Quality Management Systems in Engineering Practice

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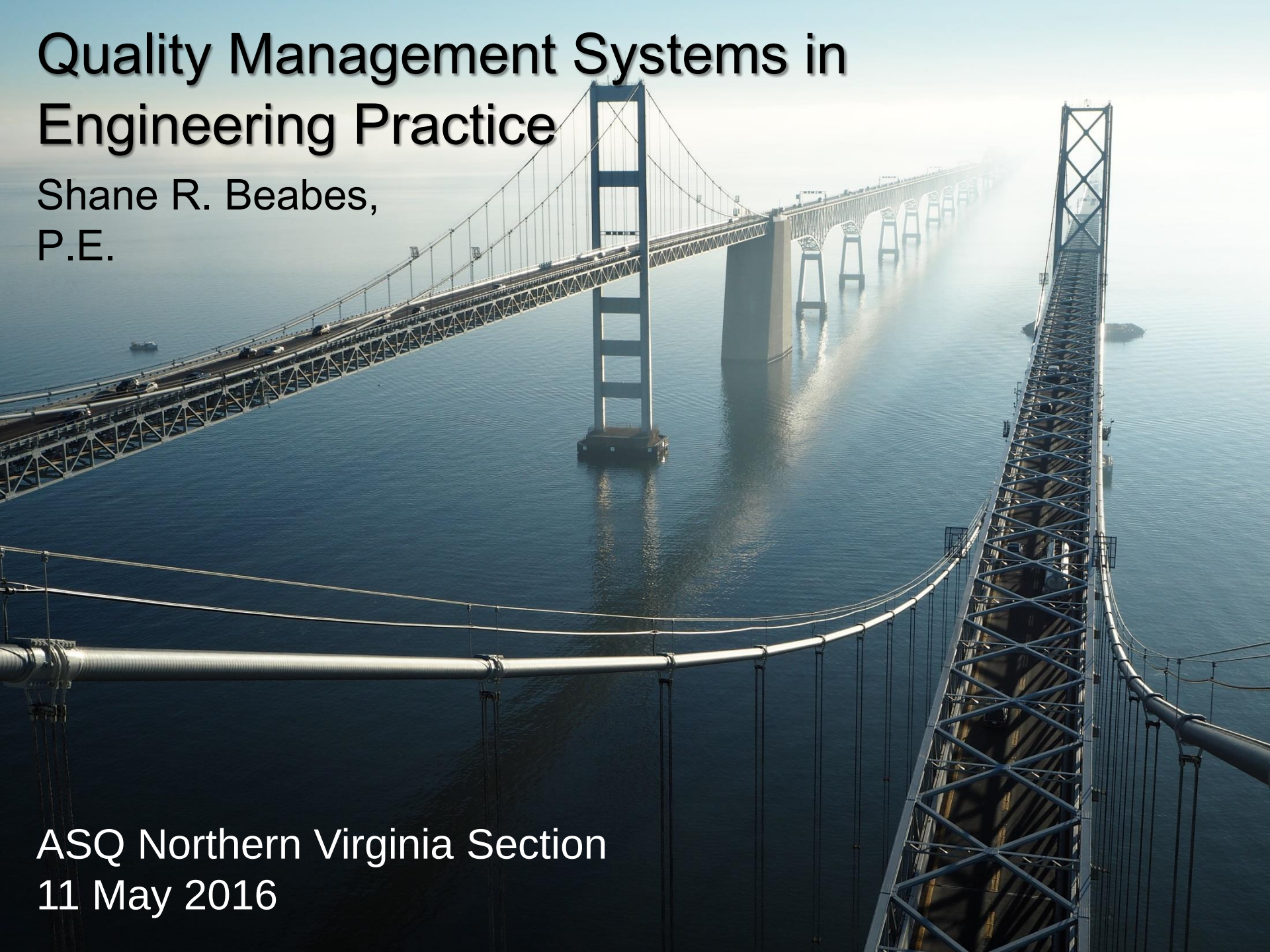
P.E.



ASQ Northern Virginia Section
11 May 2016

Agenda

1. Quality Management System
2. Quality
3. Client Requirements
4. Quality Assurance & Quality Control
5. Risk Management
6. Computer Software Validation
7. Constructability
8. Technical Peer Review
9. Interdisciplinary Review
10. Project Closeout

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Quality Management System

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Quality Management System

What is a Quality Management System (QMS)?

A QMS is set up to "direct and control an organization with regard to quality." – ISO 9000:2005

Why is a Quality Management System needed?

A QMS can provide the framework for continual improvement to increase the probability of consistently meeting a client's requirements

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Quality Management System

A Quality Management System provides a roadmap to effectively and efficiently fulfill the requested requirements.

Fulfill the requirements while performing the Work in accordance with Industry Practice and Standard of Care.

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Quality Management System

Industry Practice – "Industry Standard"

"Industry standards are a set of criteria within an industry relating to the standard functioning and carrying out of operations in their respective fields of production. In other words they are generally accepted requirements followed by the members of an industry."

http://definitions.uslegal.com

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Quality Management System

Standard of Care

"The standard of care for all professional engineering and related services furnished by Engineer under this Agreement will be the care and skill ordinarily used by members of the subject profession practicing under similar circumstances at the same time and in the same locality."

Engineers Joint Contract Documents Committee (EJCDEC) owner/engineer agreement

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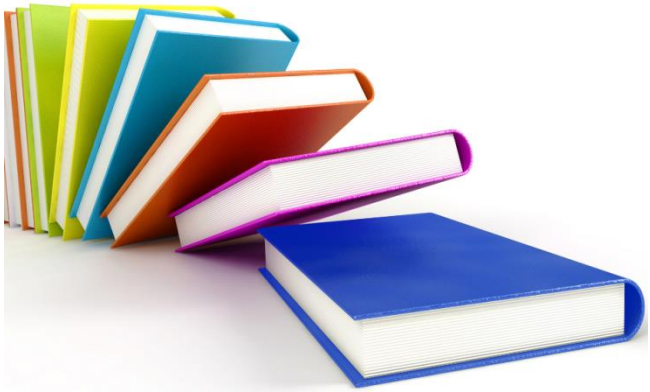
Quality Management System

To be competitive and sustain good economic performance, organizations need to leverage effective and efficient ways to manage their business.



ISO 9000 is a family of standards developed to assist organizations in the operation of effective quality management systems.

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Quality Management System

Not all consulting firms work to the ISO 9000 standards. They may have their own process in place for Quality Assurance and Quality Control.

The slides to follow are not a detailed assessment of AECOM's QMS, but instead show a general outline of items that should be considered in a robust QMS

Quality

Quality

What is Quality?

- an essential or distinctive characteristic, property or attribute
- character with respect to fineness
- high grade; superiority; excellence
- a degree of excellence
- a distinguishing attribute

Quality

In the context of a Quality Management System, what is Quality?

degree to which a set of inherent characteristics fulfills requirements – ISO 9000:2005

OR

degree to which a set of inherent characteristics fulfills client and stakeholder requirements

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Quality

Which coffee cup is of higher quality?

It depends – what was the requirement to be fulfilled?

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Client Requirements

Client Requirements

What are typical client requirements in Engineering?

- Safety
- Durable
- Economical
- Constructible
- Aesthetically pleasing
- On-time
- Within budget

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Client Requirements

In terms of a quality, failure is not meeting the client's requirements

How do we define the requirements for a project?

Through an approved Scope of Services

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Client Requirements

Scope of Services

- A written document conveying a client's requested services and objectives (i.e. the project requirements)
- A tool to manage expectations between the client and the consultant for services rendered

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Client Requirements

Scope of Services

- Project stakeholders
  - Owner
  - Environmental Agencies
  - Railroads
  - Utilities
  - Partnering agencies
- Design Criteria
  - Codes
  - Standards
  - Specifications

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Client Requirements

Scope of Services

- Frequency and Number of Submittals
  - Preliminary, TS&L, Final Review, PS&E, Advertisement
- Deliverables
  - Electronic or Hardcopy (pdf, xlsm, docx, DGN)
  - Plans, Specifications, Engineers Estimate, Reports
- Schedule

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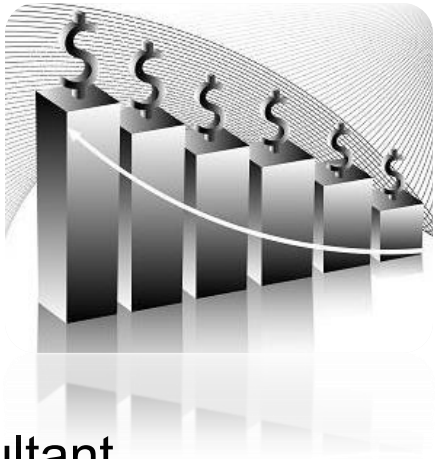
Client Requirements



Scope of Services

- Exclusions
  - Manages expectations between client and consultant
  - Assists with managing risks of design cost variances
- Discussion & identification of project risks

An agreed upon detailed scope of services facilitates a higher-confidence design cost estimate

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Quality Assurance & Quality Control

Quality Assurance & Quality Control

What is Quality Assurance (QA)?

QA focuses on *"providing confidence that the quality requirements will be fulfilled"* – ISO 9000:2005

QA is the *management process* established to provide the "infrastructure" or "environment" to successfully achieve the quality requirements

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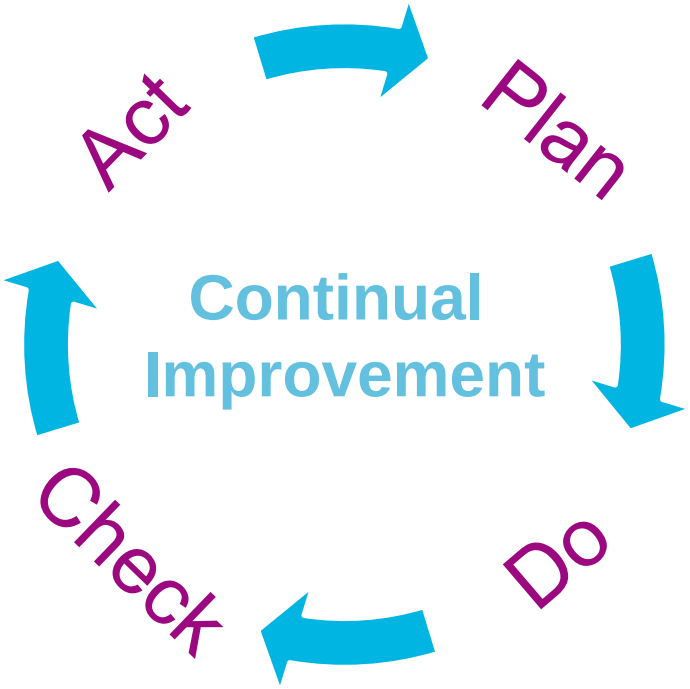
Quality Assurance & Quality Control

What is Quality Control (QC)?

QC *"focuses on fulfilling quality requirements"* – ISO 9000:2005

QC includes the *technical tools* used to examine a product [deliverable] against the stated requirements – e.g. checking the calculations or checking the plans against the design

QA process – PDCA Cycle



The goal of the PDCA Cycle is *Continual Improvement*

Quality Assurance & Quality Control

In industry, improvement is often based on “lessons learned.” Sometimes these lessons are learned the hard way which makes the *continual improvement process* under a QMS the easier and more desirable way

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Quality Assurance & Quality Control

On a project level basis, QA should cover the process from start to finish – from project initiation through project closeout

- **Project Initiation** – client's contract should be reviewed to verify the client's requirements are clearly defined
- **Project Resources** – staff and subject matter experts should be assigned that have the capability of meeting the client's requirements

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Quality Assurance & Quality Control

– **Project Plan** – should be developed in written format to guide the team and include:

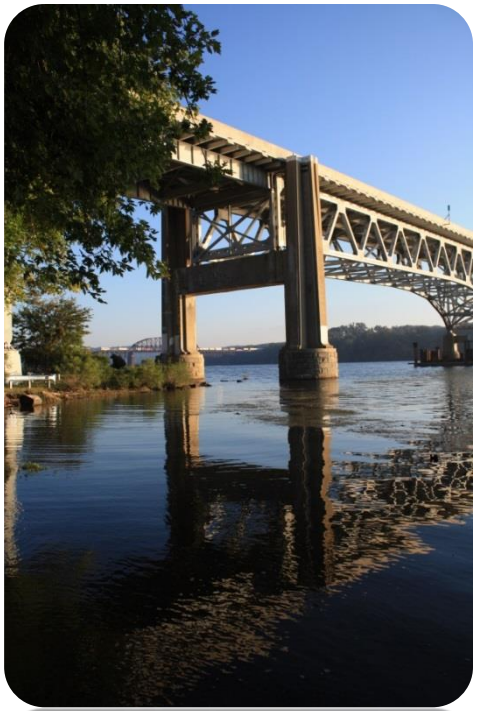
- Client requirements
- Project Design Criteria
- Goals of the project
- Project risks
- Staff assignments & responsibilities
- Project documentation procedures
- Client deliverables
- Intervals for review throughout the design process
- Project closeout process (i.e. “lessons learned”)

Quality Assurance & Quality Control

QC process is invoked during the development of the design documents

What are typical design documents?

- Calculations
- Contract drawings
- Specifications
- Reports
- Engineer's Estimate



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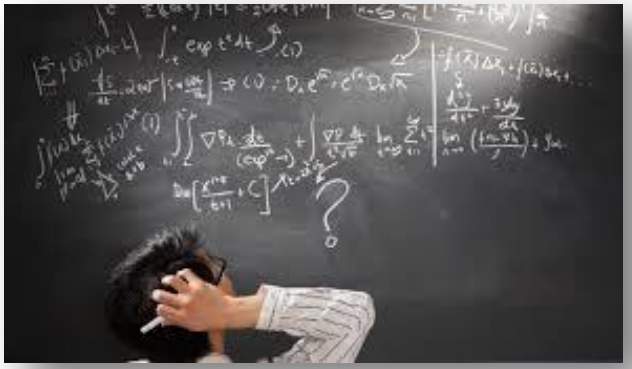
Quality Assurance & Quality Control

Checklists are often a tool in the QC process to make sure the process is comprehensive.

Checking process can vary depending on the complexity of the element under design.



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Quality Assurance & Quality Control

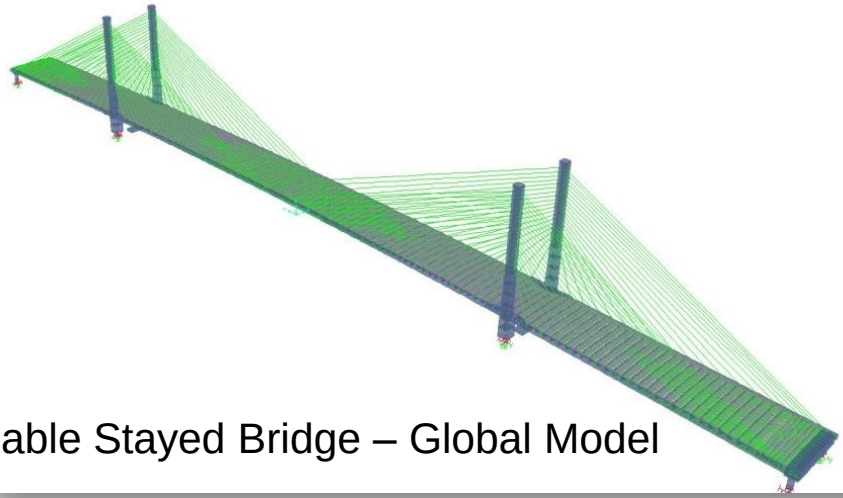
For a simple design, such as a simple-span bridge, a line-by-line check of the calculations may be adequate

In a complex bridge, such as a highly curved I-girder bridge, a design check using a separate modeling software may be warranted

As part of the project plan, the level of risk and complexity of the design is assessed and the appropriate QC procedures identified

Quality Assurance & Quality Control

The check is not limited to arithmetic check of the calculations…



Cable Stayed Bridge – Global Model

…but also an evaluation of the design methodology and appropriateness to the element under design

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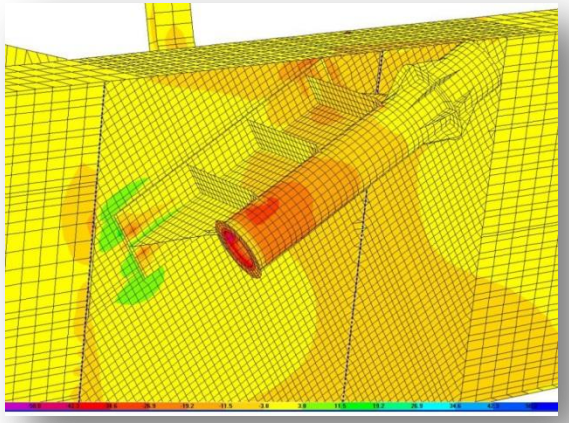
Quality Assurance & Quality Control

Verification of Design Methodology & Results

- Is the design methodology clearly outlined for verification by the checker?
- Does the design methodology envelop the predicted performance?
- Is the design methodology codified? If not,
- Is the design methodology in conformance with industry practices?



Model of cable-stay anchor on extrados bridge

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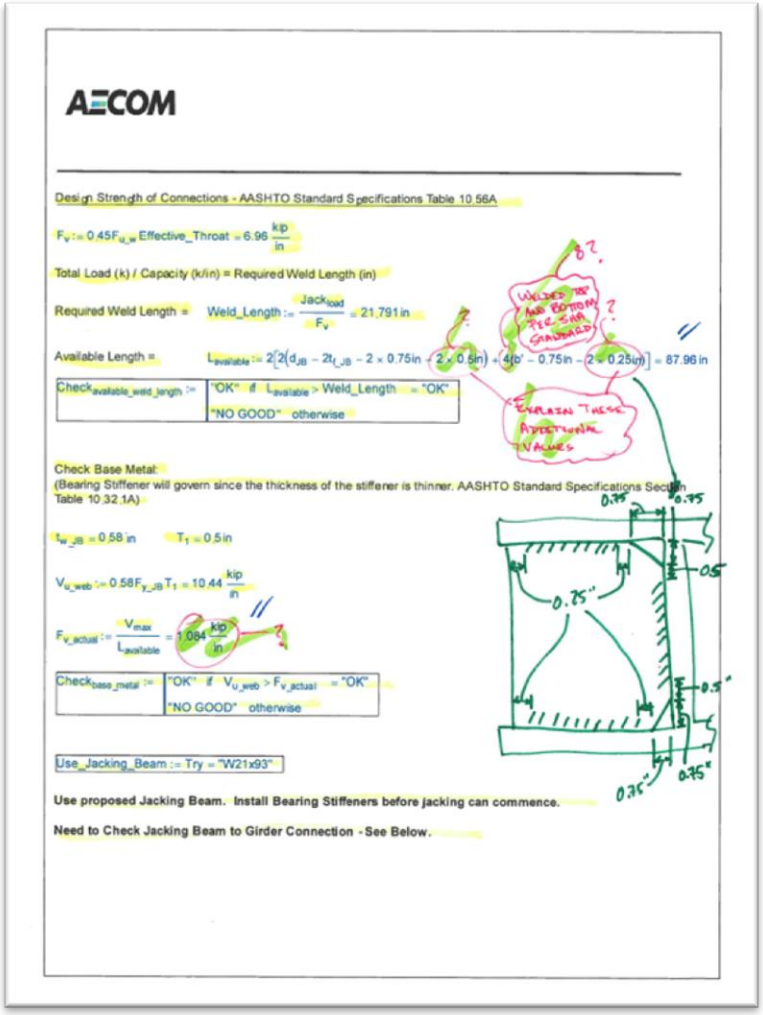
Quality Assurance & Quality Control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Design Strength of Connections - AASHTO Standard Specifications Table 10.56A

$F_v := 0.45F_{u\_w}$ Effective_Throat = 6.96 kip/in

Total Load (k) / Capacity (k/in) = Required Weld Length (in)

Required Weld Length = Weld_Length := $\frac{Jack_{load}}{F_v}$ = 21.791 in

Available Length = $L_{available} := 2\left[2\left(d_{JB} - 2t_{f\_JB} - 2 \times 0.75in - \left(2 \times 0.5in\right)\right) + \left(4in - 0.75in - \left(2 \times 0.25in\right)\right)\right]$ = 87.96 in

$Check_{available\_weld\_length}$:= "OK" if $L_{available}$ > Weld_Length = "OK"; "NO GOOD" otherwise

Check Base Metal:
(Bearing Stiffener will govern since the thickness of the stifferer is thinner. AASHTO Standard Specifications Section Table 10.32.1A)

t_{w_JB} = 0.58 in T_1 = 0.5 in

$V_{u\_web} := 0.58F_{y\_JB}T_1$ = 10.44 kip/in

$F_{v\_actual} := \frac{V_{max}}{L_{available}}$ = 1.084 kip/in

$Check_{base\_metal}$:= "OK" if $V_{u\_web} > F_{v\_actual}$ = "OK"; "NO GOOD" otherwise

Use_Jacking_Beam := Try = "W21x93"

Use proposed Jacking Beam. Install Bearing Stiffeners before jacking can commence.

Need to Check Jacking Beam to Girder Connection - See Below.

Example of a checked calculations

Establish checking procedures

- Independent check
- Color coded format
  - Yellow – check
  - Blue – checker comment
  - Red – proposed change
  - Green – back-check
  - Facilitates universal under-standing of the process

Use checklists

	Yes	No	N/A
1. Is the calculation in accordance with a standard approach to preparing the design?	☑	☐	☐
2. Have input data and information been verified and accepted?	☑	☐	☐
3. Have assumptions requiring follow-up been reviewed and confirmed?	☑	☐	☐
4. Have calculations prepared using technical software or excel spreadsheets (with macros or equations) been confirmed through a secondary method (i.e, manual, alternate software)?	☑	☐	☐
5. Are results and conclusions consistent and reasonable considering the inputs and approach?	☑	☐	☐
6. Have the originator and the checker/reviewer signed and dated the calculation?	☑	☐	☐
7. Have all previous internal review comments been addressed and closed out with the originator?	☑	☐	☐
8. Have all previous client review comments been addressed and closed out?	☐	☐	☑

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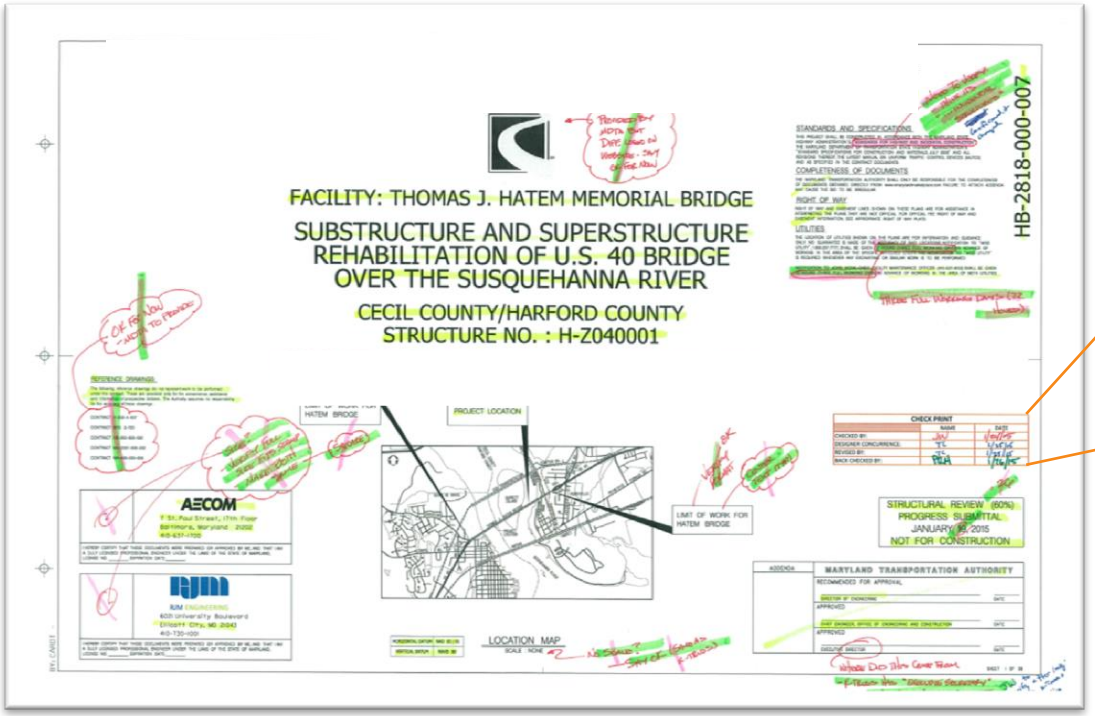
Quality Assurance & Quality Control



Example of a check of plans

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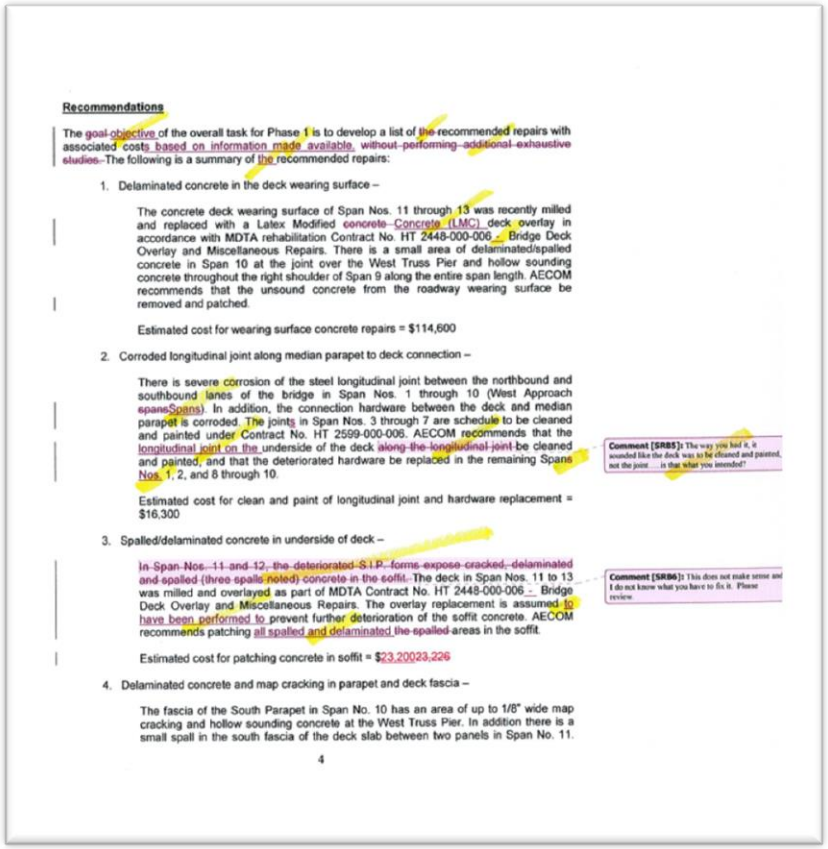
Quality Assurance & Quality Control



Recommendations

The ~~goal objective~~ of the overall task for Phase 1 is to develop a list of the recommended repairs with associated costs based on information made available, ~~without performing additional exhaustive studies~~. The following is a summary of the recommended repairs:

1. Delaminated concrete in the deck wearing surface –

   The concrete deck wearing surface of Span Nos. 11 through 13 was recently milled and replaced with a Latex Modified ~~concrete~~ Concrete (LMC) deck overlay in accordance with MDTA rehabilitation Contract No. HT 2448-000-006 – Bridge Deck Overlay and Miscellaneous Repairs. There is a small area of delaminated/spalled concrete in Span 10 at the joint over the West Truss Pier and hollow sounding concrete throughout the right shoulder of Span 9 along the entire span length. AECOM recommends that the unsound concrete from the roadway wearing surface be removed and patched.

   Estimated cost for wearing surface concrete repairs = $114,600

2. Corroded longitudinal joint along median parapet to deck connection –

   There is severe corrosion of the steel longitudinal joint between the northbound and southbound lanes of the bridge in Span Nos. 1 through 10 (West Approach ~~spans~~Spans). In addition, the connection hardware between the deck and median parapet is corroded. The joints in Span Nos. 3 through 7 are schedule to be cleaned and painted under Contract No. HT 2599-000-006. AECOM recommends that the longitudinal joint on the underside of the deck ~~along the longitudinal joint~~ be cleaned and painted, and that the deteriorated hardware be replaced in the remaining Spans Nos. 1, 2, and 8 through 10.

   Estimated cost for clean and paint of longitudinal joint and hardware replacement = $16,300

3. Spalled/delaminated concrete in underside of deck –

   ~~In Span Nos. 11 and 12, the deteriorated S.I.P. forms expose cracked, delaminated and spalled (three spalls noted) concrete in the soffit.~~ The deck in Span Nos. 11 to 13 was milled and overlayed as part of MDTA Contract No. HT 2448-000-006 – Bridge Deck Overlay and Miscellaneous Repairs. The overlay replacement is assumed to have been performed to prevent further deterioration of the soffit concrete. AECOM recommends patching all spalled and delaminated ~~the spalled~~ areas in the soffit.

   Estimated cost for patching concrete in soffit = $~~23,200~~23,226

4. Delaminated concrete and map cracking in parapet and deck fascia –

   The fascia of the South Parapet in Span No. 10 has an area of up to 1/8" wide map cracking and hollow sounding concrete at the West Truss Pier. In addition there is a small spall in the south fascia of the deck slab between two panels in Span No. 11.

4

Comment [SRB5]: The way you had it, it sounded like the deck was to be cleaned and painted, not the joint….is that what you intended?

Comment [SRB6]: This does not make sense and I do not know what you have to fix it. Please review.

Example of a check of report

- Can occur in several different ways
- Track-changes used by reviewer with proposed changes and comments
- If originator agrees, changes incorporated; else discussion occurs
- Check-document maintained in project archives

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Computer Software Validation

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Computer Software Validation

Who is responsible for the results of a commercially available software?

AASHTO LRFD Bridge Design Specifications, 6th Edition, Section 4.4 – Acceptable Methods of Structural Analysis

"The Designer shall be responsible for the implementation of computer programs used to facilitate structural analysis and for the interpretation and use of the results."

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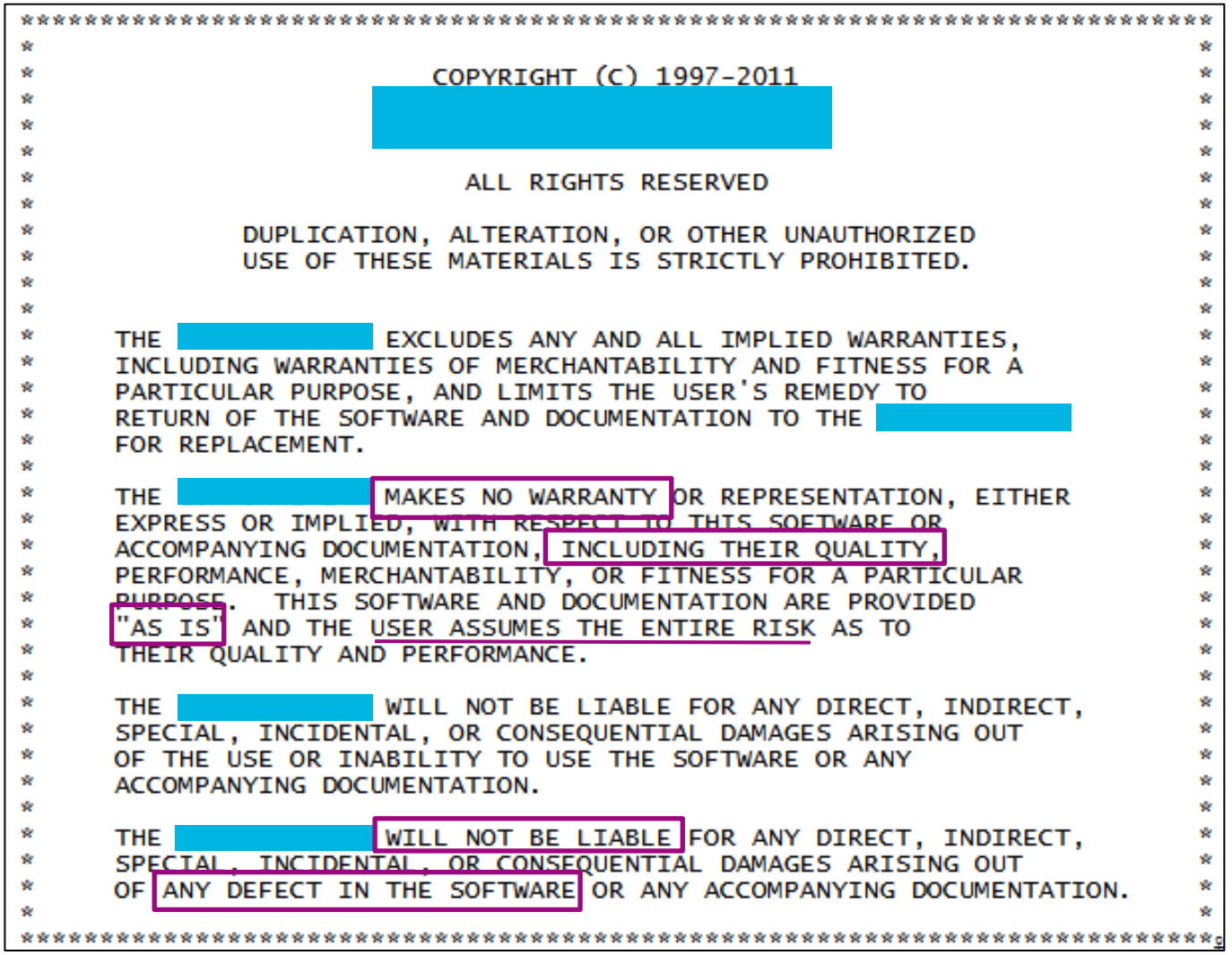
Computer Software Validation



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Computer Software Validation

The process of software ***validation*** is rarely a one-time effort.

– Continuous release of software upgrades

– Assessment of different modules or routines in comparison to last project

Regardless of the software validation process, nothing replaces sound engineering judgment.

Risk Management

Risk Management

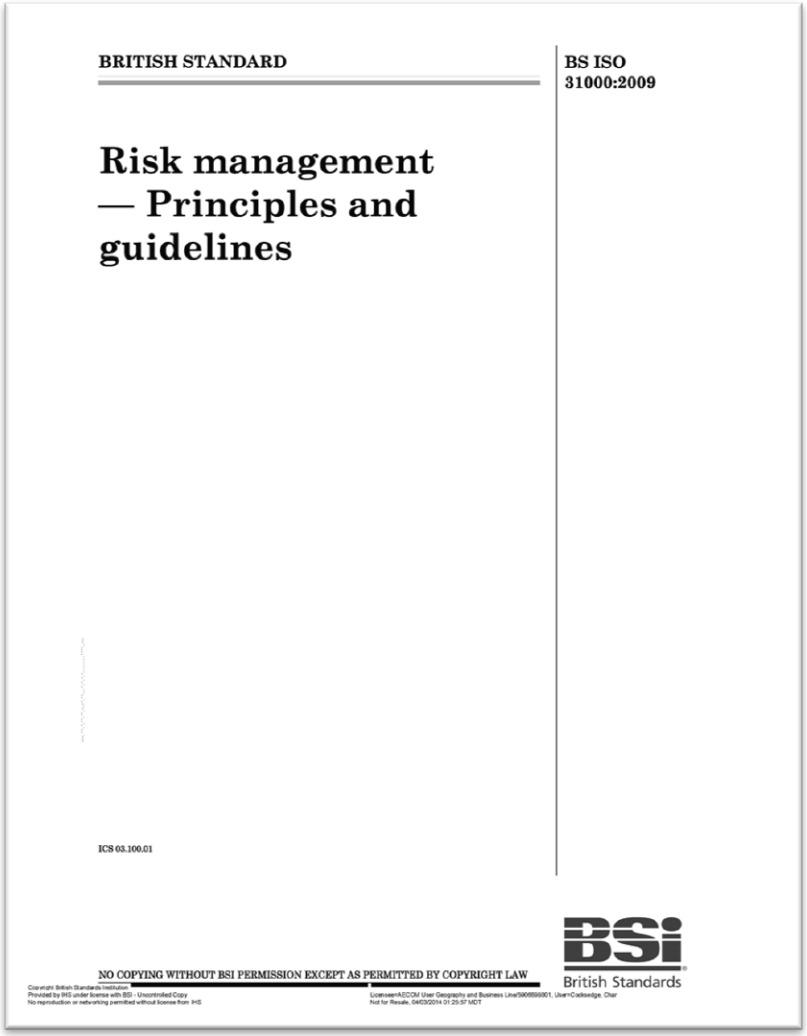
Risk –

effect of uncertainty on objectives

Risk Management –

coordinated activities to direct and control an organization with regard to risk

In a robust QMS risk is effectively managed


BRITISH STANDARD

BS ISO 31000:2009

Risk management — Principles and guidelines

ICS 03.100.01

BSI British Standards

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Risk Management

Identify risk during scoping, track risk, and communicate risk with project team [stakeholders]

Communicate with stakeholders during all stages of the risk management process

Bring different areas of expertise together to analyze risk

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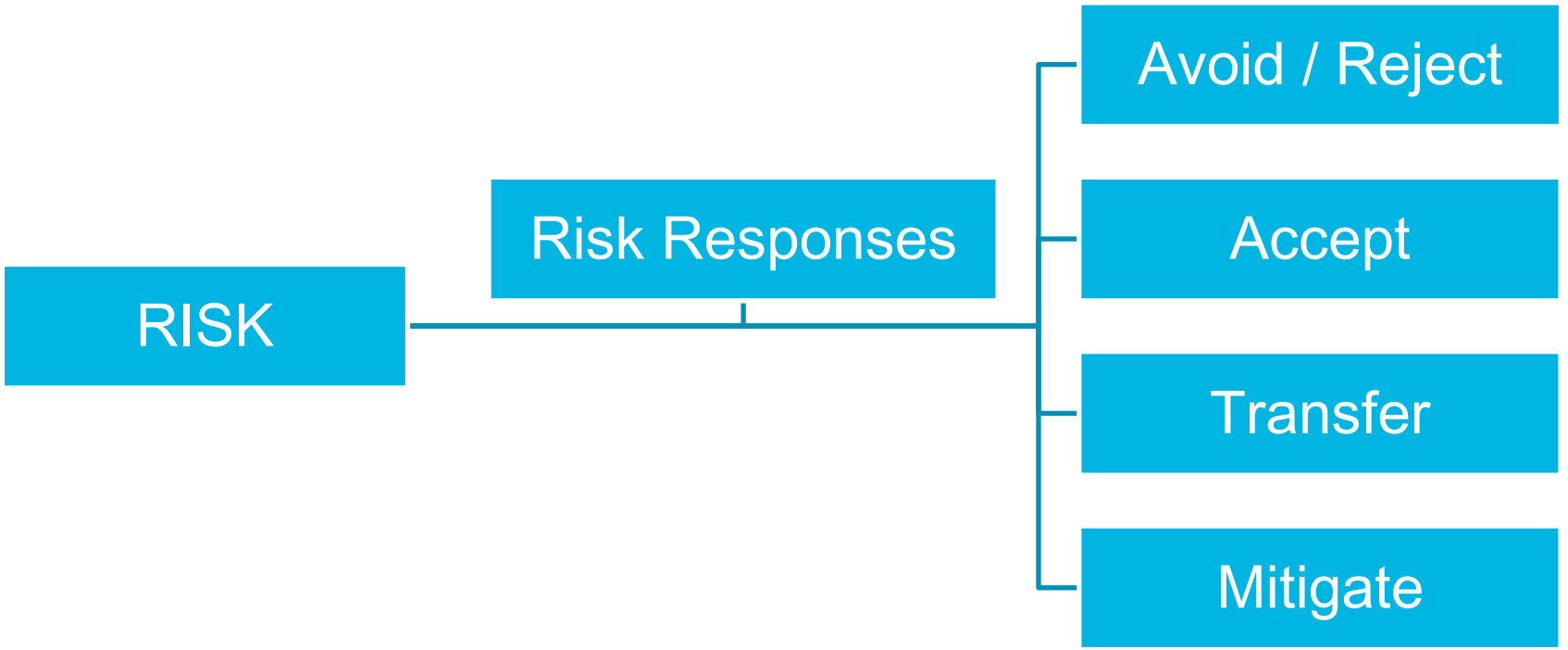
Risk Management



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Constructability

Constructability

What is Constructability?

The capability of being constructed

- An essential element of a successful project
- A QC tool that should be outlined in the project plan
- Improves the chances of achieving a better quality project, completed in a safe manner, on schedule, for a competitive cost

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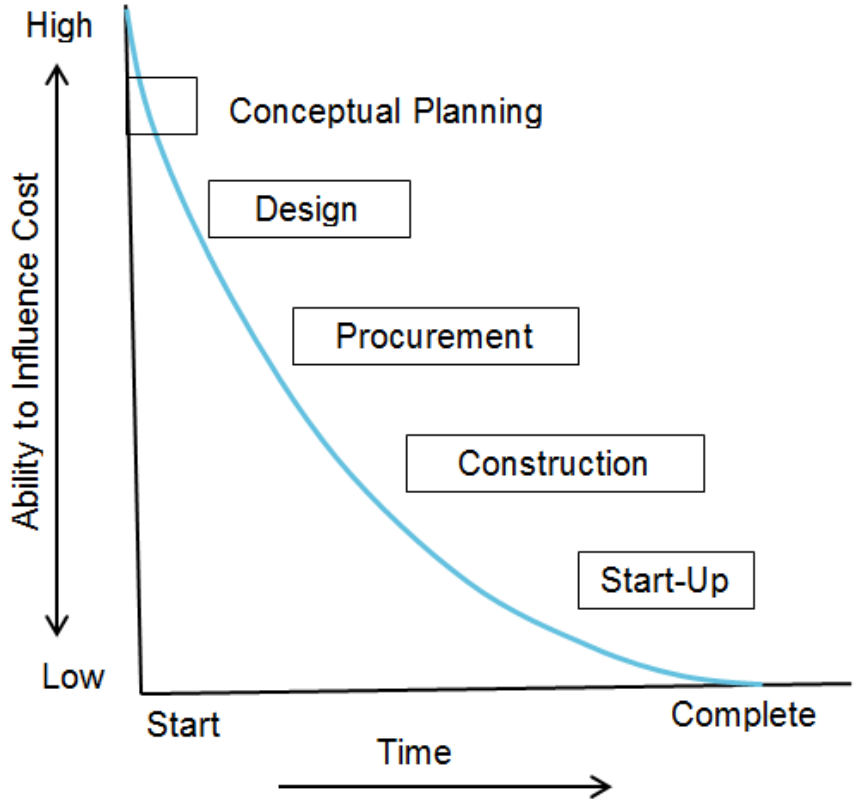
Constructability

To receive maximum benefits, constructability has to be started at the earliest stages during the concept planning stages



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Constructability

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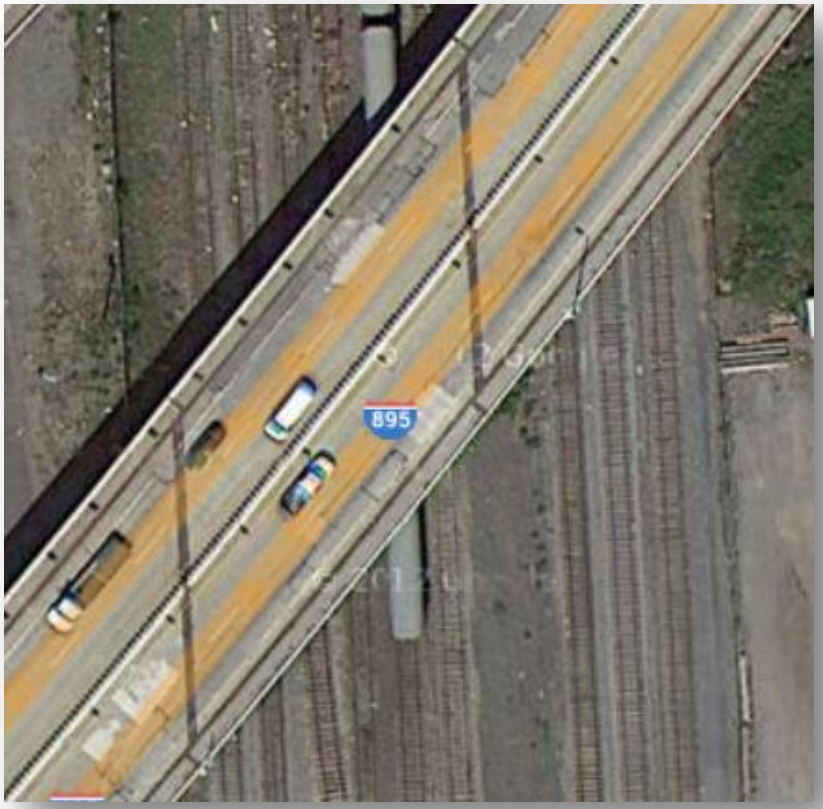
Verifying the **project** can be built



Crane access for pier demolition?

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Constructability

cr

Verifying the **project details** can be built

Bridge Deck Closure Pour

Bearing Stiffeners

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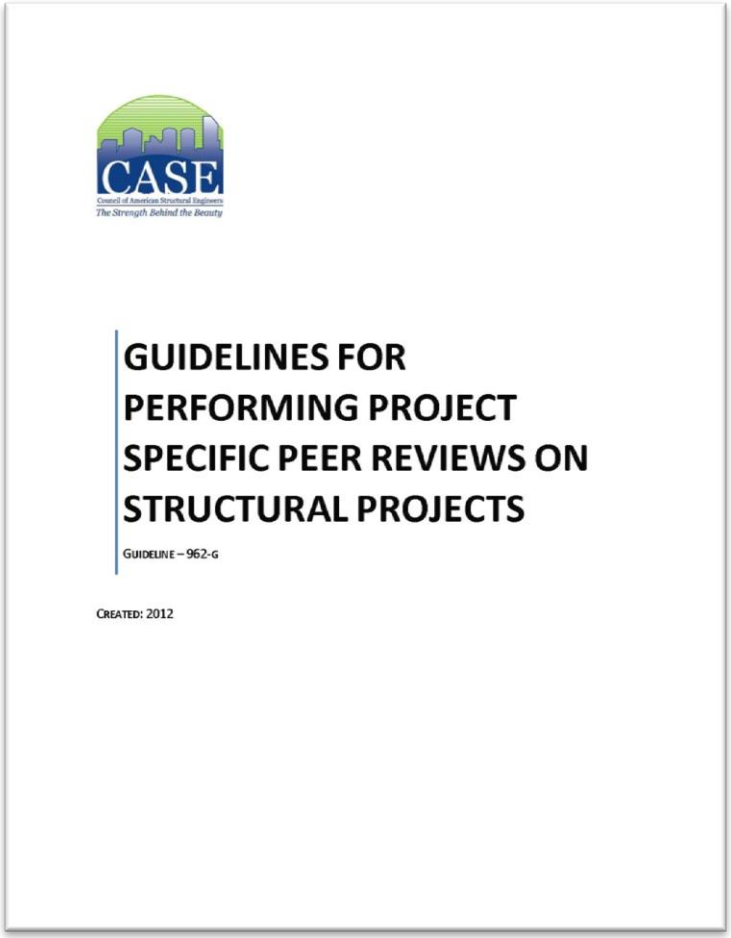
Technical Peer Review

Technical Peer Review

- Peer review intended to result in **improved project quality with less risk to all parties** (engineer, owner, contractor)
- Technical Peer Review
  - Not intended to serve as a Value Engineering
  - Enhance public safety
  - Design appears conceptually correct
  - No major errors or omissions
  - Not intended to be a comprehensive check



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Technical Peer Review

- Purpose is to provide greater degree of quality assurance and greater level of confidence in the final structure
- Provided the design conforms to the DESIGN CRITERIA, it is irrelevant if peer reviewer would have approached it differently
- To encompass a review of the design using independently generated calculations
- Not intended to assess constructability issues, including stability during construction, sequencing, etc.

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Interdisciplinary Review

Interdisciplinary Review

One of the largest risks on a project is the interface of disciplines

Mitigate the risk with periodic reviews during design & plan development process

Discipline leads review the combined project plans for review of their work in relation to other disciplines' work

11th Street Design Build Project, Washington, DC

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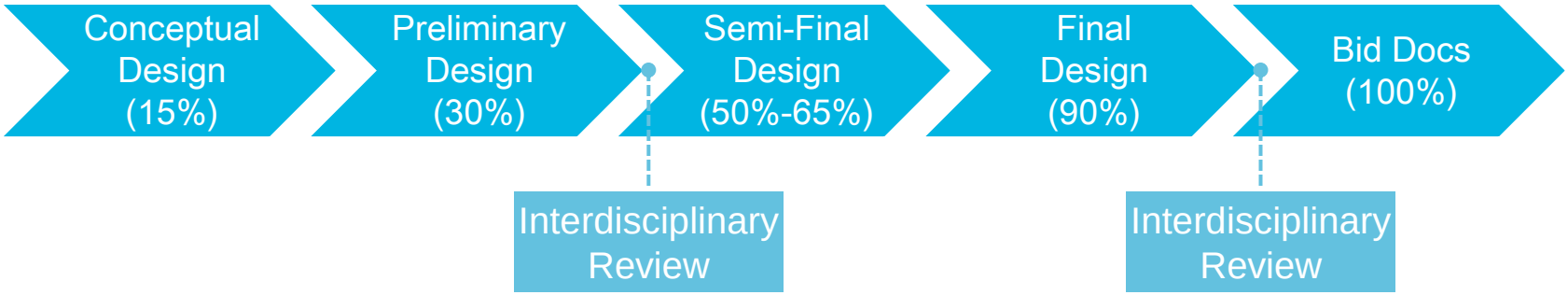
Interdisciplinary Review

Milestone Submission Schedule



Based on size and complexity of the project, determine when interdisciplinary reviews will occur

May occur during the development or at the end of a milestone submittal prior to delivery to client

Early-on coordination between disciplines will save time & resources and reduce the likelihood for major revisions

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Project Closeout

Project Closeout

Once a project is complete, the designers and managers are usually running to the next project & looming deadline

Proper project close-out requires careful review of the project and documentation of the “lessons learned” OR *“Best Practices”*

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Project Closeout

The “lessons learned” must be learned by the organization so project teams can take what has been learned on to the next project.

A QA plan must include this process to promote continual improvement

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Questions?

Thank You

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