A PROJECT DELIVERY SELECTION MATRIX FOR HIGHWAY DESIGN AND CONSTRUCTION

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ABSTRACT

Determining an appropriate delivery method for highway projects is a complex decision. This paper presents a decision support approach to assist highway agencies in evaluating and selecting the most suitable delivery method for their projects. The approach uses a matrix to consider three fundamental delivery methods currently in use by the highway industry: design-bid-build (DBB), design-build (DB), and construction manager/general contractor (CM/GC). The approach, which is in use by the Colorado Department of Transportation (CDOT), includes four primary selection factors (delivery schedule, complexity and innovation, level of design, and initial project risk assessment) and four secondary selection factors (cost, staff experience/availability, level of oversight and control, and competition and contractor experience) in the delivery decision. The research identified these eight selection factors, along with opportunities and challenges for each delivery method, through literature and tested through discussions and workshops with innovative contracting leaders from the CDOT, the Federal Highway Administration (FHWA), the American Council of Engineering Companies (ACEC), Associated General Contractors of America (AGC), and the University of Colorado. The approach enables an initial risk assessment to occur early in the project development process and prior to the project delivery decision. The project delivery selection matrix promotes a better understanding of project goals, risks, opportunities, and enhances alignment among project participants. The approach has been successfully tested and implemented through eight projects of varying scope throughout Colorado. This paper presents the project delivery selection matrix along with an illustrative case study to demonstrate the results. The research provides a defensible and repeatable process for highway agencies to select an appropriate delivery method for their projects.
INTRODUCTION AND BACKGROUND

The demand to deliver highway design and construction in less time under limited budgets has resulted in governments adopting alternative methods of contracting and delivering highway projects. Currently, highway agencies often use three fundamental project delivery methods: design-bid-build (DBB), design-build (DB), and construction manager/general contractor (CM/GC). Although federal, state, and local agencies are familiar with DBB and have a breadth of expertise and staffing to execute this delivery method, DBB can present challenges to important project objectives, such as meeting a short project delivery date. The Federal Highway Administration’s (FHWA) Every Day Counts initiative notes that DBB highway projects can take up to 13 years to deliver. The FHWA cites the separation of design and construction processes as a barrier along with the potential for claims and disputes.

Research shows that DB and CM/GC reduce time and costs on highway projects. A report to Congress by the FHWA summarizes the performance of DB projects stating that on average DB projects may reduce overall project duration by 14%, decrease the total cost by 3%, maintain the same level of quality, and lessen the number of change orders as compared to DBB projects. Gransberg and Shane also show that the major advantages of CM/GC include better constructability, real-time construction pricing capability, implementation speed, the ability to implement new and innovative technologies, and the ability to create an environment with rich collaboration. As a result, many state departments of transportation (DOTs) have explored alternative delivery methods including both DB and CM/GC over the last decade. By 2011, 44 states had full authorization to use DB, and 14 states have full authorization to use CM/GC. The FHWA initiated the Every Day Counts program in 2010, with a focus on DB and CM/GC, to accelerate technology and innovation deployment and deliver timely transportation projects to the public.

While there is an increasing trend to use alternative delivery methods in highway projects, the DB and CM/GC delivery methods are relatively new to the industry. For example, the FHWA still considers CM/GC to be experimental and state DOTs must request FHWA approval to use this delivery method when using Federal funds. A recent NCHRP study, Construction Manager-at-Risk Project Delivery for Highway Programs, found that only three states have experience delivering projects with CM/GC. Similarly, less than half of the state DOTs have experience using DB for their highway projects on more than 10 projects although the FHWA provides a framework of Federal rules for DB projects.

RESEARCH MOTIVATION

The selection of an appropriate delivery method is a complex decision process. The decision should be made in the project scoping phase and certainly before the final design phase begins. While the purpose and need are clear in the scoping stage, there is a lack of definition in the details of the project design. Furthermore, highway design and construction projects are often fraught with risk and uncertainty at this early point in project development. In this environment, selection of the appropriate project delivery method can be critical for project

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success. Research has shown that an appropriate project delivery method can enhance the probability of meeting project goals and objectives (6). This research has also shown that no single delivery method is right for all projects. However, there exists an optimal delivery method for each individual project (7, 8).

Currently, a standard framework for selecting highway project delivery methods does not exist. The AASHTO Guide for DB procurement (9), published in 2008, provides state highway agencies with strategies and methods for successful DB implementation, including the preparation of requests for qualifications (RFQ) and requests for proposals (RFP) and the selection of a qualified proposer. This guide suggests a four-step approach to obtaining successful DB projects including defining project goals, allocating risk, planning the evaluation, and writing the contract documents. However, it falls short of providing detailed selection guidance.

Recent Transit Cooperative Research Program (TCRP) and Airport Cooperative Research Program (ACRP) projects propose similar project delivery selection approaches for transit and airport projects (6, 14). The TCRP approach includes a set of 24 pertinent issues that influence the project delivery decision for transit projects. The approach categorizes factors in five groups including project-level issues, agency-level issues, public policy/regulatory issues, life cycle issues, and other issues. This study concludes that shortening the project schedule, encouraging innovation, improving risk allocation, and early contractor involvement have the greatest impact on the project delivery decision for transit agencies. Based on the results from the TCRP approach, the ACRP study uses essentially the same factors as the TCRP study (it adds operation, flow of passengers, and security issues). In addition, the ACRP study indicates that the majority of pertinent issues affecting the delivery selection process for airport projects are similar to the 24 pertinent issues in transit projects. It is important to note that although these studies investigated issues that affect the delivery selection process for transit and airport projects, they did not address highway-related projects specifically. It should also be noted that these studies promote a process that may take days for a project team to discuss.

Building upon the previous work in the transit and airport approaches and the need for a highway project delivery selection process, this paper presents a project delivery selection matrix for highway design and construction projects. The paper summarizes a concise and defensible process for agencies to select an appropriate highway project delivery method and presents a case study to demonstrate the process.

RESEARCH APPROACH
The research method for this study primarily includes four steps. First, the research identified project delivery selection factors through a literature review. Second, these selection factors were distilled to critical selection factors through industry input. Third, the critical factors formed the basis of a decision matrix that supports a project team evaluation and decision. This preliminary decision matrix was tested and calibrated on several projects. Finally, based on the results from the testing process, the research established the final selection matrix.
Project Delivery Selection Factors

The selection of a project delivery method depends upon many factors. This research identified factors through a comprehensive literature review and professional experience. Two workshops were conducted to validate these selection factors as well as to develop and implement the framework. The first workshop, which included a group of 27 members from CDOT, FHWA, the American Council of Engineering Companies (ACEC) and the Associated General Contractors of America (AGC), each providing individuals with more than 10 years professional experience in delivery methods, reviewed the factors for inclusion in the project delivery matrix. The workshop attendees consisted of project directors, program and project managers, and private owners. The outcome of this workshop was a distillation of comprehensive factors from the literature to those that are most relevant to the highway project delivery selection.

The workshop was carried out in two, four-hour sessions. The first session determined the critical selection factors. The second session identified opportunities and challenges for each delivery method corresponding to the factors. Through these two sessions, the workshop determined 13 selection factors that have a major impact on the delivery selection for highway projects. Next, the information collected from this workshop was distributed to all members for individual review and comments. After rigorously analyzing comments and suggestions, the workshop participants agreed on consolidating five overlapping factors from the 13 selection to streamline the process. As a result, the eight selection factors and associated opportunities and challenges for each delivery method were included in the selection matrix for further testing.

To validate the result of the first workshop, the second workshop was conducted to discuss the updated information for the project delivery selection factors three month later. The majority of participants in this workshop also participated in the first workshop. The result of the second workshop reached a strong consensus that the eight selection factors identified from the first workshops were sufficient to include in the delivery selection matrix approach for highway projects. The outcomes from the two workshops encompassed a checklist of general opportunities and challenges of the eight selection factors associated with each project delivery method.

The eight selection factors were classified into two groups: primary and secondary factors. The project team evaluates the primary factors first before evaluating the secondary factors. The eight primary and secondary delivery selection factors are described briefly below.

- Primary project delivery selection factors:
  1. **Delivery schedule**—the overall project schedule from scoping through design, construction and opening to the public;
  2. **Complexity and innovation**—the need for applicability of new designs or processes to resolve complex and technical issues;
  3. **Level of design**—the percentage of design completion at the time of the project delivery procurement; and
4. **Initial project risk assessment**—the process of preliminarily quantifying the risk events to ensure the selection of a delivery method that properly addresses them. The objective of evaluating this factor is to ensure that the project team becomes aware of risks associated with each delivery method. In some cases, this factor will obviously result in eliminating a project delivery method.

- **Secondary project delivery selection factors:**
  
  5. **Cost**—the financial process related to meeting budget restrictions, accuracy of cost estimation, and the control of project costs;
  
  6. **Staff experience / availability**—owner staff experience and availability to execute the project delivery methods under consideration;
  
  7. **Level of oversight and control**—the level of and manner in which the owner exercises control over design and construction processes; and
  
  8. **Competition and contractor experience**—the level of competition, experience and availability in the market place and its capacity for the project.

The critical step in the project delivery selection approach is to evaluate opportunities and challenges in relation to the project delivery methods. Based on the project conditions and constraints, the project team should analytically evaluate eight selection factors corresponding to the three different project delivery methods. This process is the core of the project delivery selection matrix approach, which is discussed in detail below.

**Development of Project Delivery Selection Matrix**

The philosophy of the delivery selection matrix approach is simple and rational, but comprehensive and objective in that it reflects the practices and the viewpoints of stakeholders. Figure 1 presents a flowchart of the delivery selection approach for highway projects. This approach encompasses three major stages: Stage 1—setting project goals and identifying project constraints, Stage 2—evaluating primary factors, and Stage 3—conducting a pass/fail analysis, and performing a complete selection matrix.
FIGURE 1 Project delivery method selection flowchart.
Stage 1 is perhaps the most crucial step in the delivery selection process. To determine an optimal delivery method, agencies must develop a clear and concise set of project goals to communicate important project characteristics. Understanding and having team alignment on project goals and constraints helps agencies identify opportunities and challenges in each delivery method. One should note that determining project goals and constraints is a key success factor, not only in the project delivery selection, but also in the development of procurement methods and the construction administration of a project.

In Stage 2, decision makers evaluate opportunities and challenges of each delivery method against three of the four primary factors: delivery schedule, project complexity and innovation, and level of design. If this evaluation process indicates an appropriate delivery method, agencies then perform an initial project risk assessment (forth primary factor) on that delivery method.

For Stage 3, based on the results from Stage 2, if the agency determines that the appropriate delivery method cannot properly allocate and manage project risks, then a risk assessment of the second most appropriate delivery method takes place. Once an appropriate delivery method is determined based on the risk assessment, a pass/fail analysis of secondary factors is performed to complete the entire project delivery selection matrix. The following sections discuss the procedure to perform a risk assessment in conjunction with the evaluation of the primary and secondary factors. At the completion of Stage 3, the agency usually has a single and clear choice for a project delivery method. If not, the decision makers will need to re-analyze all three stages more rigorously.

The risk identification and assessment process plays a pivotal role in the approach. In fact, all steps in Stages 2 and 3 involve risk assessments associated with each delivery method. A recent SHRP2 study, Project R09, “Guide for the process of managing rapid renewal projects,” (11) found that a formal risk management process is necessary to better understand and optimize project performance by anticipating and planning for potential risks. Nonetheless, this study also pointed out that the risk management process may be incompatible with some current DOT cultures. The risk management process (e.g., identifying and addressing potential problems and improvements) has rarely been integrated into the DOT’s goals for project and program delivery. Many DOTs do not have a strong commitment to perform the formal risk management process because they may have different ways to deal with potential problems. Conservative and risk averse DOTs often ignore risks because they are optimistic or they are afraid such acknowledgment will affect project approvals. Therefore, by emphasizing a risk assessment early in the project development process, the approach can enhance collaboration among project participants, improve DOT risk management cultures, and increase the project success.

**Project Delivery Selection Matrix**

Following the three-stage process shown in Figure 1, a project team completes the project delivery selection matrix by evaluating opportunities and challenges of each project delivery method against the four primary factors and then the four secondary selection factors. For a
given highway project, the process begins with blank forms for each of the eight selection
factors. First, in each selection factor, based on the project goals and constraints, the project
team members are asked to evaluate the first three primary selection factors regarding
opportunities and challenges and then perform an initial risk assessment associated with each
delivery method. Second, the project team members have to summarize their findings by rating
the delivery method as most appropriate (++) , appropriate (+) , least appropriate (−), fatal flaw
( X), and not applicable (NA). The project team should document their discussions throughout
the evaluation process.

To assist the project team in developing opportunities and challenges for each factor, the
matrix provides a checklist of general opportunities and challenges as an appendix. However, to
maximize the profits of the approach (e.g., understanding of procurement methods, construction
administration, and a risk analysis), the authors recommend that the project team members use
the blank forms and discuss their own views on opportunities and challenges before referencing
the factor checklists. The objective of the checklist is to ensure that the project team members do
not miss any important common issues in the evaluation process, but it is not an all-inclusive list.
Additionally, what might be an opportunity on one project may in fact be a challenge on another
project due to differing project goals and the overall complexity of the decision.

At the completion of Stage 3, the project team transfers the ratings of eight selection
factors to the delivery selection opportunity and challenge summary table — similar to what is
shown in Table 1 of the following section. Based on this table, the project team can select the
most appropriate delivery method. Finally, the project team documents the process and the
reasoning for the final decision, thereby creating a defensible delivery decision for justification
and later reference.

DELIVERY SELECTION: CASE STUDY
This research involved a thorough testing of the matrix with CDOT. Three initial pilot projects
were used to validate and calibrate the selection matrix during the summer of 2011. At the time
of writing this article, five more projects have employed the selection matrix, and the team has
captured lessons learned. The following section discusses one of the three pilot projects in detail
to illustrate the project delivery selection matrix approach.

Overview
CDOT has used the selection matrix on projects located throughout Colorado that vary in scope
attributes. Four of the projects are bridge replacement projects; one is a tunnel on an interstate
mountain corridor; one is an interstate interchange; and two are more complex congestion relief
projects with a variety of elements. The budget ranged from $5M up to $60M+. Of the eight
projects, all are currently either in design or early construction phases. To demonstrate the
selection matrix process, this paper summarizes one of the bridge replacement projects, the Illex
bridge replacement.
The Ilex bridge replacement project is currently a CDOT project in the planning and development phase. This project involves replacing the elevated southbound and northbound lanes of Interstate 25 that span across Ilex Street, Bennet Street, a railroad line, and several businesses in downtown Pueblo, Colorado. The project is a portion of the overall reconstruction plan of I-25 through the City of Pueblo. The project is estimated to cost $38M. As a condition of the funding, the project must be completed by May 2015.

Stage 1: Setting Project Goals
The selection matrix workshop team included members of CDOT, FHWA, the City and County of Pueblo, and the University of Colorado. In Stage 1, the team identified project constraints and created a list of project goals. The project team identified six project-specific goals:

- Minimize inconvenience to the public during construction;
- Maximize long-term performance and sustainability of the project;
- Maximize compatibility with ultimate I-25 improvements;
- Maximize public perception of a beneficial project for Pueblo, CO;
- Maximize the cost efficiency of the project while maintaining a high quality project, and
- Complete the project on schedule.

Stage 2: Evaluating Primary Factors
Upon completion of the project goals and constraints, the team evaluated the four primary factors. The following paragraphs discuss the impact of the three project delivery methods (DBB, DB, and CM/GC) on the four primary selection factors.

Delivery Schedule: The team started by evaluating the delivery schedule. Based on the developed project goals and constraints, it became apparent that two of these constraints affected the overall project schedule. First, design cannot begin in earnest before completion of a record of decision (ROD). The scheduled completion of the ROD is late Fall 2012. Second, the project must utilize the funds provided by May 2015, meaning construction has to be complete by that time. This means that the Ilex project has a design and construction delivery window of approximately two and a half years from the completion of the ROD to the required construction completion date of May 2015.

The team evaluated the delivery schedule factor across the three project delivery methods. For the traditional DBB method, it was determined that the linear DBB process of design, procure by bidding, and building of the project would not suffice for this project given the schedule constraints (12). Therefore, comparing with the DB and CM/GC delivery options, the workshop team marked DBB for project schedule as a “fatal flaw,” meaning that DBB was eliminated from the delivery selection process. The workshop team felt that they could not delay the project to complete the fill design. Additionally, it should be noted that if the agency and the
CM/GC cannot agree upon a guaranteed maximum price (GMP), the owner can revert to a DBB delivery. However, in this case study only DB and CM/GC delivery methods were considered in the remaining evaluation factors.

The results of the schedule factor evaluation indicated that DB provided more opportunities than challenges. This is because portions of the DB request for proposal can begin before the ROD is completed, and DB allows construction to begin before design is 100% complete (9). CM/GC could provide similar overlapping of design and construction with the use of phasing of the project (3). However, CM/GC would not allow construction procurement to begin before the ROD is complete, and CDOT and the contractor would have to establish a GMP, which often takes substantial completion of design. Although CM/GC allows the delivery to default to a conventional DBB process if the GMP cannot be resolved, the aggressive schedule could potentially prohibit the default DBB option as stated in the previous paragraph. Figure 2 summarizes the opportunities and challenges of each delivery method in terms of delivery schedule.

<table>
<thead>
<tr>
<th>1) Delivery Schedule Opportunities and Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESIGN-BID-BUILD</strong></td>
</tr>
<tr>
<td><strong>Opportunities</strong></td>
</tr>
<tr>
<td>• ..................................................................</td>
</tr>
<tr>
<td>• ..................................................................</td>
</tr>
<tr>
<td><strong>DESIGN-BUILD</strong></td>
</tr>
<tr>
<td>• Ability to start procurement before completion of ROD</td>
</tr>
<tr>
<td>• Project can be expedited after the ROD to meet completion date requirements</td>
</tr>
<tr>
<td><strong>CM/GC</strong></td>
</tr>
<tr>
<td>• Ability to start construction before entire design, ROW, etc is complete (i.e., phased design and construction)</td>
</tr>
<tr>
<td>• ..................................................................</td>
</tr>
<tr>
<td>• ..................................................................</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Delivery Schedule Summary</th>
<th>DBB</th>
<th>DB</th>
<th>CM/GC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Delivery Schedule</td>
<td>X</td>
<td>++</td>
<td>–</td>
</tr>
</tbody>
</table>

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FIGURE 2 Delivery schedule evaluation for the Ilex project.

Because of the schedule constraints and the overall ability of DB to shorten project delivery, the workshop team rated DB as the most appropriate project delivery method (“++” in Figure 2 summary) in terms of project schedule. In the same manner, CM/GC received the least appropriate rating (“−”), meaning CM/GC could be used, but the challenges would need to be addressed. Since DBB received a “fatal flaw” rating (“X”), DBB is no longer considered for further evaluation, and the team then focused only on DB and CM/GC.

Project Complexity and Innovation: In general, DB provides an opportunity for innovation through the RFP and best-value procurement processes, as well as the use of Alternative Technical Concept (ATC) processes (6). In the DB delivery method, because designers and constructors work together as a single entity (the design-builder), collaboration between the two entities helps to improve constructability by optimizing means and methods, and enhances innovation (9, 13). For this project, DB has the advantage of integrating contractor knowledge into the maintenance of traffic (MOT) requirements more easily than other delivery methods. However, the workshop team recognized that the DOT may have a challenge in communicating the technical requirements to the design-builder for MOT.

In evaluating CM/GC, the team identified that the opportunities included the option to provide a collaborative design process that would help to resolve MOT issues as well as collaboration throughout the design phase to improve design and reduce disputes associated with the design during construction. The team also identified two challenges corresponding to the use of CM/GC for this project. First, innovative ideas can add cost and time to the project. Second, the GMP has to be resolved to include any innovative ideas, and it has to be completed in time to meet the scheduling constraints of the project (3).

For those reasons, DB and CM/GC both received the rating of appropriate delivery method (+). Therefore, the project complexity and innovation factor was not a distinguishing factor for the Ilex bridge project delivery selection.

Level of Design: The level of design is considered primarily because DOTs often do not choose DB if design has progressed too far (ideally the level of design is at 30% or less to recognize the opportunities of DB delivery). DB provides opportunities for speed and innovation because design and construction activities are overlapped. The DB delivery method, in general, allows for development of only preliminary design and criteria before choosing a DB firm (12). This characteristic is beneficial for the Ilex project since substantial agency design cannot progress until after the ROD is complete, and the design-builder cannot be selected until this decision.

The workshop team then evaluated CM/GC in terms of level of design. The team agreed that CDOT has the opportunity to develop preliminary ideas and criteria prior to the completion of the ROD. This would allow procurement to begin as soon as the ROD is received. However, once the CM/GC firm is chosen and the design stage begins, the design is developed in
a traditional iterative process, which may increase the overall schedule of the Ilex project. As
the level of design advances, an overall project schedule may not be in place until CDOT and the
CM/GC firm agrees to and executes the GMP. If the GMP takes significant time to develop, this
may delay completion of the project, which is unacceptable based on the funding and time
constraints. On this project, the workshop team believed that DB provided more flexibility in
level of design and related issues than CM/GC. As a result, DB received a rating of most
appropriate (++) while CM/GC received a rating of appropriate (+). CM/GC could be a
potential delivery method, but DB ranked higher. Essentially, DB had fewer challenges and
more opportunities than CM/GC for level of design.

**Initial Risk Assessment:** Because highway design and construction projects can be very
complex due to risk and uncertainty, risk assessment and management is critical to improve
project performance and be able to make defensible and efficient project decisions (5). The
major benefits to conducting a risk assessment as part of the highway project development
process are to increase a project’s chances of meeting budgets and schedule objectives (6), and
encourage and support a risk analysis culture in the highway industry (11). Based on the results
of evaluating the three previous primary factors, the team decided to assess project risks relative
to the DB delivery method exclusively. One reason to assess only DB was that DBB was
removed as a potential delivery method for this project because of the first primary factor
evaluation, delivery schedule. In addition, although CM/GC is a potential candidate for this
project, DB provided more opportunities and fewer barriers than CM/GC regarding the first three
primary factors

To determine if the DB delivery method properly allocated and managed risk associated
with this project, the workshop team brainstormed and discussed critical aspects of the project.
This process resulted in a list of the most critical risks and the approach to manage them within
the DB delivery method. Table 1 summarizes the risk and associated approach developed by the
workshop team.

**TABLE 1 Initial Risk Assessment for DB Delivery**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazardous Materials:</strong></td>
<td>There is a high potential for hazardous waste contamination, however the specific nature and extent of the required mitigation is unknown. Advance investigations will be performed prior to the procurement process to better characterize the conditions. Then, through a force account format, CDOT will accept cost risks and the design-builder will be allocated schedule risk.</td>
</tr>
<tr>
<td><strong>Water Quality:</strong></td>
<td>Technical requirements are currently evolving with multi-jurisdictional differences creating design-builder risk. CDOT will accept the risk through developing a default design that the design-builder can rely upon. Then, the design-builder can accept risk</td>
</tr>
</tbody>
</table>
and propose a more cost efficient system through the Alternative Technical Concept (ATC) process, if desired.

Utilities: Risk of unforeseen utilities conflicts exist; typical conditions for transportation projects. CDOT will pursue advanced utilities investigations and agreements with utility agencies to minimize and allocate risks properly.

Railroad: Railroad coordination and agreements are required to construct bridge over the railroad. CDOT is in the best position to manage the railroad risk and will initiate railroad coordination and pursue development of railroad agreements.

Right of Way Acquisition: This risk will be time consuming, and may create schedule risk. CDOT will commence right of way acquisition immediately, well in advance of DB procurement. This risk is best managed by CDOT.

Third Party Design Approvals: The City of Pueblo design approvals will be necessary, with separate standards and processes, creating design-builder design risks. CDOT will work with the City of Pueblo to define project design standards, review processes, and review times that the design-builder will be allowed to rely on.

Based on the risk assessments, the project team believed that DB would allow all specific project risks to be properly managed and allocated to the proper party. From past experience, CDOT has worked through similar risks in previous DB contracts and believed that the risk allocation could be accomplished equitably and cost effectively for both CDOT and the design-builder. This result allowed the team to skip performing a risk assessment of CM/GC and to move on to Stage 3 of the selection approach.

Stage 3: Conducting a Pass/Fail Analysis and Performing a Complete Selection Matrix
With the decision to use DB apparent from the evaluation of the four primary factors, the team evaluated the four secondary factors with respect to DB on a pass/fail rating basis. This is done as a check to make sure DB suffices for all of the evaluation factors and does not result in a fatal flaw. If a fatal flaw occurs during the secondary factors evaluation for DB, the team would have to go back and evaluate CM/GC further.

Cost: The workshop team determined that design-builder collaboration and the best value ATC process provide for cost-efficient responses to project goals. In addition, cost for the project can be determined early in the design process (with the award of the design-builder) to have early budget certainty. The team determined DB and cost to be a “PASS.”
Staff Experience/Availability: Given CDOT’s DB project experience, the team quickly determined a “PASS” for this factor. CDOT has prior experience handling DB projects, and the local market provides good competition for the project.

Level of Oversight and Control: The team was very comfortable with the level of oversight and control for this particular project. The team had prior experience with over-the-shoulder DB design reviews and DB quality control/quality assurance processes. Thus, DB and level of oversight and control received a “PASS”.

Competition and Contractor Experience: DB passed the competition and contractor experience with the knowledge that the market would allow for high competition. The prior DB experience of CDOT means the agency knows DB firms that have experience with DB and highway projects.

Table 2 summarizes the results of the evaluation factors for DBB, DB, and CM/GC. The ratings for each method are described in the previous paragraphs.

TABLE 2  Ilex Bridge Replacement Project Results

<table>
<thead>
<tr>
<th>Primary Factors</th>
<th>DBB</th>
<th>DB</th>
<th>CM/GC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Delivery Schedule</td>
<td>X</td>
<td>++</td>
<td>—</td>
</tr>
<tr>
<td>2. Project Complexity &amp; Innovation</td>
<td>NA</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3. Level of Design</td>
<td>NA</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>4. Initial Project Risk Assessment</td>
<td>NA</td>
<td>+</td>
<td>NA</td>
</tr>
<tr>
<td>Secondary Factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Cost</td>
<td>NA</td>
<td>PASS</td>
<td>NA</td>
</tr>
<tr>
<td>6. Staff Experience/Availability (Owner)</td>
<td>NA</td>
<td>PASS</td>
<td>NA</td>
</tr>
<tr>
<td>7. Level of Oversight and Control</td>
<td>NA</td>
<td>PASS</td>
<td>NA</td>
</tr>
<tr>
<td>8. Competition and Contractor Experience</td>
<td>NA</td>
<td>PASS</td>
<td>NA</td>
</tr>
</tbody>
</table>

Results and Discussion
The decision and associated workshop took four hours to complete, and the workshop team made a firm decision in selecting DB for the Ilex bridge replacement project. The selection matrix approach workshop exhibited that the project delivery selection matrix can be used effectively to determine a proper delivery method for highway projects. In the case of the Ilex project, DB was determined as the optimal delivery method. This decision was due in part to the condensed time frame of the project and the constraints on the design-development process.

Further testing of the matrix occurred on two other pilot projects and then was employed on an additional five projects. In all cases, the process lead to a logical and well documented
selection of the delivery method. These applications demonstrate that the selection matrix
approach provides highway agencies with a justifiable and repeatable process in selecting a
project delivery method.

CONCLUSIONS
The selection of the most appropriate delivery method for highway projects is a complex
process, and can be greatly affected by project goals and objectives and project conditions. No
single delivery method is suitable for all projects. Rather, highway agencies should evaluate the
unique characteristics of each particular project to determine which delivery method is the most
likely to produce the best outcomes.

The risk assessment and risk management plays a pivotal role in the success of highway
projects (5, 11). The proposed framework not only provides a defensible and repeatable delivery
selection process for highway agencies, but also drives DOTs to perform a risk assessment early
in the project development process. This will promotes a better understanding of DOT risk
management cultures and enhances collaboration among project participants. The traditional
DBB project delivery process can promote a risk adverse culture. Low bidding, complete
designs, and the use of prescriptive specifications, while effective, can inhibit contractor
innovation and extend project delivery time. Thorough risk identification and appropriate risk
allocation through alternative delivery methods can promote thoughtful risk taking that can result
in more efficient project delivery.

While the proposed approach provides a systematic process to help highway agencies
evaluate and select the most suitable delivery method for their projects, it has not been integrated
with a quantitative cost and schedule risk analysis and project performance. To address this
limitation, the authors suggest that future research should compare the differential costs and
schedules associated with the different delivery methods based on derived risk factors. Such a
comparison could be useful for developing a sound and defensible approach for selecting an
optimal delivery method for highway projects.

In addition, the proposed framework only addresses selection of the project delivery
method. To be effective, future development of the selection matrix requires including the
selection of procurement procedures and payment provisions. The type of procurement to use
and payment provisions to include relate directly to the selected delivery method as well as the
project goals and objectives. Therefore, selecting all three during project development using a
sophisticated tool would benefit all highway agencies.

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REFERENCES
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