations from the project site.
- Geotechnical Summary Report: A document that contains the results of a review of records and geotechnical investigation of critical areas
- Preliminary Geotechnical Data Report: A document that contains the results of a partial geotechnical investigation that will eventually be included in a final GDR.

Other Relevant Terms

Because this report addresses the application of geotechnical information in a DB contract, it is also important to define the following standard terms that relate to DB project delivery:

- Design-bid-build (DBB): The "traditional" project delivery approach where the owner commissions a designer to prepare drawings and specifications under a design services contract, and separately contracts for construction, by engaging a contractor through competitive bidding or negotiation (DBIA 2009).
- Design-build (DB): The system of contracting under which one entity performs both architecture/engineering and construction under a single contract with the owner (DBIA 2009).
- Alternative technical concepts (ATC): A procedure where the design-builders are asked to furnish alternative design solutions for features of work designated by the agency in its DB Request for Proposals (RFP) (Mn/DOT 2003).
- Differing Site Conditions (DSC) Clause: A contract clause designed to give a contractor cost and time relief for (1) subsurface or latent physical conditions encountered at the site differing materially from those indicated in the contract; or (2) unknown physical conditions at the site of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract (23 CFR 635.109). There are two kinds, Type 1 and Type 2, which are defined in chapter two (Loulakis et al. 1995).

RESEARCH APPROACH

The approach to the synthesis relied on three independent sources of information. The first was a comprehensive review of the literature. An effort was made to seek not only the most current information but also historical information so that any changes in DB geotechnical practices could be mapped and related to the current state of the practice. The second line of information came from the general survey responses of state DOTs (42 states; response rate = 84%). The survey was based on the output of the literature review. The content analysis of DB solicitation documents from 26 states and DB policy documents/guidelines from 12 state DOTs and five federal agencies constituted the third source of information. Finally, short interviews with 11 design-builders were conducted to gain the contractor's perspective on the topic. Subjects where two or more of the three lines intersected were considered significant and used to develop the conclusions and candidates for the list of effective practices. Points where only one source furnished substantive information on DB project success were used to identify gaps in the body of knowledge that showed potential for future research.

Protocol to Develop Conclusions and Suggestions for Future Research

The major factor in developing a conclusion was the intersection of trends found in two or more research instruments. The intersection of more than two lines of converging information adds authority to the given conclusion. Additionally, greater authority was ascribed to information developed from the general survey of highway agencies. The literature review and specification content analysis were considered to be supporting lines of information. Finally, the case studies were used to validate the conclusion as appropriate because they were examples of how U.S. highway agencies have implemented DB contracting procedures to support their projects' geotechnical requirements.

Suggestions for future research were developed based on the effective practices described in the literature and confirmed as effective by one of the research instruments but generally not widely used. Gaps in the body of knowledge found in this study were also used to define the areas where more research would be valuable.

ORGANIZATION OF THE REPORT

The next chapter details the legal and contractual principles of differing site conditions. The major geotechnical issue in DB projects is dealing with subsurface uncertainty before contract award. Therefore, chapter two contains information to provide the reader a foundation upon which to understand chapters three through six. Chapter seven presents four geotechnical engineering case studies that demonstrate the methods that agencies used to deal with uncertainty in their DB projects.

CHAPTER TWO

CASE STUDIES IN LEGAL AND CONTRACTUAL ISSUES ASSOCIATED WITH DIFFERING SITE CONDITIONS

INTRODUCTION

One of the most important issues confronting owners, designers, and contractors on any transportation project is the nature and predictability of geotechnical conditions. Geotechnical conditions not only have an enormous impact on project design, but also directly affect project cost and schedule. This is particularly true for "differing geotechnical conditions," sometimes called "changed conditions," which are conditions that materially differ from what the contractor should have reasonably expected when it priced its contract. As discussed throughout this report, differing site conditions create project challenges, all of which leads to a fundamental question—who should bear the financial risk of these conditions?

This chapter will address the legal and contractual issues associated with differing site conditions. It will consider public policy issues, contractual approaches, and common methods that some owners use to shift liability to the contractor. This chapter will also address how the DB process affects the administration of differing site condition risk.

DIFFERING SITE CONDITIONS CLAUSE

Some owners believe that contractors should assume full risk of differing site conditions (Christensen and Meeker 2002). The basic flaw in this approach is that contractors cannot accurately value the risk of geotechnical unknowns. If they try to price the risk, they may include contingencies that either price themselves out of the procurement or (if the price is low enough to win the contract) may not be sufficient to dealing with the actual conditions. Many sophisticated contractors will simply not play in this arena—they refuse to bid on a contract where they face unlimited risk of differing site conditions (Loulakis et al. 1995; Centennial Contractors 2004).

Over time, it has become far more common for owners to agree that they are in the best position to accept the risk of differing site conditions. To accept this risk, they use what has become known as a DSC clause. One of the most frequently cited cases on DSCs is the United States Claims Court decision in *Foster Construction v. United States*, 435 F.2d 873 (1970), where the court provided a clear explanation of the purpose of the DSC clause:

> The purpose of the changed conditions clause is thus to take at least some of the gamble on subsurface conditions out of bidding. Bidders need not weigh the cost and ease of making their own borings against the risk of encountering an adverse subsurface, and they need not consider how large a contingency should be added to the bid to cover the risk. They will have no windfalls and no disasters. The Government benefits from more accurate bidding, without inflation for risks which may not eventuate. It pays for difficult subsurface work only when it is encountered and was not indicated in the logs.

A DSC clause gives a contractor cost and time relief for (1) subsurface or latent physical conditions encountered at the site differing materially from those indicated in the contract; or (2) unknown physical conditions at the site of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract (23 CFR 635.109). This helps the owner as well, in that the owner pays only for the actual costs incurred if these conditions are actually encountered, as opposed to an unliquidated contingency for a problem that may never occur.

The industry and court decisions have commonly referred to the two situations described in the preceding paragraph as Type 1 and Type 2 differing site conditions. A *Type 1 differing site condition* focuses on conditions that are indicated in the contract documents. Classic examples include (1) rock or water at different elevations than shown in the geotechnical report, (2) unknown underground utilities, and (3) soil that contains different characteristics than identified in the contract documents. By contrast, a *Type 2 differing site condition* is independent from what is set forth in the contract documents and is defined by what one would reasonably expect to encounter in performing the work (Loulakis et al. 1995). Examples could include soil compacting or rock fracturing differently than one would reasonably expect.

FEDERAL POLICY ON THE USE OF DIFFERING SITE CONDITION CLAUSES

There is a strong policy in favor of using DSC clauses in federally funded construction contracting. The federal DSC clause, contained in Federal Acquisition Regulation (FAR) 52.236-2, has been the model for dealing with the risk of unforeseen site conditions in standard-form contracts, including those published by the American Institute of Architects and the Engineers Joint Contract Documents Committee. Although the FAR language may differ slightly from that used in other private and public construction contracts, the differences are relatively minor and do not substantively affect the contractor's ability to recover the additional costs and time caused by differing site conditions.

Federal policy regarding the owner assuming differing site condition risk is evident in federal-aid highway projects. 23 CFR 635.109 contains policies, requirements, and procedures for the following DSC clause, which is mandated by the 1987 Surface Transportation and Uniform Relocation Assistance Act to be included for all federal-aid highway projects unless prohibited or otherwise defined pursuant to state law.

> (i) During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.
>
> (ii) Upon written notification, the engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the contract, an adjustment, excluding anticipated profits, will be made and the contract modified in writing accordingly. The engineer will notify the contractor of the determination whether or not an adjustment of the contract is warranted.
>
> (iii) No contract adjustment which results in a benefit to the contractor will be allowed unless the contractor has provided the required written notice.
>
> (iv) No contract adjustment will be allowed under this clause for any effects caused on unchanged work. (This provision may be omitted by the SHA's [state highway agency] at their option.)

Unlike its mandate for the use of a DSC clause on other projects, 23 CFR 635.109(c) does not require DOTs to use a DSC clause in a DB contract. Instead, the regulation states that a DOT "may consider" the use of a DSC clause when "appropriate for the risk and responsibilities that are shared with the design-builder."

The strong federal policy for DSC clauses is also evident by FHWA's Geotechnical Guideline No. 15, "Geotechnical Differing Site Conditions," dated April 30, 1996. This 36-page guideline provides an abundance of information on the geotechnical aspects of differing site conditions, including advice on adequate site investigation, disclosure and presentation of subsurface information by highway agencies, and the use of such information in mitigating or resolving contractor claims of differing site conditions (FHWA 1996).

General Requirements for Relief Under a Differing Site Condition Clause

Although Type 1 and Type 2 DSCs are intended to cover different situations, they share several common elements (Loulakis et al. 1995). They are both required to be physical conditions at the site of the work. Moreover, these conditions must differ materially from those baseline conditions either indicated in the contract documents (for Type 1) or that one would normally expect to encounter (for Type 2). Certain common requirements also have arisen as a matter of case law, including the need for prompt notice and the contractor's obligation to conduct a reasonable site investigation (Loulakis et al. 1995).

To qualify for relief under either condition, a contractor must demonstrate that the condition is a physical condition. The most common conditions have related to soil characteristics, presence of rocks in different qualities or quantities, subsurface water, and a variety of artificial and man-made conditions such as pipelines, artifacts, and debris. Although the type of physical condition that qualifies for recovery under the clause is virtually wide open, there are some constraints. For example, the term "physical condition" has not been interpreted to include physical forces that increase a contractor's efforts, such as the general unavailability of a work site (Loulakis et al. 1995).

A typical DSC clause specifically discusses physical conditions "at the site," suggesting that the project location is the only place where a DSC can occur. This raises the question, however, of how areas that are technically off the site, such as borrow pits, quarries, and access roads, are to be treated. Although only a few cases have addressed this issue, they suggest that such off-site areas can be subject to the DSC clause if their use is so bound up with the contractor's performance that the owner should be responsible for the conditions (Loulakis et al. 1995). For example, *Kaiser Industries Corp. v. United States*, 340 F.2d 322 (Ct. Cl. 1965), allowed recovery under a DSC theory because the government owned the only two quarries in the area and approved their use. Several other cases have recognized the contractor's ability to claim DSCs when the borrow pits or quarries are designated in the contract documents as an approved source of material.

Although there is little case law discussion about the issue of an alleged differing site condition needing to be materially different from the baseline condition, it is clear in practice that this is a major factual hurdle for a contractor to overcome. A condition that differs from the baseline is not enough to satisfy the test; there must be objective evidence to demonstrate that the difference creates a greater amount of work than one would normally have expected or requires a different method of performance (Loulakis et al. 1995).

Unique Type 1 Differing Site Condition Requirements

Type 1 differing site conditions are far more commonly encountered and consequently are addressed more frequently by the courts and boards than Type 2 conditions. To establish entitlement to an equitable adjustment for a Type 1 claim, the contractor must show that the alleged differing site condition was materially different from conditions "indicated" in the contract documents. The contract indications need not be "explicit or specific, but only enough to impress or lull a reasonable bidder not to expect the adverse conditions actually encountered" (Kelleher 2009).

In some instances, determining contract "indications" is relatively easy. If a geotechnical report is included as part of the contract documents and shows rock at elevations far below where they are actually encountered, it is easy for a contractor to meet the burden of showing a contract "indication." Contrast this with a situation where a contractor is responsible for installing concrete cylinder piles for a bridge, and the specifications establish minimum tip elevations for the piles and the means and methods for driving the piles. If the contractor hits refusal before achieving the minimum tip elevations, it might argue for DSC relief on the grounds that the contract indicated that the soil conditions would not be so dense as to make driving the piles by the prescribed process impossible.

In certain situations, a contract indication may be derived from documents that are not part of the contract. For example, in the *City of Columbia v. Paul N. Howard Co.*, 707 F.2d 338, 340 (8th Cir. 1983), the federal court of appeals held that soil borings were a "contract indication" even though the borings were contained in an appendix to the plans and specifications that was expressly excluded as a contract document. In this regard, the court stated,

> The test boring logs do not have to be strictly considered "a part of the contract documents" (which the Appendix states they are not) to be binding on the [owner] to the extent of their own accuracy. We can accept the [owner's] argument that the Appendix is not an item listed in the Table of Contents (but is in addition to the Table of Contents) and therefore the Appendix is not a part of the contract. The clause entitles the contractor to reimbursement when there are 'conditions at the site differing materially from those indicated in the contract.' Even though the logs may not be included in the contract, they are 'indicated' in the contract.

Note that other courts have refused to consider any document that was not specifically incorporated into the contract (Kelleher 2009).

The following are examples of Type 1 differing site conditions where express representations of conditions in the contract documents were found to have differed materially from the actual conditions encountered include:

- *Variance from actual field conditions.* During construction of a highway retaining wall, a contractor discovered that the actual interface point for two portions of the wall varied significantly from the point indicated in the specifications from the DOT. To build the wall as required by the plans, the contractor had to remove a substantial amount of rock that was unforeseen at the time of its bid. In *Thomas M. Durkin & Sons, Inc. v. Dep't of Transp.*, 742 A.2d 233 (Pa. Commw. Ct. 1999), the court found that the contractor had justifiably relied upon the DOT's representations and was entitled to claim that it encountered a Type 1 DSC (Kelleher 2009).
- *Muddy versus dry conditions.* In *Beco Corp. v. Roberts & Sons Constr. Co.,* 760 P.2d 1120 (Idaho 1988), the Supreme Court of Idaho found the subsurface mud to be materially different from the dry conditions indicated by the contract documents and affirmed the contractor's recovery for a Type 1 DSC. The contract documents stated that no water was noted in any of the test holes drilled in the area. During construction, the contractor encountered "subsurface mud covered by a cracked and deceptively dry looking surface. …" (Kelleher 2009).
- *Hard clay versus soft mud.* In *C.J. Langenfelder & Son, Inc.*, Maryland Department of Transportation 1000 (Aug. 15, 1980), the contract specifications required the contractor to remove soft mud, silt, and sand in a river-dredging project. When the contractor encountered hard, undisturbed clay instead of the soft materials specified, the board concluded that the DOT should have recognized that the contractor encountered a Type 1 DSC (Kelleher 2009).
- *"Balanced" excavated materials.* A contract for airport service roads and taxiways contained defective specifications that incorrectly stated that the amount of dirt excavated from the project site was roughly equivalent to the amount needed for fill-in requirements (a "balanced project"). In *Ace Constructors, Inc. v. United States*, 499 F.3d 1357, 1364 (Fed. Cir. 2007), the court held that the contractor encountered a Type 1 DSC and could recover its costs for the purchase of the additional soil necessary to comply with the contract's fill requirements (Kelleher 2009).

Unique Type 2 Differing Site Condition Requirements

As noted above, Type 2 DSCs do not depend on what is indicated in the contract documents. Rather, the conditions encountered must be unusual and differ materially from those reasonably anticipated, given the nature of the work and the locale. To qualify as sufficiently "unknown and unusual," the condition encountered by the contractor does not have to be in the nature of a geological freak (e.g., frost in the tropics) (Kelleher 2009). However, it is clear that the burden for proving a Type 2 DSC is more substantial than for a Type 1 DSC. Proof of a Type 1 DSC is based on relatively objective information (i.e., the contract), whereas proof of a Type 2 DSC is based on subjective criteria (i.e., unknown and unusual conditions) (Loulakis et al. 1995).

The key to recovery for a Type 2 DSC is to evaluate the contractor's actual and constructive knowledge of working conditions in the area (Kelleher 2009). For example, awareness of a condition at the site that is common knowledge to other contractors working in the area, and thus reasonably ascertainable by inquiry, may be attributed to the contractor (Kelleher 2009). Some contractors have been able to recover on Type 2 claims by establishing unexpected quantities of material at the site or more vegetation than anticipated (Loulakis et al. 1995). The following are other examples of Type 2 DSCs:

- *Hard clay.* A site preparation contractor encountered an unusual amount of clay material during its attempt to install sand drains needed for a bridge replacement project. The court in *Sutton Corp. v. Metro Dist. Comm'n*, 667 N.E.2d 838, 842 (Mass. 1996), held that the subsurface conditions encountered by the contractor differed substantially from those ordinarily encountered in the installation of sand drains using the methods specified in the contract (Kelleher 2009).
- *Subsurface water.* A water table was found to be much higher than could have been reasonably anticipated. The court in *Loftis v. United States*, 110 Ct. Cl. 551 (1948) found this to be a Type 2 DSC, as it concluded that dry and stable subsurface conditions were reasonably anticipated, even though they were not indicated in the contract (Kelleher 2009).
- *Buried pipe and debris.* While installing an underground electrical conduit, a contractor encountered asphalt, concrete, rebar, and other debris that damaged its directional drilling equipment on 19 separate occasions. Because the unanticipated subsurface materials differed considerably from the clay and occasional river rock common in the area, the board of contract appeals, in *Parker Excavating, Inc.*, ASBCA No. 54637, 06-1 BCA ¶ 33,217 (2006), concluded that the contractor encountered a Type 2 DSC (Kelleher 2009).

Type 2 DSCs may also be alleged when material at the site behaves differently than expected. Thus, even though clay was expected to be encountered at a site, percolating water caused the clay to behave in an unusual, erratic fashion with an unexpected tendency to slide, and a court found that there was a DSC (Kelleher 2009). Similarly, the unexpected shrinkage of soil, which materially increased the number of cubic yards of earth in a dam, was an unexpected property of the soil that constituted a Type 2 DSC (Kelleher 2009). Another example of a successful Type 2 DSC claim occurred when a contractor encountered subsurface water (as expected), but its flow rate was unusual and unforeseeable (Kelleher 2009).

IMPEDIMENTS TO RECOVERING UNDER A DIFFERING SITE CONDITION THEORY

Even the most liberal of DSC clauses include other clauses that attempt to minimize or reduce claims under them. These include clauses relating to site inspection and notice. Some owners will include clauses that seek to limit a contractor's ability to rely on information provided during the bidding process. Whether these additional contract clauses bar or foreclose recovery under a DSC clause usually depends on the specific circumstances of each case (Kelleher 2009).

Site Inspection

The site inspection clause required by the federal government (FAR 52.236-3) reads as follows:

> The Contractor acknowledges that it has taken steps reasonably necessary to ascertain the nature and location of the work, and that it has investigated and satisfied itself as to the general and local conditions which can affect the work or its costs, including but not limited to (1) conditions bearing upon transportation, disposal, handling, and storage of materials; (2) the availability of labor, water, electric power, and roads; (3) uncertainties of weather, river stages, tides, or similar physical conditions at the site; (4) the conformation and conditions of the ground; and (5) the character of equipment and facilities needed preliminary to and during work performance. The Contractor also acknowledges that it has satisfied itself as to the character, quality, and quantity of surface and subsurface materials or obstacles to be encountered insofar as this information is reasonably ascertainable from an inspection of the site, including all exploratory work done by the Government, as well as from drawings and specifications made a part of this contract. Any failure of the Contractor to take the actions described and acknowledged in this paragraph will not relieve the Contractor from responsibility for estimating properly the difficulty and cost of successfully performing the work, or for proceeding to successfully perform the work without additional expense to the Government (FAR 1984).

This clause is relevant to the DSC clause, because if the contractor discovered the condition through a reasonable inspection then it cannot use the DSC clause to recover (Loulakis et al. 1995). In essence, a contractor cannot be allowed to claim that it was misled by the existing conditions if it could have learned the status of the conditions through a reasonable inspection (Loulakis et al. 1995).

The level of inspection required of a contractor is not excessively burdensome, and a contractor is not required to discover latent conditions that require more time or expertise than a reasonable contractor would have (Loulakis et al. 1995). In addition, there is ample case law that even if a contractor has not done a site investigation, it still has the ability to make a claim under the DSC clause if a reasonable site investigation would not have disclosed the conditions (Loulakis et al. 1995).

Exculpatory Clauses

Another potential obstacle for a contractor claiming under the DSC clause are broad exculpatory clauses disclaiming liability for the accuracy of plans, specifications, borings, and other subsurface data. An example of such a clause follows:

> Information, data, and representations contained in the contract documents pertaining to the conditions at the site, including subsurface conditions, are for information only and are not warranted or represented in any manner to accurately show the conditions at the site of the work. The Contractor agrees that he shall make no claims for damages, additional compensation or extension of time against the Owner because of encountering actual conditions in the course of the work which vary or differ from conditions or information contained in the contract documents. All risks of differing subsurface conditions shall be borne solely by the Contractor (Kelleher, 2009).

Many courts have held that these clauses do not have the sweeping effect the drafter of the clause may have desired. This is particularly true when the exculpatory language is broad and in direct contradiction to the DSC clause (Loulakis et al. 1995). For example, in *Woodcrest Construction Co. v. United States*, 408 F.2d 406 (Ct. Cl. 1969), the United States Court of Claims allowed a contractor to recover under the DSC clause despite the extremely broad exculpatory provisions in the contract. The court stated,

> The effect of an actual representation is to make the statement of the Government binding upon it, despite exculpatory clauses which do not guarantee the accuracy of a description. …Here, although there is no (express) statement which can be made binding upon the Government, there was in effect a description of the site, upon which plaintiff had a right to rely, and by which it was misled. Nor does the exculpatory clause in the instant case absolve the Government, since broad exculpatory clauses … cannot be given their full literal reach, and "do not relieve the defendant of liability for changed conditions as the broad language thereof would seem to indicate (citing *Felhaber Corp. v. United States*, 151 F. Supp. 817, 825 (Ct. Cl.)).

Despite the traditional reluctance of the courts and boards to enforce disclaimer language, and the strong policy inherent in the DSC clause, several decisions have enforced certain disclaimers.

The owner in *Frontier Foundations, Inc. v. Layton Construction Co.*, 818 P.2d 1040 (Utah 1991) provided boring logs from a representative area near the site but expressly limited their use by stating that the logs were not part of the contract documents and were not a warranty of subsurface conditions. The contract also included a site inspection clause stating that the contractor's failure to become familiar with the prevailing work conditions would not relieve the contractor from responsibility for performing work at no additional cost to the owner. The court held that reliance on the logs was not reasonable because it did not take into consideration the clear disclaimer language in the contract (Loulakis et al. 1995).

Another important case is *Millgard Corp. v. McKee/Mays*, 49 F.3d 1070 (5th Cir. 1995), where the court rejected a contractor's DSC claim based on technical defenses. The court enforced a disclaimer that stated that the geotechnical report was (1) for the bidders' information only; (2) not a warranty of subsurface conditions and therefore took no responsibility for the accuracy, true location, and extent of soil tests prepared by others; and (3) not a part of the contract documents. In addition to enforcing the disclaimer, the court noted that because the geotechnical report was not a part of the contract documents, the contractor could not use it to support a Type 1 DSC claim, as its data would not form contractual "indications" of expected site conditions. Adding to the contractor's problems was that the instructions to bidders contained a clause that the bidders were expected to perform their own independent site investigation (Loulakis et al. 1995).

Compliance with Notice Requirements

The final general obstacle to recovery is the notice portion of the DSC clause, which requires that the contractor alert the owner to the existence of the alleged DSC, giving the owner an opportunity to evaluate the conditions before they are disturbed. Depending on state law, the failure to do so may preclude a contractor from recovering damages caused by a differing site condition.

For example, a court decision arising out of the Big Dig in Boston, *Earth Tech. Env't and Infrastructure, Inc. v. Perini/Kiewit/Cashman*, 2004 WL 2341397 (Mass Supp. 2004), held that a soil excavator's notice to the general contractor of unexpected levels of contaminated clay 4 years after the condition was discovered was neither prompt nor before the condition was disturbed, as specifically required by the contract. The court held that the unexcused failure of the excavator to comply with the contractor's notice provisions forever barred the otherwise valid DSC claim (Kelleher 2009). Certain states, such as Virginia, require strict compliance with contractual notice provisions and will not waive them under any circumstances, even if there was no prejudice to the owner by the contractor's failure to give notice.

In some states, the courts may excuse the lack of strict compliance if there is actual knowledge of the condition by the owner or its agent, or if the owner suffers no prejudice from the contractor's failure to give written notice. For example, in *Ronald Adams Contractor, Inc. v. Mississippi Trans-*

portation Commission, 777 So. 2d 649 (Mississippi 2000), the DSC clause in a highway improvement contract placed an equal burden on the contractor and the DOT to discover and notify the other of unforeseen conditions. As a result, the court excused the contractor's failure to give formal notice of unsuitable soil conditions, concluding that the DOT's actual knowledge of the poor conditions made it pointless to require the contractor to give notice of those same conditions (Kelleher 2009). Likewise, in *Weber Construction Inc. v. County of Spokane*, 98 P.3d 60 (Wash. Ct. App. 2004), the court held that a county waived strict compliance with the contractual notice terms by failing to respond to a road contractor's repeated requests for guidance on the disposal of boulders that were unsuitable for use as fill (Kelleher 2009).

DIFFERING SITE CONDITIONS AND THE DESIGN-BUILD PROCESS

A host of unique issues are associated with the investigation and liability for site conditions under a project delivered through the DB process. Depending on when the design-builder is retained, the design-builder may have significant responsibility for predesign site evaluation and may be responsible for developing the geotechnical program. This responsibility, coupled with the fact that the design-builder develops the design and drafts the construction documents, mandates that the parties consider which site condition risks the owner retains and which will be transferred (Loulakis and Shean 1996). Authors on this topic have suggested many approaches, including the following:

> One way to address site condition risks in Design-Build contracting is for the Owner to establish during the development of its concept documents and design criteria a listing of geotechnical assumptions based upon either a preliminary site exploration program or information from previous building programs. This information is then considered a baseline for the Design-Builder to rely on that, if incorrect, triggers the application of the Differing Site Conditions clause. Alternatively, the Owner and the Design-Builder can agree upon an investigation program that will be used as the baseline for differing site conditions claim (Loulakis and Shean 1996).

This "baseline" approach has been used extensively on tunneling projects and is typically included through the use of GBRs. This was undertaken on the Tren Urbano project in Puerto Rico, and established a mechanism for the parties to address the design-builder's responsibility for subsidence claims and damages (Essex 2007; Hatem 2011).

Several agencies have adopted creative contractual approaches to handling site condition risk on DB projects. Virginia DOT (VDOT) uses a Scope Validation process, whereby the design-builder is given a period of time after contract award to determine if there are any inconsistencies or defects in the Contract Documents that should be corrected. This is intended to include investigation of site conditions as well as designs proffered by VDOT in the RFP documents. The purpose of this approach is to address an issue that has long plagued DB contracts: can the owner shift the risk of errors in its RFP documents to the design-builder? Most courts that have considered this issue have rejected the notion of shifting these risks to the design-builder based on the *Spearin* doctrine, in which the owner implicitly warrants the sufficiency of its bidding documents (Mitchell 1999; Cushman and Loulakis 2001). The Scope Validation process is a way of handling this directly. A recent version of VDOT's clause reads as follows:

> 2.2.1 Scope Validation Period. The term 'Scope Validation Period' is the period of time that begins on the Date of Commencement and extends for the number of days listed in Exhibit 1. During the Scope Validation Period, Design-Builder shall thoroughly review and compare all of the then-existing Contract Documents, including without limitation the RFP Documents and the Proposal, to verify and validate Design-Builder's proposed design concept and identify any defects, errors, or inconsistencies in the RFP Documents that affect Design-Builder's ability to complete its proposed design concept within the Contract Price and/or Contract Time(s) (collectively referred to as 'Scope Issues'). The term 'Scope Issue' shall not be deemed to include items that Design-Builder should have reasonably discovered prior to the Agreement Date.
>
> 2.2.2 Scope Validation Period for Non-Accessible Areas of the Site. The Parties recognize that Design-Builder may be unable to conduct the additional geotechnical evaluations contemplated by Section 4.3.2 below because it will not have access to certain areas of the Site within the Scope Validation Period set forth in Section 2.2.1 above. Design-Builder shall notify Department at the meeting set forth in Section 2.1.2 of all such non-accessible areas and the dates upon which such areas are expected to become accessible. If Department agrees that such areas are non-accessible, then, for the limited purpose of determining Scope Issues that directly arise from geotechnical evaluations for such areas, the term 'Scope Validation Period' shall be deemed to be the thirty (30) day period after the date the specified area becomes accessible for purposes of conducting the geotechnical evaluation.
>
> 2.2.3 Submission Requirements for Scope Issues. If Design-Builder intends to seek relief for a Scope Issue, it shall promptly, but in no event later than the expiration of the Scope Validation Period, notify Department in writing of the existence of such Scope Issue. Within twenty-one (21) days of such notice, Design-Builder shall provide Department with documentation that sets forth, among other things: (a) the assumptions that Design-Builder made during the preparation of its proposal that form the basis for its allegation, along with documentation verifying that it made such assumptions in developing its proposal; (b) an explanation of the defect, error or inconsistency in the RFP Documents that Design-Builder could not have reasonably identified prior to the Agreement Date: and (c) the specific impact that the alleged Scope Issue has had on Design-Builder's price or time to perform the Work. Within a reasonable time after Department's receipt of the documentation described in the preceding sentence, the Parties shall promptly meet and confer to discuss the resolution of such

> Scope Issues. If Department agrees that Design-Builder has identified a valid Scope Issue that materially impacts Design-Builder's price or time to perform the Work, a Work Order shall be issued in accordance with Article 9 hereof. If Department disagrees that Design-Builder has identified a valid Scope Issue that materially impacts Design-Builder's price or time to perform the Work, then Design-Builder's recourse shall be as set forth in Article 10. Notwithstanding anything to the contrary in the Contract Documents or as a matter of law, Design-Builder shall have the burden of proving that the alleged Scope Issue could not have been reasonably identified prior to the Agreement Date and that such Scope Issue materially impacts its price or time to perform the Work.
>
> 2.2.4 Design-Builder's Assumption of Risk of Scope Issues. The Parties acknowledge that the purpose of the Scope Validation Period is to enable Design-Builder to identify those Scope Issues that could not reasonably be identified prior to the Agreement Date. By executing this Agreement, Design-Builder acknowledges that the Scope Validation Period is a reasonable time to enable Design-Builder to identify Scope Issues that will materially impact Design-Builder's price or time to perform the Work. After the expiration of the Scope Validation Period, with the sole exception of those Scope Issues identified during the Scope Validation Period and subject to valid requests for Work Orders in accordance with Section 2.2.3 above, the Parties agree as follows:
>
> 1. Design-Builder shall assume and accept all risks, costs, and responsibilities of any Scope Issue arising from or relating to the Contract Documents, including but not limited to conflicts within or between the RFP Documents and Proposal;
> 2. Design-Builder shall be deemed to have expressly warranted that the Contract Documents existing as of the end of the Scope Validation Period are sufficient to enable Design-Builder to complete the design and construction of the Project without any increase in the Contract Price or extension to the Contract Time(s); and
> 3. Department expressly disclaims any responsibility for, and Design-Builder expressly waives its right to seek any increase in the Contract Price or extension to the Contract Time(s) for, any Scope Issue associated with any of the Contract Documents, including but not limited to the RFP Documents (VDOT 2010).

Another contractual approach taken by owners on DB projects has been to develop contingencies and allowances for certain potential differing site conditions. For example, the Southern Nevada Water Authority concluded that the risk of potential water intrusion on its Lake Mead Intake #3 DB project, a 3-mile-deep tunnel, was so significant that it was far better for it to use a grouting allowance and assume the risk of grouting than to have the design-builder absorb this risk.

RECENT CASES ADDRESSING DIFFERING SITE CONDITION CLAIMS

Each year, a variety of cases discuss the application of the DSC clause. The following three cases are examples of the type of issues that are raised when an owner contests the existence of a DSC. The first is a Virginia case involving a claim by a contractor against VDOT, with the case analyzing the contractor's failure to meet the notice requirements of the contract and an alleged Type 2 DSC. The second is a Colorado case on a federal project that considered several defenses raised by the owner against the contractor's DSC claim. The third case involved a federal DB project where the design-builder claimed that the government provided incorrect information about existing culverts, which caused the design-builder to incur additional design efforts.

Virginia DOT v. AMEC Civil LLC

Commonwealth of Virginia v. AMEC Civil, LLC, 699 SE2d 499 (2010) is one of the most significant construction law cases addressed by the Virginia Supreme Court in many years. The litigation involved a claim by AMEC Civil, LLC (AMEC) against VDOT on a $73 million contract for the construction of the Route 58 Clarksville Bypass in Mecklenburg County that was delayed by more than 20 months. Following completion of the project, AMEC submitted a $25 million claim to VDOT for a number of individual claim items related to differing site conditions, defective design, delay, and acceleration. VDOT denied the claim and AMEC ultimately filed suit.

One of the most significant issues raised in the court proceedings was whether AMEC had given proper written notice of its claims. The trial court rejected VDOT's argument that AMEC had failed to literally comply with the contract and Virginia claim statute. It ruled that actual notice was an appropriate substitute for written notice and that, in any event, VDOT had received written notice of many of AMEC's claims. As a result, the trial court rendered a verdict for AMEC of nearly $22 million.

VDOT appealed to the Virginia Court of Appeals, which reversed the trial court's decision on a number of claims, including claims subject to VDOT's lack of notice defense. The Appeals Court held that a contractor is required to give timely written notice to VDOT of claims and that AMEC had not done so for most of its claims. This ruling resulted in a substantial reduction in the award to AMEC, which caused AMEC to appeal to the Virginia Supreme Court.

The Supreme Court agreed with the Court of Appeals that written notice is required, and addressed the requirements for written notice. First, the Court noted that the Virginia Code specifies that written notice "must announce the contractor's 'intention to file [a] claim.'" The statute also requires that such notice be given either "at the time of the occurrence" of the claim or at the "beginning of the work upon which the claim…is based." The court said, "[a]t a minimum, to satisfy the written notice requirement, the written document at issue must give notice of the contractor's intent to file its claims and must be 'given to [VDOT]' by letter or equivalent communication directed to VDOT at the appropriate time." After analyzing all of AMEC's claims that were challenged by VDOT for lack of notice, the Supreme Court largely agreed with the Court of Appeals, which resulted in final judgment for VDOT on a substantial portion of the initial verdict for AMEC.

AMEC's differing site conditions claim, which was not subject to a notice defense, was based on AMEC's construction of Bridge 616 across Kerr Lake, a dam-controlled reservoir managed by the U.S. Army Corps of Engineers. The Corps regulates Kerr Lake's water level, usually maintaining a "normal level" of 300 ft. When the water level rises to 305 ft, the Corps begins releasing water at a certain rate and increases that rate as the water continues to rise. The lake water level was critical to the construction of Bridge 616 because AMEC could not access the lake and complete the columns that hold up the bridge when the water level was too high.

The contract contemplated routine fluctuations in the water level of Kerr Lake and AMEC planned to do other tasks during the periods when the lake water level fluctuated to a higher level. However, in 2003, the lake water level remained high for 6 months, thereby substantially delaying AMEC's work, primarily the construction of Bridge 616. VDOT granted a 148-day time extension because of "unusual period of high water levels," but did not award AMEC compensation for the delays. AMEC argued, among other things, that this was a Type 2 DSC and that it was entitled to both time and money. VDOT defended on the grounds that sustained water levels could not be a Type 2 DSC because they were a known, predictable condition, and AMEC knew that there had previously been sustained periods of high water.

The Supreme Court agreed with AMEC. It found ample evidence from both parties that the sustained elevated water levels were of an "unusual duration," presenting an "unusual circumstance," and not ordinarily encountered as inherent in the construction work provided for in the contract. Moreover, the unknown physical condition was not one that could be reasonably anticipated by AMEC from its study of the contract, inspection of the site, or general experience as a contractor in the area.

> The risk of sustained high water in Kerr Lake was unusual, and not one that AMEC was charged with the responsibility of including in its bid. AMEC properly incorporated only the costs associated with routine fluctuations after consulting the U.S. Army Corps' website and reviewing historical water level information. VDOT benefited from more accurate bidding, without inflation for a risk that might not have eventuated, but now must bear the costs associated with a risk that came to fruition and adversely impacted AMEC's ability to complete construction as scheduled (*Commonwealth of Virginia v. AMEC Civil, LLC*, 699 SE2d 499 2010).

The Supreme Court also disagreed with VDOT's argument that the sustained elevated water levels were a natural event and therefore an act of God, which did not qualify as a DSC. The court noted that Kerr Lake is a dam-controlled reservoir with its water level managed by the Corps of Engineers to prevent downstream flooding on the Roanoke River. The sustained elevated water levels were not a natural event, as they resulted from the Corps of Engineers' exercise of its control over the dam, which dictated the water level of Kerr Lake. This was not sufficient to bar this event as a Type 2 DSC.

URS Group, Inc. v. Tetra Tech FW, Inc.

URS Group, Inc. v. Tetra Tech FW, Inc., 2008 WL 323767 (Colo.App.) involved a differing site condition dispute on a remediation project. Tetra Tech FW, Inc. (TTFW) entered into a contract with the U.S. Army to serve as program management contractor on an arsenal remediation project at the Rocky Mountain Arsenal. TTFW issued an RFP seeking bids for soil remediation and foundation demolition work on the project. URS Group, Inc. (URS) submitted a bid for $10,857,570 and was awarded the subcontract for the work. URS began demolition, but quickly encountered problems removing the foundations. URS argued that the concrete foundation footings did not conform to the information contained in the RFP, and submitted a claim to TTFW under the contract's DSC clause, seeking a price adjustment of approximately $9 million. The trial court ruled in favor of TTFW, finding that even though TTFW possessed information regarding subsurface conditions on the project that it did not disclose to bidders, URS had entered into a fixed-price contract and thereby assumed the risk of encountering unknown subsurface conditions.

URS appealed to the Colorado Court of Appeals, which overturned the trial court's ruling because it ignored the fundamental risk-shifting allocation of a DSC clause. TTFW argued that because URS warranted its familiarity with the project site and the "physical and other conditions, including hazardous substances, materials, agents or vapors, both surface and subsurface…," the warranty effectively overrode the DSC clause. The appeals court rejected this argument, noting that such an interpretation would improperly render the DSC clause meaningless. Indeed, the court reasoned that looking to other clauses in the contract to shift liability to investigate site conditions back to the subcontractor, as TTFW proposed, would frustrate the very purpose of the DSC provision. TTFW also advanced several other "assumption of risk" theories based on URS's conduct, but none were successful. Namely, TTFW argued that irrespective of the DSC provision, URS assumed the DSC risk through its own conduct in establishing a $103,000 contingency in its bid and submitting a lump-sum bid when it knew it did not have complete information. TTFW also argued that as-built drawings of the existing foundations were available at the Rocky Mountain Arsenal library and that URS's failure to review this information barred its recovery.

The appeals court was not persuaded by any of these arguments. It found that including a small contingency in a bid does not preclude a contractor from making a DSC claim when the subsurface conditions differ materially from those indicated in the contract. Moreover, the court ruled that the DSC clause at issue expressly permitted URS to enter into a fixed-price contract that relied on the information provided to it, and that URS was not required to go outside the RFP information provided. The court noted that the as-built drawings at the library were not referenced or included in the RFP, and that the RFP designated other drawings and specifications and expressly instructed bidders to rely on these drawings and specifications to perform the work.

Appeal of Lovering-Johnson, Inc.

In *Appeal of Lovering-Johnson, Inc.* (2005), the Armed Services Board of Contract Appeals (Board) largely denied the design-builder's claim for more than $6.8 million and 267 days of alleged delays. The project involved a housing office and community center, 140 family housing units, and associated site improvements at a former Naval Air Station in Glenview, Illinois. Lovering-Johnson, Inc. (LJI), as design-builder, was required to complete all phases of the work within 915 calendar days, by February 1998. The parties determined that LJI's design would be reviewed by the Navy in increments at 40% complete and 80% complete. LJI originally planned to complete all design work from October through December 1995, with construction to be completed within 18 months. Owing to a number of issues that arose during the design phase, however, LJI did not submit its final design drawings to the Navy until February 1997.

In May 2002, more than 4 years after substantial completion of all phases, LJI submitted its claim, which stemmed primarily from the pre-construction design period. The contracting officer denied the claim and LJI appealed to the Board. On appeal, one of LJI's main theories of recovery was that it was required to perform "unfunded preliminary design studies." For instance, LJI argued that the government required it to perform extra design work on the storm drainage system. Under the performance specifications, LJI was required to design a system capable of handling a 10-year storm and runoff from adjacent properties. In preparing its design, LJI relied on solicitation drawings by the Navy that depicted various (smaller) sized drainage pipes. LJI contended that because of an alleged DSC of high flow rates and large culverts, it ultimately had to use wider pipes in its design than shown on the initial drawings, and as such, it was entitled to damages. The Board rejected LJI's argument on several grounds, stating that—

> Fundamentally, [LJI] misconstrues the extent of its design responsibility. . .[its] differing site conditions (DSC) allegations are premised on the view that the Navy had already done the storm drainage design work for it.

According to the Board, an adequate site investigation would have revealed the presence of the twin 60-in. culverts and potentially "huge flows" from off-site water sources. In addition, the Board believed that LJI's reliance on the drawings was misplaced given that the owner's solicitation drawings were not detailed and the pipe systems identified were ambiguous. Most important, the Board concluded that the Navy's design was not "final" and that its package expressly identified that any concepts and information contained therein would have to be verified before LJI developed the "final" design. LJI, not the Navy, was responsible for designing the drainage system.

Aside from the DSC claim, LJI asserted that the Navy took too long to review its design documents. LJI asserted that in a DB setting, the government's review of the 40% and 80% design should have been a cursory, "over-the-shoulder" analysis of its design. Instead, LJI argued, the Navy approached the design review period as if the contract were a DBB delivery system. In denying LJI's claims, the Board issued a rather scathing rebuke of LJI and found its design documentation over the course of the project to be "incomplete, submitted piecemeal, error-filled, replete with variations from contractual requirements and otherwise inadequate." Ultimately, the Board concluded that LJI offered no evidence that the Navy's comments, disapprovals, or itemization of problems during the design review process were unwarranted, lacked merit, or otherwise caused LJI to perform extra work.

CONTRACTOR'S PERSPECTIVE

During the interviews, each design-builder was asked to comment on the impact of the DSC with respect to geotechnical uncertainty. There was nearly unanimous agreement (10 of 11) that interpreting the agency's DSC was "a challenge on all DB projects." The issue was not in understanding the clause's legal verbiage, but rather in determining how the agency would actually apply the clause to identify what constitutes a DSC. One interviewee called it a "trigger point." The one interviewee who responded that this issue was a challenge on only "some" rather than "all" DB projects referred to the Washington State DOT (WSDOT) practice of setting a monetary ceiling to the contractor's DSC risk and directly stating that WSDOT owns the risk for everything above that amount. Chapter five provides details on this practice. This relates to the previously cited trigger point comment of another interviewee. Hence, the outcome is to underline the need for the agency to be as clear as possible in articulating how it intends to apply its DSC clause on a project-by-project basis, and the WSDOT process appears to hold promise as a mechanism to quantify the geotechnical risk-sharing arrangement in each project.

CONCLUSIONS

The following conclusions can be drawn from this analysis:

- The design-builder is entitled to rely on the geotechnical information contained in the DB RFP, and the DSC furnishes a mechanism under which the design-builder can claim additional costs and time if the RFP information does not reasonably match the actual conditions.
- To be successful in a DSC claim, the design-builder must rigorously adhere to the notice conditions contained in DSC clause.

CHAPTER THREE

GEOTECHNICAL CONTENT OF AGENCY DESIGN-BUILD POLICIES, PROCEDURES, AND PROGRAMS

INTRODUCTION

This chapter reviews findings as they relate to the policies, principles, and guidelines currently being followed by state DOTs to implement DB contracts for transportation projects. This chapter will combine information collected through the direct experience of the authors, literature search, the RFQ/RFP content analysis, and DOT survey responses. Understanding how decisions made in the DB procurement process affect project design and construction is important to permit the final contract to allocate geotechnical risk in a fair and equitable manner.

The major issue during the procurement stage of a project relates to how much geotechnical data will be provided to the proposers to allow them to submit competitive pricing without excessive contingencies to cover the risks of uncertainties. This particular issue is exacerbated because most public owners select DB project delivery to accelerate the delivery of a particular project (Songer and Molenaar 1996). As a result, it is often impossible to include extensive geotechnical investigations in the preliminary engineering completed as part of the RFP development process (Beard et al. 2001). For example, federal military departments have used DB as a means to obligate construction funding before it expires in a given fiscal year, making development of a GBR impossible within the fund expiration time frame (Grammer 2001). For this and other reasons, the problem requires answers to the following questions:

- Will the geotechnical aspects of the site be a major factor in the project design process?
- How much time is available for geotechnical investigations and preliminary geotechnical engineering?
- How uncertain are the subsurface conditions on the project site?
- What are the critical geotechnical variables that must be known for the DOT to develop a preliminary design for funding and bidding purposes?
- What are the critical geotechnical variables that must be known for the design-builder to complete a workable design?
- Can the geotechnical risk be shared with the design-builder to reduce project costs?
- Is there flexibility in the procurement and contracting process to enable the design-builder to advance the geotechnical investigation before finalizing a price?

The remainder of this chapter explores the answers to these questions as found in the literature, the RFP content analysis, and the DOT survey responses.

DESIGN-BUILD PROJECT DELIVERY DECISION

The predominant way that DB is procured in the public sector requires that the design-builder commit to a firm fixed price before the project's design is complete (Mahdi and Alreshaid 2005). Thus, the risk of cost overruns for unforeseen geotechnical site conditions is increased, since the full geotechnical investigations necessary for each project will likely be completed after contract award, during the design process.

Given this situation, the first question a DOT will address is whether a given project is a good candidate for DB project delivery, in light of the influence of geotechnical conditions on the preliminary design, price, and time. Table 1 is a synopsis of the risk profiles for DBB and DB found in Koch et al. (2010) and adapted for geotechnical risks. One can see that the major change in the risk profile is the result of the shift in design responsibility to the design-builder. The owner's new DB risks result in many cases from the failure to relinquish the design responsibility to the design-builder. The owner's DB scope risk for geotechnical design review comments and directives is an example. The direct and tacit approval of constructive changes to the geotechnical design during construction is another example.

Assuming that the compression of the project's schedule is not an issue, the owner's ability to accurately portray the scope of work without completing the typical geotechnical investigation will provide the answer to this question. Ideally, the DOT's RFP packages should provide DB proposers with sufficient subsurface information to permit them to generate conceptual designs for the foundation, embankment, and other features of work that are dependent on the geotechnical conditions of the site.

If the subsurface and geologic project information is inadequate, then the proposing design-builder has two options (Christensen and Meeker 2002). First, it can include a large contingency in the price to cover what its geotechnical designers would believe to be the worst possible case. The second is to declare the project to be too risky and choose

TABLE 1
DBB VERSUS DB RISK PROFILES

	Design-Builder	Owner
	Geotechnical Scope Risk	
DBB	• Warranties and Guarantees • Latent Defects—Workmanship • Competent Geotechnical Construction Personnel Available	• Design Error and Omissions • Latent Defects—Design • Direct and Tacit Approval of Constructive Changes to Design
DB	• Design Errors and Omissions • Warranties and Guarantees • Latent Defects – Design – Workmanship • Competent Geotechnical Design Personnel Available	• Clear Geotechnical Scope Definition • Direct and Tacit Approval of Constructive Changes to Geotechnical Design • Geotechnical Design Review Comments and Directives • Technical Review Capability
	Geotechnical Cost Risk	
DBB	• Rework • Subcontractor Default • Market Fluctuation After Award	• Redesign and Resultant Rework • Construction Contract Amount • Market Fluctuation During Design – Material – Labor
DB	• Rework • Redesign • Subcontractor Default • Market Fluctuation During Design – Material – Labor	• Design-Build Contract Amount • Prompt Payment • Design-Builder Default
	Geotechnical Schedule Risk	
DBB	• Contract Completion • Date • Liquidated Damages	• Timely Design Completion • Owner Furnished Property Delivery
DB	• Delivery on Approved Schedule • Fast-Track Geotechnical Rework • Liquidated Damages	• Unrealistic Schedule • Timely Geotechnical Design Approvals on Fast-Track Project • Owner-Furnished Property Delivery

not to bid (Dwyre et al. 2010). Either option has a negative impact on the owner. In the first case, the contingency could drive the price outside the available budget and make it impossible to award. In the second case, the pool of qualified competitors becomes shallower, possibly leaving only those that do not recognize (or have chosen not to price) the actual scope risk. This may result in an award to a DB entity that does not know it is in trouble until the geotechnical risks are quantified during the design process. It also exposes the DOT to either a major DSC claim or a design-builder that has underpriced the job and is in financial trouble—possibly to the point of default. For these reasons, it is critical that the project delivery method selection decision be made after careful consideration of the risk associated with the site's subsurface and geological conditions.

Blanchard (2007) synopsizes the Florida DOT (FDOT) DB experience by stating that projects "with low risk of unforeseen conditions… [and] low possibility for significant change during all phases of work" are good candidates for DB project delivery. FDOT also picks projects "that demand an expedited schedule and can be completed earlier." Therefore, the issue of understanding the actual risk of unforeseen geotechnical conditions becomes more important. The DOT survey asked the respondents that did not use DB to explain their reasons. Most cited the lack of statutory authority. Two respondents indicated that they do not use DB because the liability for geotechnical aspects was unfavorable for the agency. Another two cited the lack of time to complete geotechnical investigations to a point where they could reasonably quantify the geotechnical scope. Table 2 contains a list of project characteristics found in the literature that indicate that a given project is *not* a good candidate for DB project delivery.

Diekmann and Nelson (1985) found that the three major causes for DBB construction claims were design errors (39%), owner-directed changes (30%), and DSCs (15%). One of the cited advantages of DB project delivery is that the owner is no longer liable for design errors and omissions (Mitchell 1999; Killen and Gibson 2005). However, that is only if the owner was not the source of the design error. If a design-builder's design concept during the proposal process

TABLE 2
PROJECT CHARACTERISTICS THAT INDICATE THAT A GIVEN PROJECT IS A POOR CANDIDATE FOR DB PROJECT DELIVERY

Project Characteristic	Source
• High risk of differing site conditions • Low probability to be able to expedite design and construction schedule • High possibility of change to phases of work	Blanchard (2007)
• The design must be complete for accurate pricing • The design must be complete for permitting or third-party issues • The owner wants "heavy" input into the design • Project is too small to attract competition	Gransberg et al. (2006)
• Project scope is difficult to define • Project scope has high probability of change in permitting process • Missing "sound geotechnical and environmental data prior to the bid phase"	Christensen and Meeker (2002)
• "[I]nability of design-stage investigation to eliminate risks from unknown geological conditions for construction of underground works"	Hoek and Palmieri (1998)
• Risk-shedding is owner's primary motivation for using alternative project delivery methods	Scheepbouwer and Humphries (2011)

is ultimately inadequate because it was based on the owner's design input information—such as a boring log or specification of a particular type of foundation (e.g., spread footings instead of deep foundations)—then the question of responsibility is no longer clear. There is substantial legal precedent for the fact that the owner will retain these risks under a DB delivery system to the same degree as it would under a DBB delivery system (Loulakis and Shean 1996). Therefore, DB project delivery does not necessarily insulate the owner from the three most common DBB claims related to a project's geotechnical conditions.

Table 3 summarizes state DOT policies regarding the geotechnical aspects of DB projects gleaned from the survey. Tables 4 and 5 furnish additional details from comments made regarding answers to survey questions.

Approaches to Understanding Perceived Geotechnical Risk

The North Carolina DOT (NCDOT) uses a qualitative evaluation of project characteristics that include "innovation, constructability, safety, environmental permitting, right-of-way acquisition, utilities, traffic management, public perception, and risk" (Kim et al. 2009). The agency couples that with a quantitative cost and schedule risk analysis to determine whether a given project is a good candidate for DB delivery. Part of the decision-making process includes an assessment of geotechnical investigation needs as well as the potential for delay resulting from the need to obtain permits to perform subsurface investigations. If the project is selected for DB delivery, NCDOT will then perform what it calls "prelet geotechnical investigations" and include the results in the RFP (Kim et al. 2009). The agency also conducts at least two "one-on-one" meetings with each firm on the short list to identify information gaps and assess the need for further investigation to reduce risk. NCDOT then conducts the supplementary investigation. The California (Caltrans) and Minnesota (Mn/DOT) DOTs also use one-on-one meetings to identify the need for further information and address risks perceived by the competing design-builders but not recognized during the RFP development process (Mn/DOT 2005; Trauner Consulting Services 2007). VDOT also liberally uses the concept of proprietary meetings for its two-phase DB selection processes, with the expectation that proposers will identify any perceived gaps in the geotechnical data as appropriate.

Geotechnical Issues to Be Addressed

A 2011 Strategic Highway Research Program 2 report, which is focused on earthwork projects, provides the following detailed list of questions that may be explored to determine if a given project's geotechnical requirements make it a candidate for DB delivery:

- "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 to 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 improvement? (i.e., decrease settlement, decrease construction time, increase bearing capacity, etc.)
- What technologies does the user already have experience with?" (Schaefer et al. 2011).

The purpose of this checklist is to identify issues that would make the project's geotechnical aspects unacceptably risky. In other words, to award a DB contract without a

TABLE 3
SUMMARY OF STATE POLICIES FOR THE GEOTECHNICAL ASPECTS OF DESIGN-BUILD PROJECTS

DOT	Authorized Project Delivery Methods				DB Geotech Manual	Estimate Geotech Uncertainty?	Geotech Risk Contract Clauses?[1]	Score Geotech?	Partnering Req'd?	DB Contract Payment Provisions			Geotech Warranty?[1]	Geotech Incentives?	Contractor Perform-ance Eval?	Use DB-Signif-icant Geotech Issues?[2]
	DBB	CMGC	DB	Other						Lump sum	LS GMP	LS w/unit prices				
Alabama	X			Toll roads - DB	No											
Alaska	X	X	X		No			No	Yes	X			No	No	No	No
Arkansas	X		X	DB proj > $50M	No											No
California	X		X		No	No	No	No	Yes	X			No	No	No	Yes
Colorado	X	X	X		No	Yes	No	Yes	Yes	X	X		No	No	No	No
Connecticut	X															No
Florida	X	X	X	P3		Yes	No	Yes	Yes	X	X	X	Yes	No	Yes	Yes
Idaho	X	X	X		No											
Illinois	X				No											No
Indiana	X		X		No	Yes	Yes	Yes	Yes	X			No	No	Yes	No
Iowa	X															No
Kansas	X			A+B	No											
Kentucky	X		X		No			No		X			No	No	No	No
Louisiana	X		X		No	No	No	Yes	Yes	X			No	No	No	Yes
Maine	X		X		No	No	No	Yes	Yes	X			Yes	No	No	Yes
Maryland	X		X		No	No	No	Yes	Yes	X			No	No	No	Yes
Massachusetts	X		X		No											Yes
Michigan	X	X	X		Yes	Yes	Yes	Yes	Yes			X	No	No	Yes	Yes
Minnesota	X		X		No	Yes	No	Yes	No	X			Yes	Yes	No	Yes
Mississippi	X		X		No	No	No	Yes	Yes	X			No	No	No	No
Missouri	X		X		No			Yes		X			No	No	No	No
Montana	X		X		No	Yes	No	Yes	No	X			No	No	No	Yes
Nebraska	X	X			Yes											No
Nevada	X		X		No	Yes	Yes	Yes	Yes				No	No	No	Yes
New Jersey	X		X		No			No		X			No			No
New Mexico	X		X		No	Yes	Yes	Yes	Yes	X			No		Yes	Yes
New Hampshire	X		X		Yes											No
North Carolina	X		X	P3	No	Yes	No	Yes	Yes	X			Yes	No	No	Yes

[1]See Table 4 for detailed comments.
[2]See Table 5 for detailed comments.

Table 3 continued on p.22

Table 3 continued from p.21

DOT	Authorized Project Delivery Methods				DB Geotech Manual	Estimate Geotech Uncertainty?	Geotech Risk Contract Clauses?[1]	Score Geotech?	Partnering Req'd?	DB Contract Payment Provisions			Geotech Warranty?[1]	Geotech Incentives?	Contractor Perform-ance Eval?	Use DB-Signif-icant Geotech Issues?[2]
	DBB	CMGC	DB	Other						Lump sum	LS GMP	LS w/unit prices				
North Dakota	X		X		Yes	No	No	No	Yes	X			No	No	No	No
New York	X				Yes	Yes	Yes	No								No
Ohio	X		X			Yes	No	Yes		X			No	No		Yes
Oklahoma	X			A+B	No											
Oregon	X	X	X	A+B	Yes	Yes	No	Yes	Yes	X			No	No	Yes	No
South Carolina	X		X		No	No	No	No	Yes	X			Yes	No	Yes	Yes
South Dakota	X		X		No											No
Tennessee	X		X		Yes			No		X			No	No	No	No
Texas	X	X	X	P3	Yes	Yes	No	Yes	Yes	X			No	No	No	Yes
Utah	X	X	X		Yes	Yes	Yes	Yes	No	X			Yes	No	No	Yes
Vermont	X		X		No											Yes
Virginia	X		X	P3	Yes	Yes	No	Yes	Yes	X			No	No	Yes	Yes
Washington	X		X		No	Yes	Yes	Yes	Yes	X			Yes	No	No	Yes
Wyoming	X			Nego-tiated:< $100K.												No

[1]See Table 4 for detailed comments.
[2]See Table 5 for detailed comments.

TABLE 4

DETAILS OF RESPONSES TO TABLE 3; RISK CLAUSES AND WARRANTIES

DOT	Type of Geotechnical Risk Clauses	DOT	Warranty Types
Indiana	The mitigation of secondary settlement is the owner's responsibility.	Florida	Project warranty
Michigan	We typically pay a price set by MDOT for subgrade undercutting on freeway projects and consider this a shared risk item since we set the price.	Maine	Pavement settlement
Nevada	We sometime require or prohibit certain types of geotechnical related designs. For example, driven piling and lime subgrade treatments were prohibited on the I 15 North DB job due to our local knowledge of shallow caliche deposits and lime susceptible soils in Las Vegas Valley.	Minnesota	Settlement roadways and structures
New Mexico	Pile driven and pile cut-offs paid separately; Rock Excavation unit price; obstruction removal for drilled shafts.	North Carolina	Culvert settlement limit +1-year project warranty
North Carolina	We use lump sum for geotechnical features.	South Carolina	3-year warranty for latent defects or workmanship
Utah	Sometimes we make liquefaction/lateral spread mitigation an owner-ordered change order.	Utah	Settlement warranty criteria (2–5 years)
Washington	We require that all changed condition under a certain dollar amount (different amounts for different contracts) is the contractor's risk. If that threshold is exceeded, then the department pays for the costs above the threshold.	Washington	1-year project warranty

TABLE 5

DETAILS OF RESPONSES TO TABLE 3; SPECIAL METHODS EMPLOYED ON DESIGN-BUILD PROJECTS WITH SIGNIFICANT GEOTECHNICAL ISSUES

DOT	Special Methods Included in DB RFQ/RFP to Address Significant Geotechnical Issues
California	Providing additional geotechnical report/studies as reference information for Proposers. Allow Proposers to perform additional testing prior to submittal of Proposal.
Louisiana	Our first DB project involved major piers in the Miss. River on the longest cable-stayed bridge in North America and the Geotechnical Aspects were not even considered in the primary scoring of the project…a minor oversight which had major impacts on the success and schedule of this project. On other projects, we have obtained geotechnical data and provided that data to the DB teams.
Maine	(1) A Supplemental Boring Program was conducted during the bidding where competing Proposers could request borings, lab tests; (2) Very specific geotechnical design criteria was in the RFP to control high-risk elements such as staged construction techniques, limiting driving piles to after 90% consolidation was complete; (3) Limiting foundation types and superstructure types, etc.
Maryland	A majority of our DB projects would be considered major projects where geotechnical aspects are considered to be significant. Our current DB Performance Specifications provided in the RFQ/RFP were written with major projects in mind.
Michigan	This is specific to one project under development, and traditionally we have not had DB projects with geotechnical work as complex as this project. MDOT gathered a lot of geotechnical data that will be placed in the RFP including borings, soil analysis, and artesian data.
Minnesota	On a recent project with large fills over soft soils, we required the DB Contractor to use extensive modern instrumentation to monitor short and long term settlement.
Nevada	NDOT uses project specific Geotechnical Performance Specifications for all DB projects.
New Mexico	30% Geotechnical Information ($1.5 million); 4 ATCs of complicated segments were part of RFP and used to rate RFPs.
North Carolina	We addressed them in both RFQ and RFP; In the event of geoenvironmental concerns, the department would absorb some of that risk by removing materials and being the generator of the disposal manifest while the DB team was expected to and evaluated on their minimization of impacts to areas of geoenvironmental concern. In areas where a large number of borings were needed pre-bid, the department would solicit the locations from the shortlisted DB teams and then perform the investigation accordingly and provide all information to all teams. Where shallow groundwater is concerned, the department would collect piezo data and provide to teams.
Ohio	Red flag geotechnical report in preliminary engineering work.
Oregon	We have limited experience with DB, only 1 ongoing DB project, with significant geotechnical problems which leads me to say we will not do any more DB projects when there are known geotechnical problems.
South Carolina	A more detailed subsurface investigation and preliminary design analysis is performed to quantify hazards.
Utah	We have clarified RFP language for specific concern such as lateral spread design requirements.
Washington	Our Geotechnical Design Manual (GDM) is quite detailed, but we may add special requirements in the RFP. For example, seismic ground motion requirements, floating bridge anchor design requirements, tunnel equipment selection issues, and other issues not covered in available design standards.

thorough understanding of "holes" in the subsurface investigation can create an intolerable level of uncertainty. This leads to the conclusion that DBB is more appropriate as the delivery method than DB on projects where the geotechnical scope risk is unacceptable.

DESIGN-BUILD REQUEST FOR PROPOSAL GEOTECHNICAL CONTENT

Once the decision to use DB is made, the next step is to determine what geotechnical information will be in the RFP. NCDOT typically performs the prelet geotechnical investigations. They report that they spent "0.18% to 1.15% of total contract price," which is less than the typical "3% to 5% NCDOT spends on conventional contract projects" (Kim et al. 2009). The same study reports that there "appears to be a gap in the degree of conservatism or level of risk between the NCDOT in-house foundation design and the foundation design by some design–build teams." This finding indicates that the industry was willing to work with less geotechnical information than the DOT. Thus, the one-on-one sessions between the DOT and its competing design-builders also provide an opportunity for all parties to calibrate the perceived level of geotechnical risk.

The Vermont Agency of Transportation (VTrans) and the Maine DOT issue a draft RFP to bidders on the short list and solicit comments before finalizing the RFP (Maine DOT 2003; VTrans 2010b). This approach has much the same effect as the one-on-one concept. Competing design-builders are able to point out areas of the RFP content that need clarification or more information before having to commit to a lump-sum price. By gaining industry input during the procurement process, the owner reaps the benefit of reduced contingencies and lower project costs. One DB contractor describes the process as follows:

> [Owners] can reduce costs by 'doing their homework' and by utilizing proper partnering, flexibility, risk allocation, and processes…. Proper 'homework' preparation includes developing sound geotechnical and environmental data prior to the bid phase…. included hiring the best possible geotechnical and environmental firms to provide early, prebid data on the project (Christensen and Meeker 2002).

Agency Policies for Request for Proposal Geotechnical Content

The geotechnical content of the RFP has three components:

1. The amount of geotechnical investigation that is accomplished before making the decision to use DB project delivery.

2. The amount of geotechnical investigation that is accomplished during preliminary engineering and RFP preparation.

3. The amount of geotechnical information that is required from competing design-builders in their proposal responses to the RFQ and RFP.

The synthesis used three independent sources of information to quantify the state of the practice in the above three areas. First, the survey asked respondents to indicate their agency's policy for the information of interest. Second, the content analysis of agency DB guidelines/policy documents looked for the same information as did the solicitation document content analysis, which composed the third source. Thus, intersections from the three independent lines of information allow the researchers to identify trends and draw conclusions from the analysis.

One word of caution is needed here. DB project delivery in transportation is an evolving field. Therefore, disconnects between the survey responses and the two content analyses are not necessarily contradictions. The survey responses are the most current source of information and may reflect an agency's adjustment from its DB policy as expressed in the written documents resulting from lessons learned. In other words, it is possible that the documents reviewed have not been brought up to date to reflect recent practice. This word of caution is particularly important relative to the changing dynamics of public sector DB procurement. Most DOTs currently use some form of price competition to select design-builders, and have not adopted DB procurement techniques that are used in other public sector industries, such as buildings or water treatment plants. As a result, most DOTs do not have in their procurement toolboxes "progressive design-build," where the DB firm is retained on a qualifications basis and ultimately provides a firm price after advancing the design and conducting further data collection, such as detailed geotechnical investigation centered around the detailed design. Therefore, as procurement options expand for DOTs, the conclusions expressed below on the suitability of DB for a given project may change.

Geotechnical Information Needed Before Selecting DB Project Delivery

The greatest risk to many DB projects may be the potential for unknown subsurface conditions to adversely influence DB project performance (Clark and Borst 2002). This risk is particularly acute in bridge projects, which often must be built on the weak soils found on most riverbanks. Therefore, the agency project team must evaluate the risks associated with transferring the responsibility for the final geotechnical investigation and resultant design to a design-builder (Kim et al. 2009). One agency described the issue as follows: "There are additional risks associated with facilities constructed underground because exactly what the ground is like and exactly how it will behave can be only assumed until it is excavated" (Clark and Borst 2002).

Table 6 shows the responses received from the survey of DOTs when asked to indicate the level of geotechnical information that was needed before the agency could decide to select DB project delivery. Responses range from no geotechnical investigation to a preliminary geotechnical design report before selecting a project delivery method. One respondent stated, "Geotechnical aspects of projects are not a primary consideration when deciding which project will be designed and constructed using a DB delivery method." If this comment is coupled with the FDOT policy that DB is used only on projects with a "low risk of unforeseen conditions" that "require an expedited schedule" (Blanchard 2007), one can infer that projects with a higher than normal level of geotechnical uncertainty may not be good candidates for DB project delivery. Given this potential constraint on selecting DB, the amount of geotechnical information necessary to select DB delivery will reflect the local knowledge already available to the DOT from its previous records and the preliminary investigations necessary to obtain environmental permits on the given project. This corresponds to the responses of "none," "reconnaissance report," and "geotechnical data report" in Table 6.

TABLE 6
PRELIMINARY GEOTECHNICAL INVESTIGATIONS BEFORE SELECTING DESIGN-BUILD PROJECT DELIVERY

Report	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects
	% of 28 Total Responses	
None	7%	11%
Reconnaissance Report	0%	14%
Geotechnical Data Report	7%	18%
Geotechnical Summary Report	11%	11%
Preliminary Geotechnical Design Report	4%	18%
Geotechnical Design Report	0%	0%
Geotechnical Baseline Report	0%	0%

As noted in chapter two, strong benefits are derived from a DOT conducting an early assessment on overall project risks and how its choice of project delivery, procurement, contracting, and execution can mitigate such risks. This is particularly true in the case of geotechnical risk, where an early determination of the influence of variations in geotechnical conditions on price and schedule can help the DOT determine the scope of pre-RFP geotechnical study. This does not mean that a project with significant geotechnical issues cannot be delivered using DB; it does mean that the owner must be able to put the geotechnical risks in perspective and determine the best means to mitigate those risks by sharing them with the design-builder or retaining them and allocating a contingency to cover the risks if they are realized (WSDOT 2004).

Ideally, requiring more detail helps to quantify the level of risk geotechnical uncertainty poses to the project. Although it is impossible to tell from the survey output, these risks may apply to projects where known geotechnical uncertainty is higher than typical. The table also shows the breakout between those DOTs with experience of more than five DB projects and those with experience of fewer. With one exception (California), experienced DOTs used more than one type of geotechnical report, which indicates an awareness of the need to match the pre-decision level of information with an individual project's level of uncertainty.

Experienced DOTs demonstrated that determining the appropriate level of geotechnical investigation before selecting DB is a function of formal risk analysis (see Table 7). Respondents with fewer than five DB projects did not engage in formal risk analysis before selecting DB project delivery. The two "other" responses indicated that the project team considered the geotechnical conditions risk but not in a formal manner. Twelve of the experienced DOTs had completed more than 10 DB projects. One can reasonably conclude that these agencies must be achieving success with DB project delivery, or they would not perpetuate the process. This leads to the conclusion that the emphasis on formal risk analysis before selecting DB project delivery differentiates the DOTs with multiproject DB experience from those new to the delivery method.

TABLE 7
RISK ANALYSES BEFORE SELECTING DESIGN-BUILD PROJECT DELIVERY

Risk	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects
	% of 28 Total Responses	
Scope	0%	38%
Schedule	0%	14%
Cost	0%	21%
Contracting	0%	17%
Other	7%	3%

Table 7 also shows that scope risk in a DB project is the primary concern of experienced DOTs. Given the geotechnical focus of the survey, it can be inferred that the respondents were specifically referring to the impact of geotechnical scope uncertainty. Tables 6 and 7 show that experienced DOTs formally evaluate geotechnical scope risk and then vary the amount of pre-project delivery decision investigation to that required to make an informed decision. This leads to the conclusion that an experienced DOT will tailor the level of pre-DB decision investigation and risk analysis to the specific requirements of a given project. Thus, there is no one-size-fits-all solution for selecting a project delivery method based on its geotechnical requirements.

The survey also asked the DOTs whether or not they would use DB project delivery on a project with "significant geotechnical issues." The population was evenly split between those that answered yes and those that answered no. Again, when the experienced DOTs were separated from the inexperienced ones, 15 of the 19 that answered yes had completed more than five DB projects. The question also asked them to elaborate on any "special methods" used to deal with the heightened geotechnical risk. Table 8 is a synopsis of the answers and the states that provided them (see Appendix A for details). The responses can be grouped into three categories:

1. The DOT conducts a more robust preliminary investigation and furnishes the results to the competing design-builders as part of the RFP. This may include specific testing to better characterize high-risk areas.

2. The DOT allows the competing design-builders to participate in the pre-bid geotechnical investigations by designating types and locations for tests and making the resultant information available to all competitors. This may include allowing each competitor to conduct individual testing at its own expense if desired.

3. The DOT institutes specific constraints on the types of acceptable design solutions for high-risk features of work. This may include generating ATCs that may be used in the design-builders' proposals.

Geotechnical Information Contained in the DB RFP

A successful DB project depends on a well-written, unambiguous RFP that contains the necessary information for competing design-builders to prepare responsive proposals that equitably price the value of the DB project's scope of work and the risk associated with completing that work (USACE 2009). One author describes the issue as follows:

> Experienced design-builders can *provide firm prices with a great deal of accuracy for sufficiently defined projects*

TABLE 8
SELECTED RESPONSES FROM DOTS THAT USE DESIGN-BUILD TO DELIVER PROJECTS WITH SIGNIFICANT GEOTECHNICAL ISSUES

State(s)	No. of DB Projects	Method
California	None—5 RFPs under development	Providing additional geotechnical report/studies as reference information for Proposers. *Allow Proposers to perform additional testing prior to submittal of Proposal.**
Louisiana	3–5	Our first DB project involved major piers in the Miss. River on the longest cable-stayed bridge in North America and the *Geotechnical Aspects were not even considered in the primary scoring of the project…a minor oversight which had major impacts on the success and schedule of this project.* On other projects, we have obtained geotechnical data and provided that data to the DB teams.
Maine	6–10	(1) A *Supplemental Boring Program was conducted during the bidding stage during which competing Proposers could request borings, lab tests;* (2) *Very specific geotechnical design criteria* was included in the RFP to control high-risk elements, such as requirements for staged construction techniques, limiting driving piles to after 90% consolidation was complete; (3) *Limiting foundation types* and superstructure types, etc.
Michigan	>10	This is specific to one project under development, and traditionally we have not had DB projects with geotech work as complex as this project. MDOT gathered a lot of geotechnical data that will be placed in the RFP, including borings, soil analysis, and artesian data.
Minnesota	>10	On a recent project with large fills over soft soils, we required the DB Contractor to *use extensive modern instrumentation to monitor short- and long-term settlement.*
New Mexico	3–5	30% Geotechnical Information (1.5 million dollars worth); 4 ATC's of complicated segments were part of RFP and used to rate RFPs.
North Carolina	>10	We addressed them in both RFQ and RFP; In the event of geoenvironmental concerns, the *department would absorb some of that risk by removing materials and being the generator of the disposal manifest.* We evaluated on their minimization of impacts to areas of geoenvironmental concern. In areas where a large number of borings were needed pre-bid, the department would *solicit the locations from the shortlisted DB teams and then perform the investigation accordingly and provide all information to all teams.* Where shallow groundwater is concerned, the *department would collect piezo data* and provide to teams.
Utah	>10	We've *clarified RFP language for specific concern* such as lateral spread design requirements.
Washington	6–10	Our Geotechnical Design Manual (GDM) is quite detailed, but we may *add special requirements in the RFP*. For example, seismic ground motion requirements, floating bridge anchor design requirements, tunnel equipment selection issues and other issues not covered in available design standards.

* *Note:* Italics added.

> in the … early design phases. Of course, it is not possible to develop accurate cost information through conceptual estimating unless the project scope has been sufficiently defined. This underscores the need for owners in design-build projects to have *detailed and complete RFP's that identify all of the relevant project criteria* (Friedlander 2003, italics added).

The WSDOT *Guidebook for Design-Build Highway Project Development* (2004) maintains that the DOT is "responsible for establishing the scope, project definition, design criteria, performance measurements, and existing conditions of the site (initial geotechnical investigation, subsurface conditions)." The responsibilities listed in this passage form a foundation for determining what specific data should be included in the DB RFP. This agency elaborates that "it is necessary for WSDOT to establish a baseline for design-builders to develop their technical and price proposals" and that "preliminary geotechnical investigations will be conducted by WSDOT with data provided to Proposers" (Carpenter 2010). WSDOT is consciously creating an environment of open communication regarding geotechnical uncertainty and the allocating of differing site conditions risk. In fact, the document states, "Ultimately, WSDOT will own responsibility for Changed and Differing Site conditions" (WSDOT 2004).

The Arkansas State Highway and Transportation Department (ASHTD) *Design-Build Guidelines and Procedures* (2006) also directly elaborates the geotechnical content of its DB RFPs. It requires that the geotechnical conditions for a given DB project be coordinated with the ASHTD Materials Division in the early stages of project development. This is expected to lead to the following information that will be reflected in the RFP:

- "Assessment of geotechnical risks,
- planning the appropriate preliminary investigations,
- gathering data,
- appropriately allocating the risks,
- preliminary geotechnical engineering analyses necessary to address feasibility issues and to define project design criteria such as foundation type constraints,
- risk management plans,
- establish design parameters,
- set the basis for determination of changed conditions, and
- establish preliminary project cost estimates" (ASHTD 2006).

ASHTD also develops a utility locations database that is included in the RFP. The stated aim of the process is to define "significant unknown issues" and develop contract provisions to reflect the findings of the preliminary investigations and allocate project risks accordingly.

Tables 9 and 10 illustrate the results of the RFP content analysis and the responses from the DOT survey. There is a marked difference between the survey responses and the actual DB RFPs. To put the two tables in perspective, the content analysis includes 46 solicitation documents, and nine states had multiple RFPs. The same issue shown in Table 7 is relevant for Table 9, where several respondents marked more than one level of geotechnical content depending on the type of project. As a result, the disconnect between the survey and the RFPs is not as stark as the numbers suggest, but there is still a conflict between the number of RFPs that contained no reference to geotechnical information and the survey responses, all of which indicated that at least some amount of geotechnical information is apparent.

TABLE 9

RFP CONTENT ANALYSIS RESULTS REGARDING GEOTECHNICAL CONTENT

Equivalent Report Information in RFP	No. of Responses	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects
None	11	4	7
Reconnaissance Report	4	1	3
Geotechnical Data Report	14	4	10
Geotechnical Summary Report	8	3	5
Preliminary Geotechnical Design Report	9	*1*	*8*
Geotechnical Design Report	2	2	0
Geotechnical Baseline Report	1	0	1

TABLE 10

DOT SURVEY RESPONSE RESULTS REGARDING RFP GEOTECHNICAL CONTENT

Report Information in RFP	No. of Responses	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects
None	0	0	0
Reconnaissance Report	3	0	3
Geotechnical Data Report	13	3	10
Geotechnical Summary Report	7	2	5
Preliminary Geotechnical Design Report	9	4	5
Geotechnical Design Report	7	2	5
Geotechnical Baseline Report	6	1	5

Although it is impossible to authoritatively verify from the available information, there are three possible explanations for the RFPs with no geotechnical information. First, the project may have had no significant geotechnical issues. Checking the RFPs, five had a significant vertical construction component. For example, one RFP from Virginia was for the construction of a welcome center, and another from Florida was for a bridge deck replacement and widening. Second, the need to meet an aggressive schedule may have led the agency to make a business decision to accept the cost risk of awarding the DB contract without geotechnical scope definition. Finally, the geotechnical information may have been provided separately through an addendum, and as such was not mentioned in the solicitation document.

Geotechnical Performance Criteria

The use of performance criteria rather than prescriptive specifications is one method for ensuring that design liability is transferred to the design-builder (Beard et al. 2002; Koch et al. 2010). The survey asked respondents to indicate whether geotechnical performance criteria were used in their DB projects and whether geotechnical performance verification was employed. About half (46%) answered that they used performance criteria, and the same proportion used performance verification methods. Table 11 contains selected comments regarding the types of criteria and verification methods the respondents specified.

TABLE 11
SELECTED RESPONSES FROM DOTS THAT USE GEOTECHNICAL PERFORMANCE CRITERIA AND VERIFICATION METHODS

State	No. of DB Projects	Geotechnical Performance Criteria Type	Geotechnical Verification Method Type
Indiana	>10	Deformation criteria	Instrumentation and testing
Louisiana	>10	Load test criteria	Deformation
Minnesota	>10	Settlement	Instrumentation
Nevada	1–2	Tolerable max and differential settlements, instrumentation, etc	Load tests, CSL tests, settlement monitoring, etc.
New Mexico	3–4	AASHTO standards	Settlement; PDA testing; CSL testing
Ohio	>10	Settlement	Settlement monitoring
Utah	>10	Settlement	Settlement monitoring
Washington	>10	Deflection criteria for floating bridge anchors, settlement due to tunneling or excavations.	Inclinometers, vibration measurements and deformation measurements

CSL = cross hole logging; PDA = pile driving analyzer.

Table 11 shows that DOTs with more than 10 DB projects' worth of experience tend to depend on geotechnical performance criteria backed up with performance verification methods to articulate the standards for geotechnical features of work in DB projects. Mn/DOT is one of those experienced DOTs, and the following list is an example of the DB geotechnical criteria from the Hastings Bridge project in Minnesota (presented in a case study in chapter seven)

Roadway embankments constructed under this contract on TH 61 between Stations 197+50 and 213+00 shall meet the following performance criteria:

- Engineering analysis shall show that total settlement at any point on constructed embankment will not exceed one inch during the period ranging from Substantial Completion to 25 years after Substantial Completion.
- Global Stability calculations shall use a minimum Safety Factor of 1.5.
- Lateral Squeeze calculations shall use a minimum Safety Factor of 2.0.
- Ground Improvement Techniques (and/or lightweight fill material) may be used to improve the underlying poor foundations soils. Any Ground Improvement Techniques used in design or construction shall follow the guidelines presented in the most recent FHWA publication on Ground Improvement.
- The Contractor shall monitor settlement of underlying foundation soils prior to any fill being placed, through construction and through the warranty period.
- Roadway shall not be paved until settlement data shows less than 0.125 in. of incremental vertical deformation occurring for 6 consecutive weeks with settlement readings taken on a weekly basis. Readings taken during cold weather months (November through April) will not be allowed to count for this settlement period.
- Settlement data shall be presented to Mn/DOT in tabular and graphical format (settlement in inches plotted on the y-axis and time in days plotted on the x-axis).
- Contractor shall provide, install, and monitor geotechnical instrumentation to measure total settlement of constructed embankments during the contract and warranty period. Settlement plates (flat plates with pipe extensions) shall not be used for measuring settlement.
- Within 1 week after Substantial Completion of the roadway, Contractor shall measure and submit as-built profiles of the roadway for northbound centerline, northbound 12 ft left of centerline, northbound 12 ft right of centerline, southbound centerline, southbound 12 ft left of centerline, southbound 12 ft right of centerline. The profiles shall be developed according to the State's Surveying and Mapping Manual. The Contractor shall measure these same profiles at the conclusion of the Warranty period.
- If settlement exceeds 1 in. at any point along the profiles, the contractor shall submit a settlement correction plan to Mn/DOT for approval. This correction plan will consist of major reconstruction efforts to correct the ongoing settlement problem.

TABLE 12
SURVEY RESPONSES FOR DESIGN-BUILD PROPOSAL GEOTECHNICAL CONTENT

	Typical DB Project			DB Project with Significant Geotechnical Issues		
Geotechnical Information Required in a Responsive Proposal	No. of Responses	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects	No. of Responses	DOTs with Fewer Than 5 DB projects	DOTs with More Than 5 DB Projects
None	4	1	3	3	1	2
Geotechnical Design Assumptions	10	3	7	8	2	6
Design-Builder Requested Testing	8	1	7	7	1	6
Pre-bid Investigation by Design-Builder	4	1	3	4	1	3
Geotechnical Design Values	7	2	5	9	2	7
Preliminary Geotechnical Design	6	1	5	9	0	9
Mitigation Approach Narrative	12	1	11	13	1	12
Geotechnical ATCs	11	0	11	12	1	11

- If settlement is between 0.25 in. and 1 in. at any point along the profiles, the Contractor shall submit a settlement correction plan to Mn/DOT for approval.
- If maximum settlement is less than 0.25 in. at all points along the profiles, no corrective action is necessary (Mn/DOT 2010).

Geotechnical Content of Competing Design-Builder's Proposals

The technical portion of the DB contract is the sum of the technical requirements articulated in the RFP and the proposed solution for those requirements demonstrated in the winning proposal (Koch et al. 2010). Therefore, it is important to understand the extent of the geotechnical design that owners expect competing design-builders to perform to submit responsive proposals. Tables 12 and 13 show the output from the survey and the DB RFP content analysis.

Reconciling the two sources has the same problems as discussed for the previous set of tables. However, once again the DOTs with the most DB experience require more geotechnical information in the competing proposals. The comparison is marked for projects with significant geotechnical issues to be addressed in design and construction. This conclusion agrees with the previous conclusion that the geotechnical content of the RFP must be tailored for each project and reinforces the idea that there is no single appropriate level of information in this area that will satisfy all requirements. The other important lesson from Table 12 is the willingness to allow a certain amount of interactivity between the DOT and the design-builders during proposal preparation by soliciting design-builder requested geotechnical exploration/testing and by permitting pre-bid investigations by design-builders. Both techniques foster an environment of open sharing of geotechnical information and allow the agency to gauge the industry's perception of the geotechnical risk inherent in a given DB project.

TABLE 13
RFP CONTENT ANALYSIS FOR DESIGN-BUILD PROPOSAL GEOTECHNICAL CONTENT

Geotechnical Information Required in a Responsive Proposal	No. of Responses	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects
None	22	7	15
Geotechnical Design Assumptions	4	1	3
Design-Builder Requested Testing	0	0	0
Pre-bid Investigation by Design-Builder	0	0	0
Geotechnical Design Values	11	1	10
Preliminary Geotechnical Design	11	1	10
Mitigation Approach Narrative	6	1	5
Geotechnical ATCs	13	5	8

Interactivity During Proposal Preparation

The notion of agency-design-builder interactivity during proposal preparation deserves specific attention. Geotechnical uncertainty in DB projects is impossible to eliminate (Clark and Borst 2002). Hoek and Palmieri (1998) describe it this way:

> Changes in project scope during implementation can have a significant impact on the project cost and schedules. Such changes can arise, for example, from the inability of design-stage investigation to eliminate risks from unknown geological conditions for construction of underground works.

Design-builders must make assumptions based on the best information at hand at the time the proposal is prepared. In previous discussions, the focus was on how the owner dealt with the geotechnical uncertainty in the procurement process. This is an inherently one-sided process. One author categorized the current approach to shedding geotechnical risk as a "preoccupation with exculpatory language by geo-practitioners" (Smith 2008). It is important for owners to understand the perception of the designers and builders on the DB team with regard to risk of differing subsurface conditions; permitting some form of agency-proposer interaction during the proposal preparation period is one way to gain this knowledge.

The Sound Transit Link Light Rail Project in Seattle found that the owner's initial assessment of underground risk was different than that of the proposers on the short list. This project had a mechanism to furnish interactivity through design-builder requests for information termed "risk statements" in this contract. The agency found the following:

> …there were *more risk statements that required answers* than most of us anticipated originally. As the agency staff, [its consultants] and our Technical Oversight Panel looked for more risk issues, more risks were recognized. During the evaluation process, a tremendous amount of effort was put forth by all involved with reviewing and evaluating the answers to the risk statements (Clark and Borst 2002, italics added).

The key words in this quote are "risk statements that *required* answers." The remainder of the paper showed that this specific feature of the procurement process was a key factor in identifying the risks associated with the delivery of a project that included a 4.5-mile (7.2-km) bored tunnel through an urban area.

The Naval Facility Engineering Command (NAVFAC) recently updated its DB policies to permit the competing proposers' geotechnical engineer to be on site during NAVFAC's preliminary site investigation and testing (Crofford 2010). This practice was instituted with the caveat that the winning design-builder "must depend on its own Geotechnical investigation and data for design." The WSDOT DB guide (2004) allows the agency to include a "supplementary" geotechnical investigation program that is conducted during proposal preparation based on requested supplemental information from competing design-builders.

The Maine DOT recognized the need for interactivity during proposal preparation to mitigate geotechnical risk in the DB delivery of the Bath–Woolwich Bridge, the longest precast balanced cantilever concrete segmental bridge in the United States (Phipps 2000). The agency recognized that to ensure that design-builders had the maximum latitude for their proposed designs, they needed to be able to set their own pier locations. Since the DOT could not predict the pier locations, it could not develop a preliminary boring program that would correspond to the proposers need for site-specific boring logs. As a result, the Maine DOT provided a "supplemental geotechnical program to minimize uncertainties. Each team was allowed to request up to 10 additional borings and associated laboratory tests. Results were provided to the proposers in sufficient time to be incorporated into their designs" (Phipps 2000). The Utah DOT (UDOT) encouraged design-builders to conduct their own pre-bid investigations on its Legacy Parkway project. The winning team "elected to conduct a test embankment fill and a test pile-driving operation in the vicinity of the project alignment, along with exploratory borings performed at the two test sites" (Higbee 2004).

Table 12 contains two possible responses that indicate interactivity during proposal preparation: "Design-Builder Requested Testing" and "Pre-bid Investigation by Design-Builder." With one exception, the DOTs that employ this technique use it on both typical projects and projects with significant geotechnical issues. Additionally, DOTs with more DB experience are the ones most likely to engage in this form of risk identification and mitigation. Combining that finding with the information found in the literature leads to the conclusion that permitting some level of interactivity regarding geotechnical uncertainty during DB proposal preparation appears to be an effective geotechnical risk management practice.

LIABILITY FOR GEOTECHNICAL INFORMATION CONTAINED IN THE REQUEST FOR PROPOSAL

Many owners have major concerns over their liability for the accuracy of geotechnical information furnished in the RFP. As discussed in chapter two, this is one of the central issues as to whether a contractor can be afforded relief under the DSC clause, as owner-furnished information is generally the baseline for assessing whether or not there is a differing site condition. Table 14 shows the results of the survey, in which respondents were asked about their use of a DSC clause and what geotechnical documents they provided during the RFP process that could support a DSC claim.

Table 14 shows eight negative responses to the use of a DSC clause for geotechnical conditions. This is counterintuitive. Only one of the respondents, North Carolina, elaborated on its answer, and it stated that NCDOT did "not allow differing geotechnical site conditions." This agency's approach is to conduct the "subsurface investigation and provide the information to the design–build teams" and "NCDOT prelet subsurface investigation appears to have provided the short-listed teams with a reasonable amount of subsurface information to prepare the contract proposals" (Kim et al. 2009). The remaining seven negative responses also checked "agency standard differing site conditions clause" in the next question, so it would be logical to interpret the negative response to mean that there is no special geotechnical DSC clause rather than no clause at all.

TABLE 14
SURVEY DIFFERING SITE CONDITIONS OUTPUT

Does DB Contract Include a DSC Clause for Geotechnical Conditions?	No. of Responses	DOTs with Fewer Than 5 DB Projects	DOTs with More Than 5 DB Projects
Yes	19	9	10
No	8	2	6
*What document(s) is used to define a differing geotechnical site condition?**			
Geotechnical Information Provided in the RFP	8	2	6
Geotechnical Baseline Report	2	0	2
Design-builder's Post-award Geotechnical Design Report	2	1	1
Agency Standard DSC Clause	16	9	7
None	1	0	1

**Note:* Respondents were allowed to select more than one answer.

Once again, the experienced DOTs are willing to use a greater variety of methods to deal with the geotechnical risk of DSCs. The major point in Table 14 is that the experienced DOTs recognize and accept that the geotechnical information provided in the RFP in conjunction with the standard boilerplate clause defines the parameters around which a DSC claim will be decided.

CONTRACTOR'S PERSPECTIVE

When asked to identify the greatest geotechnical challenges during procurement, 10 of 11 contractors stated that most projects faced agency distrust of the design-builder's design team. This was coupled with 100% agreement that exculpatory language in the RFP created an environment that further bred distrust. Six interviewees stated that they rarely submitted proposals based on the DB team's preferred practice, though all interviewees supported the idea of confidential pre-bid meetings to discuss ATCs and clarify RFP design intent and ambiguities. One design-builder echoed the sentiment expressed by Christensen and Meeker (2002) about the owner's ability to reduce geotechnical uncertainty by "doing their homework" before advertising the project, and added that the correct amount of geotechnical information in the RFP was "everything the DOT has" at the point of initiating competition. Two interviewees indicated that they had bid on DB projects where they were allowed to collect their own pre-bid geotechnical data, and confirmed the idea that this type of interactivity was reflected in the level of project contingency in their price proposals.

CONCLUSIONS

The above analysis arrived at the following conclusions.

- DOTs with DB experience evaluate the risk and impact of unforeseen geotechnical conditions before selecting DB project delivery, and the emphasis on formal risk analysis differentiates the DOTs with multiproject DB experience and those new to the delivery method.
- Experienced DOTs tailor the amount of geotechnical information included in the DB RFP to the specific requirements of a given project.
- Permitting interactivity during the proposal preparation period allows the agency to understand how competing design-builders perceive the geotechnical risk and provides an opportunity to adjust the procurement plan to accommodate a need for supplemental information.

The following effective practices were documented.

- The Minnesota, North Carolina, and California DOTs use one-on-one meetings with each proposer before proposal submission to identify any need for further geotechnical investigation and to clarify RFP risk issues.
- The Vermont Agency of Transportation, the North Carolina DOT, and the Maine DOT issue a draft DB RFP and ask for comments from the competing design-builders on the short list as a means to identify the geotechnical aspects of the project that need clarification before a proposal is due.
- The Washington State, North Carolina, and Maine DOTs allow proposers to request supplementary borings during proposal preparation to better align the geotechnical information with a given design-builder's proposed design.
- UDOT encourages competing design-builders to conduct their own pre-bid geotechnical investigations before developing their proposals.
- NAVFAC permits competing design-builders to have their geotechnical designer-of-record be onsite and witness the owner's preliminary geotechnical investigation.

CHAPTER FOUR

DESIGN-BUILD SELECTION METHODS

INTRODUCTION

In a review of the I-15 DB project in Utah, a consultant stated, "it is during the development of the RFQ [request for qualifications] and RFP [request for proposals] that the ultimate quality of the project can be most influenced" (Drennon 1998). Figure 1 shows the relationship between the influence of quality and the stage of the project. Quality is most influenced in procurement and the beginning of design but rapidly falls off during the later stages of design, construction, and maintenance. During the procurement phase, decisions are made as to what is included in the RFQ and/or RFP. Some of these decisions are already set by state law or published department DB guides, while others are made on a project-by-project basis. This chapter discusses the specific design-builder selection decisions involved in the procurement phase of a DB project and how the geotechnical requirements are incorporated into the selection decision.

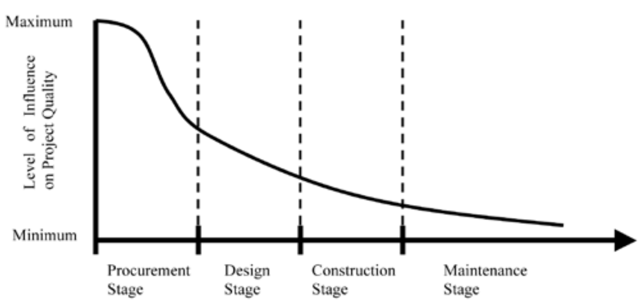

FIGURE 1 Relationship between project stage and influence of quality [*Source*: Adapted from Nickerson 2003].

Two early studies of public agency DB selection and award procedures attempted to identify best practices used by public agencies and the major project characteristics associated with each best practice subject (Gransberg and Senadheera 1998; Molenaar and Gransberg 2001). Since those studies were completed, many public entities have passed legislation authorizing the use of DB. As each jurisdiction adds a DB law, it attempts to promulgate rules regarding the proper implementation of the authorizing legislation. As a result, it is not surprising to find two states that use the same term for a specific DB award method but use different algorithms to arrive at the source selection decision. This is particularly true with the term "Best Value" (BV). This term's "official" meaning ranges from a relatively subjective comparison of price and proposal technical score in the FAR (FAR 2000) to an objective mathematical combination of the two used by several state DOTs (CDOT 1997; Carter and Burgess 1998; WSDOT 2000). Thus, the proliferation of various methodologies has created a situation where a DB contractor must ask the agency that has authored the BV selection methodology about the details of the evaluation and award decision-making process in order to properly assess the odds of winning a given project. Table 15 illustrates this point with a hypothetical project and five typical agencies that each use a different method to make the BV decision.

A synthesis of the literature found seven generic categories for public project source selection procedures. These differ from those in the Design-Build Institute of America practice manual (DBIA 2009). Table 16 lists and defines the seven categories (MDT 2008).

TABLE 15
EXAMPLE OF BEST VALUE SELECTION WITH FIVE TYPICAL AGENCIES

Firm	Technical Score	Days	Price Proposal	INDOT Low Bid, Fully Qualified[1]	AZDOT BV with Quality Credit	SCDOT Low Composite Score	WSDOT High Best Value Score	FHWA EFLHD Best Value
A	92	450	$11,880,000	$11,880,000	$10,573,200	129,130	77.44	*63.10
B	86	460	$10,950,000	$10,950,000	$10,074,000	*127,326	*78.54	62.73
C	76	500	$9,850,000	$9,850,000	*$9,554,500	129,605	77.16	59.14
D	74	500	$9,760,000	*$9,760,000	$9,564,800	NR	75.82	57.99
E	68	500	$9,700,000	NR	$9,700,000	NR	70.10	53.54

Source: Gransberg and Molenaar (2003).
[1]Fully qualified, technical score > 70; NR = not responsive, technical score < 75; *Winning proposal.

TABLE 16
BEST VALUE AWARD ALGORITHMS

Best Value Award Algorithm	Algorithm	Variables
Meets Technical Criteria –Low Bid	If $T > T_{min}$, Award to P_{min} If $T < T_{min}$, Non-Responsive	T = Technical Score; P = Project Price
Adjusted Bid	AB = P/T Award AB_{min}	AB = Adjusted Bid
Adjusted Score	AS = (T x EE)/P Award AS_{max}	AS = Adjusted Score; EE = Engineer's Estimate
Weighted Criteria	TS = $W_1S_1 + W_2S_2 + \ldots + W_iS_i + W_{(i+1)}PS$ Award TS_{max}	TS = Total Score; W_i = Weight of Factor $_i$; S_i = Score of Factor $_i$; PS = Price Score
Quantitative Cost –Technical Tradeoff	$T_{Increment} = [(T_j/T_j) - 1]$ x 100% $P_{Increment} = [(P_j/P_i) - 1]$ x 100% If $T_{Increment} > P_{Increment}$, Award Proposal$_i$ If $T_{Increment} < P_{Increment}$, Do Not Award Proposal$_j$, Repeat with Proposal$_{j+1}$ Repeat Process until $T_{Increment} > P_{Increment}$	T = Technical Score; P = Project Price
Qualitative Cost – Technical Tradeoff	Similar to above, only no quantitative analysis of difference. Award to proposal that has best value in proposed scope.	
Fixed Price – Best Proposal	Award T_{max}, Fixed P	T = Technical Score; P = Project Price

Source: After MDT (2008).

Most DOTs are constrained by enabling legislation as to which of these award methods can be used for DB projects (FHWA 2006). Nevertheless, all methods have three elements in common. First, all involve some form of evaluation of the design-builders' qualifications and past experience. Next, all evaluate the technical aspects of the proposal. Finally, all have an algorithm where the technical evaluation is related to the proposed price and the output is used to identify the winning proposal. Therefore, if desired, the special geotechnical aspects of a given DB project can be included in the criteria used to evaluate people, corporations, proposed design, and proposed price. This is accomplished by ensuring that the DB procurement strategy reflects the needs for geotechnical aspects in the source selection decision process.

Regardless of the algorithm used, it is important that the agency provide a clear expression of how it will select the design-builder and not create the impression that the process is overtly subjective (Shane et al. 2006; Kim et al. 2009). Consider a recent case, *Brayman Construction Corp. vs. Commonwealth of Pennsylvania*, 13 A.3d 925 (2011), where a contractor mounted a successful challenge to a two-step design-build best value (DBBV) procurement by Pennsylvania DOT (PennDOT), citing a lack of objectivity in PennDOT's Publication 448 procurement process. Among other findings, the court noted that PennDOT employees "were unable to give a clear description of how its best-value analysis works, with some conceding that the process is 'kind of nebulous.'"

DESIGN-BUILD PROCUREMENT STRATEGY

The special requirements for geotechnical considerations can be addressed in the typical DOT's DB procurement process in four areas of the project's solicitation documents:

1. Specific geotechnical qualifications for key personnel in the RFQ
2. Specific geotechnical design and construction experience in the RFQ
3. The inclusion and weighting of geotechnical evaluation criteria in the proposal evaluation plan
4. Geotechnical information requirements required by the RFP to be included in competing proposals.

The fourth area in this list was covered in chapter three. Therefore, the remainder of this chapter will be devoted to the remaining three areas.

Geotechnical Factors in the Request for Qualification

The survey conducted for *NCHRP Synthesis 376* (Gransberg et al. 2008) found that the qualifications of the members of the DB team and its past project experiences were rated as having the most impact on final project quality of 11 factors rated by the DOT respondents. The same question was posed in a geotechnical context for the respondents to this 42-01 survey. The same result was found. Among DOTs with more than five DB projects' experience, 94% rated the geotechnical qualifications of the design-builder's staff as the most important factor in final project quality and 88% rated the design-builder's past geotechnical project experience as the second most important factor. The same is true for respondents with fewer than five DB projects' experience, where the numbers were 82% for both categories. The results of both the *NCHRP Synthesis 376* study and the current study indicate that the qualifications and past experience of the DB team are key to achieving quality in the constructed project.

Table 17 shows the results of survey and two content analyses (which include the RFQs in the solicitation document population) regarding the evaluation of geotechnical factors contained in the DB project's RFQ. The table shows that experienced DOTs evaluate more geotechnical information in this phase of the DB procurement, with all four qualifications/past performance factors indicated by more than 50% of the respondents. The experienced DOTs also included geotechnical factors in the technical evaluation plan and in their RFQs. This is significant because knowledge of the technical evaluation plan will often influence the selection of team members (Kim et al. 2009). Most of the eight RFQs in the solicitation documents emphasized past project experience over key personnel qualifications, and this factor was the most common found in the agency DB contracting guidelines. However, the guidelines were almost silent on the topic of geotechnical evaluation factors, with all factors being found in fewer than 25% of the documents.

As indicated by the high response rate of experienced DOTs and the low rate of geotechnical factor inclusion found in both the RFQ and the DB guidelines, along with the *NCHRP Synthesis 376* findings and the experienced DOTs' rating of the impact of qualifications on constructed quality, addressing geotechnical issues early in the DB procurement process is important. The conclusion may suggest that geotechnical factors are addressed in DOT DB guidelines and that the technical evaluation factors relating to a DB project's geotechnical requirements are included in the RFQ to encourage competing design-builders to team with highly qualified geotechnical designers as well as project management and field personnel with extensive geotechnical experience on the construction team.

Geotechnical Evaluation Criteria

Evaluating geotechnical aspects of a design-builder's proposal emphasizes the importance of this aspect to the competitors. One respondent to the DOT survey included the following comment on this topic: "Our first DB project involved major piers in the Mississippi River on the longest cable-stayed bridge in North America and the *geotechnical aspects were not even considered in the primary scoring* of the project…a minor oversight which had major impacts on the success and schedule of this project." Additional emphasis can be placed on project geotechnical factors in the structure of the evaluation criteria for DB projects and how they are scored. Design-builders in writing their proposals will focus on the aspects of the project that are required in the proposal and that will be scored (Higbee 2004). Placing a specific geotechnical factor or issue in the RFQ or RFP calls extra attention to the design-builder that the project's geotechnical requirements are an important issue to the owner and that a proposal emphasizing these factors will be evaluated more favorably. An example is shown by the philosophy of the Minnesota Department of Transportation on its Interstate 494 DB project. Instead of including post-award incentives, Minnesota DOT determined that:

> …certain aspects of the RFP would provide opportunities for the right contractor with the right approach to win the work. To achieve this, RFP selection process included the following: Areas of great importance receive higher scoring weights; Contractor is rewarded in the proposal scoring for exceeding minimum requirements; and Contractor's past performance is considered during evaluations for future projects (Gladke 2006).

UDOT used a similar approach in its DB selection process for the $330 million Legacy Parkway DB project, as follows:

> On the Legacy project, the management team elected to assign a 50/50 [cost/technical] weighting... This resulted in a heavy emphasis on the technical aspects of the project between the three proposing teams… it was

TABLE 17
COMPARISON OF RFQ EVALUATION FACTORS FOUND IN THE SURVEY AND THE CONTENT ANALYSES

RFQ Evaluation Factors	DOT Survey Responses		Content Analyses	
	<5 DB (of 8 total)	>5 DB (of 17 total)	RFQs (of 8 total)	Agency DB guidelines (of 17 total)
Specific geotechnical qualifications for key personnel	25%	94%	38%	18%
Specific geotechnical project experience required	13%	65%	63%	24%
References from past projects with specific geotechnical issues	0%	59%	25%	0%
Proof of local geotechnical project experience	25%	53%	13%	18%
Geotechnical factors in rated technical evaluation plan*	63%	88%	50%	6%

*Many RFQs include a description of the technical evaluation plan, including specific technical factors (in this case, geotechnical factors).

> apparent that a significantly higher technical proposal score by a particular team could have overcome a higher cost proposal on the order of tens of millions of dollars (Higbee 2004).

In light of these quotes, there are two important aspects of the evaluation planning for projects where incorporation of geotechnical factors is key to successful project delivery:

1. Geotechnical evaluation criteria

2. Appropriate weight assigned to critical geotechnical evaluation criteria.

Inclusion of evaluation criteria for geotechnical and subsurface factors needs to be proportionate to the importance of the geotechnical factors in the context of the entire project (MDT 2008). Owners of projects with minimal routine geotechnical requirements often do not complicate the evaluation process by adding specific criteria to evaluate geotechnical factors. This is justified by the notion that all responsive proposals will probably furnish the same response and get the same score. Therefore, evaluating geotechnical factors in this type of project does not measurably add to the determination of the BV (Koch et al. 2010). An example of this type of project is a DB bridge widening where work is restricted largely to the bridge deck. However, geotechnical evaluations are appropriate for most typical highway and bridge projects (Phipps 2000).

Table 18 contains a sample of geotechnical evaluation criteria for design-builder qualifications and past experience found during the solicitation document content analysis. All

TABLE 18
SAMPLE GEOTECHNICAL QUALIFICATIONS EVALUATION CRITERIA FOUND IN THE SOLICITATION DOCUMENT CONTENT ANALYSIS

Agency	Criterion	
Florida DOT	Design and Geotechnical Services Investigations: Credit will be given for the quality of the following elements: – Quality and quantity of design resources – Design coordination (including hydraulic analyses, scour computations, and foundation determinations) and plans preparation schedule – Construction coordination plan minimizing design changes – Geotechnical investigation plan – Test load program – Knowledge of the project area	
Indiana DOT	Demonstrated Experience: Has the Respondent demonstrated its ability to undertake and successfully complete a project of this type and magnitude?	
Michigan DOT	State experience/past performance in the last 10 years with the following:	
	Contaminated soils handling, treatment, and disposal	Fill wall construction
		MSE walls
	Top down retaining wall construction	Concrete cantile
	Auger cast pile	Ground improvement
	Soil nail wall	Compaction grouting
	Sheet pile wall	Anchored mesh slope treatments
	Tieback soldier piles	Micropiling
	Slurry wall construction	Riprap and rock blanket construction on steep slopes
Mississippi DOT	The Geotechnical Staff shall contain at least one Professional Engineer licensed in the state of Mississippi with a minimum of ten (10) years experience in the design of bridge foundations	
Montana DOT	Demonstrate past experience of Firm members working together on similar type projects, both for construction and engineering services. Provide proof of the Firm members familiarity with geotechnical conditions similar to the project area.	
North Dakota DOT	The Committee shall base its determination upon the following criteria 1. Experience with comparable projects. 2. Managerial resources. 3. Abilities of professional personnel. 4. Past performance 5. ... 9. Knowledge of local or regional conditions.	
Ohio DOT	Previous Design Build projects, similar in nature including cost and schedule to the proposed project, for which the individual has performed a similar function. Give specific information regarding responsibilities on the noted previous projects, and how this experience directly relates to the proposed project.	
Utah DOT	Relevance and strength of qualifications and experience of Key Personnel and other staff that the Proposer offers to assign to the Project (10 pts) Record of Past Performance relating to goals and objectives of the Project (10 pts).	

had significant geotechnical requirements associated with the project. The table shows that evaluation criteria range from the general criteria used by Indiana to the more comprehensive criteria used by Michigan. The Michigan project was devoted to slope stabilization and as such was purely geotechnical in nature. Thus, the extensive list of experiences was intended to cover the gamut of possible acceptable design solutions without constraining the competitors in a technical sense. The Utah project was a tunnel and had a number of technical evaluation criteria that required specific expertise. As a result, the key personnel's qualifications were constrained by the technical requirements of the project, and UDOT did not need to be more explicit in its evaluation criteria.

Table 19 lists sample technical evaluation criteria that relate to planning and executing the geotechnical portions of a DB projects. Again, the detail expressed in the criteria ranges from general to specific. The Delaware criterion is for a requirement to submit a narrative outlining the various geotechnical risks. Maine's two criteria aim to set an adjectival standard for earning a "superior score." It has the effect of influencing the competitors into proposing an instrumentation program. Florida also telegraphs its preference when it states that credit will be given for the "Test Load Program." Minnesota uses a different approach by requiring a 5-year warranty for differential settlement and evaluating this criterion on a pass/fail basis.

In the solicitation document content analysis, 37 of 46 of the project documents explicitly listed some form of evaluation criteria for geotechnical factors. More than two-thirds of those 37 projects evaluated the qualifications of the project's geotechnical personnel. Next, 62% evaluated the DB firm's past experience designing and building projects with similar geotechnical requirements. Slightly more than one-third included geotechnical evaluation criteria in the technical and/or price evaluation plan. In the survey response, 94% of experienced and 53% of inexperienced respondents required and evaluated the qualifications of the project's geotechnical personnel. Past geotechnical experience was rated at 65% and 33%, respectively. In 53% of the experienced DOT responses local experience was also rated, with only 20% of the inexperienced DOTs asking for that information.

Geotechnical Factors Weight in the Evaluation Plan

Tables 18 and 19 each have one example where a specific number of points were listed. These are examples of how DB evaluation criteria are weighted. The literature (Scott et al. 2006) and solicitation document content analysis found two methods for assigning weight to evaluation criteria. The first is the direct point score. In this method, each evaluation criterion is assigned a specific number of points, with the ratio of individual criterion's point score to the total available points for the entire evaluation representing its weight or relative importance relative to the other evaluation criteria. The UDOT qualifications criteria in Table 18 were each assigned 10 possible points. The maximum possible point score on this project was 100 points. Thus, qualifications carried 10% of the weight in this evaluation plan. The Table 19 FDOT technical criterion carried 20 points, which gave it a 20% weight in the FDOT 100-point evaluation plan.

TABLE 19
SAMPLE GEOTECHNICAL TECHNICAL EVALUATION CRITERIA FOUND IN THE SOLICITATION DOCUMENT CONTENT ANALYSIS

Agency	Criterion
Delaware DOT	What risks are there to the structural integrity of the approach embankment and MSE walls?
Florida DOT	Design and Geotechnical Services/Investigations (20 points). Credit will be given for the quality of the following: – Quality and quantity of design resources – Design coordination and plans preparation schedule – Construction coordination plan minimizing design changes – Geotechnical Investigation plan – Test load program – Structure design
Maine DOT	Superior scores in this category will be awarded to design concepts that: – Demonstrate a thorough understanding of the potential geotechnical challenges associated with the project; – Incorporate an instrumentation program for monitoring structures and soils with consideration for future monitoring of the structures with the same instrumentation by the department during the design life.
Minnesota DOT	Design-builder must provide 5-year warranties for many features, including but not limited to differential settlement in roadway.
Missouri DOT	For mechanically stabilized earth walls, the Proposer shall define the wall systems to be used and their associated application criteria.
Montana DOT	Prepare a proposal outlining a [geotechnical investigation] program that will establish various test sites and a testing, instrumentation, and analysis program.

The other method corresponds to the weighted criteria method shown in Table 18. The Montana DOT DB guidelines state, "the award will be based upon stated criteria or evaluation factors; cost will not be the only consideration. The RFP will state the relative importance of all evaluation factors" (MDT 2008). Hence, each evaluation category is assigned a weight consistent with the objectives of the project, and the score for each evaluation criterion in the category is summed and then multiplied by the category weight. The sum of the weighted scores in each category is the final score for each proposal, as shown in Table 20. The product of the category weight and its score becomes the category value and the sum of the "weighted criteria values" becomes the overall value (V) for a given proposal for factors other than bid price. This relationship can be expressed as the following equation:

$$V = W_1S_1 + W_2S_2 + \ldots\ldots + W_iS_i \quad (1)$$

where:

V is the nonprice value;
W_i is the weight of category i; and
S_i is the score for criterion i.

The survey asked two questions in this vein. The first was whether geotechnical factors were evaluated and the second asked respondents to indicate the relative weight given geotechnical factors versus the rest of the proposal. The results found that 20 of 33 respondents that use DB score geotechnical factors as part of the selection process. Of those 20, 13 assign "minor" (<10%) or "no weight" to the geotechnical factors, 5 give geotechnical factors "some" (11–20%) weight, and only 2 assign "heavy" (>20%) weight. The solicitation document content analysis found that only 4 of 46 documents gave more than 10% weight to geotechnical factors in the published evaluation plans. Two of those are the Florida and Utah examples shown in Table 18. Six FDOT documents were sampled in the content analysis: two had no weight for geotechnical, three assigned minor weights, and one (a bridge project with significant geotechnical issues) assigned heavy weight to the proposed solutions for the geotechnical factors. Based on the seemingly light weighting given to geotechnical evaluation criteria found in the survey and the content analysis, one can conclude that the weight of geotechnical factors must be assigned relative to the other factors that define success for a given DB project. Additionally, the variation in geotechnical weight found in the FDOT RFPs confirms that weights are a function of a specific project's overall requirements and FDOT tailors the relative geotechnical weight as it deems appropriate for each DB project.

Alternative Technical Concepts

ATCs allow public agencies to "seek innovation from the private sector to help reduce project costs and add technical enhancements" (Papernik and Farkas 2009) without giving up control of the design process. ATCs are generally implemented in one of four ways:

1. The agency lists acceptable ATCs in the DB RFP and the competing design-builders select those they want to include in their proposal and price the scope of work including the ATCs. Often proposers are required to furnish two prices: one for the base configuration and another for the project including the ATCs (WSDOT 2010).

2. The agency furnishes a pre-proposal period in which competing design-builders can submit ATCs to the agency for review and approval. The individual ATCs are confidential and price proposals are completed including the approved ATCs (Mn/DOT 2003; Caltrans 2010).

3. The agency allows competing design-builders to submit ATCs to the agency for review and approval at the time of the proposal submission. A compilation of adjustments to the proposal price is submitted for the ATCs, with the compilation being submitted in a separate envelope from both the ATC technical proposals and the proposal price. The agency will act upon each ATC based on the technical submission, and will adjust the proposal price for each ATC that is accepted (Texas Turnpike Authority 2001).

4. The process described in #2 is used, but once an ATC is approved, it is added to the RFP and all competing design-builders are allowed to decide whether to use the given ATC in their proposal (FDOT 2011).

TABLE 20
EXAMPLE OF WEIGHTED CRITERIA METHOD

Evaluation Category	Wt	Proposal No. 1 Score	Weighted Score	Proposal No. 2 Score	Weighted Score	Proposal No. 3 Score	Weighted Score
Technical	30	4	120	5	150	3	90
Management	5	4	20	3	15	3	15
Traffic Control	5	5	25	4	20	2	10
Personnel	10	4	40	5	50	3	30
Experience	15	4	60	3	45	3	45
Past Performance	15	4	60	4	60	3	45
Schedule	20	4	80	3	60	3	60
Totals	100		405*		400		295
Price		$4.4 million		$4.3 million		$4.0 million	

5 = Excellent; 4 = Exceeds Requirement; 3 = Meets Requirement; 2 = Below Requirement but Correctable;
0 = Nonresponsive; *Apparent winning proposal.

From a geotechnical perspective, ATCs are a mechanism to manage subsurface risk. Regardless of which method an agency uses to implement ATCs, each alternative will have its own unique risk profile and each competitor is afforded an opportunity to select an alternative that has the lowest perceived geotechnical risk. Theoretically, this should reduce the size of contingencies included in the price proposal.

Chapter three included a discussion of the use of one-on-one question and answer sessions, sometimes called "proprietary meetings," during proposal preparation to permit competing design-builders to clarify RFP intent and ask questions that might lead to the submission of an ATC. A number of DOTs use these sessions to review and approve ATCs.

Table 21 is a synopsis of ATC usage found in the literature. A number of the projects shown in the table generated ATCs that were related to geotechnical aspects. For example, an ATC presented during proposal preparation on the Minnesota DOT Hastings River Bridge DB project (detailed in chapter two) resulted in the "north approach roadway constructed on a column-supported embankment, with less than 2 inches of total settlement complete within three months of embankment construction" (Behnke and Ames 2010). Caltrans is planning to emphasize the use of geotechnical ATCs during proposal preparation to resolve a number of thorny subsurface, seismic, and environmental issues on the Gerald Desmond Bridge project (Thiessen 2010).

All three of the primary research instruments looked for the use of ATCs. Figure 2 illustrates the results. It must be noted that the survey specifically asked whether geotechnical-specific ATCs were allowed. The figure shows that the experienced DOTs routinely include ATCs and the ones new to DB do not. Since the two population samples are roughly equal in size (17 and 15, respectively) this becomes a significant difference. There is no explanation for the result and therefore, it identifies a gap in the body of knowledge for DOTs with little or no DB experience. Consequently, the finding leads to a suggestion for future research to quantify the benefits of geotechnical ATCs on DB projects, which can be made available to agencies that are new to alternative project delivery methods. The suggestion is further reinforced by the two content analyses, which both found that around half the population did not include this tool to reduce risk and enhance innovation in their text.

TABLE 21
ALTERNATIVE TECHNICAL CONCEPT USE

Agency	DB Project	Project Value	Remarks	Literature Citation
California DOT	Gerald Desmond Bridge	$950 million	Confidential one-on-one meetings; approved ATCs could be furnished to the winning proposer for use	Thiessen (2010)
Florida DOT	I-595 Corridor Improvements	$1.8 billion	Confidential one-on-one meetings; approved ATCs could be furnished to the winning proposer for use	Papernik and Farkas (2009)
Maryland State Highway Administration	Intercounty Connector	$2.5 billion	Confidential one-on-one meetings; ATCs submitted for review and approval	Papernik and Farkas (2009)
Minnesota DOT	Hastings Bridge	$120 million	Confidential one-on-one meetings	Behnke and Ames (2010)
Mississippi DOT	Airport Parkway	$500 million	Confidential ATCs submitted for review and approval	Papernik and Farkas (2009)
Missouri DOT	I-270/Dorsett Rd. Interchange	$20 million	Confidential one-on-one meetings; approved ATCs could be furnished to the winning proposer for use	Schnell et al. (2008)
North Carolina Transportation Authority	Mid-Currituck Bridge	$250 million	Confidential one-on-one meetings; approved ATCs could be furnished to the winning proposer for use	Papernik and Farkas (2009)
Orange County Transportation Authority	SR-22 Reconstruction/ Widening	$300 million	Confidential ATCs submitted for review and approval	Papernik and Farkas (2009)
Texas DOT	IH-635 Managed Lanes	$2.7 billion	Confidential ATCs submitted for review and approval; approved ATCs could be furnished to the winning proposer for use	Papernik and Farkas (2009)
Utah DOT	Pioneer Crossing	$180 million	Confidential ATCs submitted for review and approval; approved ATCs could be furnished to the winning proposer for use	Walker and Haines (2010)
Virginia DOT	US Route 460	$1.5 billion	Confidential ATCs submitted for review and approval	Papernik and Farkas (2009)
Washington State DOT	I-405, 112th Ave SE to SE 8th St. Widening	$125 million	Confidential one-on-one meetings; ATCs submitted for review and approval; approved ATCs could be furnished to the winning proposer for use	Carpenter (2010)

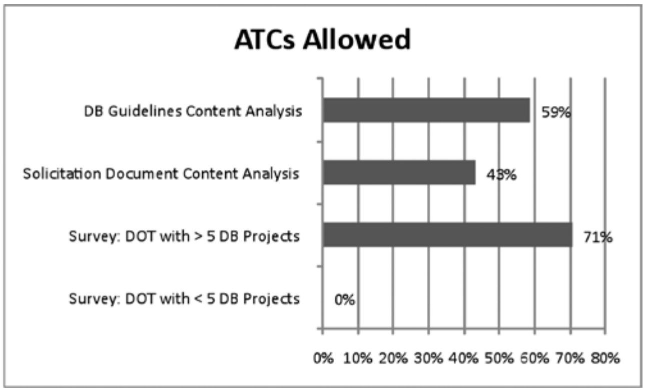

FIGURE 2 Research instrument output regarding alternative technical concept use.

FDOT describes the purpose of ATCs as follows: "The ATC process allows innovation, flexibility, time and cost savings on the design and construction of Design/Build projects. ATC's allow the Department to obtain the best value for the public" (FDOT 2011). The Minnesota DOT states, "ATCs have successfully been used on a variety of projects to generate innovative ideas and cost saving" (Mn/DOT 2003). ATCs have proven to be so effective that a number of DOTs joined in a request to the FHWA to allow the ATC process to substitute for the mandatory value engineering analysis required before advertising a DB project (Papernik and Farkas 2010). Given the above discussion and the information found in the literature, one can conclude that the ATC process is a viable approach to reducing perceived geotechnical risks by allowing competing design-builders to propose design solutions with which they have both experience and confidence. The nearly unanimous use of confidential one-on-one meetings to discuss, review, and approve ATCs before DB proposals are submitted indicates that this is an effective practice used by many DOTs with multiple DB project delivery experience.

CONTRACTOR'S PERSPECTIVE

When asked to rate the impact of various components of the selection process during the procurement process on project quality from a geotechnical perspective, 91% of the design-builders indicated that qualifications of their geotechnical design and construction staff had a high or very high impact. Past project experience was rated high or very high by 82% of the interviewees, and 82% believed that the clarity of the owner's requirements for QM plans and processes also had a major impact. However, six indicated that finding qualified geotechnical personnel to meet DOT RFQ standards was challenging on all DB projects, and four had difficulty on some projects. More than half of the contractors stated that they developed their proposals with the idea that they would not be able to use their preferred approaches to geotechnical design and construction either because of specific exclusion in the RFP or because they sensed that the owner's personnel would not relinquish control of the process. The contractors' remedy was to increase the proposal contingency accordingly.

CONCLUSIONS

The analyses discussed in this chapter resulted in the following conclusions:

- The qualifications of the geotechnical designers and the past experience with geotechnical projects of companies that make up the DB team are key to achieving quality in the constructed DB project.
- Addressing geotechnical issues early in the DB procurement process is important.
- The weight of geotechnical factors must be assigned proportionately to the other factors that define success for a given DB project.
- The ATC process is a viable approach to reducing perceived geotechnical risks by allowing competing design-builders to propose geotechnical design solutions with which they have both experience and confidence.

Additionally, the following effective practices were identified in this chapter:

- The relative geotechnical weight can be tailored as appropriate for each DB project in a manner similar to that used by the FDOT.
- DOTs across the nation have effectively used confidential one-on-one meetings to discuss, review, and approve ATCs before DB proposals are submitted.

The following suggestions for future research are made:

- Guidance is needed on how to effectively address and evaluate how geotechnical factors can be developed and incorporated into DOT DB guidelines. The research would elaborate on the value of including geotechnical technical evaluation factors in the DB project's RFQ to encourage competing design-builders to team with highly qualified geotechnical designers and include project management and field personnel with extensive geotechnical experience in the construction team.
- Research is needed to quantify the benefits of geotechnical ATCs on DB projects. The results can be made available to agencies that are new to alternative project delivery methods and furnish both guidance and factual performance information to assist them in determining whether or not ATCs are attractive in their markets.

CHAPTER FIVE

DESIGN-BUILD POST-AWARD DESIGN PROCEDURES

INTRODUCTION

NCHRP Synthesis 376 (2008) describes the design phase of a DB project as "the phase where the ultimate quality of the constructed facility is quantified through the production of construction documents." A 2004 study of DB quality management stated, "Quality cannot be assumed into the project. It must be designed and built into the project in accordance with the DB contract itself" (Gransberg and Molenaar 2004). Achieving high-quality design demands information-rich and frank communication between the owner and the design-builder's staff during the design phase (Ernzen et al. 2000; Beard et al. 2001). Partnering is one tool that has been used to enhance communications on DB projects (Allen et al. 2002), and DBIA's *Manual of Policy Statements* states, "DBIA advocates both formal and informal project partnering and considers the partnering philosophy to be at the foundation of design-build delivery" (DBIA 1998).

Partnering Design-Build Projects with Geotechnical Issues

Partnering has been used successfully in transportation projects since the late 1980s. Its central concept is to bring the various parties to a construction contract together and create an environment of open communication and trust. "Open communications is the key to any partnering process" (Ernzen et al. 2000). A study of the Texas DOT's early DBB partnering program found that partnering provided an effective means to control both cost and time growth (Gransberg et al. 1999). Similar research on NAVFAC's DB partnering process reached the same conclusions and demonstrated the benefits of applying partnering principles to DB projects (Allen et al. 2002). Ernzen et al. (2000) completed a study of the Arizona DOT's partnering efforts on a major DB project in Phoenix, and concluded,

> Design-build by its nature lends itself to the partnering concept. The partnering concept ideas of increased communication, alignment of goals, and development of a dispute resolution system fit perfectly with design-build's overarching theme of single-point responsibility for the owner. Increased pressure because of schedule compression typical of most design-build projects makes partnering a vital necessity (Ernzen et al. 2000).

Most formal partnering programs are initiated before design commences. Partnering facilitates conflict avoidance during the initial stages of design as the geotechnical investigation and its subsequent design reports are completed (Ernzen et al. 2000). "Actual partnering" begins during the design-builder's team-building period as the proposal is developed during the procurement phase between the designers and constructors on the design-builder's team (Allen et al. 2002). Additionally, during the DOT's procurement phase, internal partnering efforts often involve internal DOT lawyers, engineering discipline areas, procurement personnel, and others. Many DOTs use the principles of partnering to cement positive working relationships with external stakeholders such as state environmental agencies, and pre-award partnering efforts can have the same effect on the project as the DB team partnering before contract award. Figure 3 shows the survey responses on DOT policy requiring partnering on DB projects, separated by the experienced DOTs and the less experienced DOTs. All but three agencies require partnering on DB projects. Those three DOTs (Minnesota, Montana, and Utah) encourage partnering, but their contracts do not mandate a formal partnering session. Hence all the respondents, regardless of DB experience, agree that partnering adds value to DB project execution, which leads to the conclusion that some form of partnering clause is used in most DOT DB contracts.

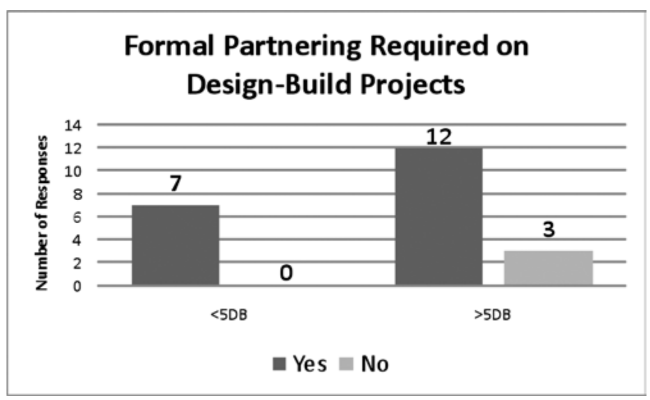

FIGURE 3 Survey results for partnering requirements on DB projects *Note*: Of the 17 DOTs that reported having fewer than 5 DB projects, 10 did not respond to this question.

The first opportunity for the DOT and design-builder to conduct formal partnering occurs at contract award. The first partnering meeting must be designed to develop communication pathways that are critical to furnishing specific design information, as well as owner preferences for tried-and-true geotechnical engineering design solutions, to the design-builder's design team. It should also build the communications structure to ensure that the designers on the owner's and designer's teams are aware of critical geotechnical information, and to incorporate the constructors in the geotechnical design information exchange to make sure that final designs are constructible and conform to the means and methods assumptions reflected in the price proposal (Ernzen et al. 2000). For DB projects with significant geotechnical issues, experience has shown that a second partnering meeting held after the geotechnical investigation and geotechnical design report is completed creates an opportunity to talk through and resolve potential changed site conditions issues, thereby avoiding adverse schedule impacts (Higbee 2004).

Changing the Design Administration Culture

The culture shift from DBB design administration to DB design administration requires that both the owner and the design-builder agree at the outset of the project to create a design administration system that supports the development of a design that responds fully to the DB contract. This is particularly critical with regard to the project's geotechnical aspects. Since the geotechnical design will occur at the earliest stages of the process, it is often on the critical path, and any failure to jointly work through the problems identified by the full-scale geotechnical investigation could threaten the entire project's schedule. The WSDOT's DB guideline articulates this requirement as follows:

> Partnering should be considered an integral part of the Design Quality Control/Quality Assurance program. A partnering agreement is recommended to handle disputes. In addition a separate procedure for conflict resolution should be developed and agreed to by the partnering participants (WSDOT 2004).

The WSDOT survey response included the following comment, which describes a tool for expediting any DSCs that may be encountered in these critical early stages of the DB project:

> We [assign] all changed conditions under a certain dollar amount (different amounts for different contracts) to the contractor's risk. If that threshold is exceeded, then the department pays for the costs above the threshold.

This is an elegant solution to a potentially thorny problem. Including this mechanism in the DB contract affords the design-builder an opportunity to include an appropriate contingency in its proposed price without adding extra money to cover the possibility that the agency will not recognize a DSC claim. It also bounds the agency's liability for this particular type of uncertainty.

A national design-builder's DB project administration manual expresses the same sentiments about the importance of changing the design administration culture for DB projects:

> It is vital for the long-term success of the project to involve the owner/client in a relationship where everyone understands the roles and responsibilities of the client as well as the executing team. Indeed, design/build is the ultimate partnering relationship (Centennial Contractors 2004).

Both parties to the DB contract recognize the value in formally agreeing to work together during the design phase to achieve the required levels of quality in the ultimate project. Open communication is the catalyst to making the design administration culture shift. WSDOT again provides an example of the owner's role in DB design administration after the shift is complete.

> WSDOT is expecting a proposed project that meets the design criteria and can be further developed for construction….WSDOT is expecting to be available in a matter of hours or days, not days or weeks, to answer questions and provide feedback during the process. We would like to operate under a partnering environment with over-the-shoulder reviews, if possible. WSDOT will not be approving the design or construction, the Design-Builder will have the responsibility for ensuring the project proposal is correct. The Design-Builder will likewise have the responsibility for correcting any mistakes made in the proposal process, unless the mistakes are the result of an unclear RFP (WSDOT 2004).

The survey contained a question regarding DOT partnering policies on projects with significant geotechnical aspects, and 84% of the respondents indicated that they used formal partnering on their DB projects. Therefore, it appears that most DOTs have at least a foundation in place to build the communications conduit that will help produce a quality geotechnical design for a DB project.

GEOTECHNICAL DESIGN PROCESS

The post-award geotechnical design process for DB projects is established by the DB contract itself, and it has three components that prescribe the work process.

1. The requirements articulated in the DB RFP.

2. The agency's DB guidelines, which are incorporated by reference in the contract.

3. The contents of the winning DB proposal, which spell out the design-builder's specific approach to the geotechnical design.

Agency-Controlled Design Process Features

The agency is able to control two of the three documents that define the geotechnical design process in a DB project. Table 22 contains a list of design criteria, specifications, standard design details, and references from a content analysis of the

17 DB guidelines and the 46 solicitation document sampled for the synthesis. It is apparent that the amount of specific geotechnical information required in the agency-developed documents is sparse. There are two possible explanations. First, each of the solicitation documents contains a list of documents incorporated by reference, which usually include the agency's geotechnical design manual. Thus, the expectation is that the design-builder will follow those procedures and produce essentially the same design deliverables required in a similar DBB project. One guide states that the intent is to "use the Department's existing systems to the extent possible, changing or adding only as necessary to facilitate the design-build method of contracting" (WSDOT 2004). Second, the DB guidelines are meant to furnish general guidance applicable to all types of projects, rather than specific direction on each disciplinary area such as geotechnical engineering.

Nevertheless, the paucity of specific information indicates a gap in the body of knowledge. Future research as to what types of geotechnical information should be contained in agency-level DB guidelines and in RFPs for projects with significant geotechnical aspects is recommended. The value would be to sensitize agency personnel and consultants who develop DB solicitation documents to the need to evaluate the requirements for geotechnical input and output at the earliest opportunity to ensure that the decision to use DB project delivery is indeed a good decision, and to see that efforts are made to develop the preliminary geotechnical information necessary to encourage competitive/responsive proposals. One DB guideline describes it this way: "It is particularly important that WSDOT staff be able to define the basic objectives of the design-build project very early in the process" (WSDOT 2004).

Design-Builder-Controlled Design Process Features

Table 23 shows the results of the two content analyses for the output required of the winning design-builder during the post-award geotechnical design process. As with the previous table, the frequency of most observations is low. This rate is affected by the same two reasons as Table 23: incorporated references and generalized guidelines. A third reason may also be in play here. A number of the agency guidelines encourage agency personnel to have a hands-off approach regarding design directives. Below is a common clause from a DOT DB guide:

> The design-builder usually has the responsibility for any project specific geotechnical or subsurface investigations beyond what WSDOT provides… As the design-builder is ultimately responsible for the design, wherever

TABLE 22
CONTENT ANALYSIS OUTPUT FOR AGENCY-CONTROLLED POST-AWARD GEOTECHNICAL DESIGN

Post-award Design Criteria, Specifications, Design Details, and References	Number of Observations			
	Agency Guidelines (No./%)		Solicitation Documents (No./%)	
Use of geotechnical baseline report as a contract document	5	29%	3	7%
Use of geotechnical baseline report as a reference document	3	18%	1	2%
Geotechnical safety factors mandated	5	29%	6	13%
Geotechnical design values mandated	6	35%	11	24%
Preliminary design of geotechnical features of work completed	3	18%	11	24%
Use of performance verification and measurement methods mandated	0	0%	14	30%
Test piling mandated	3	18%	13	28%
Instrumentation mandated	3	18%	14	30%
Methods for mitigating high-risk geotechnical conditions specified (e.g., landslides and contaminated soils)	8	47%	8	17%
Pile foundation design specified	2	12%	3	7%
Bridge foundation design specified	1	6%	3	7%
Documents Incorporated by Reference				
FHWA Administration Checklist	3	18%	15	33%
FHWA Geotechnical Instrumentation	1	6%	3	7%
FHWA Geotechnical Circular 4	0	0%	4	9%
FHWA Geotechnical Circular 5	1	6%	2	4%
FHWA Geotechnical Circular 6	0	0%	11	24%
AASHTO Standard Specifications	3	18%	12	26%
FHWA Design and Construction of Driven Pile Foundations	0	0%	5	11%
FHWA Mechanically Stabilized Earth Walls	1	6%	2	4%
AREMA Manual of Recommended Practice	0	0%	1	2%

> possible WSDOT project personnel should resist the temptation to insert their preferences or solutions into the RFP (WSDOT 2004).

Again, this supports the need for future research to determine the value of including detailed requirements for geotechnical design output in DB guides and solicitation documents.

GEOTECHNICAL DESIGN REVIEWS

The formal method for exchanging detailed geotechnical design information is through the contractual design review process. Although there is no standard definition for the composition of geotechnical design review, most agency DB guidelines typically address how a design review should be conducted (Mn/DOT 2001; WSDOT 2004). The North Carolina DOT provides specific guidance for DB geotechnical design reviews in a two-page document that lists "design calculations and supporting documentation in the geotechnical design submittals for the NCDOT Geotechnical Engineering Unit's review and acceptance" (NCDOT 2009).

According to a design-builder's DB procedures manual, the greatest single obstacle to timely completion is the owner's design review process: "Design reviews will always be on the DB project's critical path because the consequences of proceeding at our own risk without assurance that what we build will ultimately be acceptable to the owner are unacceptable" (Centennial Contractors 2004).

Many owners believe that there is a difference between "approving" a submittal and "accepting" a submittal (Mn/DOT 2001; WSDOT 2004). For the most part, however, courts have been not willing to differentiate the two terms. This is particularly true when an owner that has substantial technical expertise and resources (as do most DOTs) tries to shield itself from responsibility by "accepting" rather than "approving." Consequently, the owner of a DB project should carefully decide which submittals it will simply "review" and those which it will influence or act upon.

Most owners select DB to compress the project delivery period (Songer and Molenaar 1996), which creates a sense of urgency during early design efforts that is not present in a traditional DBB project. Attempting to impose the traditional linear process—design submittals followed by reviews, and then by resubmittals to address comments—amounts to attempting to execute a DB project with a DBB mentality (Pappe 2008). As a result, the issue of how the agency will satisfy its statutory responsibility for due diligence to ensure geotechnical design adequacy must be determined before the DB contract commences. "Since the design work is usually fast tracked, it is imperative for the PM [project manager] to have the design review team in place and ready to go upon award of the contract" (ADOT 2001). The Mn/DOT confirms the ADOT approach in its guide when it specifies three objectives to be achieved in the design review process:

> Place the primary responsibility for design quality on the design-builder and its designer(s). Facilitate early construction by the design-builder. Allow the Department to fulfill its responsibilities of exercising due diligence in overseeing the design process and design products while not relieving the design-builder from its obligation to comply with the contract (Gonderinger 2001).

Two primary issues must therefore be addressed regarding the review of geotechnical design submittals and products:

1. The appropriate number of design reviews.

2. The content of each design submittal to be reviewed.

Appropriate Number of Design Reviews

The literature review found that the number of design reviews required by owners varies across the nation. However, *NCHRP Synthesis 376* (2007) identified three main approaches:

TABLE 23
CONTENT ANALYSIS OUTPUT FOR DESIGN-BUILDER PROPOSED POST-AWARD GEOTECHNICAL DESIGN

Required Post-award Design Deliverables	No. of Observations			
	Agency Guidelines		Solicitation Documents	
Final Geotechnical Investigation/Test Results	8	47%	25	54%
Final Geotechnical Report	4	24%	23	50%
Preliminary Design of Geotechnical Features	4	24%	10	22%
Geotechnical Design Approach Narrative	4	24%	8	17%
List of Geotechnical Assumptions	2	12%	3	7%
Test Piling Program Report	3	18%	11	24%
Foundation Certification Package	2	12%	10	22%
Instrumentation/Monitoring Program	3	18%	13	28%
High-Risk Geotechnical Conditions Mitigation Analysis	8	47%	8	17%

- No formal review before final (release-for-construction) design review,
- One review before the final design review,
- Multiple reviews prior to the final design review.

In many of the documents reviewed in the content analysis, the design-builder is directed to request informal reviews that allow the owner to provide more frequent input to ensure that the final design will meet the contract requirements. These reviews are often called "over-the-shoulder" or "oversight" reviews to indicate that the design process will not stop to wait for comments from the informal review process. Table 24 summarizes the categories of design reviews and the corresponding percentage of occurrences in the *NCHRP Synthesis 376* (2007) content analysis.

TABLE 24
REQUIRED NUMBER OF DESIGN REVIEWS

No. of Reviews	% Projects *NCHRP Synthesis 376* Content Analysis	Comments
No review prior to final	15%	Owner still provides oversight and comments informally
One review prior to final	56%	Can be anywhere from preliminary design until just before the final design review
Multiple reviews prior to final	29%	The exact number of reviews can range from two to a separate review for every major feature of work

Source: Gransberg et al. (2007).

No Mandated Reviews

When no owner-mandated design review checkpoint is required before final design, the burden of design compliance is placed fully on the design-builder. In theory, this is one of the benefits of utilizing DB project delivery. However, the owner must still provide assurance that the contract will be completed with all the requirements met in a timely manner. In the RFPs analyzed in the *NCHRP Synthesis 376* study, 41 mentioned the design review requirements. Fifteen percent used the approach of no owner-mandated design review checkpoints before the release-for-construction design review. Mn/DOT detailed its design review approach an RFP for one of its first DB projects as follows: "The Department will participate in oversight reviews and reviews of early construction as part of its due diligence responsibilities" (Mn/DOT 2001). The agency used the following verbiage in its DB RFP for the Hastings River Bridge project, a project with significant geotechnical issues:

> Contractor shall furnish the Released for Construction Documents and other Design Documents to Mn/DOT… Contractor shall obtain Mn/DOT's Acceptance of the Released for Construction Documents … Mn/DOT shall have the right to review and comment on all Released for Construction Documents and other Design Documents for compliance with the requirements of the Contract Documents… (Minnesota DOT 2010).

The term "released for construction" means that the design-builder's engineer-of-record has reviewed and approved the design and is certifying it as ready for final review by the agency. Since much of the design effort relies on the final geotechnical design, allowing the design-builder to proceed with this particular effort without interruptions for mandated agency design reviews preserves the project schedule and permits the design-builder to bring the final design to "released for construction" stage as expeditiously as possible. Mn/DOT utilizes "over-the-shoulder" design reviews as the primary mechanism to make input during the design process and defines these as "The over-the-shoulder reviews are not hold points that restrict the progress of design… they are simply reviews of the design as it progresses and opportunities for Mn/DOT to provide comments and feedback on the design" (Mn/DOT 2005). As seen in the Hastings Bridge case study in this synthesis, the "hands-off" approach to design review used in Minnesota led to the design-builders proposing an external peer review of the geotechnical designs for the problematic north embankment on that bridge, The expert's duties were to "advise and perform a peer review of the LTP [load transfer platform] and the lightweight fill used in the transition between the CSE [column stabilized embankment] and the existing embankment" (Behnke and Ames 2010).

The primary issue in the use of this process is for the agency to be able to demonstrate that it has discharged its statutory responsibility of "due diligence" (FHWA 2011). Minnesota uses the oversight approach referenced above. The Arizona DOT follows a similar procedure that it describes as follows:

> Over-the-shoulder-reviews are performed while the design is being developed. They are proactive in nature, informal, interactive, and intended to catch omissions and oversights that may lead to a major redesign of the work (ADOT 2001).

Arizona also uses a design review procedure that is uniquely well-suited to geotechnical design deliverables. It is called the "early construction review" and is reserved for design products that will be released for construction before the design is 100% complete. "The intent is to ensure that enough detail has been provided in the plans to allow construction to begin and that ADOT's minimum design standards are maintained" (ADOT 2001). This process reinforces the due diligence requirements and allows the agency to obtain the necessary level of comfort with the design quality of early geotechnical features of work scheduled in support of achieving an aggressive project delivery period.

The WSDOT approach to the no-review process also clarifies the obligations of both the agency and the design-builder with regard to delaying construction waiting for design reviews to be completed:

> WSDOT will not perform an official review that might be interpreted as acceptance or approval of the design, after the acceptance of the proposal…However, *construction is not required to wait for Department responses to submittals*. The review teams must understand that timely reviews, checking for contract compliance, are in everyone's best interest (WSDOT 2004, italics added).

Single or Multiple Design Reviews

A single formal design review before the review of the final released-for-construction documents provides an intermediate point for the owner's review team to verify that the design complies with the contract requirements and a milestone to check that it is progressing according to the schedule. The major advantage of this approach is the avoidance of lost design effort by furnishing a prescribed review that indicates the owner's satisfaction with the design details before moving onto final construction documents. The Mississippi DOT uses this approach for their DB projects. An example is provided here:

> The CONTRACTOR will prepare and submit a single preliminary design submittal for the entire project. Preliminary design shall include roadway plan and profile, bridge type, selection layout, drainage, erosion control, signing, architectural and traffic control plans. MDOT will review Preliminary Design Submittals within 21 Days of the submittal… (Mississippi DOT 2005).

The Mississippi DOT also provides for an "optional design review" with the following RFP clause:

> At the request of the CONTRACTOR, MDOT will provide optional design reviews on design packages as requested by the CONTRACTOR. MDOT as appropriate will review optional design Submittals within 14 Days…. (Mississippi DOT 2005).

Mississippi's optional design review concept inside the single review approach would work well with the early geotechnical design products. It would give the agency's geotechnical engineers an opportunity to become comfortable with the early foundation design assumptions without needing to stop the entire design process just to review a single feature of work.

Many (30%) of the RFPs reviewed in the content analysis required more than one official owner review before the design can be released for construction, which was also found in 29% of the RPFs studied in *NCHRP Synthesis 376*. In one RFP, The Maine DOT required that "formal design package submittals shall be made…at the 50% and 80% design development stage of any design package intended to be RFC [released-for-construction]" (Maine DOT 2010). Maine also includes an "early release for construction" design review process targeted at the geotechnical elements of bridge projects. The process is described as follows:

> The Design-Builder has the option to RFC design plans for a particular bridge element. *Early release can be for driving piles, constructing the footings and or foundation,* and submission and approval of the superstructure in order to meet procurement schedules. The Early Release process requires submission of the design plans of the particular bridge element, associated computations, and QC/QA documentation … and a description of the elements to be released. The plans and computations shall be sealed by a Maine Licensed Professional Engineer. Plans should note that they represent an early release submittal and shall identify exactly what element is to be released. Any items shown on the design plans that are not to be RFC shall be clouded and cross-hatched within the clouds (Maine DOT 2010, italics added).

In 2007, the U.S. Army Corps of Engineers (USACE) changed its DB design reviews policy and reduced the number of mandated design reviews from four (30%, 60%, 90%, and final) to two (intermediate and final) (USACE 2007). The change was made to decrease potential delays during government reviews. In a personal communication with the author, Joel Hoffman of USACE (2010) explained the rationale: "Philosophy is that once the designer of record approves construction and extension of design submittals, the builder can proceed—don't wait on us, unless there is a specific government approval required." This and the previous discussions in this section lead to the conclusion that the appropriate number of design reviews is a function of the need for the design-builder to maintain an aggressive schedule. If the project is not schedule-constrained, the DB design reviews can afford to inject more design review points, whereas design reviews can be minimized on a fast-track project.

Table 25 shows the results of the solicitation document content analysis with regard to the use of over-the-shoulder design reviews and provisions for optional early design reviews that might be used to gain an early resolution to geotechnical design issues. It shows that experienced agencies are far more likely to use the over-the-shoulder and optional early design reviews than those with less experience. This leads to the identification of two effective practices for geotechnical design reviews. First, the use of over-the-shoulder design reviews creates a mechanism for geotechnical personnel to have input into the design without causing the design-builder to pause for a formal review. Second, the inclusion of optional early design reviews for design packages gives the design-builder an opportunity to gain agency concurrence on the geotechnical design approach when it is most needed, rather than having to wait for the first formal design review.

TABLE 25
DESIGN REVIEW OUTPUT FROM SOLICITATION DOCUMENT CONTENT ANALYSIS

Design Review Types	DOT < 5 DB Projects	DOT > 5 DB Projects
Single or Multiple Design Reviews Before Final	5	9
Over-the-Shoulder	1	17
Optional Early Design Reviews	3	12

CONTRACTOR'S PERSPECTIVE

The design-builder interviews yielded valuable information regarding the geotechnical design process. Respondents were asked to rate the impact on final geotechnical quality of a number of components to the DB design process. The majority (67%) believed that the use of geotechnical performance criteria/specifications had a major impact, and more than half stated that being given detailed design criteria also promoted design and construction quality. They were less supportive of being required to use agency standard specifications and design details; one interviewee indicated that the standard specifications eliminated the possibility for innovation and turned the selection process into a "low-bid" selection.

A majority also cited multiple design reviews (7 of 11), sequential design reviews by different agency design personnel (8 of 11), and agency personnel's willingness to accept over-the-shoulder design reviews (9 of 11) as challenges on all DB projects. In a similar vein, six respondents stated that the owner's unwillingness to specify satisfactory corrective action to deficiencies found in over-the-shoulder and formal design reviews was a major challenge to completing the geotechnical design process and getting the construction documents released on time.

CONCLUSIONS

The analyses discussed in this chapter resulted in the following conclusions:

- A partnering clause of some form is used in most DOT DB contracts.
- The appropriate number of design reviews is a function of the need for the design-builder to maintain an aggressive schedule and the technical complexity of the scope of work. A project that is not schedule-constrained or without significant geotechnical issues affords the owner the opportunity to inject more design review points, whereas design reviews can be minimized on a fast-track project.

Additionally, the following effective practices were identified in this chapter:

- All survey respondents, regardless of DB experience, agree that partnering adds value to DB project execution.
- Effective partnering (sometimes termed "true partnering") starts in the procurement phase with the owner minimizing the amount of "exculpatory verbiage" (Christensen and Meeker 2002) in the RFP.
- Effective partnering is promoted by the agency expressing a sincere willingness in its solicitation documents to both share geotechnical risk (Allen et al. 2002) and seriously consider not only ATCs but also broader alternative approaches to the geotechnical design (Ernzen et al. 2000).
- Experienced agencies use over-the-shoulder design reviews to create a mechanism for agency geotechnical personnel to have input into the design without stopping the design process, thereby facilitating progress on early DB work packages.
- Including the option for early design-builder-requested design reviews on specific design packages creates the opportunity to gain agency concurrence on the adequacy of the geotechnical design at the point when it is most needed, rather than having to wait for the first formal design review.

The following suggestions for future research are made:

- Future research is recommended on the types of geotechnical review steps that should be contained in agency-level DB guidelines and in RFPs for projects with significant geotechnical issues.

CHAPTER SIX

DESIGN-BUILD GEOTECHNICAL QUALITY MANAGEMENT PROCEDURES

INTRODUCTION

Quality management (QM) is an overarching term that describes all the tasks undertaken during planning, procurement, design, and construction to ensure that the final constructed project conforms to the requirements agreed upon by the owner, its internal and external design engineers, and the construction contractors that will build the project (Leahy et al. 2009). The fundamental need for quality does not change with the type of project delivery method used (Finnish Road Administration 2003). In the traditional DBB method, the owner performs the design with in-house assets or hires a design consultant on a design contract. Thus, the owner can influence the contractual level of project quality during the design phase before the construction contract is awarded. The final design documents are integrated with the construction contract and referred to as the "construction documents." From the geotechnical perspective, since the design is complete, the geotechnical engineering is complete and a remaining risk to quality is the possibility of differing site conditions (Smith 2008).

This is not the case for the geotechnical engineering requirements in DB project delivery. With DB, the final geotechnical design documents are a deliverable that flows from the awarded DB contract, and by definition the construction contract is awarded before the design is complete, diminishing the owner's ability to influence the level of quality portrayed in the details of the completed design (Beard et al. 2001). Most DB projects are designed and built by contractor-led teams (e.g., a general construction contractor as prime with the design being furnished through a design subcontract) (Songer and Molenaar 1996). This arrangement can lead to a concern that the "fox may be guarding the henhouse," a criticism that has plagued DB since its inception (Keston Institute 2007). A 2002 study by Ernzen and Feeney titled "Contractor-Led Quality Control and Quality Assurance Plus Design-Build: Who Is Watching The Quality?" looked at Arizona DOT's DB program and addressed the issue by comparing project QA compaction and sieve analysis test data on a DB project (where the design-builder had been assigned the responsibility for QA) with data from a similar traditional DBB project. It found the following:

> Analysis of the data shows that despite a highly compressed schedule, the quality of the material on the project exceeded the project specifications and was similar to the quality of work completed for the state under traditional contracting methods with an Arizona DOT-operated quality assurance program (Ernzen and Fenney 2002).

As a result, the owner's clear communication of the requirements for not only the quality of the constructed project but also the quality of its design is important to DB project success. To accomplish clear communications, all DB contract parties must understand the definition of quality in the context of a given project's geotechnical requirements.

Definitions for Design and Construction Quality in DB Projects

Defining quality is difficult at best and impossible at worst. The determination of the required minimum values is part of the specification writing process that occurs during design. Since shifting design liability is one of the benefits touted in the literature (ADOT 2001; WSDOT 2004; Potter and McMahon 2006), prescriptive specifications create the danger that the owner will unintentionally assume design liability for the geotechnical performance of the features of work for which it prescribed test values (Gonderinger 2001; USACE 2009). The literature furnishes a number of operational definitions for quality. Table 26 compares the definitions found in the literature and categorizes them according to the fundamental definitions provided by the American Society for Quality (ASQ).

The ASQ maintains a "quality glossary" that seeks to furnish standard definitions for quality terminology (Nelsen 2007). *Transportation Research Circular E-C137* (Leahy et al. 2009) is a *Glossary of Highway Quality Assurance Terms.* It should be noted that those two sources of quality definitions were not written recognizing the intricacies of DB project delivery. However, a study of DB RFPs (Gransberg and Molenaar 2004) identified and defined a number of separate approaches that public owners use to articulate the QM requirements for DB projects.

Quality Management Theory Applied to Geotechnical Issues in Design-Build Projects

"Highway construction specifications have been evolving from prescriptive (method-based) to alternative types that are designed to ensure that the initial quality and in-service

TABLE 26
COMPARISON OF AMERICAN SOCIETY FOR QUALITY DEFINITIONS WITH DEFINITIONS FOUND IN THE LITERATURE

ASQ Quality Type	ASQ Definition (ASQ 2007)	E-C137 Definitions (Leahy et al. 2009)	Owner DB Quality Approach (Gransberg and Molenaar 2004)
Relative	"loose comparison of product features and characteristics"	"end-result specifications"	"Quality by Specified Program: The RFP requires the design-builder to submit a proposed QM program which complies with an owner-specified program in the proposal, and the owner verifies this compliance."
Product-Based	"precise and measurable variable… reflect differences in quantity of some product attribute"	"performance-based specifications" "quality assurance specifications"	"Quality by Performance Criteria: The RFP requires the design-builder to submit a proposed technical solution which is responsive to owner-furnished technical performance criteria, and the owner competitively evaluates it."
User-Based	"fitness for intended use"	"performance-related specifications"	"Quality by Evaluated Program: The RFP requires the design-builder to submit a proposed QM program of its own design in the proposal, and the owner competitively evaluates it."
Manufacturing-Based	"conformance to specifications"	"material and methods specifications"	"Quality by Specification: The RFP requires the design-builder to submit proposed technical solutions which were responsive to the owner's prescriptive technical specifications, and the owner verifies this compliance during the design submittal process."
Value-Based	"conformance at an acceptable cost"	"value engineering" "warranty specifications"	"Quality by Qualifications: The RFP requires past performance and/or personnel qualifications which indicate the owner is concerned about the qualifications of the DB team. It is vague or silent on specific requirements for a DB QM program." "Quality by Warranty: The RFP requires some type of performance warranty or maintenance bond."

performance of highway pavements meet the expectations set at the design phase" (Gharaibah and Miron 2008). The paper from which this quote was drawn presents a model called the "advanced quality system" (AQS). Although the paper's focus was on the development of warranty specifications for highway pavements, the AQS model can be adapted to apply to DB geotechnical projects, as shown in Figure 4. Essentially, the AQS is the typical cycle of continuous quality improvement (Smith 2001; Panchmatia 2010). The model has been modified to reflect the following sequence. It starts with the preliminary geotechnical design information, criteria, and specification input provided by the agency to competing design-builders in the DB RFP. Next, it follows the chronology of post-award activities completed by the design-builder through the owner's verification/acceptance of constructed geotechnical features of work to the post-construction performance evaluation based on instrumentation. It ends with lessons learned, which are then fed back into the system to improve the geotechnical design criteria package for the next DB project.

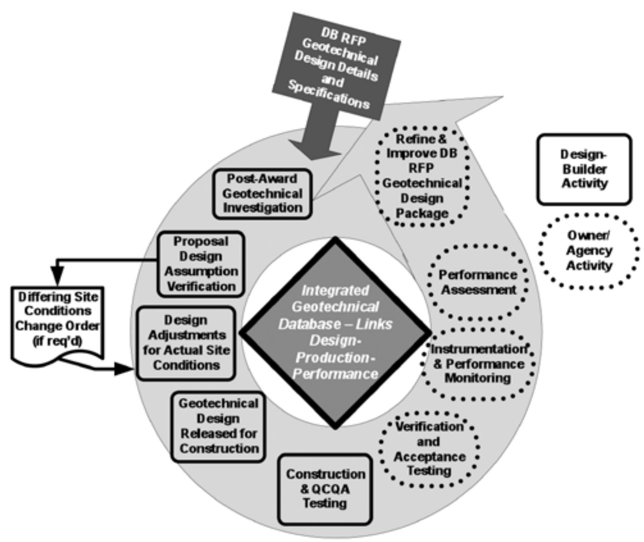

FIGURE 4 Advanced quality system model applied to geotechnical aspects of DB projects [*Source*: After Gharaibeh and Miron 2008].

The critical point in the process is at the beginning of the cycle, when the design-builder executes the final geotechnical site investigation and verifies the design assumptions used in the price proposal. This is where the quality of the agency's RFP input is tested against the facts found after award. If there is no significant difference, then the cycle continues with minor adjustments being made to the assumed geotechnical design solution to account for actual conditions. If there is a significant difference, then the DB contract's DSC clause comes into play and a change order is negotiated to adjust the project's price and schedule.

Gharaibeh and Miron (2008) advocate capturing the linkage between design-production-performance in a historical database for use in future projects through the preceding process. At this early stage of the DB project delivery process, no construction has been completed, so no performance quality can be measured on the structure itself. However, because the preliminary geotechnical information contained in the RFP did not accurately reflect actual conditions, the agency has an opportunity to reevaluate the decision-making process used to arrive at the geotechnical information package used in the solicitation. The fundamental idea of capturing this type of lesson is expressed in WSDOT's DB guidelines:

> Ultimately, WSDOT will own responsibility for Changed and Differing Site conditions. As such, it is necessary for WSDOT to *establish a baseline for design-builders* to develop their technical and price proposals (WSDOT 2004, italics added).

To foster continuous improvement, the agency would consider what would have been done differently during preliminary engineering to characterize the actual site conditions more accurately and furnish the "baseline for design-builders." That analysis would be folded into the remaining agency geotechnical QM activities to put it into the "design-production-performance" linkage required by the AQS model. One possible outcome might be a change in the agency's DB preliminary engineering milestone schedule to permit additional time and funding for a more developed geotechnical design information and criteria package on future projects of this type. The North Carolina DOT has done this very thing and now budgets an amount for preliminary geotechnical investigations for DB RFPs based on the analysis of past DB projects (Kim et al. 2009). Arkansas State Highway and Transportation Department DB guidelines (2006) require that the preliminary geotechnical engineering analyses be sufficient to "set the basis for determination of changed conditions, and establish preliminary project cost estimates." VDOT has developed and maintains its own version of the ASQ integrated geotechnical database, with the following objective:

> The purpose of this project [the integrated geotechnical database] was to develop a practical, comprehensive, enterprise-wide system for entry, storage, and retrieval of subsurface data. The resulting product satisfies the work flow requirements of VDOT and streamlines the delivery of geotechnical information (Hoppe et al. 2011).

The above discussion leads to the conclusion that there is a need for future research in the area of applying QM theories, such as the AQS, to the development of preliminary geotechnical engineering and site investigation plans on DB projects where there is a significant potential for geotechnical issues to arise that cannot be resolved before issuing the DB RFP. The research would seek to establish a relationship between (1) the risk of cost and time growth owing to DSCs, and (2) the amount of money and time an agency spends on the preliminary site investigation and geotechnical engineering analysis. The ultimate deliverable would be a stochastic risk-based decision-making tool that DOTs could use to estimate the cost/benefit of decreasing geotechnical uncertainty before advertising a DB project. This would also be useful for DOTs that are considering public-private partnerships as a tool to quantify changed conditions risk for potential concessionaires.

GEOTECHNICAL QUALITY MANAGEMENT ISSUES

QM is implemented in DB project delivery using a systems approach involving three primary components (Smith 2001; Panchmatia 2010):

1. Personnel: Each party to the DB contract has clearly defined roles and responsibilities that line up with the unique qualifications and past experience each brings to the project.

2. Plans: The DB project's quality requirements must be addressed in a written document that spans the project delivery life cycle, starting at procurement, running through design and construction, and ending with final acceptance and payment.

3. Procedures: The DB project's QM plan is implemented through a standard set of quality control (QC) and quality assurance (QA) procedures that define the process for final acceptance of the project's technical features of work.

This section will discuss the above components to the QM system in the geotechnical context of a DB project based on the results of the survey, literature review, and other research instruments used in the synthesis.

Qualifications, Roles, and Responsibilities

Chapter four concluded that the qualifications of the geotechnical designers and the past geotechnical project experience of the companies on the DB team are critical to achieving quality in the constructed DB project. This conclusion can be extended one level down to the qualifications and experience of the personnel whose primary roles are to implement the QM program on a DB project. Additionally, the personnel involved in the geotechnical design and construction QM tasks must possess the requisite technical knowledge to ensure the quality of both the design products and the constructed project.

Another significant issue involves the redistribution of traditional DBB QM roles and responsibilities in a DB project. One of the major motivations for using DB project delivery is to shift design liability from the owner to the design-builder (ADOT 2001; Gonderinger 2001; WSDOT 2004). To effectively transfer design liability to the design-builder, a DOT must also transfer many of the traditional QM responsibilities. The survey asked respondents to indicate which party to the contract was assigned the responsibility for completing each QM task in the geotechnical aspects of the DB project. Figure 5 shows the consolidated output from the survey on that question. Four primary entities were assigned specific QM tasks. Two are part of the owner's team (i.e., the agency staff and the agency-hired consultant) and the other two are the design and construction staff working on the design-builder's team. One can see that with the exception of routine construction inspection and quality control testing, the agency staff retained the responsibility for the list of QM tasks found in the survey question. If the agency and design-builder assignments are combined, QC testing is the only task that is more often assigned to the design-builder than the agency. Figure 5 illustrates the results. The survey also asked the respondents if their QA program for geotechnical design and construction was different on DB projects than the one used on DBB projects. Roughly two-thirds of the respondents answered "no," including almost half of the DOTs that completed more than five DB projects. This result explains the QM task assignments shown in Table 27.

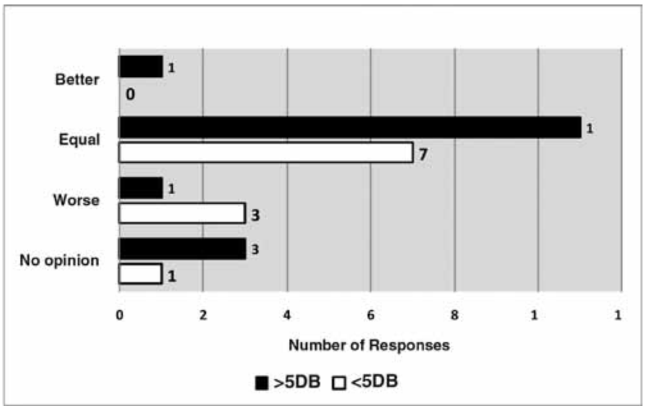

FIGURE 5 DB quality versus DBB quality.

The Table 27 output contradicts the survey responses for the same set of roles and responsibilities found in *NCHRP Synthesis 376: QA in DB Projects* (2004). However, it must be noted that the *NCHRP Synthesis 376* study looked at QM in the overall DB project and did not focus directly on the geotechnical aspects. Table 28 is a comparison of the two surveys. Note that the output was converted to relative percentages of totals in each study to account for the difference in sample sizes. This comparison shows that the DOTs responding under *NCHRP Synthesis 376* were more willing to shift QM responsibilities for routine review of design and construction submittals to the design-builder than the DOTs responding to the survey for this synthesis, where they focused on submittals related to the geotechnical aspects of the DB project. This leads to the conclusion that agencies retain most of the traditional roles and responsibilities related to geotechnical QM tasks on DB projects.

Quality Management Plans

The cornerstone of a DB project's quality management program is the QA/QC plans that are developed, reviewed, and approved before the work begins. The survey queried its

TABLE 27
DISTRIBUTION OF QUALITY MANAGEMENT ROLES AND RESPONSIBILITIES FOUND IN THE SURVEY

Quality Management Task	Design-Builder's Construction Staff	Design-Builder's Design Staff	Agency-Hired Consultant	Agency Staff
Quality Control Testing	55%	5%	18%	21%
Routine Construction Inspection	37%	7%	22%	35%
Independent Assurance Testing/Inspection	11%	0%	43%	46%
Technical Review of Material Submittals	22%	15%	24%	39%
Technical Review of Shop Drawings	13%	23%	25%	38%
Approval of Post-award QA Plans	6%	3%	27%	64%
Punch List	18%	16%	25%	41%
Acceptance Testing	17%	7%	30%	46%
Verification Testing	16%	5%	28%	51%

TABLE 28
COMPARISON OF QUALITY MANAGEMENT ROLES AND RESPONSIBILITIES FOUND IN THE GEOTECHNICAL SURVEY FOR SYNTHESIS 42-01 WITH THE RESULTS FROM *NCHRP SYNTHESIS 376* OVERALL DBQM SURVEY

Quality Management Task	Design-Builder NCHRP Synthesis 42-01	Agency NCHRP Synthesis 42-01	Design-Builder *NCHRP Synthesis 376*	Agency *NCHRP Synthesis 376*
Quality Control Testing	61%	39%	84%	16%
Routine Construction Inspection	43%	57%	69%	31%
Independent Assurance Testing/Inspection	11%	89%	12%	88%
Technical Review of Material Submittals	37%	63%	50%	50%
Technical Review of Shop Drawings	37%	63%	68%	32%
Approval of Post-award QA Plans	9%	91%	8%	92%
Punch List	33%	67%	30%	70%
Acceptance Testing	24%	76%	14%	86%
Verification Testing	21%	79%	13%	87%

recipients regarding the geotechnical QM plan development process in the procurement, design, and construction phases of the DB project delivery period. Table 29 shows the output from five questions regarding the perceived importance of QM plans in each phase of project delivery. Again, the data are broken into two subpopulations: DOTs that have completed more than five DB projects and those that have less experience. The weighted average of the ratings shows that experienced DOTs place a higher importance on the QM plans than those with less experience. It also shows that both groups place their highest importance on the design phase aspects of QM, and both agree on the value of involving the construction contractor in the geotechnical design.

The Table 29 output leads to the conclusion that the design QA plan is perceived as the most important aspect of the geotechnical QM planning process. It also implies that a successful DB design QA plan includes specific procedures for involving the construction contractor in reviewing the constructability of geotechnical designs, as well as details on how the agency will be involved in the design QA process through its role of oversight, review, and acceptance of design deliverables.

The Mn/DOT uses the following objectives for its design quality management plans:

- "Place the primary responsibility for design quality on the design-builder and its designer(s).
- Facilitate early construction by the design-builder.
- Allow the Department to fulfill its responsibilities of exercising due diligence in overseeing the design process and design products while not relieving the design-builder from its obligation to comply with the contract" (Gonderinger 2001).

These objectives validate the conclusion drawn in the previous paragraph. First, by placing "primary responsibility" on the design-builder, the DOT is allocating the responsibility for developing a process that guarantees design quality, as well as placing design liability with the party that can best manage that risk (Dwyre et al. 2010). Second, "facilitating early construction" demands that the design of geotechnical features be highly constructible in order to build them without delays induced by poorly developed designs, which demands that the builder be involved in the design QA process through constructability reviews, biddability reviews, and other preconstruction service tasks. Third, it speaks to the agency's involvement in design QA through its oversight role. Presumably, a typical design QA plan produced for a Minnesota DOT DB project would fulfill these objectives.

Changes in the Traditional Quality Assurance Procedures to Accommodate Design-Build Delivery

Agencies are not making many changes to their QA procedures with regard to roles and responsibilities to implement the geotechnical aspects of DB contracting. However, the one major issue found in the literature is the pace at which the agency QA procedures must be conducted in DB projects. This returns to the original theme of agencies selecting DB project delivery to accelerate the project's schedule and taking advantage of the single point of responsibility within the design-builder's team for both design and construction to start building before 100% design completion. A study commissioned by the Keston Institute for Public Finance and Infrastructure Policy Research (2007) reached the following conclusion:

> It seems to be apparent that implementing DB requires a well-qualified technically competent staff at the agency to achieve success. Several respondents indicated that they assigned their best engineers to DB projects and that implementing DB required them to exercise a great deal more engineering judgment… [E]xperienced agencies agree that DB projects require the most experienced agency engineers (Keston Institute 2007).

Therefore, the major change in DOT QA policy for geotechnical aspects appears to return to the first category (personnel qualifications) by assigning well-qualified, experienced geotechnical engineers to oversee the geotechnical aspects of DB projects.

TABLE 29
QUALITY ASSURANCE PLAN RATED IMPORTANCE IN EACH PROJECT PHASE

Phase	Procurement				Design				Construction	
Rated Importance to Geotechnical Success	Specific Geotechnical Reference in Proposal Design QA Plan		Specific Geotechnical Reference in Proposal Construction QA Plan		Early Contractor Involvement in Design QA Plan		Agency Involvement in Design QA Plan		Agency Involvement in Construction QA Plan	
	<5DB	>5DB	<5DB	>5DB	<5DB	>5DB	<5DB	>5DB	<5DB	>5DB
Average	2.3	1.8	2.5	1.9	1.4	1.4	1.6	1.3	1.8	1.6
Essential =1	2	3	2	4	7	10	5	12	3	7
Important =2	4	13	2	9	4	6	5	4	7	8
Not Important =3	5	0	7	3	0	0	1	0	1	1

PERCEIVED IMPACT OF DESIGN-BUILD ON ULTIMATE PROJECT QUALITY

Since quality is inherently qualitative, the perceptions of agency personnel play a large part in how the impact of DB is assessed within an agency. In public policy, perceptions are often just as important as facts (Keston Institute 2007). Legislative action is heavily influenced by perceptions, and as previously discussed, implementation of DB for public infrastructure projects has had to overcome the perceptions that DB project delivery would result in an inherently poor-quality and possibly unsafe final product because the designer's fiduciary loyalty has been moved to the builder's team. One report on DB implementation classifies perceptions as "barriers to broad acceptance" (Byrd and Grant 1993). One respondent to the survey summarized the perception issue in the following survey comment:

> From a geotechnical perspective, we would not choose the DB process if we had a choice. The DB's [design-builder's] primary intent is to increase profit and tighten schedule, so quality tends to suffer on DB jobs.

When the uncertainties associated with the geotechnical aspects of a typical DBB project are translated to a DB project, the perception that the agency may be forced to accept inferior quality can become an overwhelmingly powerful force inside the project team. Another survey respondent expressed the sentiment in this manner: "There is a tendency to accept lesser quality geotechnical work resulting from the lack of a contractual method of dealing with [geotechnical requirements] as independent issue.…"

The literature review also found that one major internal barrier to implementing DB is the perception that the agency will lose control over the design details and thus end up with less than satisfactory quality (FHWA 2006; Keston Institute 2007). An interesting discussion of the issue of perceptions creating a barrier to implementing DB was published in 2005. Although it is specifically directed at architectural projects, its content applies equally to transportation. The article states that "architects have groomed a cultural perception that builders can't be trusted" and as a result participating in a DB project must be inherently unethical. The author goes on to state, "That perception [that DB is unethical] subsequently contributed to many bidding and contracting laws that made design-build cumbersome or impossible in the U.S." (Nicholson 2005).

Although this perception appeared to be a major issue as the modern era of DB was starting in the mid-1990s, it certainly must be viewed as an aberration today. This is evident by, for instance, the proliferation of legislation that authorizes the use of DB on all types of projects across the country. Nevertheless, the perception of the owner's loss of control remains, as shown by the survey comments cited above. Thus, the synthesis research attempted to measure the perception of DB's impact on project quality in the general survey and compared it with the facts obtained in the literature.

First, the survey respondents were asked how they felt the quality of their DB projects compared to their DBB projects. Figure 5 shows the response divided by levels of experience. It shows that most respondents believed that the quality of the geotechnical features on DB projects was not degraded as a result of DB project delivery.

The survey also asked the respondents to articulate their perceptions of the impact of various DB project factors on final project quality. The results are shown in Table 30. The weighted average in the last column of Table 30 allows the impact of each factor to be rank ordered. It shows that the two factors with the most impact on quality are related to the qualifications and past experience of the geotechnical personnel on the design-builder's staff. Once again, it did not matter how a survey question was asked or which aspect of the DB project it referred to; geotechnical success in DB contracting is primarily a function of the quality of the people who will execute the geotechnical design, design review, and construction tasks required by the project. The next factor involved the use of agency-mandated geotechnical specifications and design details. This factor attempts to address the agency geotechnical personnel having a level of comfort with the design by requiring geotechnical design solutions with which the agency has past experience and in which the agency has confidence. The involvement of the constructor in the design process, thereby assuring a constructible design, was rated fourth in impact on final quality. Enhanced constructability equates to a reduction in the risk of schedule delay (Friedlander 2003; Smith 2008; Kim et al. 2009).

A recent study of the impact on quality posed by alternate project delivery methods asked essentially the same questions of its DOT survey respondents (Shane et al. 2011). Figure 6 compares the results of this synthesis with those found by Shane et al. (2011). It must be noted that in order to make this study's output comparable to Shane, the Shane Likert scale ratings were reversed to coordinate with those shown in Table 27. If one neglects the relative difference in the rated level of impact and looks at the rank each group placed on each factor, all but two factors shared a rank that was equal to or only one rank different in each study. Hence, there are two major differences in the way DOT respondents perceived quality impact on the overall DB project versus only the geotechnical aspects of the DB project. First, the Shane study ranked agency interactivity during the design phase fourth, while this study ranked it seventh. Second, the use of agency standard specifications and design details was ranked sixth by Shane versus this study's rank of third.

TABLE 30
SURVEY RESULTS—IMPACT OF VARIOUS FACTORS ON THE GEOTECHNICAL QUALITY OF DESIGN-BUILD PROJECTS.

Factor	Very High Impact = 1	High Impact = 2	Some Impact = 3	Slight Impact = 4	No Impact = 5	Weighted Average
Qualifications of the Design-Builder's Geotechnical Staff	8	16	2	1	0	1.85
Design-Builder's Past Project Experience With Geotechnical Issues	4	19	3	1	0	2.04
Use of Agency Geotechnical Specifications and/or Design Details	12	6	5	4	0	2.06
Early Contractor Involvement in Geotechnical Design	8	9	8	2	0	2.15
Amount of Geotechnical Information Expressed in the Procurement Documents	7	10	6	3	1	2.3
Use of Geotechnical Performance Criteria/ Specifications	7	11	4	1	4	2.41
Quality Management Plans	4	7	11	4	1	2.67
Level of Agency Involvement in the QA Process	3	7	11	4	2	2.81
Agency Interactivity with Geotechnical Design Team During Proposal Phase	1	5	9	4	7	3.42
Agency Interactivity with Geotechnical Design Team During Design Phase	5	12	4	5	1	2.44
Warranty Provisions	2	4	8	5	8	3.48

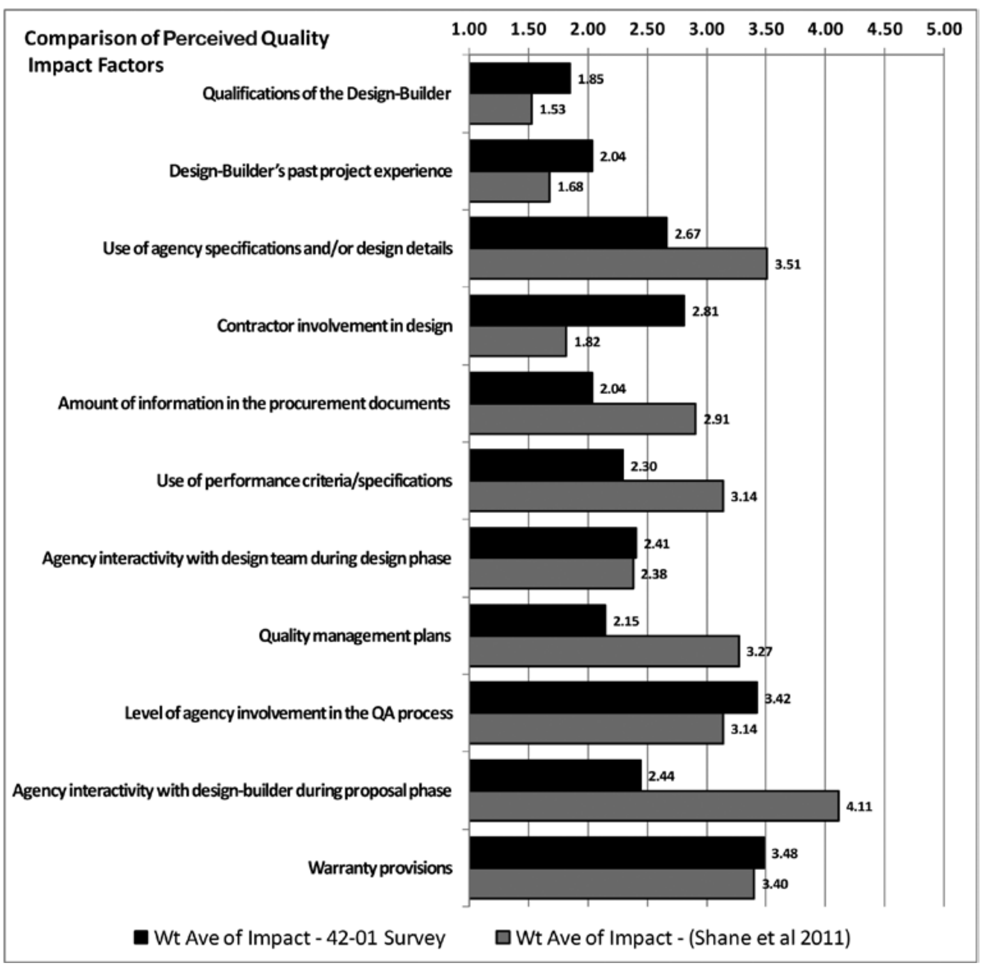

FIGURE 6 Comparison of the perceived impact of various factors on the quality of DB projects [*Source*: Synthesis 42-01 and Shane et al. 2011].

The differences are actually complimentary. The required use of agency-mandated geotechnical specifications and design details on DB projects reduces the agency's need to be involved during the actual design process. This then permits the expeditious review of geotechnical engineering products and facilitates the use of design QA oversight practices such as the over-the-shoulder review. The literature (Christensen and Meeker 2002; Higbee 2002; Papernik and Farkas 2009) and the agency DB guidelines (WSDOT 2004; ASHTD 2006; DoD 2010) promote the concept that prescriptive design requirements in the DB process limit the ability of the design-builder to innovate. However, obtaining innovative design solutions requires the agency to spend the time necessary to satisfy its statutory due diligence requirements, which could create schedule delay and nullify the benefits gained from the innovative design (Beard et al. 2002; Koch et al. 2010).

Thus, the delivery process for any given project seeks to optimize the costs and benefits of engineering innovation with the need to deliver the project within both schedule and budget constraints (Koch et al. 2010). Comparing synthesis survey results with the results published by Shane et al. (2011) suggests that agencies are willing to sacrifice potential technical innovation for proven performance that can reduce schedule risk. Adding weight to this conclusion are the issues discussed in chapter four regarding a heightened level of interactivity by experienced DOTs with competing proposers through the use of pre-approved ATCs and one-on-one discussion/clarification sessions on allowable technical design solutions before proposals are submitted. Combining selected design detail and specifications mandates with preproposal approval of geotechnical design approach appears to provide a vehicle to manage technical and schedule risk on the geotechnical features of a DB transportation project.

CONTRACTOR'S PERSPECTIVE

Table 31 contains the output from the design-builder interviews (sorted in order of impact) and can be compared with the owner survey responses in Table 30. It shows that owners and contractors agree that qualifications and past project experience have the greatest impact on the geotechnical quality of the project. The same can be said for early contractor involvement in geotechnical design and the use of geotechnical performance criteria and specifications. The contractors rated geotechnical QM plans as having more impact than the DOT survey respondents. This may be because they were referring to their own internal plans. They also cited "implementing a joint design QA/QC plan" as a challenge in most projects. Follow-up questioning revealed that the issue was both internal and external. First, the DB design team was reluctant to allow construction team input to interfere with their process; second, 10 of 11 contractors cited agency distrust of the design-builder's design team as a challenge to getting geotechnical design product released for construction. To reinforce this idea, 9 of 11 cited "developing a geotechnical QM plan that meets the agency's expectations" as a challenge on all DB projects. Thus, QM planning appears to play an important role in the design-builder's geotechnical risk mitigation planning.

Table 31 also shows that 45% rated the use of standard specifications and details as well as the level of geotechnical information contained in the procurement documents as having a major impact on quality. This output must be interpreted in the context of the question: impact on final constructed project quality. Although the level of geotechnical information in the RFP was found to influence the way

TABLE 31
IMPACT ON FINAL DESIGN-BUILD GEOTECHNICAL QUALITY—CONTRACTOR RESPONSES

Factor	Very/High Impact	Some/Slight Impact	No Impact
Qualifications of the design-builder's staff	91%	9%	0%
Design-builder's past project experience	82%	18%	0%
Quality management plans	82%	18%	0%
Early contractor involvement in geotechnical design	73%	27%	0%
Use of geotechnical performance criteria/specifications	64%	36%	0%
Level of agency involvement in the geotechnical QA process	55%	45%	0%
Detailed geotechnical design criteria	55%	27%	0%
Use of agency specifications and/or design details	45%	45%	9%
Level of detail expressed in the procurement documents	45%	45%	9%
Warranty provisions	18%	55%	27%

design-builders perceived and subsequently priced the risk, Table 31 shows that the ultimate quality of geotechnical features of work was found to be a function of something other than the pre-award information. One might argue that the contractors' responses indicate that the impact of QM plans on developing highly qualified and experienced geotechnical personnel is indeed the critical factor to geotechnical quality in a DB project.

CONCLUSIONS

The analyses discussed in this chapter resulted in the following conclusions:

- The agencies that responded to the survey retain most traditional roles and responsibilities for QM on geotechnical QC/QA tasks.
- The design QA plan is perceived as the most important aspect of the DB geotechnical QM planning process.
- Achieving satisfactory quality of geotechnical design and construction deliverables in DB contracting is perceived to be most affected by the qualifications and past experience of the people who will execute the geotechnical design, design review, and construction.
- Comparisons of the synthesis survey results with the results published by Shane et al. (2011) on DB project quality shows that agencies are willing to sacrifice potential geotechnical design innovation for proven performance as defined by agency-mandated design details and specifications, and are using this mechanism to manage schedule risk.

This chapter also identified the following effective practices:

- Experienced DOTs require the geotechnical engineering design QA plan to include specific procedures for involving the construction contractor in reviewing the constructability of geotechnical designs, as well as details on how the agency will be involved in the design QA process through its role of oversight, review, and acceptance of design deliverables.
- Combining selected design detail and specifications mandates with preproposal approval of geotechnical design approach provides a vehicle to manage technical and schedule risk on the geotechnical features of a DB transportation project.

The following are suggestions for future research:

- There is a need for future research in the area of applying QM theories such as the AQS to the development of preliminary geotechnical engineering and site investigation plans to support DB projects with significant geotechnical issues that cannot be resolved before issuing the DB RFP.
- Research that explores the concept of optimizing technical risk of unfamiliar/innovative geotechnical design approaches with schedule risk would furnish DOTs guidance on the amount of prescriptive design content that should be included in projects with significant geotechnical issues.

CHAPTER SEVEN

DESIGN-BUILD GEOTECHNICAL CASE STUDIES

INTRODUCTION

Case study data collection was based on the results of the literature review. The team proposed to identify and analyze at least four projects from across the spectrum of DB transportation projects with geotechnical aspects of specific interest to the synthesis. The cases are separated into geotechnical engineering case studies and geotechnical case law studies. The engineering case studies each highlight a specific geotechnical issue that was solved by means of the use of DB project delivery. Table 32 is a summary of the geotechnical engineering case study projects that were sampled for this research. One can see that the projects span from coast to coast.

The team was able to identify and gain access to information on four geotechnical engineering projects worth more than $600 million in four states that represent the cross section of variations on DB delivery. The projects ranged from a low of $0.55 million to a high of $483 million. The project types spanned the spectrum from the use of a GBR for an urban elevated guideway project to an emergency repair of a landslide on an interstate highway.

GEOTECHNICAL ENGINEERING CASE STUDY PROJECT DETAILS

The following sections relate the details of each geotechnical case study project. The objective of this section is to portray the breadth and depth of the case study project population. The format has been standardized for each project to enable each project to be compared with all other projects in the sample. In all cases, the details shown in this chapter were obtained through structured interviews (either in person or by telephone) with the agency and then supplemented as required by specifics found about the project from the literature.

West O'ahu/Farrington Highway Guideway Project, Section I—City and County of Honolulu, Hawaii (CCH)

The project was selected for inclusion because it illustrates the use of the GBR as a contract document on a DB project that had highly variable subsurface conditions along a significant project length. The project involved the construction of 6.5 miles of elevated rail guideway resting on columns/piers spaced at roughly 150 ft. This yields about 220 separate foundations in conditions that included older and recent allu-

TABLE 32
SYNTHESIS CASE STUDY PROJECT SUMMARY

Agency (case no.)	Case Study Project (Value)	Construction Type (location)	Geotechnical Issue	Solicitation Type	Payment Provision Type
City and County of Honolulu (1)	Section I—West O'ahu/ Farmington Highway ($483 million)	Elevated Computer Rail Guideway (Honolulu, Hawaii)	Use of GBR as contract document	RFQ/RFP	Lump sum
Montana DOT (2)	US Highway 2 Rockfall Mitigation ($3.0 million)	Rockfall mitigation features (Flathead County, Montana)	Adequate slope to prevent rockfall can't be known until construction start	RFQ/RFP	Lump sum with unit price items
Minnesota DOT (3)	Hastings River Bridge ($120 million)	Steel arch bridge over the Mississippi River (Hastings, Minnesota)	Use of preproposal ATCs and PAEs for geotechnical design – resulted in pile-supported embankment w/3-year warranty	RFQ/RFP	Lump sum
Missouri DOT (4)	I-270—St. Louis County Slide Repair ($0.55 million)	Emergency landslide remediation on interstate highway (St. Louis County, Missouri)	Use of a "nested" DB contract provision in a DBB contract with known geotechnical issues to respond to a major geotechnical problem	Invitation for bids with requirement to include a prequalified geotechnical specialty subcontractor	Time and materials

vium, localized areas of coralline deposits, isolated boulders and boulder fields, residual soils, and basalt bedrock.

Case 1—City and County of Honolulu: West O'ahu/Farrington Highway Guideway Project

Value: $483 million

Scope: Design and construction of a 6.5-mile elevated commuter rail guideway. The geotechnical scope work includes the final subsurface investigation and foundation design for approximately 220 column/pier structures that support the elevated guideway. The owner anticipated that drilled shafts would be proposed for the majority of the alignment because "they can be installed faster; a smaller area of soil is disturbed; and it is quieter than driving piles" (CCH 2008). Figure 7 shows the alignment for the entire corridor project. This case study section lies inside the dotted line.

Rationale: The City and County of Honolulu (CCH) chose DB project delivery for this difficult geotechnical project for two reasons. First, it wanted to award the construction as fast as possible to take advantage of a drop in construction costs (Petrello 2009). This was realized when the project came in under the engineer's estimate. Second, since the alignment was completely through an urban area, CCH was restricted in the amount of preliminary investigation it could do, and as a result it used DB to have competing design-builders optimize the alignment with respect to means and methods, constructability issues such as traffic disruption, and noise mitigation (Dwyre et al. 2010).

Procurement: The project used a typical two-step process, with CCH first issuing an RFQ from which it developed a short list. It then issued an RFP to the members of the short list. The major technical issue that had to be resolved in the development of the RFP was to equitably allocate the risk of differing subsurface conditions. The owner settled on the use of a GBR to mitigate the significant risk of delay and/or cost escalation (Dwyre et al. 2010). Dwyre et al. describe the process used to develop the GBR as follows:

> A key decision in developing the GBR was that *only subsurface material properties would be baselined*, and that no baselines would be developed for soil foundation interaction properties. It was *not considered feasible or appropriate to baseline parameters* such as foundation friction and end bearing values *which would be influenced by the contractor's choice of deep foundation type and the means and methods of installation*. Specific parameters baselined in the GBR focused on the factors of greatest significance to the design and construction of foundations, including stratigraphy, groundwater conditions (including an area with confined artesian conditions), USCS soil types, shear strength of cohesive soils, the incidence of cobbles and boulders, clinker zones and voids within the intact basalt, the Rock Quality Designation (RQD) and unconfined compressive strength of the basalt, and seismic site class (Dwyre et al. 2010, italics added).

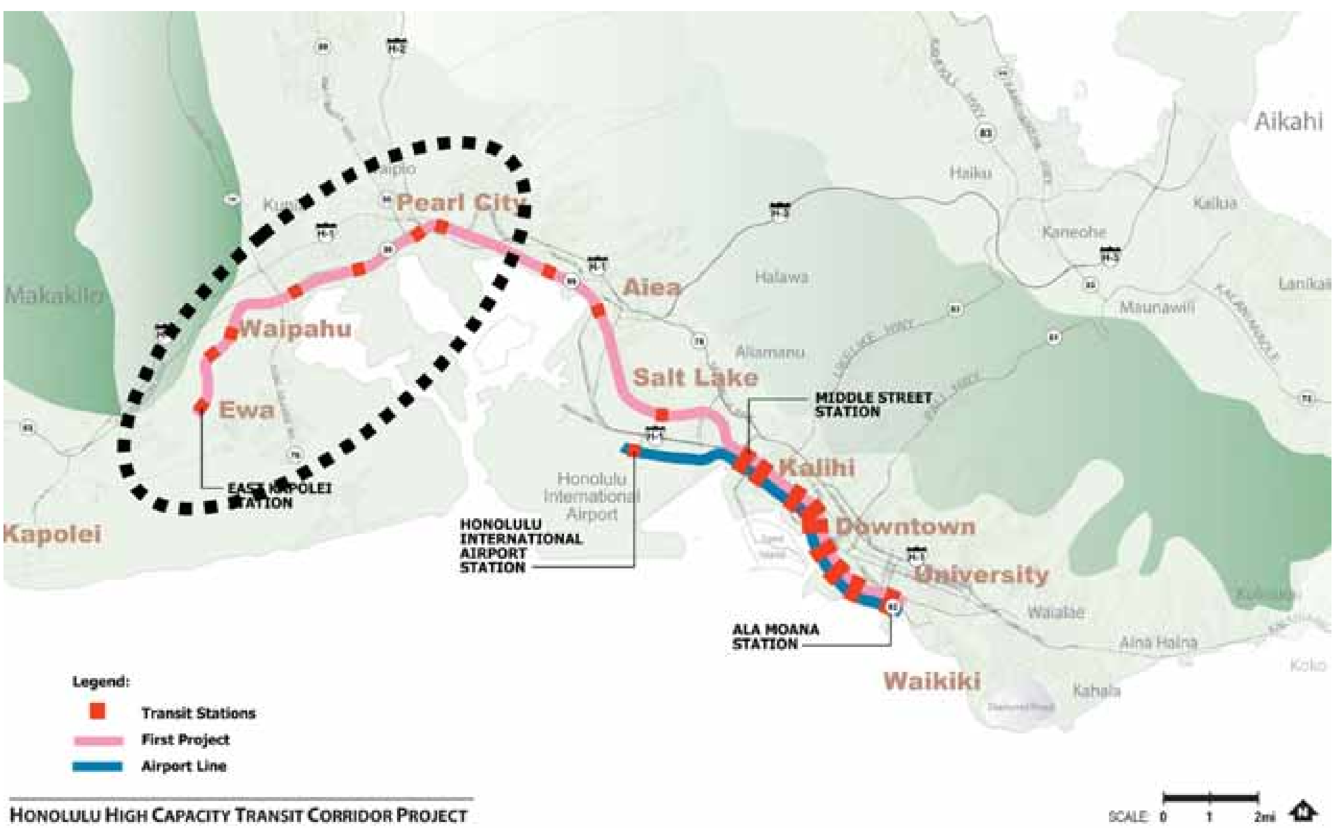

FIGURE 7 Honolulu high-capacity transit corridor project alignment [*Source*: CCH 2008].

TABLE 33

SUMMARY OF GEOTECHNICAL BASELINE REPORT BASELINES FOR CITY AND COUNTY OF HONOLULU: WEST O'AHU/ FARRINGTON HIGHWAY GUIDEWAY PROJECT

Parameter	Stratigraphy Baselines	Material Property Baselines
Fill	As deep as profile line; up to 5 ft deep where not shown	• Not baselined.
Coralline	Undistributed quantity, not shown on subsurface profile	• % #200 • % stratum depth cemented • Unconfined strength range
Recent Alluvium	Suburface profile	• USCS types • Average shear strength by station reach
Older Alluvium	Suburface profile	• USCS types • Average shear strength by station reach
Cobbles and Boulders	Lengths of foundation in cobble/boulder zone	• Thickness ranges of clinker and void zones
Clinker and Voids	Percent of foundations where clinker/voids will be present	• Thickness ranges of clinker and void zones
Rock	Subsurface profile line, with upper/lower bounds for planning construction means and methods	• Minimum RQD for specified percentage of core run • UCS
Groundwater Elevations	Varying groundwater conditions shown on profile	• Water table or confined aquifer

Source: Dwyre et al. (2010).

USCS = Unified Soil Classification System; UCS = unconfined compressive strength; RQD = Rock Quality Designation.

Table 33 is a summary of the GBR for the guideway project. It shows the method the owner's geotechnical consultant chose to establish the baselines for each soil type. This was developed using preliminary geotechnical data obtained from a boring program with a spacing of roughly one boring every 1,000 ft. Since the design-builder had authority to vary the alignment, this particular data set could easily be off the final alignment.

Quality Management: Table 34 shows the distribution of quality management responsibilities among parties to the contract. It shows that the agency's general engineering consultant was responsible for most of the day-to-day QM tasks. The project also required considerable interaction between the design-builder and the agency's consultant. Note that the two-dimensional Refraction Microtremor (2D ReMi) method was successfully used to map soft soil zones under the Farrington and the Kamehameha Highways, both of which support high traffic volumes, without the need to interrupt traffic flow (Sirles and Batchko 2010). This is another example of innovation that was brought to the project by the use of DB project delivery.

Summary: The project is currently under way. The fact that the award price was 15% less than expected indicates that the use of the GBR as a means to allocate risk was successful. Multiyear DB projects of this magnitude with significant geotechnical risks typically carry large contingencies inside the price proposal (Finley 2011). The CCH actually saved $87 million. Although it is impossible to know what percentage of the savings is due to lower construction prices, at least some of it must be assigned to a lower design-builder's contingency owing to the well-defined geotechnical risk.

TABLE 34

CITY AND COUNTY OF HONOLULU PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/ Quality Control Tasks	Does Not Apply	Agency	Design-Builder	Agency-Hired Consultant
Technical review of construction shop drawings			X	X
Technical review of construction material submittals			X	X
Checking of pay quantities				X
Routine construction inspection			X	
Quality control testing			X	
Verification testing				X
Acceptance testing				X
Independent assurance testing/ inspection				X
Approval of progress payments for construction progress		X		X
Approval of construction post-award QM/QA/QC plans		X		X
Report of nonconforming work or punch list		X		X

US 2 Rockfall Mitigation Project—Montana DOT (MDT)

This project was selected for inclusion for three reasons. First, the geotechnical problem that had to be solved was how to quantify a scope of work when the agency does not know the minimum angle of repose for an unstable rock slope, and the angle cannot be found until construction commences. Therefore, this represents the high end of geotechnical uncertainty, and that MDT chose DB project delivery represents an interesting and valuable rationale for projects with high geotechnical uncertainty. The second reason was the mechanism that MDT chose to allocate risk: unit price pay items for the uncertain features of the scope. Finally, MDT developed an innovative approach to getting as much rockfall mitigation completed as possible for the available funding, recognizing that once it had reached the end of the budget, the project was over regardless of how many linear feet of slope had been stabilized.

Case 2—Montana DOT: US 2 Rockfall Mitigation Project, Flathead County

Value: $3.0 million

Scope: Design and construction of rockfall mitigation measures and slope stabilization along 14 miles of US Highway 2 east of West Glacier. The project identified six reaches that must be mitigated and two more to be fixed if the contract funding is available. Traffic control is a major issue on this job since the road provides access to Glacier National Park. The project includes scaling, draped rockfall protection, trim blasting, and other techniques as may be determined by the design-builder.

Rationale: MDT chose DB project delivery because it appeared to be the best method for sharing the risk of geotechnical uncertainty. The preferred rockfall mitigation method was to scale the rock faces back to a safe angle of repose. However, there is no economical method for determining the angle, if there is one, by any other method than field trial. As a result, completing the design before setting the construction contract carried an unacceptable risk because of the high potential for DSC changes/claims. The project had a fixed budget of $3.0 million with no contingency. Therefore, MDT originally looked at using a fixed-price best-proposal BV award algorithm (Gransberg and Molenaar 2003). In this manner, the contract price would have been fixed at $3 million and each competing proposal would have stated how many of the eight reaches in the 14-mile zone it could do for that amount. Unfortunately, MDT's enabling legislation requires it to use an adjusted score award algorithm, which requires the price be divided by the technical score with the lowest adjusted score becoming the BV (MDT 2011). The final alternative was to develop a unit price approach to those pay items that were expected to vary in quantities and bundle the remaining items into a single lump sum price.

Procurement: The partial unit price method shown in Figure 8 allowed the technical proposal to be scored and did not constrain the competitors to a stipulated price. The RFP used the following clause to articulate this approach:

> Bid Price Proposals will be submitted on the blank Bid Price Proposal Requirements Form included as an attachment to this RFP. The Bid Price Proposal form will include unit prices for the items indicated, a lump sum price for the remainder of the project scope and the completion date proposed by the Firm. The unit prices will include all costs associated with the construction of the items indicated. Each unit price will be multiplied by the quantity provided by MDT to determine the total amount for each of the unit price items. *The Total Lump Sum for the project will be calculated by adding the extended sum of the unit price items with the lump sum amount for the remainder of the project scope*. This total lump sum will be the final contract amount. The lump sum price will include costs for all design, surveying, geotechnical work, engineering services, Quality Management Plan, construction of the project (all items except the unit price items) and all other work necessary to fully and timely complete the project in accordance with the Contract Documents. The lump sum price will also include all job site and home office overhead and profit. It is understood payment of the lump sum amount for the project will be full, complete and final compensation for all work required to complete the project. *If project* [unit priced quantities] *overruns or under runs occur at sites, the unit prices will be utilized to extend or reduce the work at other sites to maximize the amount of work accomplished for three million dollars* (MDT 2011, italics added).

STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION
BID PRICE PROPOSAL REQUIREMENTS

PROJECT NO.: SFCN 1-2(169)154 CONTROL NO.: 7586

PROJECT/LOCATION/DESCRIPTION: US-2 ROCKFALL MITIGATION

Item Description	Unit	UNIT PRICE	Quantity	Price
Scaling	Machine Hours	$	2600	
Draped Rockfall Protection	Square Feet	$	145,000	
Rock Bolting	Linear Feet	$	3700	
Trim Blasting	Cubic Yards	$		
Design-Build	Lump Sum	$	1	
Contingency	UNIT	$1	100,000	$100,000.00
TOTAL LUMP SUM BID PRICE PLUS CONTINGENCY FUND				

FIGURE 8 Design-build bid price proposal form with unit price items.

The clause makes it clear that MDT intends to spend the entire budget for this project and get as much work done as possible. This clause was followed by a second clause that describes what MDT will do if all price proposals exceed the budget: it will ask each responsive competitor to submit a "Best and Final Offer" that details the scope of work each competitor could complete for the specified budget. MDT would then repeat technical scoring and compute the BV based on the adjusted score.

The RFP also explicitly encouraged including ATCs in the proposal. "Credit will be given for innovation in design and construction methods that minimize public impacts, minimize traffic delays, mitigate the risk of quantity overruns, and accelerate project delivery by reducing the total project duration. Credit will also be given for design proposals that improve functionality and safety of the project" (MDT 2011). It contained a "Design and Construction Criteria Package (DCCP)" to furnish technical guidance to the design-builders during proposal preparation. The RFP described the ATC proposal process in the following manner:

> The Firm will *identify separately all innovative aspects* as such in the Technical Proposal and each must be *explained in detail with any estimated cost increase or decrease*. The Technical Proposal must state whether any cost increase or cost decrease resulting from innovation is included in the base Bid Price Proposal Amount. An innovative aspect does not include changes to specifications or established MDT policies and must conform to the RFP and DCCP requirements. *Innovation should be limited to the Firm's means and methods, approach to the project, rockfall mitigation techniques, use of new products and new uses for established products*. Proposed changes to the RFP, DCCP, Design Concept, specifications or established MDT policies should be identified as **Alternatives or Options** in the Technical Proposal and explained in detail with any estimated cost increase or decrease to be considered together with innovative aspects, as the basis for scoring Technical Proposals. The estimated cost increase or cost decrease associated with any Alternative or Option that proposes changes to the RFP, DCCP, specifications or established MDT policies must not be included in the base Bid Price Proposal Amount (MDT 2011, italics added).

The clause is an excellent example of a way for the owner to express its desires as well as its requirements. The phrase "an innovative aspect *does not include changes* to specifications or established MDT policies" indicates that MDT specifications and policies must be used. However, innovation is encouraged in "means and methods, approach to the project, rockfall mitigation techniques, use of new products and new uses for established products."

Quality Management: Table 35 shows the distribution of quality management responsibilities among parties to the contract. The table shows that MDT plans to stay actively involved in the QM process and share many of the design and construction QA tasks with the design-builder. This makes sense owing to the need to maximize the amount of work completed for the fixed budget. Joint responsibility also supports the issue that the final design will be functionally reliant on trial and error data obtained in the field during actual scaling operations. It also supports the potential decision to reduce the number of reaches mitigated if the quantities overrun on early reaches by ensuring that the agency is actively engaged in verifying the actual angles of repose for the types of rock faces encountered in the field.

Summary: MDT's procurement approach on this project illustrates an alternative for sharing the risk of geotechnical uncertainty on a DB project. "Unit price contracts are used for work where it is not possible to calculate the exact quantity of materials that will be required" (Schexnayder and Mayo 2004). In a lump sum contract, the design-builder bears the entire quantity risk. Unit pricing for specific features of work inside a lump sum DB contract allows the agency to share the risk of the final quantities of work with the contractor and reduce the price. Requiring a lump sum price in a DB contract forces the contractor to bid the worst possible case for those items whose quantities cannot be accurately measured during proposal preparation (Gransberg and Riemer 2009). Thus, it makes sense to use the DB contract payment provisions to manage geotechnical uncertainty through unit pricing. This case, plus the fact that three of the RFPs reviewed in the content analysis (two from Virginia and one from Delaware) lead to identifying the use of selective unit pricing as an effective practice, also lead to a suggestion for future research to examine potential costs and benefits of employing selective unit pricing as a geotechnical risk management technique.

TABLE 35
MONTANA DOT PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/ Quality Control Tasks	Does Not Apply	Agency	Design-Builder	Agency-Hired Consultant
Technical review of construction shop drawings		X	X	
Technical review of construction material submittals		X	X	
Checking of pay quantities		X	X	
Routine construction inspection		X	X	
Quality control testing			X	
Verification testing		X	X	
Acceptance testing		X		
Independent assurance testing/ inspection		X		
Approval of progress payments for construction progress		X		
Approval of construction post-award QM/QA/QC plans		X		
Report of nonconforming work or punch list		X	X	

TH 61 Hastings Bridge Design-Build Project—Minnesota DOT (Mn/DOT)

This project was included because of the difficult foundation conditions that had to be dealt with on the north approach to this bridge. The project involved replacing an existing bridge whose northern abutment had serious settlement issues throughout its 30-year service life. It had been jacked back up into alignment three times. During the proposal preparation period, Mn/DOT successfully employed the use of pre-approved elements (PAEs) that resulted from the analysis of ATCs proposed and discussed during confidential one-on-one meetings, which resulted in the winning design-builder proposing a column-supported embankment to address the extremely poor north approach subsurface conditions.

Case 3—Minnesota DOT: TH 61 Hastings Bridge Design-Build Project, Hastings, Minnesota

Value: $120 million

Scope: Design and construction of a freestanding arch main span segment with low-maintenance, robust, and highly redundant concrete tie girders and knuckles. A main span is a 545-ft tied arch with freestanding, trapezoidal vertical steel arch ribs and post-tensioned concrete knuckles and tie girders. It is erected using a low float-in operation to maximize public safety. The south approach segment includes two side-by-side bridges that are five-span, solid cast-in-place post-tensioned concrete slabs with an arched soffit over Second Street and a constant 5-ft-deep cross section for the remainder of the spans. The north approach segment is a low-maintenance five-span precast concrete girder bridge. A north approach roadway is constructed on a column-supported embankment, with less than 2 in. of total settlement complete within 3 months of embankment construction. Project requires a 3-year warranty on settlement of the north approach and includes installed instrumentation for Mn/DOT to monitor settlement. Figure 9 is a rendering of the winning proposal's design.

Rationale: The highway commissioner directed Mn/DOT to accelerate the replacement of this particular bridge. Therefore, Mn/DOT selected DB as the most appropriate project delivery method to reduce the delivery period available within its statutory procurement constraints. The agency had recently completed the emergency replacement of the I-35W Bridge in Minneapolis and had an experienced project team in the same district. Additionally, Mn/DOT has successfully employed a sophisticated method to confidentially clarify RFP intent and evaluate/pre-approve ATC before award and believed that it could leverage these one-on-one conferences to not only encourage innovative solutions to the north

FIGURE 9 Renderings of Hastings Bridge Design.

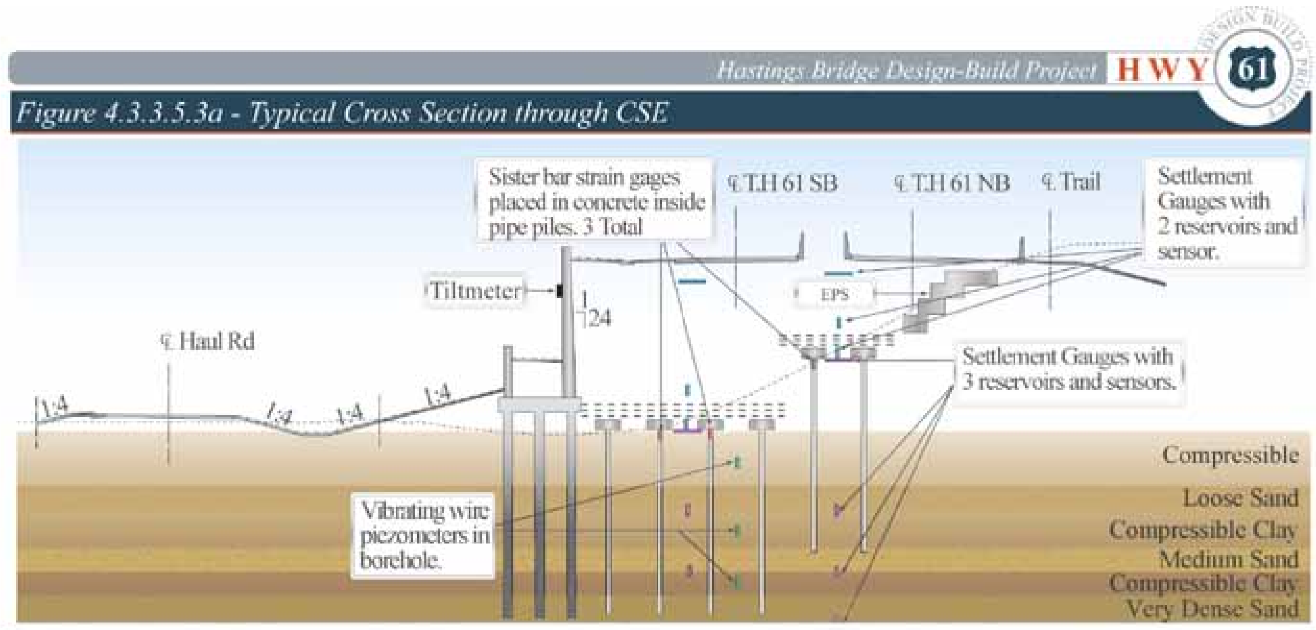

FIGURE 10 Cross section of the Hastings Bridge column-supported embankment (Behnke and Ames 2010).

approach geotechnical problem but also to share the differing conditions risk with the winning design-builder.

Procurement: The project used a typical two-step process with Mn/DOT first issuing an RFQ from which it developed a short list. The RFQ evaluated the qualifications and past experience of the geotechnical engineering team, assigning it 8% of the weight in the evaluation scheme. It then issued an RFP to the members of the short list. Geotechnical was assigned 5% of the total weight in the proposal's technical evaluation. The literature confirms that a weight of 5% or more would be considered "heavily weighted" (Scott et al. 2006). The unique aspect of the procurement process that was particularly important to the geotechnical aspects of the project was the use of "private preproposal meetings" whose purpose was described as follows:

> Each Proposer is invited and encouraged to attend a private preproposal meeting at which the Department will address and respond to the Proposer's concerns and questions regarding details of the project scope, administrative procedures, outstanding issues for the remainder of the bid process, and any other related matters. Each meeting would be private in that only one Proposer would meet with Mn/DOT representatives at a time. Proposers are not required to accept the meeting invitation (Mn/DOT 2010).

The one-on-one meetings in this project generated between 6 and 13 ATCs from each competing design-builder. These resulted in as many as nine PAEs for one proposal, and the winning design-builder had eight that were incorporated into its technical approach (Behnke and Ames 2010). Two of those, the column-supported embankment and continuous settlement monitoring, were specifically related to innovative design solutions for the north approach geotechnical problems. Figure 10 is a cross section of the column-supported embankment that illustrates the design-builder's approach to this issue. Figure 11 is a detail of the continuous settlement monitoring instrumentation.

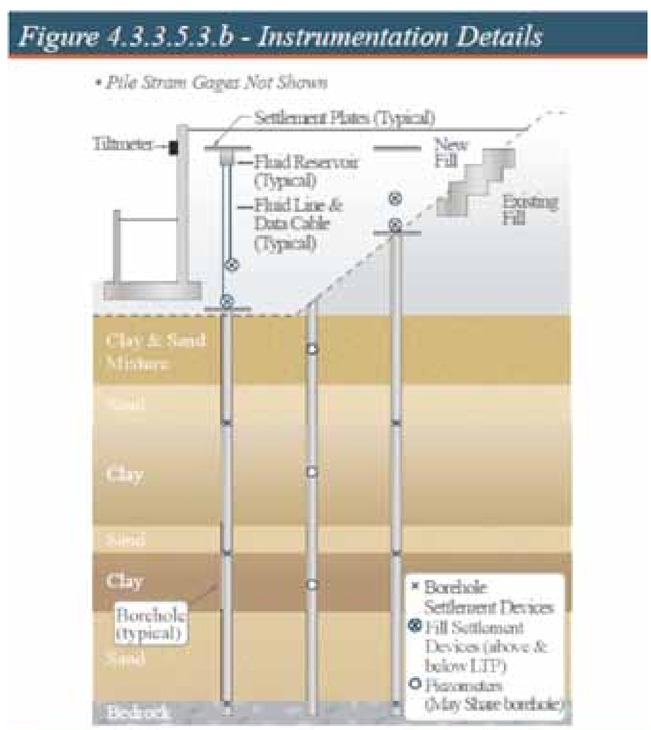

FIGURE 11 Detail of the Hastings Bridge continuous settlement monitoring instrumentation (Behnke and Ames 2010).

The effectiveness of the one-on-one meetings with the competing design-builders can be directly measured by the fact the project was awarded at a price that was $100 million under the engineer's estimate. The RFP stated that "price proposals that exceed $220 million will be considered non-responsive" (Mn/DOT 2010). Therefore, all the competitors had knowledge of the project's budget. The adjusted score best-value award algorithm used in this project essentially makes the price equal to all other evaluation criteria by dividing it by the technical score (Scott et al. 2006). Thus, there would be some pressure on the competitors to keep their prices down. However, the success of the preproposal interaction between the agency and its proposers to clarify project risk and to furnish PAEs was ably demonstrated by the outcome of the proposal evaluation. The winning proposal was scored only 1 point in 100 lower than the best technical proposal while delivering the project for nearly 30% less cost. This leads to the conclusion that encouraging interactivity during DB proposal preparation for projects with significant geotechnical issues reduces risk and results in benefits to the agency.

Quality Management: Table 36 shows the distribution of quality management responsibilities among parties to the contract. It shows that Mn/DOT chose to retain much of the QA responsibility on this project. The Mn/DOT response to the synthesis survey, which portrayed a broader perspective of Mn/DOT DB policy, assigned sole responsibility for routine inspection to the design-builder and indicated that a major role for an agency-hired oversight consultant was absent in this particular project. This project also had a 3-year warranty for settlement. Warranties are often used in DB to relieve the agency of some QA responsibility (Byrd and Grant 1993). However, that was not the case in this project. One reason was that the design QM plans used on this project are different from those used on traditional design projects. The QM plans are project specific and quite complex regarding the geotechnical design. They require an internal audit and certification by the design-builder. Mn/DOT satisfied its due diligence duty by performing over-the-shoulder reviews throughout the geotechnical design.

Summary: The project is under construction. This case study furnishes an example of the value of clarifying risk during proposal preparation rather than the traditional fielding of requests for information. That the competing design-builders had a contractual mechanism to approach Mn/DOT with possible design solutions to the thorny geotechnical issues associated with this project greatly reduced the risk that an innovative design would ultimately be disapproved. Without the confidential one-on-one meetings and the PAEs, Mn/DOT would not have had the opportunity to consider technical solutions that its engineers and consultants had not contemplated. The extraordinary cost savings and the innovative solution to the north approach settlement problem validate the value of interactivity during DB proposal preparation, making this method an effective practice candidate.

TABLE 36
MINNESOTA DOT PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/ Quality Control Tasks	Does Not Apply	Agency	Design-Builder	Agency-Hired Consultant
Technical review of construction shop drawings		X	X	
Technical review of construction material submittals		X		
Checking of pay quantities		X		
Routine construction inspection		X	X	
Quality control testing			X	
Verification testing		X		
Acceptance testing		X		
Independent assurance testing/ inspection		X		
Approval of progress payments for construction progress		X		
Approval of construction post-award QM/QA/QC plans		X		
Report of nonconforming work or punch list		X	X	

I-270 Slide Repair Project—Missouri DOT

This project was selected for inclusion because it illustrates an innovative approach to including a DB provision inside of a DBB contract. Additionally, the case was successful in that it generated an innovative geotechnical design that permitted construction without lane closures on an urban freeway (McLain and Shane 2009). The case is an emergency repair and stabilization project that resulted from a landslide that damaged a triple box culvert and threatened to close the eastbound lanes of I-270 in St. Louis County, Missouri.

Case 4—Missouri DOT: I-270 Slide Repair Project, St, Louis County

Value: $552,148

Scope: Design and construction of temporary shoring needed to protect the interstate traffic as well to allow quick repair of the box culvert after a landslide (see Figure 12). The temporary shoring also allowed the slope to be restored with shot rock. The project ultimately designed and built a temporary soil nail wall that had more than 150, 40-ft nails spaced at 5 ft horizontal and 5 ft vertical and was 45 ft high.

The design-builder originated this innovative solution to replace MoDOT's conventional slide plane removal and replace technique (McLain 2008).

FIGURE 12 I-270 slide aftermath.

Rationale: MoDOT awarded a DBB project on a conventional project in this location that contained a "nested" DB provision for repair of slides during construction by a prequalified geotechnical specialty subcontractor as required during the contract period. The primary rationale for selecting this form of DB to shorten the time the roadway is out of commission and to encourage innovative methods to lessen the cost of the slope repair projects.

Procurement: The typical MoDOT process to award a low-bid project includes a 10- to 14-week design review period before a construction contract can be advertised if the project costs more than $1.0 million. Added to this is another 3-week period to award the construction contract. By adding the "nested DB provision" for landslide repairs inside the DBB contract, MoDOT avoided the delays inherent in developing a new project or the issues of getting waivers to react to an emergency requirement. The nested DB provision required the prime contractor to subcontract this work with a prequalified geotechnical specialty contractor that had experience successfully completing MoDOT slide repair and other types of projects.

Quality Management: Table 37 shows the distribution of quality management responsibilities among parties to the contract. Since this DB project was constructed inside a larger DBB contract, one would expect MoDOT to approach QA in the same manner that it uses for DBB projects. However, it did assign the design-builder the responsibility for QC testing.

Summary: The project was completed 120 days after the slide damage occurred. The design took 5 days. These periods compare to an average of 205 days from slide to construction completion and 50 days for design for two similar projects that were procured using DBB (McLain and Shane 2009). The use of the soil nail wall permitted the construction to be completed without closing any lanes on I-270. In a conventional slide plane removal and replacement method, MoDOT would have needed to close at least one lane of traffic throughout construction.

TABLE 37
MISSOURI DOT PROJECT QUALITY MANAGEMENT RESPONSIBILITIES

Quality Assurance/ Quality Control Tasks	Does Not Apply	Agency	Design-Builder	Agency-Hired Consultant
Technical review of construction shop drawings		X		
Technical review of construction material submittals		X		
Checking of pay quantities		X		
Routine construction inspection		X		
Quality control testing			X	
Verification testing		X		
Acceptance testing		X		
Independent assurance testing/ inspection		X		
Approval of progress payments for construction progress		X		
Approval of construction post-award QM/QA/QC plans		X		
Report of nonconforming work or punch list		X		

CONCLUSIONS

The analyses discussed in this chapter resulted in the following conclusions:

- The use of a GBR as a means to allocate subsurface condition risk appeared to result in savings on the O'ahu Elevated Guideway project.
- Mn/DOT's interactivity with competing design-builders during DB proposal preparation through the RFP clause that initiated confidential one-on-one meetings and resulted in PAE reduced risk to the design-builders and resulted in significant benefits to the agency on the Hastings Bridge project.

- DB project delivery permitted MoDOT to complete an emergency slide repair on the I-275 project in significantly less time than two previous DBB slide repair projects.

This chapter also identified the following effective practices:

- The use of a "nested" DB provision that required a prequalified geotechnical specialty subcontractor to be a member of DBB general contractor's team on a project with known geotechnical issues provided a mechanism to expeditiously resolve a landslide. This technique not only saved time but also brought an innovative temporary soil nail wall solution that permitted the slope to be stabilized without lane closure on an urban freeway.
- The use of selective unit pricing as done by the Montana, Delaware, and Virginia DOTs provides an effective means for managing geotechnical quantity risk.
- Permitting some form of confidential discussion and clarification of geotechnical risk during DB proposal preparation through a process such as the Mn/DOT one-on-one meetings assists competing design-builders in making design assumptions that can be priced without including large contingencies.
- The ability to assess design-builder ATCs before proposal submission and the use of PAEs encourages innovative design solutions to difficult geotechnical design problems, such as the north approach settlement problem in the Hastings Bridge project. The confidentiality of the process is key to its success.

The following suggestions for future research are made:

- Guidance is needed about effectively managing geotechnical cost, time, and technical risk in DB projects. The research will include the following:
  - Examination of potential costs and benefits of employing selective unit pricing as a geotechnical risk management technique.
  - Use of specialty geotechnical DB subcontracts in DBB prime contracts, such as MoDOT's.
  - When to employ GBRs in DB projects.
- Since a number of state DOTs use some form of interactivity during DB proposal preparation, research is needed to quantify the costs and benefits of instituting a program such as Mn/DOT's PAE process and to furnish guidance to agencies that do not allow interaction in their DB programs. The research would also explore legal barriers to implementation as well as case studies of any litigation or protests that resulted from the use of this approach.

CHAPTER EIGHT

CONCLUSIONS

INTRODUCTION

Chapter one sets the criteria used in this report for drawing conclusions and identifying effective practices. Subjects where two or more lines of information from the survey, literature review, and/or content analysis intersected were considered significant and used to develop the conclusions and candidates for the list of effective practices. Substantive points on design-build (DB) project success that was corroborated by only one source of information showed potential for future research. That process was followed rigorously throughout the entire report. Both results are based on the four research instruments used to collect in the information in the synthesis: comprehensive literature review, survey of U.S. agencies, DB solicitation document content analysis, and case studies. When a gap in the body of knowledge was revealed, a suggestion for future research was made. Therefore, based on that foundation, this chapter presents conclusions, effective practices, and suggestions for future research.

Figure 13 depicts the DB project geotechnical decision process used by departments of transportation (DOTs) as documented in the synthesis study. DOTs use risk mitigation measures such as mandated geotechnical design solution, confidential alternative technical concepts (ATCs), and specifying performance measurements as tools to manage risk while necessarily releasing control over the DB project.

CONCLUSIONS

The following conclusions were reached in the conduct of this research. They are not listed in any order of importance.

- DOTs with DB experience evaluate the risk and impact of unforeseen geotechnical conditions before selecting DB project delivery. The emphasis on formal risk analysis differentiates the DOTs with multiproject DB experience and those new to the delivery method. The case studies proved that DB provisions can be nested in design-bid-build (DBB) contracts for specific geotechnical work.
- Experienced DOTs tailor the amount of geotechnical information that is included in the DB request for proposal (RFP) to the specific requirements of a given project. Thus, there is no one-size-fits-all solution for selecting a project delivery method based on its geotechnical requirements. The use of a Geotechnical Baseline Report (GBR) or a Geotechnical Data Report is a means to allocate subsurface condition risk.
- Permitting interactivity during the proposal preparation period allows the agency to understand how competing design-builders perceive the geotechnical risk and provides an opportunity to adjust the procurement plan to accommodate a need for supplemental information. This could include interactivity with competing design-builders during DB proposal preparation by means of an RFP clause that initiates confidential one-on-one meetings resulting in preapproved elements (PAEs) that reduce risk to the design-builders.
- The qualifications of the geotechnical designers and the experience with geotechnical projects of companies that make up the DB team are key to achieving quality in the constructed DB project. Also, achieving satisfactory quality of geotechnical design and construction deliverables in DB contracting is perceived to be most affected by the qualifications and experience of the people who will execute the geotechnical design, design review, and construction tasks required by the project.
- Addressing geotechnical issues early in the DB procurement process is important.
- The appropriate number of geotechnical design reviews is a function of the need for the design-builder to maintain an aggressive schedule. If the project is not schedule-constrained, the owner can afford to add more design review points. On the other hand, for fast-track projects, the process can be expedited through the use of over-the-shoulder reviews and other similar techniques (see chapter five for more information on these techniques).
- The agencies that responded to the survey retain most traditional roles and responsibilities for quality management (QM) that are related to geotechnical quality control/quality assurance (QC/QA) tasks.
- The design QA plan is perceived as the most important aspect of the DB geotechnical QM planning process.
- The design-builder is entitled to rely on the geotechnical information in the DB RFP, and the differing site conditions (DSCs) furnish a mechanism under which the design-builder can claim additional costs and time if the RFP information does not reasonably match the actual conditions.

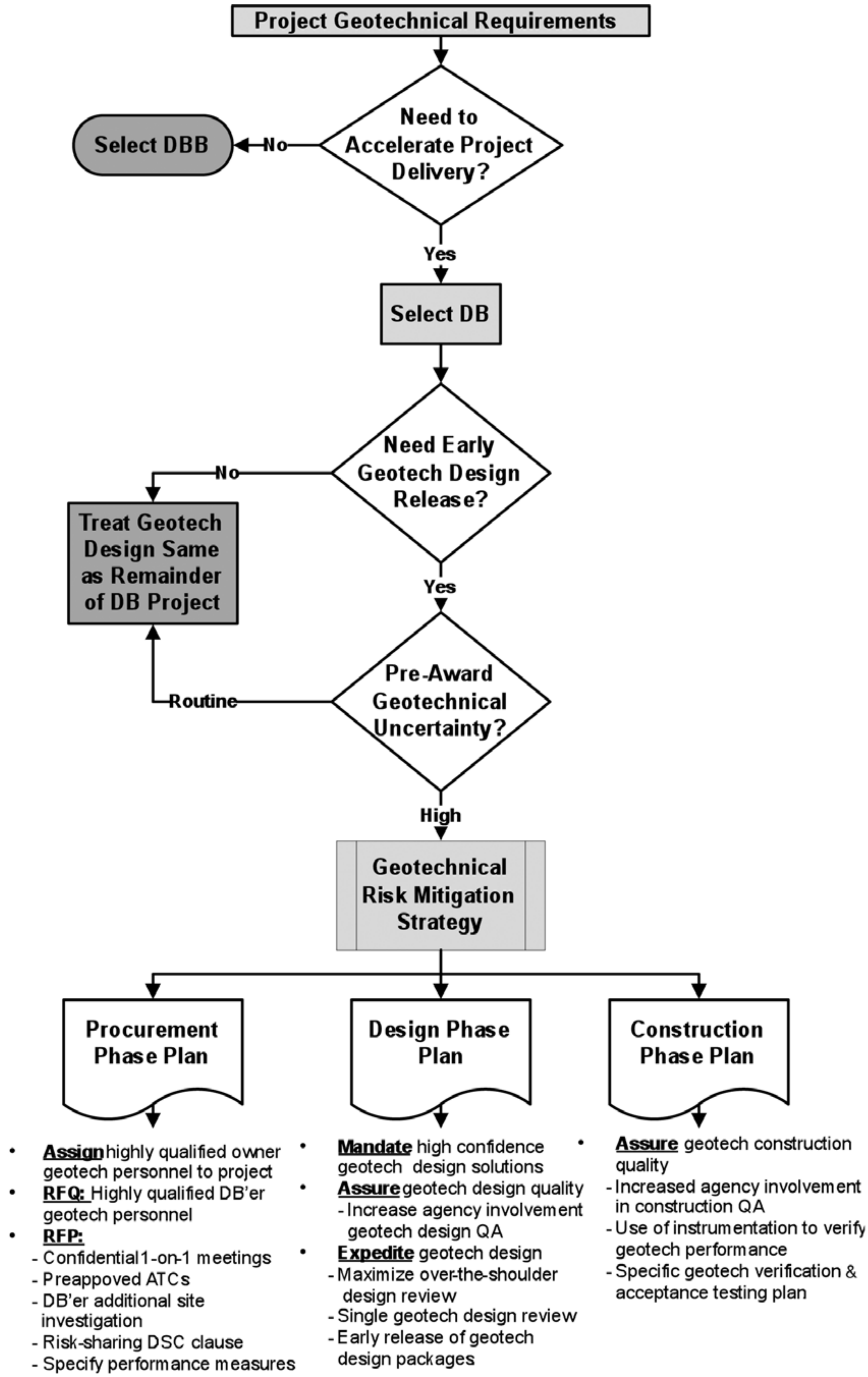

FIGURE 13 Design-build geotechnical decision process based on the conclusions and effective practices.

- The weight of geotechnical factors must be assigned proportionately to the other factors that define success for a given DB project.
- The ATC process is a viable approach to reducing perceived geotechnical risks by allowing competing design-builders to propose geotechnical design solutions with which they have both experience and confidence.
- A partnering clause of some form is used in most DOT DB contracts.
- Comparisons of the synthesis survey results with the results published by Shane et al. (2011) regarding DB project quality show that agencies are willing to sacrifice potential geotechnical design innovation for proven performance as defined by agency-mandated design details and specifications and are using this mechanism to manage schedule risk.
- To be successful in a DSC claim, the design-builder must rigorously adhere to the notice conditions in the DSC clause.

EFFECTIVE PRACTICES

Effective practices are identified when the analyses found instances of success when certain techniques or approaches were utilized in the procurement, design, or QM of a DB project. Additionally, the case study analysis identified a few other effective practices based on the detailed analysis found in those projects.

Effective Practices in Design-Build Geotechnical Procurement

- Seven DOTs (see Table 21) use confidential one-on-one meetings with each proposer before proposal submission to identify need for further geotechnical investigation as well as to clarify RFP risk issues. These meetings are also used to discuss, review, and approve ATCs before DB proposals are submitted.
- Another five DOTs (see Table 21) allow confidential ATCs be submitted for review and approval before DB proposals are submitted.
- The Vermont Agency of Transportation and the Maine DOT issue a draft DB RFP and ask for comments from the competing design-builders on the short list as a means to identify geotechnical aspects of the project that need clarification before a proposal is due.
- The Washington State, North Carolina, and Maine DOTs allow proposers to request supplementary borings during proposal preparation to better align the geotechnical information with a given design-builder's proposed design.
- Some DOTs, such as Utah, encourage competing design-builders to conduct their own pre-bid geotechnical investigations before developing their proposals.
- The relative geotechnical weight can be tailored as appropriate for each DB project in a manner similar to those used by the Florida, Virginia, and Washington State DOTs.

Effective Practices in Design-Build Geotechnical Design

- All survey respondents, regardless of DB experience, agree that partnering adds value to DB project execution.
- Experienced agencies use over-the-shoulder design reviews to create a mechanism for agency geotechnical personnel to have input into the design without stopping the design process and thus facilitate progress on early DB work packages.
- Including the option for early design-builder-requested design reviews on specific design packages can gain agency concurrence on the adequacy of the geotechnical design at the point when it is most needed, rather than having to wait for the formal design review.

Effective Practices in Design-Build Geotechnical Quality Management

- Experienced DOTs require the geotechnical engineering design QA plan to include specific procedures for involving the construction contractor in reviewing the constructability of geotechnical designs, as well as details on how the agency will be involved in the design QA process through its role of oversight, review, and acceptance of design deliverables.
- Combining selected design detail and specifications mandates with preproposal approval of geotechnical design approach provides a vehicle to manage technical and schedule risk on the geotechnical features of a DB transportation project.

Case Study Effective Practices

- The use of a "nested" DB provision that required a prequalified geotechnical specialty subcontractor to be a member of DBB general contractor's team on a project with known geotechnical issues provided a mechanism to expeditiously resolve a landslide. This technique not only saved time, but also brought an innovative temporary soil nail wall solution that permitted the slope to be stabilized without lane closure on an urban freeway.
- The use of selective unit pricing as done by the Montana, Delaware, and Virginia DOTs provides an effective means for managing geotechnical quantity risk.
- Permitting some form of confidential discussion and clarification of geotechnical risk during DB proposal preparation through a process such as the Mn/DOT one-on-one meetings can help competing design-builders make design assumptions that can be priced without the need to include large contingencies.
- The ability to assess design-builder ATCs before proposal submission and the use of PAEs encourages innovative design solutions to difficult geotechnical design

problems, such as the north approach settlement problem in the Hastings Bridge project. The confidentiality of the process is the key to its success.

SUGGESTIONS FOR FUTURE RESEARCH

The synthesis uncovered a number of gaps in the body of knowledge about addressing the geotechnical aspects of DB projects. The following is a list of suggestions for future research and a brief description of what form that research might take.

- The major issue that must be addressed in this topic was not specifically identified in any of the chapters. However, when one takes a broad perspective of the issues discussed in this report, an important research need is for new methods to characterize the geotechnical conditions of DB project sites during preliminary engineering. The literature review uncovered a number of technologies that may hold promise for providing required geotechnical data without the time and expense of traditional site investigation. One example is a reusable instrumented test pile under development by the California DOT. This device can measure temperature, pore pressure, acceleration, inclination, and axial and radial loads. Other technologies such as the application of geophysics and the robust use of the cone penetrometer as well as technologies in use in the petroleum industry may also hold promise. The recommended research could focus on the investigative practices and guidelines that various agencies have used to address geotechnical risk on DB projects and their level of success. Geophysical and various in-situ testing techniques could also be incorporated into the research. The research would also consider the perspective of the geotechnical community and DB contractor. The goal of the research ultimately would be to provide meaningful information for use by the state agencies in development of guidelines in performing a site and subsurface for DB projects pre-award. Therefore, an NCHRP synthesis project is recommended to benchmark the state of the practice in geotechnical data collection technologies that can be used to rapidly characterize project subsurface conditions in a manner that permits the data collected to be used for information in DB RFPs. The outcome of the synthesis could then be used to develop a full-scale project to exploit the technologies with the most promise for accomplishing this objective.
- Guidance is needed on how to effectively address and evaluate geotechnical factors that can be developed and incorporated into DOT DB guidelines. The research would elaborate on the value of including geotechnical technical evaluation factors in the DB project's requests for qualifications to encourage competing design-builders to team with highly qualified geotechnical designers and include project management and field personnel with extensive geotechnical experience in the construction team.
- Research is needed to quantify the benefits of geotechnical ATCs on DB projects. The results can be made available to agencies that are new to alternative project delivery methods and furnish both guidance and factual performance information to assist them in determining whether ATCs are attractive in their markets.
- Future research on what types of geotechnical review steps should be contained in agency-level DB guidelines and in RFPs for projects with significant geotechnical aspects is recommended. The research would include the process for effectively implementing over-the-shoulder design reviews.
- Future research is needed in the area of applying QM theories such as the advanced quality system to the development of preliminary geotechnical engineering and site investigation plans to support DB projects with significant geotechnical issues that cannot be resolved before issuing the DB RFP.
- Research is recommended that explores optimizing technical risk of innovative geotechnical design approaches with schedule risk. The research would furnish DOTs with guidance on the amount of prescriptive design content to include in projects with significant geotechnical issues.
- Guidance is needed about effectively managing geotechnical cost, time, and technical risk in DB projects. The research will examine—
  - Potential costs and benefits of employing selective unit pricing as a geotechnical risk management technique.
  - The optimal use of payment provisions and incentives to share geotechnical risk, both in the solicitation documents and during project execution.
  - Use of specialty geotechnical DB subcontracts in DBB prime contracts such as the Missouri DOT "nested" DB contract.
  - When to employ GBRs in DB projects and how to effectively obtain contractor input to the final GBR.
- Since a number of state DOTs use some form of interactivity during DB proposal preparation, research is needed to quantify the costs and benefits of instituting a program such as Minnesota DOT's PAE process and to furnish guidance to agencies that do not allow interaction in their DB programs. The research would also include the exploration of legal barriers to implementation as well as case studies of any litigation or protests that resulted from the use of this approach.

REFERENCES

Allen, L.N., D.D. Gransberg, and K.R. Molenaar, "Partnering Successful Design-Build Contracts in the Naval Facilities Engineering Command Southwest Division," *The Military Engineer*, Vol. 94, No. 616 (Mar. 2002), pp. 47–48.

American Society of Civil Engineers (ASCE), "2009 Report Card for America's Infrastructure," ASCE, Reston, Va., 2010, pp. 75–106.

Arizona Department of Transportation (ADOT), *Design-Build Procurement & Administration Policy*, ADOT, Phoenix, 1997.

Arizona Department of Transportation (ADOT), Intermodal Transportation Division, *Design-Build Procurement and Administration Guide*, 2nd ed., ADOT Construction Group, Phoenix, Dec. 2001 [Online]. Available: http://www.azdot.gov/Highways/ConstGrp/DesignBuild-Guide.asp [accessed Jan. 24, 2007].

Arkansas State Highway and Transportation Department (ASHTD), *Design-Build Guidelines and Procedures* ASHTD, Little Rock, Ark., Apr. 2006, 29 pp.

Atzei, A., P. Groepper, M. Novara, and K. Pseiner, "Innovations for Competitiveness: European Views on 'better-faster-cheaper'," *Acta Astronautica*, Vol. 44 (7–12) (April–June 1999), pp. 745–754.

Avant, J., "Innovative Government Contracting," master's thesis, University of Florida, Gainsville, Fla., 1999, pp. 22–29.

Beard, L.J., C.M. Loulakis, and C.E. Wundram, *Design-Build: Planning Through Development*, 1st ed., McGraw–Hill Professional, New York, N.Y., 2001, p. 10.

Behnke, D.L. and R.G. Ames, "Technical Proposal, TH61, Hastings Bridge Design-Build Project," Lunda-Ames JV, Hastings, Minn., May 17, 2010, 34 pp.

Blanchard, B., "Design-Build Lessons Learned Florida DOT," *Proceedings, Louisiana Transportation Engineering Conference*, Baton Rouge, La., Feb. 2007, pp. 6–14.

Byrd, L.G. and A.A. Grant, "Prerequisites for a Successful Design/Build/Warranty Highway Construction Contract," A Report to the U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1993 [Online]. Available: http://www.fhwa.dot.gov/programadmin/contracts/byrd.cfm [accessed Dec. 4, 2010].

California Department of Transportation (Caltrans), "Design-Build Demonstration Program," Web Document, Caltrans, Sacramento, 2010 [Online]. Available: http://www.dot.ca.gov/hq/oppd/designbuild/db.htm [accessed Oct. 30, 2010].

Carpenter, J., "WSDOT Design-build Project Delivery Guidance Statement: Alternative Technical Concepts," Washington State DOT, Olympia, Apr. 10, 2010, 15 pp.

Carter & Burgess, Inc., *I-15 Corridor Reconstruction Project; Design/Build Evaluation 1998 Annual Report*, Utah Department of Transportation Report No. UT-98.10, 1998, pp. 1–45.

Centennial Contractors, Inc., *Design-Build Project Manual*, Centennial Contractors, Inc., Vienna, Va., 2004, 137 pp.

Christensen, M.R. and L.E. Meeker, "Design/Build Projects—Lessons Learned from the Contractor's Perspective," *Proceedings*, American Railway Engineering and Maintenance-of-Way Association, Lanham, Md., 2002, p. 14.

City and County of Honolulu (CCH), "Honolulu High-Capacity Transit Corridor Project Draft Environmental Impact Statement: Appendix C—Construction Process," City and County of Honolulu, Hawaii, 2008, pp. 2–9.

Clark, G.T. and A. Borst, "Addressing Risk in Seattle's Underground," *PB Network*, Jan. 2002, pp. 34–38.

Colorado Department of Transportation (CDOT), "Colorado Department of Transportation Design-Build Guidelines," Draft issued Feb. 1, 1997 for Review and Comment, 3 pp.

Crofford, C., "What's New in Facility Design Requirements" presentation, Naval Facilities Engineering Command, NAVFAC Atlantic Design Conference, Norfolk, Va., June 22, 2010, 24 pp.

Cushman, R.F. and M.C. Loulakis, *Design-Build Contracting Handbook*, 2nd ed., Aspen Publishers, New York, N.Y., 2001, 603 pp.

Department of Defense (DoD), *Unified Facilities Criteria (UFC)*, UFC 1-300-09N 25 May 2005 Including Change 7, DoD, Washington, D.C., Jan. 27, 2010, 93 pp.

Design-Build Institute of America (DBIA), *Manual of Policy Statements*, DBIA, Washington, D.C., 1998, p. 5.

Design-Build Institute of America (DBIA), *Design-Build Manual of Practice*, DBIA, Washington, D.C., 2009, pp. 6–35.

Diekmann, J.E. and M.C. Nelson, "Construction Claims: Frequency and Severity," *Journal of Construction Engineering Management*, Vol. 111, No. 1, 1985, pp. 74–81.

Dowall, D.E. and J. Whittington, *Making Room for the Future: Rebuilding California's Infrastructure*, Public Policy Institute of California, San Francisco, 2003, 13 pp.

Drennon, P.W., "Utah's I-15, a Transportation Case Study: Role of the Owner's Design Professional in Design/Build and in the Provisions for Quality," *Quality Congress. ASQ's ... Annual Quality Congress Proceedings*, Milwaukee, Wis., 1998, p. 166.

Dwyre, E.M., Z. Batchko, and R.J. Castelli, "Geotechnical Baseline Reports for Foundation Projects," *Proceedings, GeoFlorida 2010: Advances in Analysis, Modeling & Design* (GSP 199), Orlando, Fla., 2010, pp. 1–10.

Ernzen, J., G. Murdough, and D. Drecksel, "Partnering on a Design-Build Project: Making the Three-Way Love Affair Work," *Transportation Research Record 1712,* Transportation Research Board, National Research Council, Washington, D.C., 2000, pp. 202–212.

Ernzen, J. and T. Feeney, "Contractor-Led Quality Control and Quality Assurance Plus Design-Build: Who Is Watching the Quality?" *Transportation Research Record: Journal of the Transportation Research Record, No. 1813*, Transportation Research Board of the National Academies, Washington, D.C., 2002, pp. 253–259.

Essex, R., "Geotechnical Baseline Reports for Construction: Suggested Guidelines," Underground Technical Research Council, ASCE, Reston, Va., 2007, 72 pp.

Federal Acquisition Regulation (FAR), "Two Phase Design Build Selection," *Federal Register*, 62 FR 271, Vol. 62, No. 1, 2000.

Federal Acquisition Regulation (FAR), "Site Investigation and Conditions Affecting the Work," Part 52.236-3, 1984 [Online]. Available: https://www.acquisition.gov/far/html/52_233_240.html#wp1113375 [accessed July 8, 2011].

Federal Highway Administration (FHWA), "Geotechnical Differing Site Conditions," *Geotechnical Engineering Notebook*, Geotechnical Guideline No. 15, FHWA, Washington, D.C., Apr. 30, 1996, 36 pp.

Federal Highway Administration (FHWA), "SEP-14 Active Project List," Washington, D.C. [Online]. Available: http://www.fhwa.dot.gov/programadmin/contracts/sep14list.cfm [accessed Dec. 2, 2009].

Federal Highway Administration (FHWA), *Design-Build Effectiveness Study—As Required by TEA-21 Section 1307(f): Final Report*, FHWA, Washington, D.C., Jan. 2006, 215 pp. [Online]. Available: http://www.fhwa.dot.gov/reports/designbuild/designbuild0.htm [Mar. 20, 2011].

Federal Highway Administration (FHWA), "Current Design-Build Practices for Transportation Projects," 2011 [Online]. Available: http://www.fhwa.dot.gov/construction/contracts/pubs/dbpractice/06.cfm [June 2, 2011].

Finnish Road Administration, "Procurement Strategy of the Finnish Road Administration," Finnish Road Administration, Helsinki, Finland, 2003, pp. 27–29.

Finley, R.C., "What Does Contingency Mean to You?" Design-Build Contractor Contingency Planning, Slater & Son, Inc., 2011, p. 1 [Online]. Available: http://www.slaterandson.com/page/article.php [June 16, 2011].

Florida Department of Transportation (FDOT), "Alternative Technical Concepts Reviews," *FDOT Design-build Guidelines*, Vol. 2, Feb. 4, 2011 [Online]. Available: http://www.dot.state.fl.us/construction/designbuild/DBDocuments/RFPDocs/AlternativeTechnicalConcepts.pdf [May 26, 2011].

Friedlander, M.C., *Risk Allocation in Design-Build Construction Projects*, Schiff Hardin LLP, Chicago, Ill., 2003, 31 pp.

Gharaibeh, N.G. and A.G. Miron, "Warranty Specifications for Highway Construction Current Practices and Evolution to Advanced Quality Systems," *Transportation Research Record: Journal of the Transportation Research Board, No. 2081*, Transportation Research Board of the National Academies, Washington, D.C., 2008, pp. 77–82.

Gladke, J., "Incentives on Design-build Projects: Two Different Approaches," *Design-Build: A Quality Process*, Transportation Research Circular E-C090, Transportation Research Board, Washington, D.C., 2006, p. 8.

Gonderinger, C., "TH 14/218 Design-Build Project Technical Memorandum Quality Management Plan (QC/QA Requirements)," Minnesota Department of Transportation Technical Memorandum, St. Paul, Minn., 2001, pp. 1–17.

Grammer, M., "Design-Build in the Corps of Engineers, A Work in Progress," *The Military Engineer*, No. 609 (Jan.–Feb. 2001), pp. 21–22.

Gransberg, D.D. and S.P. Senadheera, "Design-Build Contract Award Methods for Transportation Projects," *Journal of Transportation Engineering*, ASCE, Vol. 125, No. 6, Nov. 1998, pp. 565-567.

Gransberg, D.D., W.D. Dillon, H.L. Reynolds, and J. Boyd, "Quantitative Analysis of Partnered Project Performance," *Journal of Construction Engineering and Management*, ASCE, Vol.125, No. 3, June 1999, pp 161-166.

Gransberg, D.D. and K.R. Molenaar, "A Synthesis of Public Design-Build Source Selection Methods" *Journal of Construction Procurement*, Vol. 9, No. 2, 2003, pp. 40–51.

Gransberg, D.D. and K.R. Molenaar, "Analysis of Owner's Design and Construction Quality Management Approaches in Design-Build Projects," *Journal of Management in Engineering*, ASCE, Vol. 20, No. 4, Oct. 2004, pp. 162–169.

Gransberg, D.D., K.R. Molenaar, and J.N. Datin, NCHRP Synthesis 376: *Quality Assurance in Design-Build Projects*, Transportation Research Board National Academies, Washington, D.C., 2008, 139 pp.

Gransberg, D.D. and C. Riemer, "Impact of Inaccurate Engineer's Estimated Quantities on Unit Price Contracts," *Journal of Construction Engineering and Management*, ASCE, Vol. 135, No. 11, Nov. 2009, pp. 1138–1145.

Hatem, D.J., "Risk Allocation for Subsurface Conditions and Defective Design," *Design-Build Subsurface Projects*, G.S. Brierley, D.H. Corkum, and D.J. Hatem, Eds., Society for Mining, Metallurgy and Exploration, Englewood, Colo., 2011, 228 pp.

Higbee, J.B., "Geotechnical Issues with Large Design–Build Highway Projects," *Transportation Research Record: Journal of the Transportation Research Board, No. 1868*, Transportation Research Board of the National Academies, Washington, D.C., 2004, pp. 147–153.

Hoek, E. and A. Palmieri, "Geotechnical Risks on Large Civil Engineering Projects," International Association of Engineering Geologists Congress, Vancouver, BC, Canada, Sep. 1998.

Hoppe, E.J., J. Yoon, D.H. Whitehouse, and L.E. Kodger, "Geotechnical Data Management at the Virginia Department of Transportation," 90th Annual Meeting of the Transportation Research Board, Jan. 23–27, 2011, Transportation Research Board of the National Academies, Washington, D.C., 15 pp.

Hung, C.J., J. Monsees, N. Munfah, and J. Wisniewski, *Technical Manual for Design and Construction of Road Tunnels—Civil Elements*, Technical Report FHWA-NHI-10-034, National Highway Institute, New York, N.Y. 2009, 704 pp.

Jones, J., "Newly Developed Test Pile Intended to Improve Pile Design," *Civil Engineering*, June 2011, pp. 42–43.

Kelleher, T.J., *Smith, Currie & Hancock's Common Sense Construction Law: A Practical Guide for the Construction Professional*, 4th ed., John Wiley & Sons, Inc., New York, N.Y., 2009, 573 pp.

Keston Institute for Public Finance and Infrastructure Policy Research, "Impacts of Design-Build on the Public Workforce," Keston Institute for Public Finance and Infrastructure Policy Research Paper 07-01, Apr. 2007, 48 pp. [Online]. Available: http://www.usc.edu/schools/sppd/keston/research/index.html [June 1, 2011].

Killen, J.J. and G.E. Gibson, "Construction Litigation for the U.S. Naval Facilities Engineering Command, 1982–2002," *Journal of Construction Engineering and Management*, Vol. 131, No. 9, 2005, pp. 24–31.

Kim, K.J., C.A. Kreider, and M.D. Valiquette, "North Carolina Department of Transportation's Practice and Experience with Design–Build Contracts Geotechnical Perspective," *Transportation Research Record: Journal of the Transportation Research Board, No. 2116*, Transportation Research Board of the National Academies, Washington, D.C., 2009, pp. 47–52.

Koch, J.E., D.D. Gransberg, and K.R. Molenaar. *Project Administration for Design-Build: A Primer for Owners, Engineers, and Contractors*, ASCE Press, Reston, Va., 2010, 286 pp.

Leahy, R.B., et al., *Transportation Research Circular E-C137: Glossary of Highway Quality Assurance Terms*, Transportation Research Board of the National Academies, Washington, D.C., May 2009, 44 pp.

Loulakis, M.C., B.P. Wagner, and H.C. Splan, "Differing Site Conditions," Chapter 11, *Construction Claims Deskbook*, R.S. Brams and C. Lerner, Eds., Aspen Law and Business, New York, N.Y., 1995, pp. 131–166.

Loulakis, M.C. and O.J. Shean, "Risk Transference in Design-Build Contracting," *Construction Briefings*, 2nd series, Federal Publications, Washington, D.C., 1996, 12 pp.

Mahdi, I.M. and K. Alreshaid, "Decision Support System for Selecting the Proper Project Delivery Method Using Analytical Hierarchy Process," *International Journal of Project Management*, Vol. 23, 2005, pp. 564–572.

Maine Department of Transportation, *Request for Proposals, I-295 Commercial Street Connector*, FHWA Project No. IMD-7589(300), Maine DOT Project No. 7589.30, Maine Department of Transportation, Augusta, 2003.

Maine Department of Transportation, *Request for Proposals, Caribou Connector New Highway and Bridge Construction Design-build Project*, Project No. HPP-STP-6462-500, Maine Department of Transportation, Augusta, Oct. 13, 2010.

McLain K.W. and J.S. Shane, "A Case for Design-Build with the Missouri Department of Transportation," *Kansas City Business Journal*, Design Build Institute of America Supplement, 2009, 4 pp.

McLain, K.W., "Design-Build Procurement Process for Slope Repairs and Slope Stabilization Projects for Roadways on the Missouri State System," master's thesis, Iowa State University, Ames, Iowa, 2008, 66 pp.

Mendez, V., "Every Day Counts: Innovation Initiative," Federal Highway Administration, Washington, D.C., 2010, pp. 1–2.

Minnesota Department of Transportation (Mn/DOT), *Request for Qualifications T.H. 52 Design-Build Project S.P. 5502-67, 5507-45, 5508-78; HPPMN45(101), NH014(308)*, District Six—Rochester, Minnesota Department of Transportation, Rochester, Minn., 2001.

Minnesota Department of Transportation (Mn/DOT), "Approach to Alternative Technical Concepts," Mn/DOT Design-Build Program White Paper No. MN-11, St. Paul, Aug. 12, 2003, p. 1.

Minnesota Department of Transportation (Mn/DOT), *Addendum 5 Project Management Book 2B, Trunk Highway 52 Oronoco Design-Build Project*, St. Paul, 2005.

Minnesota DOT (Mn/DOT), *Request for Proposals, Book 1—TH 61 Hastings Bridge Design-Build Project S.P. 1913-64*, Mn/DOT, Metro District, St. Paul, Jan. 13, 2010, p. 7.

Mississippi Department of Transportation, *Request for Proposals, Addendum 1, A Design-Build Project Bridge Replacement on US 90 Biloxi to Ocean Springs Bridge Jackson and Harrison Counties, Mississippi*, Contract No. ER/BR-0003-01(099) 104556/301000—Biloxi/Ocean Springs Bridge, Mississippi Department of Transportation, Jackson, 2005.

Mitchell, B.P., "The Applicability of the Spearin Doctrine: Do Owners Warrant Plans and Specifications?" Find Law for Legal Professionals, 1999 [Online]. Available: http://library.findlaw.com/1999/Aug/1/128038.html [accessed Mar. 24, 2007].

Molenaar, K.R. and D.D. Gransberg, "Design-builder Selection for Small Highway Projects," *Journal of Management in Engineering*, Vol. 17, No. 4, Oct. 2001, pp. 214–223.

Montana Department of Transportation (MDT), *Design-Build Guidelines*, MDT, Helena, Apr. 14, 2008, p. 34.

Montana Department of Transportation (MDT), *Design-Build Request for Proposal US 2—Rockfall Mitigation, Flathead County*, Project # SFCN 1-2(169)154, MDT, Helena, Mar. 25, 2011, 39 pp.

Nelsen, D., "Quality Glossary," *Quality Progress*, American Society for Quality, June 2007 [Online]. Available: http://asq.org/quality-progress/2007/06/quality-tools/quality-glossary.html [accessed June 5, 2011].

Nicholson, T., "AIA Teaching Architects to Lead Design-Build Teams," *Design-Build Magazine*, McGraw–Hill Construction, May/June 2005 [Online]. Available: http://designbuild.construction.com/features/archive/2005/0506_feature2.asp [accessed Dec. 4, 2010].

Nickerson, R.L. and S.A. Sabol, *NCHRP Research Results Digest 274: Quality Assurance of Structural Materials*, Transportation Research Board of the National Academies, Washington, D.C., Aug. 2003, 21 pp.

North Carolina Department of Transportation (NCDOT), "Geotechnical Guidelines for Design-Build Projects," NCDOT, Raleigh, June 2009, pp. 1–2 [Online]. Available: http://www.ncdot.org/doh/preconstruct/altern/design_build/geotechGuidelines062909.pdf [accessed Sep. 29, 2011].

Panchmatia, P., "Quality Through People: A Practical Approach," American Society for Quality, 2010 [Online]. Available: http://www.asq-qm.org/pandp-qfd [accessed June 5, 2011].

Papernik, B.G. and D.J. Farkas, "Using Alternative Technical Concepts to Improve Design-Build and PPP Procurements," Nossaman E-Alerts [Online]. Available: http://www.nossaman.com/using-alternative-technical-concepts-improve-designbuild-ppp, [accessed May 26, 2011].

Pappe, R.S., "ODOT's Design-build Program," Presentation, American Council of Engineering Companies Conference, Salem, Oreg., 2008. [Online]. Available: http://www.oregon.gov/ODOT/HWY/MPB/docs/designbuild/Design_Build_Conversation_041508.pdf?ga=t [accessed June 2, 2011].

Perkins, R.A., "Sources of Changes in Design–Build Contracts for a Governmental Owner," *Journal of Construction Engineering and Management*, Vol. 135, No. 7, July 1, 2009, pp. 89-94.

Peters, M., "An Important Project," Canal Road Intermodal Connector Meeting, Gulfport, Miss., 2003 [Online]. Available: http://www.fhwa.dot.gov/pressroom/re031021.htm [accessed Sep. 16, 2006].

Petrello, R., "Kiewit Wins $483M Oahu Rail Contract," *Pacific Business News*, pp. 1–2 [Online]. Available: http://www.bizjournals.com/pacific/stories/2009/10/19/daily32.html [accessed June 16, 2011].

Phipps, A.R., "Maine Builds Longest-Span Precast Segmental Bridge with Unique Design-Build Selection Process, *Transportation Research Record: Journal of the Transportation Research Board, No. 1696*, Transportation Research Board of the National Academies, Washington, D.C., 2000, pp. 71–76.

Potter, J.M. and D.K. McMahon, *Selecting a Quality Control/Quality Assurance Program for a Mega Design-Build Project*, Rummel, Klepper, and Kahl, LLP, Baltimore, Md., 2006, 12 pp.

Richmond, D., J. Cown, D. Ball, and J.M. Rolland, "Private Sector Investments in Public Infrastructure," Canadian Council for Public–Private Partnerships, 2006, p. 14 [Online]. Available: http://www.pppcouncil.ca/pdf/metropolis_06152006.pdf [accessed Mar. 20, 2011].

Schaefer, V.R., S.C. Douglas, and R.R. Berg, "SHRP2 R02 Geotechnical Solutions for Transportation Infrastructure: Guidance and Selection System," 90th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 23–27, 2011.

Schexnayder, C.J. and R. Mayo, *Construction Management Fundamentals*, McGraw–Hill, New York, N.Y., 2004, pp. 282–283.

Scott, S., K.R. Molenaar, D.D. Gransberg, and N. Smith, *NCHRP Report 561: Best Value Procurement for Highway Construction Projects*, Transportation Research Board of the National Academies, Washington, D.C., Sep. 2006, p. 103.

Shane, J.S., D.D. Gransberg, K.R. Molenaar, and J.R. Gladke, "Legal Challenge to a Best-Value Procurement

System," *Journal of Leadership and Management in Engineering*, Vol. 5, No. 1 (Jan. 2006), pp. 1–6.

Shane, J.S., D.D. Gransberg, and K. Strong, "Project Delivery Method Impact on Final Project Quality: Perceptions in the Transportation Industry," 90th Annual Meeting of the Transportation Research Board, Washington, D.C., Jan. 23–27, 2011.

Sirles, P.C. and Z. Batchko, "Mapping Soft Soil Zones and Top-of-Bedrock Beneath High-Traffic Areas in Honolulu Using 2D ReMi," *Proceedings*, GeoFlorida 2010: Advances in Analysis, Modeling & Design (GSP 199), West Palm Beach, Fla., Feb. 20–24, 2010, 900 pp.

Smith, N.C., "Getting What You Paid For: The Quality Assurance and Acceptance Process for Transportation Projects," *Proceedings*, American Bar Association Forum on the Construction Industry, Denver, Colo., 2001, pp. 17–18.

Smith, R., "An Evolving View of Geotechnical Engineering—A Focus on Geo-Risk Management," *Geotechnical Special Publication No. 178*, GeoCongress 2008: Geosustainability and Geohazard Mitigation, New Orleans, La., Mar. 9–12 2008, pp. 231–239.

Songer, A.D. and K.R. Molenaar, "Selecting Design-Build: Private and Public Sector Owner Attitudes," *Journal of Management in Engineering*, Vol. 12, No. 6, 1996, pp. 47–53.

Texas Turnpike Authority, "Request for Proposals to Construct, Maintain and Repair the SH 130 Turnpike Through an Exclusive Development Agreement," Texas Department of Transportation, Austin, 2001.

Thiessen, D.A., "Gerald Desmond Bridge," Port of Long Beach Design-Build Industry Workshop, Long Beach, Calif., Aug. 10, 2010, 36 pp.

Trauner Consulting Services, "Innovative Procurement Practices Alternative Procurement and Contracting Methods," California Department of Transportation Report No. 53A0104 Sacramento, 2007, pp. 10–12

Tufenkjian, M., *Review of Geotechnical Services, California Department of Transportation*, Final Report, Federal Highway Administration, U.S.DOT, Washington, D.C., May 2007, 76 pp. [Online]. Available: http://www.dot.ca.gov/hq/esc/geotech/page/fhwa.pdf [accessed Mar. 20, 2011].

U.S. Army Corps of Engineers (USACE), *MILCON Transformation Model RFP*, Department of the Army, Washington, D.C. 2007 [Online]. Available: ftp://ftp.usace.army.mil/pub/hqusace/MILCON%20TRANSFORMATION [accessed Apr. 14, 2007].

U.S. Army Corps of Engineers (USACE), *Army Reserve Design/Build RFP Instruction Manual*, USACE, Washington, D.C., Sep. 2009, 73 pp.

Vermont Agency of Transportation (VTrans), "Design-Build Contracting," Montpelier, Vt., 2010a [Online] Available: http://www.aot.state.vt.us/conadmin/Design-Build.htm [accessed Mar. 20, 2011].

Vermont Agency of Transportation (VTrans), *Request for Qualifications, US Route Bridge Improvement, Bridge No. 24, Town of Richmond Vermont*, VTrans Project No. Richmond STP-RS 0284(11), VTrans, Montpelier, Vt., 2010b, 46 pp.

Virginia Department of Transportation (VDOT), "General Conditions of Contract Between Department and Design-Builder," Design-Build Standard Template Documents, VDOT, Richmond, 2010, 187 pp. [Online]. Available: http://www.virginiadot.org/business/resources/ipd/2010_TemplateDocuments_100511.pdf; [accessed July 8, 2011].

Washington State Department of Transportation (WSDOT), *Request for Proposals, Thurston Way Interchange, SR500 MP3.15 to MP 4.73*, Clark County, WSDOT, Kelso, 2000.

Washington State Department of Transportation (WSDOT). *Guidebook for Design-Build Highway Project Development*, WSDOT, Olympia, 2004, 109 pp.

APPENDIX A

Survey Questionnaire

NCHRP Synthesis Topic 42-01: Geotechnical Information in Design-Build Projects

INTRODUCTION/BACKGROUND:

The purpose of this questionnaire is to identify state highway agency policies and procedures for articulating geotechnical information and requirements on Design-Build (DB) projects. The results of the study will be a synthesis of highway agency procurement procedures for agencies that using DB project delivery to procure their construction projects. Its specific focus is on the geotechnical information that is contained in DB solicitation documents as well as the geotechnical information that is produced as a portion of the DB project's final design. It seeks to identify successful approaches to managing geotechnical risks across the DB project's life cycle as well as discuss those practices that did not adequately address the geotechnical requirements and caused the agency to hold geotechnical liability that it had hoped to shed.

DEFINITIONS:

The following definitions are used in conjunction with this questionnaire:

- Design-bid-build (DBB): A project delivery method where the design is completed either by in-house professional engineering staff or a design consultant before the construction contract is advertised. Also called the "traditional method."
- Design-build (DB): A project delivery method where both the design and the construction of the project are simultaneously awarded to a single entity.
- Typical project: A project whose geotechnical content is considered by the respondent to be normal.
- A project with significant geotechnical issues: A project whose geotechnical content is considered by the respondent to be great enough as to warrant special treatment in the procurement phase and extra oversight in the design and construction phases.
- Alternative technical concepts (ATC): A procedure where the design-builders are asked to furnish alternative design solutions for features of work designated by the agency in its DB Request for Proposals (RFP).

Please e-mail, fax, or post this questionnaire by one of the following means:

Doug Gransberg, PhD, PE
Civil, Construction, and Environmental Engineering
Iowa State University
494 Town Engineering Building
Ames, IA 50011
Voice: 515-294-1703
Fax: 515 294-3845
Email: dgran@iastate.edu

General Information:

1. Please furnish respondent contact information:

Contact name: ______________________________

Phone number: ______________________________

E-mail address ______________________________

U.S. state in which the respondent is employed: ______________

2. You are employed by what type of organization?

☐ State department of transportation

- ☐ Other public transportation agency; name of agency: ______________
- ☐ Federal Agency; Name of Agency: ____________________________
- ☐ Other, please describe: ____________________________________

3. What group/section do you work in?
   - ☐ Design group/section
   - ☐ Construction group/section
   - ☐ Operations group/section
   - ☐ Geotechnical/foundations group/section
   - ☐ Alternative project delivery group/section
   - ☐ Materials group/section
   - ☐ Contracts/procurement group/section
   - ☐ Other, please specify: ____________________________________

4. What project delivery methods is your organization allowed to use?
   - ☐ DBB ☐ Construction Manager-at-Risk or Construction Manager/General Contractor
   - ☐ DB ☐ Other; please specify: ____________________

5. If you do not use DB, why not?
   - ☐ No legal authority
   - ☐ Have authority but have not yet found a project where it makes sense
   - ☐ Have authority but political/policy issues prevent its use
   - ☐ Have authority but agency upper management is unwilling to use it
   - ☐ Have authority but industry opposition prevents its use
   - ☐ Other, please specify: ____________________________________

If your agency does not use DB project delivery please skip to the final question.

6. How many DB projects has your agency delivered?

   ☐ 1–2 ☐ 3–5 ☐ 6–10 ☐ >10

7. Roughly what percentage of your average annual construction program, in terms of number of projects, is your DB program?

   ☐ <10% ☐ 11%–25% ☐ 26%–50% ☐ >50%

8. Roughly what percentage of your average annual construction budget, in terms of dollar volume, is your DB program?

   ☐ <10% ☐ 11%–25% ☐ 26%–50% ☐ >50%

9. How long have you been using DB project delivery?

   ☐ 1–2 years ☐ 3–5 years ☐ 6–10 years ☐ >10 years

Geotechnical Information Section (Please obtain the information from your organization's geotechnical group)

10. Does your agency have a manual or document that specifically describes the procedures to be used with the geotechnical requirements of DB projects?

☐ No ☐ Yes.

If yes, please add the website URL address where it can be accessed___________________
or e-mail dgran@iastate.edu so he can arrange to get a copy.

11. Do you use DB project delivery on projects where the geotechnical aspects are considered to be significant, i.e., more important than the usual project?

☐ Yes ☐ No

12. If the answer to the previous question is "Yes," what if any special methods were used to address the geotechnical issues in the DB RFQ/RFP?

Please specify: ____

13. If the answer to the previous question is "No," why not?

☐ Liability considerations are not favorable for the agency

☐ Not willing to give up control of the geotechnical design

☐ Could use DB on these projects but political/policy issues prevent its use

☐ Could use DB on these projects but agency upper management is unwilling to use it

☐ Not enough time to conduct preliminary geotechnical engineering investigations

☐ Other, please specify: ___________________________________

14. How much preliminary geotechnical investigation is conducted before making the decision to use DB project delivery for a given project?

☐ None

☐ Reconnaissance Report (Review of records observations from site)

☐ Geotechnical Data Report (Review of records and limited investigation data)

☐ Geotechnical Summary Report (Review of records and geotechnical investigation of critical areas)

☐ Preliminary Geotechnical Design Report (Partial geotechnical investigation)

☐ Geotechnical Design Report (Full subsurface investigation for all structures and geotechnical features)

☐ Geotechnical baseline report (GBR)

☐ Other, please specify: ___________________________________

15. Is a formal geotechnical risk analysis conducted on a typical project in any of the following areas?

☐ Project Scope ☐ Project Schedule ☐ Project Cost ☐ Contracting Risk

16. Do your project cost estimates involve an analysis of geotechnical uncertainty (i.e., was a range cost estimate developed)?

☐ Yes ☐ No

17. Do you employ any formalized geotechnical risk allocation techniques to draft the contract provisions? (An example would be the decision to pay for piling or unsuitable material replacement by unit price rather than including it in the lump sum amount.)

☐ Yes ☐ No

If yes, please describe: ______________________________________

18. During the initial stages of the DB process Request for Qualifications (RFQ), how do you evaluate a DB geotechnical design team/subconsultant? Please check all factors that apply.

- ☐ Geotechnical summary from past projects
- ☐ Qualifications of the geotechnical designers
- ☐ Proof of familiarity with local geotechnical conditions in the project area
- ☐ Geotechnical design report (GDR) preparation process narrative
- ☐ Geotechnical design report (GDR) quality assurance process narrative
- ☐ Designated GDR peer review
- ☐ Narrative discussing geotechnical risks and approach to mitigating them
- ☐ References attesting to performance specifically relating to geotechnical issues on past projects
- ☐ Claims history regarding geotechnical disputes
- ☐ Other, please specify: ______________________

19. Do you score DB team proposals based on their approach to geotechnical issues?

☐ Yes ☐ No

20. If the answer to the previous question is "Yes," how heavily are the evaluated geotechnical factors weighted with regard to all other evaluated factors?

☐ no weight ☐ minor weight ☐ some weight ☐ heavy weight

21. How much geotechnical information is provided in the DB Request for Proposals (RFP) in a *DB typical project?*

- ☐ None
- ☐ Reconnaissance Report (review of records observations from site)
- ☐ Geotechnical Data Report (review of records and limited investigation data)
- ☐ Geotechnical Summary Report (review of records and geotechnical investigation of critical areas)
- ☐ Preliminary Geotechnical Design Report (partial geotechnical investigation)
- ☐ Geotechnical Design Report (full subsurface investigation for all structures and geotechnical features)
- ☐ Geotechnical baseline report (GBR)
- ☐ Other, please specify: ______________________

22. How much geotechnical information is provided in the DB Request for Proposals (RFP) in a *DB project with significant geotechnical issues?*

- ☐ None
- ☐ Reconnaissance Report (review of records observations from site)
- ☐ Geotechnical Data Report (review of records and limited investigation data)
- ☐ Geotechnical Summary Report (review of records and geotechnical investigation of critical areas)
- ☐ Preliminary Geotechnical Design Report (partial geotechnical investigation)
- ☐ Geotechnical Design Report (full subsurface investigation for all structures and geotechnical features)
- ☐ Geotechnical baseline report (GBR)
- ☐ Other, please specify: ______________________

23. How much additional geotechnical information is required from the design-builders in DB proposals for a typical project?

- ☐ None
- ☐ List of assumptions made regarding geotechnical conditions
- ☐ Limited additional testing as requested by the design-builders
- ☐ Pre-award geotechnical investigation of critical areas by design-builders
- ☐ Geotechnical design values to be used
- ☐ Preliminary designs for foundation features of work
- ☐ Proposed mitigation approaches for known/potential geotechnical risk areas
- ☐ Alternative technical concepts for geotechnical features of work
- ☐ Other, please specify: ______________________________

24. How much additional geotechnical information is required from the design-builders in DB proposals in a DB project with significant geotechnical issues?

- ☐ None
- ☐ List of assumptions made regarding geotechnical conditions
- ☐ Limited additional testing as requested by the design-builders
- ☐ Pre-award geotechnical investigation of critical areas by design-builders
- ☐ Geotechnical design values to be used
- ☐ Preliminary designs for foundation features of work
- ☐ Proposed mitigation approaches for known/ potential geotechnical risk areas
- ☐ Alternative technical concepts for geotechnical features of work
- ☐ Other, please specify: ______________________________

25. Rate the following areas as to importance to the success of the project during the procurement process 1 = essential; 2 = important; 3 = not important.

- ☐ Sufficient geotechnical information to allow competitors to price the project without
- ☐ excessive contingencies
- ☐ Highly qualified geotechnical design engineers
- ☐ Verification of knowledge and experience working in the project area
- ☐ Mandated use of agency design criteria
- ☐ Detailed GBR in RFP
- ☐ Geotechnical design QA plan in proposal
- ☐ Peer-review of GDR and supplemental GDRs
- ☐ Geotechnical construction QA plan in proposal
- ☐ Geotechnical risk mitigation plan in proposal
- ☐ Correct weight of geotechnical issues in relation to other project requirements

Geotechnical Aspects of Design-Build Contracts (Please obtain the information from your organization's project delivery group)

26. Does your agency encourage or require a formal partnering process on DB projects?

☐ Yes ☐ No

27. What type of payment provisions are contained in your typical agency DB projects?

☐ Lump sum ☐ Lump sum guaranteed maximum price (GMP)

☐ Unit price GMP

☐ Unit price ☐ Cost reimbursable ☐ Combination lump sum and unit prices

☐ Other; Please specify: ________________________

28. Does your agency use the GBR as a contract document?

☐ Yes ☐ No

29. Do you provide and require geotechnical design criteria in DB contracts?

☐ Yes ☐ If yes: what types? __________ ☐ No

30. Do you provide and require geotechnical performance criteria in DB contracts?

☐ Yes ☐ If yes: what types? __________ ☐ No

31. Do you use performance verification or measurement methods (instrumentation, etc.) for geotechnical features of work?

☐ Yes If yes: what types? __________ ☐ No

32. Does your DB contract contain a clause that regarding geotechnical differing site conditions?

☐ Yes ☐ No

33. If the answer to the previous question is Yes, how often does a design-builder's claim of a differing geotechnical site condition result in a compensable change order?

☐ Never ☐ Occasionally ☐ Usually ☐ Always

34. What document, if any, is used to define a differing geotechnical site condition?

☐ Geotechnical information contained in RFP

☐ GBR contained in RFP

☐ GDR produced by design-builder

☐ Contract differing site conditions clause definition only

☐ No document

☐ Other, please specify: ________________________

35. Do you use warranties in conjunction with the geotechnical features?

☐ Yes. If yes, what types? __________ ☐ No

36. Do you have incentives that are used to align owner and contractor geotechnical risks and rewards?

☐ Yes. If yes, what types? __________ ☐ No

37. Have you had a major claim regarding a geotechnical issue on any of your DB projects?

☐ Yes. If yes, please describe the issue and the final decision: ____________ ☐ No

38. Do you use a different QA program for DB projects than you do for DBB projects?

☐ Yes. If yes, what is the major difference? ____________________________ ☐ No

39. Who performs the following geotechnical-related construction quality management tasks in your DB projects?

Check all that apply	Does Not Apply	Agency Staff	Designer's Staff	Design-Builder's Construction Staff	Agency-Hired Consultant
Technical review of construction shop drawings	☐	☐	☐	☐	☐
Technical review of construction material submittals	☐	☐	☐	☐	☐
Checking of pay quantities	☐	☐	☐	☐	☐
Routine construction inspection	☐	☐	☐	☐	☐
Quality control testing	☐	☐	☐	☐	☐
Verification testing	☐	☐	☐	☐	☐
Acceptance testing	☐	☐	☐	☐	☐
Independent assurance testing/inspection	☐	☐	☐	☐	☐
Approval of construction post-award QA plans	☐	☐	☐	☐	☐
Report of nonconforming work or punchlist	☐	☐	☐	☐	☐

40. How do you rate the final quality of geotechnical work on DB projects compared to DBB projects?

☐ Better ☐ Same ☐ Worse ☐ No opinion

41. If the answer to the previous question is either "Better" or "Worse," explain primary reason for difference:

____

42. Do you formally evaluate the design-builder's performance quality and use that for future DB selections?

☐ Yes ☐ No

43. If the answer to the previous question is "Yes," do you believe that the performance rating creates an incentive to achieve quality?

☐ Yes ☐ No

44. Please rate the following geotechnical factors for their impact on the final quality/performance of the DB project.

Factor	Very High Impact	High Impact	Some Impact	Slight Impact	No Impact
Qualifications of the Design-Builder's geotechnical staff	☐	☐	☐	☐	☐
Design-Builder's past project experience with geotechnical issues	☐	☐	☐	☐	☐
Quality management plans	☐	☐	☐	☐	☐
Level of agency involvement in the QA process	☐	☐	☐	☐	☐
Use of agency geotechnical specifications and/or design details	☐	☐	☐	☐	☐
Amount of geotechnical information expressed in the procurement documents	☐	☐	☐	☐	☐
Use of geotechnical performance criteria/specifications	☐	☐	☐	☐	☐
Early contractor involvement in geotechnical design	☐	☐	☐	☐	☐
Agency interactivity with geotechnical design team during proposal phase	☐	☐	☐	☐	☐
Agency interactivity with geotechnical design team during design phase	☐	☐	☐	☐	☐
Warranty provisions	☐	☐	☐	☐	☐

45. Have you experienced significant geotechnical issues with any of your DB projects?

☐ 0 Yes ☐ No

46. If the answer to the previous question is Yes, would you be willing to allow the research team to contact you to do a structured interview and collect case study information?

☐ Yes ☐ No

Please furnish contact information if different than respondent:

Contact name: ______________________________

Phone number: ______________________________

E-mail address ______________________________

47. Do you have anything else you would like to share regarding the geotechnical aspects on your DB projects?

____

TABLE A1
SURVEY RESPONSE DATA

1: State:	AL	AK	AR	CA	CO	CT	FL	ID	IL	IN
5: delivery method DBB	X	X	X	X	X	X	X	X	X	X
5: CMGC		X			X		X	X		
5: DB		X	X	X	X		X	X		X
5: P3							X			
6: DB why not?										
6: No legal authority	X					X			X	
6: Have authority no project where it makes sense			X					X		
7: How many DB projects		1-2	1-2		11-100		11-100			11-100
8: % average annual construct number of projects		0-9%	0-9%	0-9%	0-9%		0-9%			0-9%
9: %average annual construct budget, dollar volume DB?		0-9%	0-9%	0-9%	11%-25%		11%-25%			11%-25%
10: How long have you been using DB project delivery?		11+years	1-2 years	1-2 years	11+years		11+years			11+years
11: manual/document DB geotechnical?		No	No	No	No	No			No	No
12: DB project delivery geotechnical aspects significant		No	No	Yes	No	No	Yes		No	No
15: preliminary geotech investigation before decision to use DB										
15: None										
15: Reconnaissance Report										X
15: Geotechnical Data Report				X			X			
15: Geotechnical Summary Report				X						X
15: Preliminary Geotechnical Design Report					X					
15: Geotechnical Design Report										
15: Geotechnical baseline report (GBR)										
15: Other										
16: Is a formal geotechnical risk analysis										
16: Project Scope							X			X
16: Project Schedule										
16: Project Cost										
16: Contracting Risk							X			
17: project cost estimates with geotechnical uncertainty				No	Yes		Yes			Yes
18: geotechnical risk to draft the contract provisions?				No	No		No			Yes
19: During (RFQ), how evaluate a DB geotechdesign team?										
19: Geotechnical summary from past projects					X		X			X
19: Qualifications of the geotechnical designers				X	X		X			X
19. Proof of familiarity with local geotechnical					X		X			X
19: (GDR) preparation process narrative							X			X
19: (GDR) quality assurance process narrative					X		X			X
19: Designated GDR peer-review										X
19: Narrative discussing geotechnical risks and approach to mitigating them					X		X			X
19: References					X		X			X
19: Claims history										

1: State:	AL	AK	AR	CA	CO	CT	FL	ID	IL	IN
20: Do you score DB proposal approach to geotechnical		No		No	Yes		Yes			Yes
21: geotechnical factors weighting					Minor weight		Minor weight			Some weight
22: How much geotechnical information (RFP)										
22: None										
22: Reconnaissance Report										X
22: Geotechnical Data Report				X			X			X
22: Geotechnical Summary Report				X						X
22: Prelim Geotechnical Design Report				X	X					X
22: Geotechnical Design Report				X						
22: Geotechnical baseline report										
23: Geotech info (RFP) significant geotechnical issues?										
23: None										
23: Reconnaissance Report										X
23: Geotechnical Data Report				X			X			X
23: Geotechnical Summary Report				X						X
23: Prelim Geotech Design Report				X						
23: Geotechnical Design Report				X	X					
23: Geotechnical baseline report										
24: How much geotech info in DB proposal typical project?										
24: None										
24: List of assumptions geotechnical conditions				X			X			X
24: Limited additional testing by the design-builders				X	X					X
24: Preaward investigate of critical areas by DBrs										
24: Geotechnical design values										X
24: Preliminary designs for foundation features of work										X
24: Proposed mitigation approaches geotechnical risk							X			X
24: Alternative technical concepts for geotech features							X			X
25: How much geotech info DB proposals with significant geotech issues										
25: None										
25: List of assumptions made regarding geotechnical				X						X
25: Limited additional testing by the design-builders				X						X
25: Preaward geotech investiga critical areas by DBrs										
25: Geotechnical design values to be used							X			X
25: Preliminary designs for foundation features of work					X		X			X
25: Proposed mitigation approaches geotechnical risk					X		X			X
25: Alternative technical concepts for geotechnical					X		X			X

Table continued from preceding page

1: State:	AL	AK	AR	CA	CO	CT	FL	ID	IL	IN
26: Rank importance to the success during the procurement process										
26: Sufficient geotech info		2		1	1		1			1
26: Highly qualified geotechnical design engineers		2		2	1		1			1
26: Verification of experience working in the project area		2		2	1		1			1
26: Mandated use of agency design criteria		2		2	2		1			2
26: Detailed GBR in RFP		3		2	2		3			1
26: Geotechnical design QA plan in proposal		3		2	2		2			2
26: Peer-review of GDR and supplemental GDRs		3		2	2		3			1
26: Geotechnical construction QA plan in proposal		3		2	2		2			1
26: Geotechnical risk mitigation plan in proposal		2		1	2		1			1
26: Correct weight of geotechnical issues		3		2	2		3			3
27: formal Partnering process on DB projects?		Yes		Yes	Yes		Yes			Yes
28: payment provisions DB projects?										
28: Lump sum		X		X	X		X			X
28: Lump sum GMP					X		X			
28: Unit price GMP										
28: Unit price										
28: Cost reimbursable										
28: Combo lump sum and unit prices							X			
29: Does your agency use the GBR as a contract document?		No		No	No		No			Yes
30: Do you provide/require geotechnical design criteria		Yes		Yes	No		Yes			No
30: If yes: please specify				must use standards in ourmanuals.			Our DOT standards must be followed.			
31: Do you provide/require geotech performance criteria		Yes		No	No		No			Yes
31: If yes: please specify										Deformation
32: performance verification for geotechnical?		No			No		No			Yes
32: If yes: please specify the types2										Instrumentation & Testing
33: geotechnical differing site conditions clause?		Yes		Yes	Yes		No			Yes
34: If Yes, claim result in a compensable change order?					Never					Occasionally
35: What document,define a differing geotech site condition?										
35: Geotechnical information contained in RFP				X	X					
Question 35: GBR contained in RFP										
35: GDR produced by design-builder										
35: Contract differing site conditions clause definition only		X		X	X		X			X
35: No document										
35: Other, please specify										
36: warranties the geotechnical features?		No		No	No		Yes			No
36: If yes: please specify							PROJECT WARRANTY			
37: incentives geotechnical risks and rewards?		No		No	No		No			No

1: State:	AL	AK	AR	CA	CO	CT	FL	ID	IL	IN
38: major claim geotechnical issue on DB project?				No	No		No			No
38: If yes:describe		No								
39: different QA program for DB projects than DBB projects?				Yes	Yes		No			No
40:Who does the following										
40: Technical review of construction shop drawings										
40: Does not apply		X								
40: Agency personnel				X						X
40: Designer's staff				X	X					
40: DB's construction staff										
40: Agency hired consultant							X			
41: Tech review material submittals										
41: Does not apply		X								
41: Agency personnel				X						X
41: Designer's staff		X								
41: DB's construction staff					X					
41: Agency hired consultant							X			
42: Checking of pay quantities										
42: Does not apply		X		X						
42: Agency personnel					X		X			X
42: Designer's staff		X								
42: DB's construction staff					X		X			
42: Agency hired consultant							X			
43: Routine construction inspection										
43: Does not apply		X								
43: Agency personnel				X	X					X
43: Designer's staff		X								
43: DB's construction staff				X	X		X			
43: Agency hired consultant										
44: Quality control testing										
44: Does not apply										X
44: Agency personnel										
44: Designer's staff										
44: DB's construction staff				X	X		X			
44: Agency hired consultant										
45: Verification testing										
45: Does not apply										
45: Agency personnel				X	X					X
45: Designer's staff		X								
45: DB's construction staff										
45: Agency hired consultant							X			X

Table continued from preceding page

1: State:	AL	AK	AR	CA	CO	CT	FL	ID	IL	IN
46: Acceptance testing										
46: Does not apply										
46: Agency personnel		X		X	X		X			X
46: Designer's staff										
46: DB's construction staff					X					
46: Agency hired consultant							X			X
47: Independent assurance 2										
47: Does not apply										
47: Agency personnel		X		X	X		X			
47: Designer's staff										
47: DB's construction staff				X						
47: Agency hired consultant					X		X			X
48: Approval of construction post-award QA plans										
48: Does not apply										
48: Agency personnel		X		X	X		X			X
48: Designer's staff										
48: DB's construction staff										
48: Agency hired consultant							X			X
49: punchlist										
49: Does not apply										
49: Agency personnel		X		X	X		X			X
49: Designer's staff				X						
49: DB's construction staff					X					
49: Agency hired consultant							X			X
50: final quality of geotechnical work on DB projects compared to DBB		Same		No opinion	No opinion		Same			Same
52: evaluate the performance quality for future DB selections?		No		No	No		Yes			Yes
53: If Yes, is performance rating an incentive quality?							Yes			Yes
54: rate impact on the final quality of the DB project										
54: Qualifications of the DB's geotechnical staff		1		2	2		2			2
54: DB's past experience with geotechnical issues		1		3	2		2			2
54: Quality management plans		1		2	1		3			2
54: Level of agency involvement in the QA process		2		3	3		3			5
54: Use of agency geotech specs/design details		4		1	2		1			1
54: Amount of geotech info in procurement docs		4		2	2		1			2
54: Use of geotech performance criteria/specs		2		3	2		1			1
54: Early contractor involvement in geotech design		2		2	1		3			1
54: Agency interactivity during proposal phase		5		2	2		3			2
54: Agency interactivityduring design phase		4		2	2		1			2
54: Warranty provisions		1		3	4		2			3
55: significant geotech issues with your DB proj?		Yes			No					No

1: State:	IA	KS	KN	LA	ME	MD	MA	MI	MN
5: delivery method DBB	X	X	X	X	X	X	X	X	X
5: CMGC								X	
5: DB			X	X	X	X	X	X	X
5: P3									
6: DB why not?									
6: No legal authority	X	X							
6: Have authority no project where it makes sense									
7: How many DB projects			1-2	3-5	6-10	11-100	6-10	11-100	11-100
8: % average annual construct number of projects			0-9%	0-9%	0-9%	0-9%	0-9%	0-9%	0-9%
9: %average annual construct budget, dollar volume DB?			0-9%	11%-25%	0-9%	11%-25%	0-9%	0-9%	11%-25%
10: How long have you been using DB project delivery?			6-10 years	3-5 years	11+years	11+years	6-10 years	11+years	6-10 years
11: manual/document DB geotechnical?	No		No	No	No	No	No	No	Yes
12:DB project delivery geotechnical aspects significant	No		No	Yes	Yes	Yes	Yes	Yes	Yes
15: preliminary geotech investigation before decision to use DB									
15: None									X
15: Reconnaissance Report					X			X	
15: Geotechnical Data Report									
15: Geotechnical Summary Report						X			
15: Preliminary Geotechnical Design Report				X				X	
15: Geotechnical Design Report									
15: Geotechnical baseline report (GBR)									
15: Other									
16: Is a formal geotechnical risk analysis									
16: Project Scope						X		X	X
16: Project Schedule								X	X
16: Project Cost								X	X
16: Contracting Risk								X	
17: project cost estimates with geotechnical uncertainty				No	No	No		Yes	Yes
18: geotechnical risk to draft the contract provisions?				No	No	No		Yes	No
19: During (RFQ), how evaluate a DB geotech-design team?									
19: Geotechnical summary from past projects				X	X	X		X	
19: Qualifications of the geotechnical designers				X	X	X		X	X
19. Proof of familiarity with local geotechnical					X			X	X
19: (GDR) preparation process narrative						X			
19: (GDR) quality assurance process narrative						X			
19: Designated GDR peer-review									
19: Narrative discussing geotechnical risks and approach to mitigating them				X		X		X	
19: References					X				X
19: Claims history									

Table continued from preceding page

1: State:	IA	KS	KN	LA	ME	MD	MA	MI	MN
20: Do you score DB proposal approach to geotechnical			No	Yes	Yes	Yes		Yes	Yes
21: geotechnical factors weighting				Some weight	Some weight	Some weight		Minor weight	Minor weight
22: How much geotechnical information (RFP)									
22: None									
22: Reconnaissance Report								X	
22: Geotechnical Data Report					X			X	
22: Geotechnical Summary Report						X		X	
22: Prelim Geotechnical Design Report				X				X	
22: Geotechnical Design Report								X	X
22: Geotechnical baseline report								X	X
23: Geotech info (RFP) significant geotechnical issues?									
23: None									
23: Reconnaissance Report								X	
23: Geotechnical Data Report					X			X	
23: Geotechnical Summary Report						X		X	
23: Prelim Geotech Design Report				X				X	
23: Geotechnical Design Report								X	X
23: Geotechnical baseline report								X	X
24: How much geotech info in DB proposal typical project?									
24: None						X			
24: List of assumptions geotechnical conditions			X		X			X	
24: Limited additional testing by the design-builders					X			X	
24: Preaward investigate of critical areas by DBrs					X			X	
24: Geotechnical design values			X					X	
24: Preliminary designs for foundation features of work				X	X				
24: Proposed mitigation approaches geotechnical risk					X			X	X
24: Alternative technical concepts for geotech features					X			X	X
25: How much geotech info DB proposals with significant geotech issues									
25: None						X			
25: List of assumptions made regarding geotechnical			X		X			X	
25: Limited additional testing by the design-builders					X			X	
25: Preaward geotech investiga critical areas by DBrs					X			X	
25: Geotechnical design values to be used			X					X	X
25: Preliminary designs for foundation features of work					X			X	X
25: Proposed mitigation approaches geotechnical risk					X			X	X
25: Alternative technical concepts for geotechnical					X				X

1: State:	IA	KS	KN	LA	ME	MD	MA	MI	MN
26: Rank importance to the success during the procurement process									
26: Sufficient geotech info			2	2	1	1		1	1
26: Highly qualified geotechnical design engineers			2	1	1	1		1	1
26: Verification of experience working in the project area			2	1	1	2		1	1
26: Mandated use of agency design criteria			2	2	1	2		1	1
26: Detailed GBR in RFP			3	2	3	2		2	2
26: Geotechnical design QA plan in proposal			2	1	2	2		2	1
26: Peer-review of GDR and supplemental GDRs			3	1	2	2		3	2
26: Geotechnical construction QA plan in proposal			3	1	2	2		2	2
26: Geotechnical risk mitigation plan in proposal			2	2	2	2		2	1
26: Correct weight of geotechnical issues			3	1	1	3		1	2
27: formal Partnering process on DB projects?				Yes	Yes	Yes		Yes	No
28: payment provisions DB projects?									
28: Lump sum			X	X	X	X			X
28: Lump sum GMP									
28: Unit price GMP									
28: Unit price									
28: Cost reimbursable									
28: Combo lump sum and unit prices								X	
29: Does your agency use the GBR as a contract document?			No	No	No	Yes		No	No
30: Do you provide/require geotechnical design criteria			Yes	Yes	Yes	Yes		Yes	Yes
30: If yes: please specify					Simply specify AASHTO LRFD and Maine Bridge Design Guide. Typically DBer permitted to excercise engineering judgement where allowed in AASHTO Articles 10 and 11.			Our DOT standards must be followed.	
31: Do you provide/require geotech performance criteria			No	Yes	No	Yes		No	Yes
31: If yes: please specify				Load Test criteria		Such as FS			
32: performance verification for geotechnical ?			No	Yes	Yes	Yes		No	Yes
32: If yes: please specify the types2				Deformation	In the past instrumention programs have been specified to projects involving emankments on soft, compressible soils. Defer to AASHTO LRFD for pile & shaft installation QC.	"instrumentation"			
33: geotechnical differing site conditions clause ?			Yes	Yes	No	No		No	Yes
34: If Yes, claim result in a compensable change order?				Occasionally					Usually
35: What document,define a differing geotech site condition?									
35: Geotechnical information contained in RFP						X			
Question 35: GBR contained in RFP									
35: GDR produced by design-builder				X					
35: Contract differing site conditions clause definition only			X		X				
35: No document									
35: Other, please specify								It depends on the project	DB Special Provisions
36: warranties the geotechnical features?			No	No	Yes	No		No	Yes
36: If yes: please specify					Only for pavement settlement.				Settlement limitations on roadways and structures
37: incentives geotechnical risks and rewards?			No	No	No	No		No	Yes

Table continued from preceding page

1: State:	IA	KS	KN	LA	ME	MD	MA	MI	MN
38: major claim geotechnical issue on DB project?				Yes	Yes	No		No	No
38: If yes:describe				Drilled shafts… pending.	modify their design to incorporate additional/ unwarranted geotech-nical instrumention				
39: different QA program for DB projects than DBB projects?			Yes	No	Yes	Yes		No	Yes
40:Who does the following									
40: Technical review of construction shop drawings									
40: Does not apply									
40: Agency personnel			X	X		X		X	X
40: Designer's staff			X	X	X			X	
40: DB's construction staff				X	X				X
40: Agency hired consultant				X		X		X	X
41: Tech review material submittals									
41: Does not apply									
41: Agency personnel			X	X		X		X	X
41: Designer's staff				X	X				
41: DB's construction staff				X	X				X
41: Agency hired consultant				X		X		X	X
42: Checking of pay quantities									
42: Does not apply					X				
42: Agency personnel			X	X					X
42: Designer's staff				X					
42: DB's construction staff				X					X
42: Agency hired consultant				X		X		X	X
43: Routine construction inspection									
43: Does not apply									
43: Agency personnel			X					X	
43: Designer's staff									
43: DB's construction staff				X	X				X
43: Agency hired consultant				X		X		X	
44: Quality control testing									
44: Does not apply									
44: Agency personnel			X					X	
44: Designer's staff									
44: DB's construction staff				X	X	X			X
44: Agency hired consultant				X				X	
45: Verification testing									
45: Does not apply									
45: Agency personnel			X	X	X	X		X	X
45: Designer's staff				X					
45: DB's construction staff				X					
45: Agency hired consultant				X					X

1: State:	IA	KS	KN	LA	ME	MD	MA	MI	MN
46: Acceptance testing									
46: Does not apply									
46: Agency personnel			X	X				X	X
46: Designer's staff				X	X				
46: DB's construction staff				X	X	X			
46: Agency hired consultant				X				X	X
47: Independent assurance 2									
47: Does not apply									
47: Agency personnel			X		X			X	X
47: Designer's staff									
47: DB's construction staff				X					
47: Agency hired consultant				X		X			X
48: Approval of construction post-award QA plans									
48: Does not apply									
48: Agency personnel			X	X	X			X	X
48: Designer's staff									
48: DB's construction staff									
48: Agency hired consultant				X		X			X
49: punchlist									
49: Does not apply									
49: Agency personnel			X	X				X	X
49: Designer's staff				X	X				
49: DB's construction staff				X	X	X			
49: Agency hired consultant				X		X		X	X
50: final quality of geotechnical work on DB projects compared to DBB			Same	Worse	Same	No opinion		No opinion	Better
52: evaluate the d performance quality for future DB selections?			No	No	No	No		Yes	No
53: If Yes, do you believe performance rating creates an incentivequality?								Yes	
54: rate impact on the final quality of the DB project									
54: Qualifications of the DB’s geotechnical staff			1	1	1	2		2	2
54: DB’s past experience with geotechnical issues			1	2	1	2		2	2
54: Quality management plans			4	2	1	2		3	3
54: Level of agency involvement in the QA process			4	2	4	1		2	3
54: Use of agency geotech specs/design details			1	3	1	2		2	1
54: Amount of geotech info in procurement docs			4	3	2	1		1	1
54: Use of geotech performance criteria/specs			4	1	3	2		5	1
54: Early contractor involvement in geotech design			2	1	3	1		2	3
54: Agency interactivity during proposal phase			4	2	4	3		2	3
54: Agency interactivityduring design phase			4	2	4	2		2	1
54: Warranty provisions			4	5	4	5		5	2
55: significant geotech issues with your DB proj?			No	Yes	Yes	No		No	Yes

Table continued from preceding page

1: State:	MS	MO	MT	NE	NV	NJ	NM	NH
5: delivery method DBB	X	X	X	X	X	X	X	X
5: CMGC				X	X			
5: DB	X	X	X		X	X	X	X
5: P3								
6: DB why not?								
6: No legal authority				X				
6: Have authority no project where it makes sense								
7: How many DB projects	3-5	1-2	6-10		1-2	3-5	3-5	1-2
8: % average annual construct number of projects	0-9%	0-9%	0-9%		11%-25%	0-9%	0-9%	0-9%
9: % average annual construct budget, dollar volume DB?	0-9%	0-9%	0-9%		11%-25%	0-9%	0-9%	0-9%
10: How long have you been using DB project delivery?	3-5 years	1-2 years	3-5 years		3-5 years	6-10 years	6-10 years	
11: manual/document DB geotechnical?	No	No	No	No	Yes	No	No	No
12:DB project delivery geotechnical aspects significant	No	No	Yes	No	Yes	No	Yes	No
15: preliminary geotech investigation before decision to use DB								
15: None					X			
15: Reconnaissance Report								
15: Geotechnical Data Report	X		X					
15: Geotechnical Summary Report							X	
15: Preliminary Geotechnical Design Report			X					
15: Geotechnical Design Report								
15: Geotechnical baseline report (GBR)								
15: Other								
16: Is a formal geotechnical risk analysis								
16: Project Scope			X					
16: Project Schedule								
16: Project Cost								
16: Contracting Risk								
17: project cost estimates with geotechnical uncertainty	No		Yes		Yes		Yes	
18: geotechnical risk to draft the contract provisions?	No		No		Yes		Yes	
19: During (RFQ), how evaluate a DB geotechdesign team?								
19: Geotechnical summary from past projects		X			X	X	X	
19: Qualifications of the geotechnical designers	X	X	X		X	X	X	
19. Proof of familiarity with local geotechnical	X		X		X		X	
19: (GDR) preparation process narrative					X		X	
19: (GDR) quality assurance process narrative					X		X	
19: Designated GDR peer-review							X	
19: Narrative discussing geotechnical risks and approach to mitigating them			X			X	X	
19: References	X				X		X	
19: Claims history							X	

1: State:	MS	Missouri	MT	NE	NV	NJ	NM	NH
20: Do you score DB proposal approach to geotechnical	Yes	Yes	Yes		Yes	No	Yes	
21: geotechnical factors weighting	Minor weight	No weight	Heavy weight		Some weight		Minor weight	
22: How much geotechnical information (RFP)								
22: None								
22: Reconnaissance Report								
22: Geotechnical Data Report	X				X			
22: Geotechnical Summary Report					X			
22: Prelim Geotechnical Design Report			X		X		X	
22: Geotechnical Design Report					X			
22: Geotechnical baseline report					X			
23: Geotech info (RFP) significant geotechnical issues?								
23: None								
23: Reconnaissance Report								
23: Geotechnical Data Report					X			
23: Geotechnical Summary Report					X			
23: Prelim Geotech Design Report			X		X		X	
23: Geotechnical Design Report					X			
23: Geotechnical baseline report					X			
24: How much geotech info in DB proposal typical project?								
24: None					X			
24: List of assumptions geotechnical conditions	X							
24: Limited additional testing by the design-builders								
24: Preaward investigate of critical areas by DBrs							X	
24: Geotechnical design values			X				X	
24: Preliminary designs for foundation features of work			X					
24: Proposed mitigation approaches geotechnical risk	X		X					
24: Alternative technical concepts for geotech features			X					
25: How much geotech info DB proposals with significant geotech issues								
25: None					X			
25: List of assumptions made regarding geotechnical								
25: Limited additional testing by the design-builders								
25: Preaward geotech investiga critical areas by DBrs							X	
25: Geotechnical design values to be used			X				X	
25: Preliminary designs for foundation features of work			X					
25: Proposed mitigation approaches geotechnical risk			X				X	
25: Alternative technical concepts for geotechnical			X				X	

Table continued from preceding page

1: State:	MS	Missouri	MT	NE	NV	NJ	NM	NH
26: Rank importance to the success during the procurement process								
26: Sufficient geotech info	2	2	2		2	2	2	
26: Highly qualified geotechnical design engineers	2	2	1		1	1	1	
26: Verification of experience working in the project area	1	2	1		1	1	1	
26: Mandated use of agency design criteria	1	2	2		2	2	3	
26: Detailed GBR in RFP	3	3	2		2	3	2	
26: Geotechnical design QA plan in proposal	3	3	1		2	2	1	
26: Peer-review of GDR and supplemental GDRs	3	3	2		2	3	1	
26: Geotechnical construction QA plan in proposal	3	3	1		2	3	1	
26: Geotechnical risk mitigation plan in proposal	2	2	2		3	2	1	
26: Correct weight of geotechnical issues	3	3	1		2	3	2	
27: formal Partnering process on DB projects?	Yes		No		Yes		Yes	
28: payment provisions DB projects?								
28: Lump sum	X	X	X			X	X	
28: Lump sum GMP								
28: Unit price GMP								
28: Unit price								
28: Cost reimbursable								
28: Combo lump sum and unit prices								
29: Does your agency use the GBR as a contract document?	No	No	No		Yes	No	Yes	
30: Do you provide/require geotechnical design criteria	Yes	Yes	Yes		Yes	Yes	No	
30: If yes: please specify			Geotechnical Alignment and Structure Report, Geotechnical Engineering Report, Foundation Designs, Soils reports, Surfacing Design Guidelines.		AASHTO/FHWA		Meet AASHTO standards	
31: Do you provide/require geotech performance criteria	No	No	Yes		Yes	Yes	No	
31: If yes: please specify			If the project includes significant geotechnical issues, we require qualified geotechnical key personnel, approach and understanding of geotechnical considerations, mitigation techniques for geotech issues, etc		Tolerable max and differential settlements, instrumentation, etc		AASHTO standards	
32: performance verification for geotechnical ?	Yes		No		Yes	No	Yes	
32: If yes: please specify the types2	compaction etc				Load tests, CSL tests, settlement monitoring, etc		settlement mitigation; PDA testing; CSL testing	
33: geotechnical differing site conditions clause ?	No	Yes	Yes		Yes	Yes	Yes	
34: If Yes, claim result in a compensable change order?			Occasionally		Occasionally		Occasionally	
35: What document,define a differing geotech site condition?								
35: Geotechnical information contained in RFP					X			
Question 35: GBR contained in RFP								
35: GDR produced by design-builder			X					
35: Contract differing site conditions clause definition only	X	X				X	X	
35: No document								
35: Other, please specify								
36: warranties the geotechnical features?	No	No	No		No	No	No	
36: If yes: please specify								
37: incentives geotechnical risks and rewards?	No	No	No		No			

1: State:	MS	Missouri	MT	NE	NV	NJ	NM	NH
38: major claim geotechnical issue on DB project?			No		Yes		No	
38: If yes:describe					down hole hammer misled		site conditions	
39: different QA program for DB projects than DBB projects?	No	No	Yes		Yes	No	No	
40:Who does the following								
40: Technical review of construction shop drawings								
40: Does not apply								
40: Agency personnel	X	X	X		X	X		
40: Designer's staff			X					
40: DB's construction staff					X		X	
40: Agency hired consultant	X				X			
41: Tech review material submittals								
41: Does not apply								
41: Agency personnel	X	X	X		X			
41: Designer's staff								
41: DB's construction staff			X			X	X	
41: Agency hired consultant	X							
42: Checking of pay quantities								
42: Does not apply								
42: Agency personnel	X	X	X		X			
42: Designer's staff								
42: DB's construction staff			X			X		
42: Agency hired consultant	X						X	
43: Routine construction inspection								
43: Does not apply								
43: Agency personnel		X	X		X			
43: Designer's staff								
43: DB's construction staff	X		X		X	X	X	
43: Agency hired consultant					X			
44: Quality control testing								
44: Does not apply								
44: Agency personnel					X			
44: Designer's staff								
44: DB's construction staff	X	X	X		X	X	X	
44: Agency hired consultant					X			
45: Verification testing								
45: Does not apply								
45: Agency personnel	X	X	X		X			
45: Designer's staff								
45: DB's construction staff			X		X	X		
45: Agency hired consultant	X						X	

Table continued from preceding page

1: State:	MS	Missouri	MT	NE	NV	NJ	NM	NH
46: Acceptance testing								
46: Does not apply								
46: Agency personnel	X	X	X					
46: Designer's staff								
46: DB's construction staff						X		
46: Agency hired consultant	X				X		X	
47: Independent assurance 2								
47: Does not apply					X			
47: Agency personnel	X	X	X					
47: Designer's staff								
47: DB's construction staff						X		
47: Agency hired consultant	X						X	
48: Approval of construction post-award QA plans								
48: Does not apply					X			
48: Agency personnel	X	X	X					
48: Designer's staff							X	
48: DB's construction staff						X		
48: Agency hired consultant								
49: punchlist								
49: Does not apply					X			
49: Agency personnel	X	X	X					
49: Designer's staff			X					
49: DB's construction staff						X		
49: Agency hired consultant							X	
50: final quality of geotechnical work on DB projects compared to DBB	Same	Same	Same		Worse	Same	Worse	
52: evaluate the d performance quality for future DB selections?	No	No	No		No		Yes	
53: If Yes, do you believe performance rating creates an incentivequality?							No	
54: rate impact on the final quality of the DB project								
54: Qualifications of the DB's geotechnical staff	2	2	1		3	2	2	
54: DB's past experience with geotechnical issues	2	2	2		2	2	2	
54: Quality management plans	4	4	3		2	3	3	
54: Level of agency involvement in the QA process	3	3	3		3	2	3	
54: Use of agency geotech specs/design details	1	2	4		2	1	4	
54: Amount of geotech info in procurement docs	2	3	4		3	1	3	
54: Use of geotech performance criteria/specs	5	2	1		2	2	3	
54: Early contractor involvement in geotech design	3	2	3		4	1	1	
54: Agency interactivity during proposal phase	5	5	3		3	3	3	
54: Agency interactivityduring design phase	3	3	2		1	2	2	
54: Warranty provisions	5	4	5		5	3	3	
55: significant geotech issues with your DB proj?	No		No		Yes	No	Yes	

1: State:	NC	ND	NY	OH	OK	OR	SC	SD	TN
5: delivery method DBB	X	X	X	X	X	X	X	X	X
5: CMGC						X			
5: DB	X	X		X		X	X	X	X
5: P3	X								
6: DB why not?									
6: No legal authority			X		X				
6: Have authority no project where it makes sense									
7: How many DB projects	11-100	1-2		11-100		11-100	11-100	1-2	1-2
8: % average annual construct number of projects	11%-25%	0-9%		0-9%		0-9%	0-9%		0-9%
9: %average annual construct budget, dollar volume DB?	26%-50%	0-9%		0-9%		26%-50%	11%-25%		0-9%
10: How long have you been using DB project delivery?	6-10 years	1-2 years		11+years		6-10 years	11+years		3-5 years
11: manual/document DB geotechnical?	Yes	No	Yes	Yes		No	Yes	No	No
12: DB project delivery geotechnical aspects significant	Yes	No	No	Yes		No	Yes	No	No
15: preliminary geotech investigation before decision to use DB									
15: None		X					X		
15: Reconnaissance Report									
15: Geotechnical Data Report									
15: Geotechnical Summary Report				X					
15: Preliminary Geotechnical Design Report	X					X			
15: Geotechnical Design Report									
15: Geotechnical baseline report (GBR)									
15: Other									
16: Is a formal geotechnical risk analysis									
16: Project Scope				X					
16: Project Schedule									
16: Project Cost						X			
16: Contracting Risk									
17: project cost estimates with geotechnical uncertainty	Yes	No	Yes	Yes		Yes	No		
18: geotechnical risk to draft the contract provisions?	No	No	Yes	No		No	No		
19: During (RFQ), how evaluate a DB geotechdesign team?									
19: Geotechnical summary from past projects	X						X		
19: Qualifications of the geotechnical designers	X	X		X		X	X		
19. Proof of familiarity with local geotechnical	X			X					
19: (GDR) preparation process narrative	X								
19: (GDR) quality assurance process narrative	X								
19: Designated GDR peer-review	X								
19: Narrative discussing geotechnical risks and approach to mitigating them	X								
19: References	X			X					
19: Claims history	X						X		

Table continued from preceding page

1: State:	NC	ND	NY	OH	OK	OR	SC	SD	TN
20: Do you score DB proposal approach to geotechnical	Yes	No	No	Yes		Yes	No		No
21: geotechnical factors weighting	Heavy weight			Minor weight		Minor weight			
22: How much geotechnical information (RFP)									
22: None									
22: Reconnaissance Report	X								
22: Geotechnical Data Report	X						X		
22: Geotechnical Summary Report	X			X					
22: Prelim Geotechnical Design Report	X								
22: Geotechnical Design Report	X								
22: Geotechnical baseline report	X								
23: Geotech info (RFP) significant geotechnical issues?									
23: None									
23: Reconnaissance Report	X								
23: Geotechnical Data Report	X								
23: Geotechnical Summary Report	X								
23: Prelim Geotech Design Report	X			X		X			
23: Geotechnical Design Report	X								
23: Geotechnical baseline report	X						X		
24: How much geotech info in DB proposal typical project?									
24: None						X	X		
24: List of assumptions geotechnical conditions	X								
24: Limited additional testing by the design-builders	X								
24: Preaward investigate of critical areas by DBrs	X								
24: Geotechnical design values	X								
24: Preliminary designs for foundation features of work	X			X					
24: Proposed mitigation approaches geotechnical risk	X								
24: Alternative technical concepts for geotech features	X								
25: How much geotech info DB proposals with significant geotech issues									
25: None							X		
25: List of assumptions made regarding geotechnical	X								
25: Limited additional testing by the design-builders	X								
25: Preaward geotech investiga critical areas by DBrs	X								
25: Geotechnical design values to be used	X								
25: Preliminary designs for foundation features of work	X			X					
25: Proposed mitigation approaches geotechnical risk	X								
25: Alternative technical concepts for geotechnical	X								

1: State:	NC	ND	NY	OH	OK	OR	SC	SD	TN
26: Rank importance to the success during the procurement process									
26: Sufficient geotech info	1	2		1		2	1		2
26: Highly qualified geotechnical design engineers	1	2		2		1	1		2
26: Verification of experience working in the project area	1	2		2		2	2		3
26: Mandated use of agency design criteria	1	1		1			1		3
26: Detailed GBR in RFP	1	3		3			1		3
26: Geotechnical design QA plan in proposal	2	3		2		1	2		3
26: Peer-review of GDR and supplemental GDRs	1	3		3		1	3		3
26: Geotechnical construction QA plan in proposal	1	3		2		1	2		3
26: Geotechnical risk mitigation plan in proposal	2	3		3		1	2		2
26: Correct weight of geotechnical issues	2	3		3		1	3		3
27: formal Partnering process on DB projects?	Yes	Yes				Yes	Yes		
28: payment provisions DB projects?									
28: Lump sum	X	X		X		X	X		X
28: Lump sum GMP									
28: Unit price GMP									
28: Unit price									
28: Cost reimbursable									
28: Combo lump sum and unit prices									
29: Does your agency use the GBR as a contract document?	Yes	No		No		No	No		No
30: Do you provide/require geotechnical design criteria	Yes	Yes		Yes			Yes		No
30: If yes: please specify		state design specs				depends on project			
31: Do you provide/require geotech performance criteria	Yes	No		Yes			No		No
31: If yes: please specify				settle-ment		not to date			
32: performance verification for geotechnical?	Yes	No				No	Yes		No
32: If yes: please specify the types2	used during construction.						Rideability spec		
33: geotechnical differing site conditions clause?	No	No		Yes		Yes	No		Yes
34: If Yes, claim result in a compensable change order?				Occa-sionally		Occasion-ally			
35: What document,define a differing geotech site condition?									
35: Geotechnical information contained in RFP									
Question 35: GBR contained in RFP									
35: GDR produced by design-builder									
35: Contract differing site conditions clause definition only		X		X		X			X
35: No document							X		
35: Other, please specify	We do not allow differing geotechnical site condition.								
36: warranties the geotechnical features?	Yes	No		No		No	Yes		No
36: If yes: please specify	culvert settlement.						3 year warranty latent defects/ workmanship		
37: incentives geotechnical risks and rewards?	No	No		No		No	No		No

Table continued from preceding page

1: State:	NC	ND	NY	OH	OK	OR	SC	SD	TN
38: major claim geotechnical issue on DB project?	Yes	No		No		Yes	No		
38: If yes:describe	Culvert settle more than allowed.					ancient landslides impact $50m			
39: different QA program for DB projects than DBB projects?	No	No		No		No	No		No
40:Who does the following									
40: Technical review of construction shop drawings									
40: Does not apply									
40: Agency personnel	X	X					X		X
40: Designer's staff						X			
40: DB's construction staff									
40: Agency hired consultant				X			X		X
41: Tech review material submittals									
41: Does not apply									
41: Agency personnel	X	X					X		X
41: Designer's staff						X			
41: DB's construction staff									
41: Agency hired consultant				X			X		
42: Checking of pay quantities									
42: Does not apply									
42: Agency personnel	X	X				X	X		X
42: Designer's staff									
42: DB's construction staff									
42: Agency hired consultant				X			X		X
43: Routine construction inspection									
43: Does not apply									
43: Agency personnel	X	X		X			X		X
43: Designer's staff						X			
43: DB's construction staff		X							
43: Agency hired consultant	X			X			X		X
44: Quality control testing									
44: Does not apply									
44: Agency personnel	X	X							X
44: Designer's staff									
44: DB's construction staff		X		X		X	X		
44: Agency hired consultant	X								X
45: Verification testing									
45: Does not apply									
45: Agency personnel	X	X		X		X	X		X
45: Designer's staff									
45: DB's construction staff									
45: Agency hired consultant	X			X			X		

1: State:	NC	ND	NY	OH	OK	OR	SC	SD	TN
46: Acceptance testing									
46: Does not apply									
46: Agency personnel	X	X		X		X	X		X
46: Designer's staff									
46: DB's construction staff									
46: Agency hired consultant	X						X		X
47: Independent assurance 2									
47: Does not apply		X							
47: Agency personnel	X					X	X		
47: Designer's staff									
47: DB's construction staff									
47: Agency hired consultant	X			X		X			X
48: Approval of construction post-award QA plans									
48: Does not apply									
48: Agency personnel	X	X		X		X	X		X
48: Designer's staff									
48: DB's construction staff									
48: Agency hired consultant	X								
49: punchlist									
49: Does not apply									
49: Agency personnel	X	X		X		X	X		X
49: Designer's staff									
49: DB's construction staff									
49: Agency hired consultant				X		X	X		
50: final quality of geotechnical work on DB projects compared to DBB	Same	Same		Same		Same	Same		Same
52: evaluate the d performance quality for future DB selections?	No	No				Yes	Yes		No
53: If Yes, do you believe performance rating creates an incentivequality?						Yes	Yes		
54: rate impact on the final quality of the DB project									
54: Qualifications of the DB’s geotechnical staff	1	2		2		2	3		4
54: DB’s past experience with geotechnical issues	1	2		2		2	3		4
54: Quality management plans	1	4		3		2	2		5
54: Level of agency involvement in the QA process	1	4		4		2	1		5
54: Use of agency geotech specs/design details	1	1		1		3	3		4
54: Amount of geotech info in procurement docs	1	3		2		2	3		5
54: Use of geotech performance criteria/specs	1	5		3		1	2		5
54: Early contractor involvement in geotech design	1	3		2		2	3		3
54: Agency interactivity during proposal phase	1	5		5			4		5
54: Agency interactivityduring design phase	1	5		4		2	2		4
54: Warranty provisions	2	5		4		1	2		5
55: significant geotech issues with your DB proj?	Yes	No		No		Yes	No		

Table continued from preceding page

1: State:	TX	UT	VT	VA	WA	WY
5: delivery method DBB	X	X	X	X	X	X
5: CMGC	X	X				
5: DB	X	X	X	X	X	
5: P3	X			X		
6: DB why not?						
6: No legal authority						X
6: Have authority no project where it makes sense						
7: How many DB projects	6-10	11-100	3-5	11-100	6-10	
8: % average annual construct number of projects	0-9%	0-9%	0-9%	0-9%	0-9%	
9: %average annual construct budget, dollar volume DB?	11%-25%	>50%	11%-25%	11%-25%	11%-25%	
10: How long have you been using DB project delivery?	6-10 years	11+years	6-10 years	6-10 years	6-10 years	
11: manual/document DB geotechnical?	Yes	Yes	Yes	No	Yes	No
12:DB project delivery geotechnical aspects significant	Yes	Yes	Yes	Yes	Yes	No
15: preliminary geotech investigation before decision to use DB						
15: None					X	
15: Reconnaissance Report	X					
15: Geotechnical Data Report	X	X		X		
15: Geotechnical Summary Report			X			
15: Preliminary Geotechnical Design Report						
15: Geotechnical Design Report						
15: Geotechnical baseline report (GBR)						
15: Other						
16: Is a formal geotechnical risk analysis						
16: Project Scope	X	X		X	X	
16: Project Schedule		X			X	
16: Project Cost		X		X	X	
16: Contracting Risk	X	X			X	
17: project cost estimates with geotechnical uncertainty	Yes	Yes		Yes	Yes	
18: geotechnical risk to draft the contract provisions?	No	Yes		No	Yes	
19: During (RFQ), how evaluate a DB geotechdesign team?						
19: Geotechnical summary from past projects	X	X			X	
19: Qualifications of the geotechnical designers	X	X		X	X	
19. Proof of familiarity with local geotechnical						
19: (GDR) preparation process narrative						
19: (GDR) quality assurance process narrative						
19: Designated GDR peer-review						
19: Narrative discussing geotechnical risks and approach to mitigating them	X				X	
19: References	X	X			X	
19: Claims history						

1: State:	TX	UT	VT	VA	WA	WY
20: Do you score DB proposal approach to geotechnical	Yes	Yes		Yes	Yes	
21: geotechnical factors weighting	Minor weight	Minor weight		Minor weight	Minor weight	
22: How much geotechnical information (RFP)						
22: None						
22: Reconnaissance Report						
22: Geotechnical Data Report	X	X		X	X	
22: Geotechnical Summary Report						
22: Prelim Geotechnical Design Report						
22: Geotechnical Design Report	X				X	
22: Geotechnical baseline report	X				X	
23: Geotech info (RFP) significant geotechnical issues?						
23: None						
23: Reconnaissance Report						
23: Geotechnical Data Report		X				
23: Geotechnical Summary Report	X			X		
23: Prelim Geotech Design Report						
23: Geotechnical Design Report						
23: Geotechnical baseline report					X	
24: How much geotech info in DB proposal typical project?						
24: None						
24: List of assumptions geotechnical conditions	X			X		
24: Limited additional testing by the design-builders		X			X	
24: Preaward investigate of critical areas by DBrs						
24: Geotechnical design values					X	
24: Preliminary designs for foundation features of work						
24: Proposed mitigation approaches geotechnical risk	X	X		X	X	
24: Alternative technical concepts for geotech features	X	X		X	X	
25: How much geotech info DB proposals with significant geotech issues						
25: None						
25: List of assumptions made regarding geotechnical	X			X		
25: Limited additional testing by the design-builders		X			X	
25: Preaward geotech investiga critical areas by DBrs						
25: Geotechnical design values to be used					X	
25: Preliminary designs for foundation features of work						
25: Proposed mitigation approaches geotechnical risk	X	X		X	X	
25: Alternative technical concepts for geotechnical	X	X		X	X	

Table continued from preceding page

1: State:	TX	UT	VT	VA	WA	WY
26: Rank importance to the success during the procurement process						
26: Sufficient geotech info	1	1		1	1	
26: Highly qualified geotechnical design engineers	1	1		1	1	
26: Verification of experience working in the project area	3	2		2	3	
26: Mandated use of agency design criteria	1	1		3	1	
26: Detailed GBR in RFP	1	1		3	1	
26: Geotechnical design QA plan in proposal	2	2		2	2	
26: Peer-review of GDR and supplemental GDRs	2	2		3	2	
26: Geotechnical construction QA plan in proposal	3	2		3	3	
26: Geotechnical risk mitigation plan in proposal	2	1		1	2	
26: Correct weight of geotechnical issues	2	1		3	2	
27: formal Partnering process on DB projects?	Yes	No		Yes	Yes	
28: payment provisions DB projects?						
28: Lump sum	X	X		X	X	
28: Lump sum GMP						
28: Unit price GMP						
28: Unit price						
28: Cost reimbursable						
28: Combo lump sum and unit prices						
29: Does your agency use the GBR as a contract document?	No	Yes		No	Yes	
30: Do you provide/require geotechnical design criteria	Yes	Yes		Yes	Yes	
30: If yes: please specify	Preliminary geotech report and special requirements	We require them to follow everything in the RFP and our MOI. AASHTO is heavily referenced.			GDM and special requirements	
31: Do you provide/require geotech performance criteria	No	Yes		No	Yes	
31: If yes: please specify		Settlement warranty criteria (2-5 years).			deflection criteria for floating bridge anchors, settlement caused by tunneling or excavations.	
32: performance verification for geotechnical?		Yes			Yes	
32: If yes: please specify the types2		Yes for settlement.			Inclinometers, vibration measurements and deformation measurements	
33: geotechnical differing site conditions clause?	Yes	Yes		Yes	Yes	
34: If Yes, claim result in a compensable change order?	Occasionally	Usually		Never	Occasionally	
35: What document,define a differing geotech site condition?						
35: Geotechnical information contained in RFP	X	X		X	X	
Question 35: GBR contained in RFP		X			X	
35: GDR produced by design-builder						
35: Contract differing site conditions clause definition only	X					
35: No document						
35: Other, please specify						
36: warranties the geotechnical features?	No	Yes		No	Yes	
36: If yes: please specify					1 year general warranty	
37: incentives geotechnical risks and rewards?	No	No		No	No	

1: State:	TX	UT	VT	VA	WA	WY
38: major claim geotechnical issue on DB project?		Yes			No	
38: If yes:describe		Several				
39: different QA program for DB projects than DBB projects?	Yes	No		No	Yes	
40: Who does the following						
40: Technical review of construction shop drawings						
40: Does not apply						
40: Agency personnel		X		X	X	
40: Designer's staff	X	X		X	X	
40: DB's construction staff		X		X		
40: Agency hired consultant	X	X		X		
41: Tech review material submittals						
41: Does not apply						
41: Agency personnel		X		X		
41: Designer's staff	X	X		X	X	
41: DB's construction staff		X		X		
41: Agency hired consultant	X	X		X		
42: Checking of pay quantities						
42: Does not apply						
42: Agency personnel		X		X		
42: Designer's staff		X			X	
42: DB's construction staff	X	X		X		
42: Agency hired consultant	X	X		X		
43: Routine construction inspection						
43: Does not apply						
43: Agency personnel		X		X		
43: Designer's staff				X	X	
43: DB's construction staff	X	X		X	X	
43: Agency hired consultant		X		X		
44: Quality control testing						
44: Does not apply						
44: Agency personnel		X		X		
44: Designer's staff				X	X	
44: DB's construction staff	X	X		X	X	
44: Agency hired consultant		X		X		
45: Verification testing						
45: Does not apply						
45: Agency personnel		X		X	X	
45: Designer's staff				X		
45: DB's construction staff		X		X		
45: Agency hired consultant	X	X		X		

Table continued from preceding page

1: State:	TX	UT	VT	VA	WA	WY
46: Acceptance testing						
46: Does not apply						
46: Agency personnel	X	X		X		
46: Designer's staff				X		
46: DB's construction staff		X		X	X	
46: Agency hired consultant	X	X		X		
47: Independent assurance 2						
47: Does not apply						
47: Agency personnel		X			X	
47: Designer's staff						
47: DB's construction staff		X				
47: Agency hired consultant	X	X		X		
48: Approval of construction post-award QA plans						
48: Does not apply						
48: Agency personnel		X		X	X	
48: Designer's staff						
48: DB's construction staff		X				
48: Agency hired consultant	X	X		X		
49: punchlist						
49: Does not apply						
49: Agency personnel	X	X		X	X	
49: Designer's staff	X	X		X	X	
49: DB's construction staff	X	X		X	X	
49: Agency hired consultant	X	X		X		
50: final quality of geotechnical work on DB projects compared to DBB	Same	Worse		Same	Same	
52: evaluate the d performance quality for future DB selections?	No	No		Yes	No	
53: If Yes, do you believe performance rating creates an incentivequality?				Yes		
54: rate impact on the final quality of the DB project						
54: Qualifications of the DB’s geotechnical staff	1	2		1	2	
54: DB’s past experience with geotechnical issues	2	2		2	3	
54: Quality management plans	3	3		3	3	
54: Level of agency involvement in the QA process	3	2		3	2	
54: Use of agency geotech specs/design details	3	2		3	1	
54: Amount of geotech info in procurement docs	2	2		2	1	
54: Use of geotech performance criteria/specs	2	2		2	2	
54: Early contractor involvement in geotech design	1	4		2	2	
54: Agency interactivity during proposal phase	3	5		3	4	
54: Agency interactivityduring design phase	3	1		3	2	
54: Warranty provisions	3	3		3	3	
55: significant geotech issues with your DB proj?	No	Yes		No	No	

APPENDIX B

Missouri Dot Sample Request for Qualifications for Emergency Slope Repair/Stabilization Design-Build Project

The sample RFQ was developed by Kevin McClain, PE of the Missouri DOT as part of his master's thesis in construction engineering at Iowa State University (McClain 2008). Mr. McClain is geotechnical engineer at MoDOT.

Introduction

The Missouri Department of Transportation (MoDOT) issues this Request for Qualifications (RFQ) to seek design-build teams to perform emergency slide repairs and/or slope stabilization for state roads and Interstates. The purpose of the RFQ is to short-list or prequalify design-build teams. Prequalifying teams before a roadway slide occurrence will give MoDOT a list of qualified design-build (d-b) teams that can design and construct economical and innovative slope repairs. The prequalifying of d-b teams will also save valuable time in the procurement and selection process, because time is a valuable asset to the public as well as the department. Design-build offers the opportunity to provide greater innovation and more productivity generated by both design and construction than design-bid-build. Design-build also provides the opportunity for savings in project delivery time.

Slide repair projects picked for design-build will be projects that fit the following criteria:

1. Slides that have taken out the roadway or rendered it unsafe for the public to continue to use the roadway in a high traffic volume area where detours are deemed too long and time consuming to the public.

2. The slide requires technical or unique design and construction, such as tiebacks, soil nails, secant or tangent walls, etc. Conventional slide repairs or slope stabilization will not work due to foundation conditions, terrain, limited right-of-way, adjacent streams, railroads, or other structures.

Design-build teams for slope repairs/stabilization can consist of the following:

1. General Contractor/Geotechnical Specialty Contractor/Engineering Consulting Firm

2. General Contractor/Geotechnical Specialty Contractor/Geotechnical Engineering Consulting Firm

3. Geotechnical Specialty Contractor/Engineering Consulting Firm

4. Geotechnical Specialty Contractor/Geotechnical Engineering Consulting Firm

5. Geotechnical Specialty Contractor (with a design department or element)

6. Integrated design build firm (with experience in slide repair/slope stabilization).

Note: Plans and design calculations for future RFPs must be stamped by a Professional Engineer registered in the state of Missouri.

Submitting Proposals
Sealed submittals should be marked:
Statement of Qualification
Slope Repairs and Stabilization
PO Box 270
Jefferson City, Missouri 65102

Proposals should be submitted by (**date**). The sealed submittal shall contain one original Statement of Qualification (SOQ) with seven copies of the SOQ. The Introductory letter shall contain the signature of a design-build team member who is authorized to represent the team and obligate the team to the SOQ. By submitting an SOQ the design-build team becomes bound to the requirements in the SOQ. Faxed submittals will not be accepted. Proposers must submit the SOQ in writing and must respond to the entire requirement stated in the RFQ.

Requirements for Content in Statement of Qualification

SOQ format, style, and length
A
SOQs shall be organized as follows:

Letter of introduction

1.1 Joint Team and Individual Company's Experience in Slope Repair/Slope Stabilization
1.2 Design-Build Experience of the Team
1.3 Organization of the Team Explaining Primary Roles and Paths of Communication
1.4 Regional Experiences
1.5 Safety Record/Program
1.6 Incidents of Litigation and/or Dispute
1.7 Compliance with MoDOT DBE Requirements

The stated criteria in the SOQ should be concise and succinct. Lengthy narrative with extraneous information is discouraged. The Submittal must be formatted for 8.5" x 11" paper. Minimum font size is 11 point; however, 10 point text may be used within graphs or tables. Charts and other graphical information may be placed in foldouts not to exceed 11" x 17".

Letter of Introduction

The letter of introduction shall contain the following information:

1. The design-build team's interest to have the potential to propose on future MoDOT slide repair projects chosen for design-build.

2. Statement disclosing receipt of all RFQ addenda if issued.

3. Statement that the key personnel noted in the SOQ are dedicated to meet MoDOT schedule and quality expectations.

4. Statement that all entities in the design-build team will comply with MoDOT's DBE requirements and MoDOT's non-discrimination policy.

5. Statement that the design-build team will comply with all applicable local, state, and federal laws.

Scored Evaluation Criteria

Key Personnel and Processes (500 Points)

1. Describe in detail the organizational structure of the design-build team and entities that compose the team. Provide details of the teaming arrangement and lines of communication. Also state any team members who will have financial responsibility for future slide repair or slope stabilization projects, along with liability limitations.

2. Identify the following key personnel in the design-build team.

    - **Design-Build Project Manager**—State the person who will be responsible for aspects of the project that includes but is not limited to overall design, construction, contract administration, quality assurance and quality control, and public information. State the person's authority within the design-build team. Discuss previous slide repair/slope stabilization projects for which the person acted as a design-build project manager.
    - **Design Project Manager or Engineer**—State the person who will be responsible for the design of the project and ensuring that it is complete and that it meets all design requirements. State similar experience the person has had in slide repairs or slope stabilization projects. List the relevant experience, professional registrations, education and other qualifications that are relevant to slide repair and slope stabilization. Identify the person's experience working with state, federal or AASHTO regulations or guidelines.
    - **Construction Project Manager**—State the person or persons who will be responsible for construction of the project. List slide repair project and/or slope stabilization projects in which the person had duties as Construction Project

Manager. Discuss other experience, professional registrations, education and other qualifications. State the person's experience in construction inspection, quality control and quality assurance and materials testing.
- **Project Engineer and/or Other Key Personnel**—State other key members of the design-build team. State experience in slope repair and/or slope stabilization projects. Also state experience working with state, federal, and AASHTO specifications and guidelines.

3. List any specialized equipment and techniques used to construct slide repairs and slope stabilization projects.

4. List methods the design-build teams have for schedule "crashing" to attain planned completion dates.

MoDOT Scoring Criteria

A. The design-build team's organizational chart and organization description clearly depict the structure and paths of communication between members of the team. Lines of management and responsibility are clearly shown, demonstrating that the design team can design and construct slope repairs and slope stabilization quickly and within a reasonable budget. **(200 Points)**
B. The design-build team's financial statement, staffing, specialized equipment and techniques exhibit that the team can effectively design and construct slope repairs and slope stabilization projects. **(150 Points)**
C. Key personnel demonstrate experience on slope repairs and slope stabilization projects. **(75 Points)**
D. Key personnel demonstrate unique qualifications to design and construct slope repairs and stabilization projects. **(75 Points)**

Design-Build Teams Past Performance (200 Points)

1. List recent work history on the Slope Repair/Stabilization Experience form in Exhibit B. If the team is organized just to design and construct MoDOT slide repairs, list slope repair/slope stabilization project completed by each firm in the team for the last 5 years. Include a contact name, current address, telephone number(s) and fax number.

2. Provide examples where the design build team and/or individual firm have completed projects ahead of schedule and / or below budget. Explain how this was accomplished.

MoDOT Scoring Criteria

A. The design-build team and member firms have demonstrated management and organizational capability to effectively design and construct slope repair projects. **(100 Points)**
B. The design build team and or member firms have shown, in completing past slope repair and slope stabilization projects, little or no schedule growth with methods to avoid or work around delays. **(100 Points)**

Quality Control Program (150 Points)

- List design-build team's and/or member firms' guidelines and procedures for quality control and quality assurance. **(75 Points)**
- The experience level of the design-build teams and/or member firms exhibit sound QC/QA procedures that produce quality projects. **(75 Points)**
- Design and Construction Managers experience have shown excellent QC/QA practices and methods. **(75 Points)**

Safety Program (150 Points)

1. Provide a summary overview of the design-build team's safety program.

2. Describe construction side of the design-build team's safety record during construction for the last five years. List all OSHA safety violations or citations. Submit the name and experience of the design-build team's safety officer.

A. Design-build team and member firms possess an established and successful safety program. **(60 Points)**
B. Design-build team and member firms have a minimum of lost time accidents. **(50 Points)**
C. Design-build team's safety officer has adequate experience to manage the team's safety program. **(40 Points)**

Disadvantaged Business Enterprises

As a recipient of federal funds, MoDOT is required to comply with Title VI of the Civil Rights Act of 1964 which states:

"No Person in the United States shall, on the grounds of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

So MoDOT hereby notifies all potential design-build teams for slope repair/stabilization projects, Disadvantaged Business Enterprises will be provided full opportunity to submit SOQs and will not be discriminated against on the grounds of race, color, sex, or national origin in consideration for prequalifying design-build teams for the purpose of designing and constructing slope repairs.

Changes in Key Personnel or Firms within a Design- Build Team

MoDOT requires the design-build team to resubmit the SOQ with all pertinent changes of personnel and firm changes. The SOQ will be reevaluated to keep the design-build team on the active prequalified list for slope repair/stabilization design-build projects.

Statement of Qualification Evaluation and Short Listing

Submitted Statements of Qualifications are checked to determine if the SOQ is responsive. MoDOT may exclude any SOQ that is not responsive to the RFQ. MoDOT will then evaluate and score the SOQ accordingly by a Technical Review Committee (TRC) composed of representatives from MoDOT Divisions or Sections that will be engaged in the slide repair or slope stabilization process. The scored SOQ must receive a minimum score of 750 points to qualify for team short listing.

Confidentiality and Security

Due to the need for absolute confidentiality, all documents related to the prequalification process shall be stored in a locked room and cabinet during non-work hours. Prequalification documents will not be available to the public or MoDOT employees not involved in the prequalification process.

Exhibit A: Design-Build Team Information

Name of Design-Build Team: ______________________________

Year Established: ______________________________

Federal Tax ID No.: ______________________________

Contact Person for the Design-Build Team: ______________________________

Contact Telephone No.: ______________________________

Fax No.: ______________________________

Authorized representative to bind the D-B team: ______________________________

Title: ______________________________

1. Business Organization Type (check one):

☐ Corporation. Year and state of incorporation ____________________
(Complete Sections 1–6)

☐ Partnership (Complete Sections 1–6 for each member.)

☐ Joint Venture (Complete Sections 1–6 for each member.)

☐ Other (describe): ______________________________
(Complete sections 1–5 for each member.)

2. Design-Build Team Office Address: ____________________

3. Bonding Capacity:

   Total: ____________________ Available: ____________________

4. If the design-build is a joint venture, partnership, or other type of joint organization, state the name, role and amount of financial liability of each firm of the D-B Team. Provide the information requested below.

   Member Firm Name | Role | Financial Liability

5. Are any of the member firms of the design-build team under investigation from federal government or any state agencies?

   If, yes explain the situation:

   I certify the information contained in the Exhibit is true and correct, and I am the design-builds team's Official Representative and Respondent:

   By: ____________________

   Print ____________________

   Name: ____________________

   Title: ____________________

   Date: ____________________

Exhibit B—Slope Repair/Stabilization Experience

Firm Name: ____________________

Indicate one: ____________________

Integral or Self Contained Design-Build Firm ____________________

Construction Firm ____________________

Design Firm ____________________

Provide information on slope repair or slope stabilization projects from the last five years. If the design-build team is specifically organized to design and construct slide repairs on MoDOT projects, then each member firm shall provide design or construction information on slope repair/stabilization projects. Also include total project costs with change orders and claims issued by the firm(s). Please include contact name, current address, telephone number(s), and fax number of each project listed. Additional sheets may be used if necessary.

Abbreviations used without definition in TRB Publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETY-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

TRANSPORTATION RESEARCH BOARD
500 Fifth Street, N.W.
Washington, D.C. 20001

ADDRESS SERVICE REQUESTED

THE NATIONAL ACADEMIES™

Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org

ISBN: 978-0-309-22356-0
90000
9 780309 223560