Cost/Benefits of Constructibility Reviews

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INTRODUCTION

Constructibility, defined as the optimum use of construction knowledge and experience in the planning, design, procurement, and field operations to achieve overall project objectives, is the key concept that addresses both the “biddability” and “buildability” of transportation projects. Constructibility reviews, the focused effort to address issues relating to constructibility at planned stages in the development of transportation projects, are the key mechanism for insuring that plans and specifications fulfill these quality objectives. The constructibility review process (CRP), therefore, is recommended as an indispensable means toward achieving quality in the delivery of transportation projects.

Several state transportation agencies (STAs) have established procedures for conducting constructibility reviews, and the AASHTO Subcommittee on Construction has highlighted the features of many of these CRP programs in the Constructibility Review Best Practices Guide. Key elements for successful CRPs are outlined and various forms of each element are described to provide an overview of potentially effective options. Further information on CRPs can be found in NCHRP Reports 390 and 391 which provide background and demonstration of constructibility review concepts for STAs.

The critical concept behind constructibility reviews is the understanding that the early infusion of construction knowledge into the project development process (PDP) results in the greatest impact and the least disruption in terms of cost. Major oversights can be avoided, and therefore, the average numbers of addenda and contract changes can be drastically reduced. In addition, overall duration of project development—planning, design, and construction—is minimized. Finally, the win-win attitude that evolves from successful team building creates a highly beneficial inter-agency cooperation in the delivery of projects to the public, not to mention enhanced cooperation between functional units within the STA.
Rather than being a new and separate process, the CRP should be thought of as a framework for enhancing the quality of both the process and product of project development. When conducted properly, the CRP can be a tool in the hands of the transportation project manager to pace the development and review of the project. Furthermore, the focus of the plan reviews is properly extended to address total quality through the project life cycle. Projects are typically reviewed for constructibility as deemed appropriate at milestones in the PDP that roughly coincide with project design initiation and at 30%, 60%, and 90% design stages. The frequency of reviews is determined to match the size, complexity, and public impact of the project. The CRP provides project engineers with a mechanism for pacing the development of plans and specifications and for exploiting the interaction between numerous agency units through a coordinated team-building activity. The already busy schedules of all interested parties are ultimately less disrupted due to more effective use of their expertise.
The features of a CRP are straightforward and rather simple to comprehend, and a basic program can be initiated quite easily and expanded as an Agency’s knowledge base grows and new supporting tools become available. The CRP has four basic components that must be established for successful implementation and realization of the full range of potential benefits:

(1) a Constructibility Champion responsible for oversight, training, and documentation of lessons learned,

(2) recognition of the benefit of a quality-driven process in favor of a schedule-driven process,

(3) flexible guidelines for application of constructibility concepts at various levels of expertise, degrees of effort, and times in the PDP, and levels of resources, and

(4) effective incorporation of construction expertise.
THE CONSTRUCTIBILITY CHAMPION

The Constructibility Champion is a senior management level sponsor whose primary role is to maintain a high level of awareness and visibility of the constructibility program and to support implementation efforts at lower levels within the organization. This individual or office is essentially a keeper of institutional knowledge concerning CRP practice and is also responsible for its continued oversight. The institutionalization of the Champion signifies corporate commitment to the CRP and insures the long-term maintenance of the CRP. One responsibility of the Champion, in addition to providing implementation support, might be the conducting or coordinating of training in constructibility review concepts, procedures, and tools. Another might be the collecting and disseminating of lessons learned from past constructibility reviews.
A QUALITY-DRIVEN PROCESS

A major element in the corporate culture that facilitates effectiveness in the CRP is an emphasis upon a quality-driven PDP in favor of one that is schedule-driven. The CRP is a vehicle for the project delivery team to maintain schedule from concept through construction, and the focus on quality extends through maintenance. Incorporating constructibility ideas may sometimes call for changes which will add time to the design schedule. Assurance that the Champion has the authority to approve such changes, encourages the proper commitment of time to perform productive constructibility reviews. The message is conveyed that the standard for top performance is measured by quality in terms of biddability, buildability, and maintainability in the project rather than by merely meeting a predetermined schedule.
FLEXIBLE GUIDELINES FOR APPLICATION

Due to the broad variation in type, size, complexity, uniqueness, and public impact of highway transportation projects, it is essential that an agency’s CRP program be designed for flexibility. A formal (written) policy should be instituted that provides guidance on the application of constructibility concepts to suit various levels of expertise, degrees of effort, and levels of resources. Three important elements for which guidance is critical are (1) organization for constructibility reviews, (2) a scheme to classify projects for determining the appropriate frequency of constructibility reviews, and (3) tools to ensure thorough review.

Organization for Constructibility Reviews

As noted in the AASHTO Best Practices Guide, various approaches exist for establishing the constructibility review team. The most highly recommended approach, however, is to charge the Project Design Manager with the task of coordinating the CRP and to compose the constructibility review team from the various stakeholding units within the Agency, including construction and maintenance. Additional team members may come from cooperating agencies, design consultants, and construction professionals. The scheduled reviews are ideally executed with well organized meetings in the office or field. Alternatively, scheduled independent reviews might be coordinated by the team leader for simpler projects.
A Scheme for Determining Review Frequency

With regard to frequency of constructibility reviews, the most comprehensive scheme practiced among STAs is one that incorporates up to four milestone review points. The output of each review is a list of action items aimed at clarifying, correcting, or improving some aspect of the design to enhance biddability, buildability, and maintainability. The timing of these reviews is typically at (1) the project design initiation stage, (2) the 30% design stage, (3) the 60% design stage, and (4) the 90% design or final stage. These points roughly correspond to the following points in the time horizon of the PDP.

<table>
<thead>
<tr>
<th>Percent of Design</th>
<th>Design Tasks Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initiation</td>
<td>Approval of Scope</td>
</tr>
<tr>
<td>30</td>
<td>Completion of Geometrics Stage, i.e., determination of alignment, grade, and geometric features</td>
</tr>
<tr>
<td>60</td>
<td>Completion of Detailed Design, i.e., structure plans, drainage, traffic details, etc.</td>
</tr>
<tr>
<td>90</td>
<td>Completion of Final Design, i.e., plans and contract document development</td>
</tr>
</tbody>
</table>
The Project Design Manager or CRP Coordinator may determine the appropriate level of review for a given project. As the following table shows, the number of reviews may be modified to suit the size and type characteristics of the project.

<table>
<thead>
<tr>
<th>CRP LEVEL</th>
<th>TYPE OF PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1</strong></td>
<td>Design initiation, 30%, 60%, and Final reviews</td>
</tr>
<tr>
<td>• Major roadway/facility improvements</td>
<td></td>
</tr>
<tr>
<td>• Major, complex interchanges</td>
<td></td>
</tr>
<tr>
<td>• Major structures with complex or very high cost features</td>
<td></td>
</tr>
<tr>
<td>• Major preservation projects that involve widening, and replacement of existing structures, drainage features, etc.</td>
<td></td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td>Design initiation, 30%, and Final reviews</td>
</tr>
<tr>
<td>• All other roadway/facility improvements</td>
<td></td>
</tr>
<tr>
<td>• Major, less complex, structures and interchanges</td>
<td></td>
</tr>
<tr>
<td>• Preservation projects that involve widening, structure rehabilitation, new rights-of-way, or safety improvement, including roadside features</td>
<td></td>
</tr>
<tr>
<td><strong>Level 3</strong></td>
<td>Design initiation and Final reviews</td>
</tr>
<tr>
<td>• All other projects</td>
<td></td>
</tr>
</tbody>
</table>
Tools for a Thorough Review

Drawing upon the expertise of people constitutes the heart of a CRP, but the extraction of that expertise must be facilitated through CRP tools. Initiating a CRP does not require the development of expensive resources, however, just simple well-considered tools that aid in thorough reviews. CRP tools include checklists, documentation forms, and modeling methods.

Checklists

The success of the CRP relies upon thorough review that considers all the important aspects of the project with regards to constructibility and maintainability of the project. The basic tool common to all successful CRPs is a set of standard checklists designed to guide the constructibility review team through a thorough consideration of each element of the project design established at that stage. Checklists include such areas as roadway, structures, traffic, environmental, utilities, drainage, erosion control, signalization, signage, lighting, right of way, and landscaping. The Best Practices Guide provides samples from several states. Each STA and regional office should ideally design its own checklists that contain the level of detail suitable for its types of projects and operations. The Constructibility Champion should be involved in the development and periodic updating of these checklists.

Documentation Forms

Documentation of the reviews is critical to the ongoing success of the CRP. Methods of documentation can be as simple as meeting minutes, but forms designed for logging constructibility ideas are valuable not only for the current project but also for collecting lessons learned to be shared for future projects. Proven constructibility ideas might be maintained in a lessons learned database and/or disseminated by the Constructibility Champion in an agency newsletter.

Modeling

Modeling for the CRP could be either a graphical or physical mock-up of some portion(s) of the highway transportation project. The basic idea is to aid the reviewers in visualizing the outcome of design alternatives, in this case, relative to its impact on construction. Models can include 2-D drawings, 3-D computer modeling, computer simulations, and solid modeling or field mock-ups.
The CRP team can readily determine what is appropriate and cost effective for the project.

**EFFECTIVE INCORPORATION OF CONSTRUCTION KNOWLEDGE**

It is highly recommended that construction industry professionals be engaged to participate in constructibility reviews. The most effective approaches to accomplishing this objective have involved the state or local contracting associations in the invitation, and selection of participants from a list of volunteers from the construction industry. Contractor participation in the reviews does not have to preclude the contractor from bidding and should be made clear when communicating the STA’s CRP policy. Although retired contractors are sometimes hired as reviewers, the current knowledge of active contractors is ideal. Two chief benefits from engaging contractors are quality projects due to the inclusion of up-to-date construction knowledge and improved relations between the STA and the local contracting industry.

Many STA’s utilize various procedures to incorporate construction knowledge from contractors. The California Department of Transportation (CALTRANS), as an example, employs an alternative approach where contractors are invited to participate in the process of establishing, disseminating and promoting lessons learned. Contractors also participate in closeout meetings on projects and in liaison meetings between the STA and construction industry. CALTRANS has viewed this approach as a very effective way to include the best and latest construction information in the project development process.
Successful implementation of constructibility reviews on many projects is self-evident. That is, the savings derived from design modifications to facilitate constructibility are easily recognized as being much greater than the cost of the constructibility effort. Anecdotal cases of this sort can be found in several states, but measuring the routine costs and benefits of constructibility reviews is important to evaluating the effectiveness of an ongoing CRP program.

Constructibility Benefits for the SR520 Floating Bridge Project

The rehabilitation of the SR520 floating bridge, a critical link between Seattle and the Eastside, demonstrates an innovative constructibility review process with exceptional results. A storm in 1993 caused severe damage to the bridge, a vital link between two economic centers handling an average of 125,000 daily commuters. In order to fix the present damage and preclude future traffic disruption, the Washington State Department of Transportation (WSDOT) was faced with establishing more stringent performance criteria. Faced with this daunting task, WSDOT enlisted the expertise of KPFF consultants to head the engineering efforts. A constructibility review expert was contracted to join the design collaboration effort along with numerous other subconsultants and contractors. In addition to constructibility discussions during project team meetings, parties participating in the project design routinely considered constructibility in its daily evolution.

The KPFF design called for post-tensioning with 3,600 feet long tendons and 15 post-tensioning strands, a feat never before performed. KPFF and WSDOT collaborated to develop a full-scale mock-up demonstrating the installation process, inviting prospective general contractors to witness the procedural demonstration. For a cost of approximately $300,000, this full-scale mock-up reduced the risk to the contractor and WSDOT, and resulted in a construction bid $2.3 million under the engineer’s estimate. The collaboration with WSDOT, consultants, and contractors regarding constructibility issues allowed the project, originally budgeted for $20 million, to be completed for $8 million. The innovative tendon design also enabled construction to occur with the minimal traffic impact of only two weekend closures. Finally, the successful rehabilitation deferred the immediate need for an expensive replacement bridge and ensured the long-term viability of this vital transportation corridor.¹

This example demonstrates the tremendous impact of incorporating both ongoing and scheduled constructibility review procedures early in the design process to affect the success of a complex project. The cost items for constructibility review are difficult to capture beyond the consultant’s fee and the full-scale mock-up, but the greater magnitude of monetary benefits in contract price and the avoidance of negative user impacts speaks for itself.

¹ The Vital Link — Rehabilitating the Evergreen Point Floating Bridge (SR 520), a presentation of KPFF Consulting Engineers, and the Washington State Department of Transportation.
A BENEFIT/COST MODEL

A solid approach to measuring costs and benefits should recognize design and construction efficiencies that result from CRP implementation. Measurable benefits include reduced contract changes and more effective use of design time. With that rationale in mind, the benefit-cost model below may be applied to evaluate the CRP. Two case analyses follow and terms in the model are more fully explained in the glossary of this brochure.

\[
\begin{align*}
\text{Design Related Benefits} &= (\text{DCE}_{\text{med},i} - \text{DCE}) + \left(\frac{\text{DdurE}_{\text{med},i} - \text{DdurE}}{\text{Lday}_{\text{med}}}\right) \\
\text{Construction Related Benefits} &= \text{CCCS}_i + (\text{CCCE}_{\text{med},i} - \text{CCCE}) + \left(\frac{\text{CCDurE}_{\text{med},i} - \text{CCDurE}}{\text{Lday}_{\text{med}}}\right) + (\text{CECE}_{\text{med},i} - \text{CECE})
\end{align*}
\]

\[
\frac{B}{C} = \frac{\text{Design Related Benefits (DRB)} + \text{Construction Related Benefits (CRB)}}{\text{Design Related Costs (DRC)} + \text{Construction Related Costs (CRC)}}
\]

Design Related Costs = \text{DHExp} + \text{Travel} + \text{Tools} + \text{Misc.\%}

\[
\begin{align*}
\text{DHExp} &= \text{design-hour expenditures; person-hour CRP costs during design (dollars)} \\
\text{Travel} &= \text{costs attributed to field or remote office visits for constructibility reviews (dollars)} \\
\text{Tools} &= \text{major costs associated with tools dedicated to constructibility reviews such as computer modeling or mock-ups (dollars)} \\
\text{Misc.\%} &= \text{combined cost of minor expenses such as simple computing, record-keeping, copies, transmittals, etc. (dollars)}
\end{align*}
\]

Construction Related Costs = \text{CHExp} + \text{Travel} + \text{Tools} + \text{Misc.\%}

\[
\begin{align*}
\text{CHExp} &= \text{construction-hour expenditures—person-hour CRP costs during construction, including pre-construction and post-construction review (dollars)}
\end{align*}
\]

Cost /Benefits of Constructibility Reviews
CASE 1: CHANNELIZATION

PROJECT 1: SR20/PULVER ROAD
CHANNELIZATION PROJECT

Contract Number: 005313
Work Order Number: OL2535

Project Description: Collision reduction project to construct opposing left turn lanes and provide illumination at the SR20/Pulver Road intersection.

Project Cost: $831,252

Project Life Cycle:
  Design – 24 Months
  Construction – 39 Working Days

Responsibility for:
  Planning – Washington State Department of Transportation
  Design – Washington State Department of Transportation
  Construction – Strider Construction

Constructibility Review Meetings:
  Pre-design Meeting – 8 February 1996
  30% Review Meeting – 7 November 1996

B/C ratio: 2.29

Comparison Projects:
  005354 JCT SR 536 NB & SB Ramps
  005564 SR 530 NB & SB Ramps
  005671 Useless Bay Road
  005685 116th St NE, NB & SB Ramps
  005899 JCT SE 456th & E of Scatter CR
## CRP BENEFIT/COST WORKSHEET PART I
### (COSTS)

**Project Title:** SR20/PULVER ROAD CHANNELIZATION  
**Project Code/Contract No.:** 005313  
**Project Closeout Date:** November, 1999

<table>
<thead>
<tr>
<th>No.</th>
<th>Cost Item</th>
<th>Costs for Project Reviewed for Constructibility ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>DESIGN</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Design Person-Hour Expenditures for CRP</td>
<td>8,291.43</td>
</tr>
<tr>
<td>2</td>
<td>Travel</td>
<td>54.40</td>
</tr>
<tr>
<td>3</td>
<td>Tools</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Misc% (5% of design time cost)</td>
<td>10,464.70</td>
</tr>
<tr>
<td>5</td>
<td>Design CRP Cost (DRC)</td>
<td>(Sum 1-4) 18,810.53</td>
</tr>
<tr>
<td></td>
<td><strong>CONSTRUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Construction Person-Hour Expenditures for CRP</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>Travel</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>Tools</td>
<td>—</td>
</tr>
<tr>
<td>9</td>
<td>Misc% (XX% of const. admin. time cost)</td>
<td>—</td>
</tr>
<tr>
<td>10</td>
<td>Construction CRP Cost (CRC)</td>
<td>(Sum 6-9)</td>
</tr>
<tr>
<td>11</td>
<td><strong>TOTAL CRP COST</strong></td>
<td>(5+10) 18,810.53</td>
</tr>
</tbody>
</table>

### NOTES
1. Design (or Construction) Person-Hour Expenditures for CRP includes all time costs associated with CRP meetings, meeting preparation, and post meeting assignments.
2. Travel includes all trips made to the project specifically for constructibility reviews and significant travel that is necessary for some offices to participate in CRP meetings, e.g., bridge, materials, etc.
3. Tools include major computing expenses for method analysis unique to the project and other construction analysis methods such as solid modeling, mock-ups, or field trials.
4. Misc% include all other costs of minor size that are related to support of the CRP such as copies, transmittals, record-keeping, etc.

### Benefits to Design
- Early opportunity for designer to explain intent.
- Increase in the designer’s knowledge of current construction industry practices.
- Ability to gather input about the construction site without an official visit.
- Contract review with outside eyes.
- Updates on licensing and permitting issues.
- Reduction in design time.

### Benefits to Construction
- Early collaboration with the designer resulting in plan clarity.
- Pre-bid input regarding estimated working days, reasonable project staging, and scheduling timelines.
- Early opportunity to discuss future weather related issues that may affect the design or project execution.
- Decreased construction cost by $20K.
- Only 2 change orders logged (at no cost to the agency).

### Benefits to Maintenance
- Input into the design and construction of ponds as well as access to ponds by maintenance crews.
- Discussion of maintenance issues related to design aspects such as flat grades and slopes.
### CRP BENEFIT/COST WORKSHEET PART II (BENEFITS)

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>A Median for Pooled Projects</th>
<th>B Project Reviewed for Constructibility</th>
<th>C Factor(s) [$/day]</th>
<th>D Difference (A-B)xC [$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design Cost Escalation (DCE)</td>
<td>$54,715</td>
<td>$29,294</td>
<td></td>
<td>$25,421</td>
</tr>
<tr>
<td>2</td>
<td>Design Duration Escalation (DdurE)</td>
<td>0 days</td>
<td>0 days</td>
<td>(a)</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Construction Contract Cost Savings (CCCS)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>Construction Contract Cost Escalation (CCCE)</td>
<td>$6,434</td>
<td>$2,442</td>
<td></td>
<td>$3,992</td>
</tr>
<tr>
<td>5</td>
<td>Construction Contract Duration Escalation (CCDurE)</td>
<td>0 days</td>
<td>-1 days</td>
<td>(a)</td>
<td>$1,225</td>
</tr>
<tr>
<td>6</td>
<td>Construction Engineering Cost Escalation (CECE)</td>
<td>$8,806</td>
<td>$-3,623</td>
<td></td>
<td>$12,429</td>
</tr>
</tbody>
</table>

#### Design Related Benefits (DRB)

#### Construction Related Benefits (CRB)

**7 TOTAL CRP BENEFIT**

| Sum (1-6) | $43,067 |

*a = median per-day rate for liquidated damages for pooled projects = $1,225*

**Benefit/Cost Ratio**

\[
\frac{B}{C} = \frac{\text{TOTAL CRP BENEFIT (Section II, line item 7)}}{\text{TOTAL CRP COST (Section I, line item 11)}} = \frac{$43,067}{$18,810.53} = 2.29
\]

**Cost /Benefits of Constructibility Reviews**
CASE 2: DECK REPAIR AND SEISMIC RETROFIT

Project 2: SR513 - MONTLAKE 513/12 BRIDGE DECK REPAIR AND SEISMIC RETROFIT PROJECT

Contract Number: 005570
Work Order Number: OL2964

Project Description: Deck Repair and Seismic Retrofit of the Montlake Bridge

Project Cost: $2,633,507
Project Life Cycle:
  Design – 21 Months
  Construction – 182 Working Days

Responsibility for:
  Planning – Washington State Department of Transportation
  Design – Washington State Department of Transportation
  Construction – Guy F. Atkinson Construction Company

Constructibility Review Meetings:
  Pre-design Meeting – 17 February 1998
  30% Review Meeting – 2 June 1998
  70% Review Meeting – 4 August 1998
  Roundtable Meeting – 28 October 1998

B/C ratio: 2.10

Comparison Projects:
  005793 N FK Stillaguamish R BR.
  005397 BR. 5/525N-N, 599/1S-S& 509/119
  005527 Spokane St Overcrossing

Cost /Benefits of Constructibility Reviews
CRP BENEFIT/COST WORKSHEET PART I (COSTS)

Project Title: Montlake Bridge 513/12 Deck Repair and Seismic Retrofit Project
Project Code/Contract No.: 005570
Project Closeout Date: (last charged October, 2000)

<table>
<thead>
<tr>
<th>No.</th>
<th>Cost Item</th>
<th>Costs for Project Reviewed for Constructibility ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>DESIGN</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Design Person-Hour Expenditures for CRP</td>
<td>28,644.00</td>
</tr>
<tr>
<td>2</td>
<td>Travel</td>
<td>38.80</td>
</tr>
<tr>
<td>3</td>
<td>Tools</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Misc% (5% of design time cost)</td>
<td>10,350.00</td>
</tr>
<tr>
<td>5</td>
<td>Design CRP Cost (DRC)</td>
<td>(Sum 1-4) 39,374.80</td>
</tr>
<tr>
<td></td>
<td><strong>CONSTRUCTION</strong></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Construction Person-Hour Expenditures for CRP</td>
<td>—</td>
</tr>
<tr>
<td>7</td>
<td>Travel</td>
<td>—</td>
</tr>
<tr>
<td>8</td>
<td>Tools</td>
<td>—</td>
</tr>
<tr>
<td>9</td>
<td>Misc% (XX% of const. admin. Time cost)</td>
<td>—</td>
</tr>
<tr>
<td>10</td>
<td>Construction CRP Cost (CRC)</td>
<td>(Sum 6-9) —</td>
</tr>
<tr>
<td>11</td>
<td>TOTAL CRP COST (5+10)</td>
<td>$39,374.80</td>
</tr>
</tbody>
</table>

Notes
1. Design (or Construction) Person-Hour Expenditures for CRP includes all time costs associated with CRP meetings, meeting preparation, and post meeting assignments
2. Travel includes all trips made to the project specifically for constructibility reviews and significant travel that is necessary for some offices to participate in CRP meetings, e.g., bridge, materials, etc.
3. Tools include major computing expenses for method analysis unique to the project and other construction analysis methods such as solid modeling, mock-ups, or field trials.
4. Misc% include all other costs of minor size that are related to support of the CRP such as copies, transmittals, record-keeping, etc.

Benefits to Design
- Opportunity for collaboration with agencies such as METRO, city of Seattle, US Coast Guard, Seattle Harbor Patrol and University of Washington.
- Input from participating agencies regarding bridge closure, detour routes and overall construction scheduling to minimize impacts on vehicular and marine traffic.
- Early resolution of significant problems that may have arisen during project execution.
- Reduction in design time.

Benefits to Construction
- Opportunity to effect changes that minimize problems during construction and reduce the number of change orders.
- Pre-bid input regarding estimated working days, reasonable project staging, and scheduling time lines.
- Input into the development of a traffic control plan.
- Reduction of construction cost by $47K.

Benefits to Maintenance
- Opportunity to discuss issues of maintainability often overlooked during design.
- Input into the design of safe and convenient access to bridge components by maintenance crews.
- Input into the selection of replacement parts for bridge components.
# CRP Benefit/Cost Worksheet Part II (Benefits)

<table>
<thead>
<tr>
<th>No. Item</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Median for Pooled Projects</strong></td>
<td><strong>Project Reviewed for Constructibility</strong></td>
<td><strong>Factor(s) [$/day]</strong></td>
<td><strong>Difference (A-B)xC [$]</strong></td>
</tr>
<tr>
<td>1 Design Cost Escalation (DCE)</td>
<td>$2,347</td>
<td>$111,000</td>
<td></td>
<td>$ -108,653</td>
</tr>
<tr>
<td>2 Design Duration Escalation (DdurE)</td>
<td>0 days</td>
<td>-35 days</td>
<td>(a)</td>
<td>46,585</td>
</tr>
<tr>
<td>3 Construction Contract Cost Savings (CCCS)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>4 Construction Contract Cost Escalation (CCCE)</td>
<td>-556</td>
<td>-46,557</td>
<td></td>
<td>46,001</td>
</tr>
<tr>
<td>5 Construction Contract Duration Escalation (CCDurE)</td>
<td>-9 days</td>
<td>2 days</td>
<td>(a)</td>
<td>-14,641</td>
</tr>
<tr>
<td>6 Construction Engineering Cost Escalation (CECE)</td>
<td>$2,305</td>
<td>$ -110,926</td>
<td></td>
<td>113,231</td>
</tr>
<tr>
<td><strong>7 TOTAL CRP BENEFIT</strong></td>
<td></td>
<td></td>
<td><strong>Sum (1-6)</strong></td>
<td>$82,523</td>
</tr>
</tbody>
</table>

**Benefit/Cost Ratio**

\[
\frac{B/C}{C} = \frac{\text{TOTAL CRP BENEFIT (Section II, line item 7)}}{\text{TOTAL CRP COST (Section I, line item 11)}} = \frac{$82,523}{\$39,374.80} = 2.10
\]

a = median per-day rate for liquidated damages for pooled projects = $1,331

Cost /benefits of Constructibility Reviews
THE BOTTOM LINE

The benefits to be obtained from constructibility reviews are numerous and accrue at both the program and project level. The structured and well-coordinated review process supports team building and communication between functional units and other project stakeholders. Quality documents facilitate quality construction and good relations with the construction industry, and projects delivered cost-effectively without extended duration greatly enhance public image for the STA.
GLOSSARY OF TERMS

**Construction contract cost escalation (CCCE):** The increase of the construction contract award amount due to contract changes, claims, etc.

**Construction contract cost savings (CCCS):** The sum of the estimated cost savings in the contract award amount due to incorporating documented design alternatives developed through the CRP. Such alternatives may be either changes from initial design ideas or deviations from standard designs.

**Construction contract duration escalation (CCDurE):** The increase of the construction contract duration due to contract changes, claims, etc.

**Construction engineering cost escalation (CECE):** The difference between the actual and budgeted costs to administer the contract, including the cost of engineering associated with changes.

**Construction-hour expenditures (CHExp):** Costs of personnel time attributable to the CRP during the construction phase, including pre-construction and post-construction.

**Construction related benefits (CRB):** All cost savings attributable to the CRP during the construction phase of the project development process, including pre- and post-construction.

**Construction related costs (CRC):** The summation of costs incurred for the CRP during the construction phase of the project development process.

**Design cost escalation (DCE):** The increase in cost beyond the funds initially budgeted, i.e. the final design cost less the initial estimated design cost.

**Design duration escalation (DdurE):** The increase in time beyond the project design schedule initially estimated, i.e. the final design duration less the initial estimated design duration.

**Design-hour expenditures (DHExp):** Costs of personnel time attributable to the CRP during the planning and design phases.

**Design related benefits (DRB):** All cost savings attributable to the CRP during the planning and design phases of the project development process.
Design related costs (DRC): The summation of costs incurred for the CRP through the planning and design phases of the project development process.

Liquidated damages (Lday\textsubscript{med}): The median value of the liquidated damage rates for the pool of projects not reviewed for constructibility that are selected for comparison against the reviewed projects that are being analyzed. This value is used as a rate estimate of the cost of delaying the completion of the project due to escalation of the project design schedule.

\textbf{Miscellaneous (Misc\%):} Estimated separately as a percentage of either planning and design costs or construction administration/engineering costs, respectively, the total cost of communications and documentation associated with the CRP. Actual percentage should be estimated by the CRP coordinator or project manager.
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DISCLAIMER
The opinions and conclusions expressed or implied in the report are those of the research agency. They are not necessarily those of the Transportation Research Board, the National Research Council, the Federal Highway Administration, the American Association of State Highway and Transportation Officials, or the individual states participating in the National Cooperative Highway Research Program.

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