

CONSTRUCTABILITY REVIEW: A VALUE ADD IN VALUE ENGINEERING

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ABSTRACT

The classic Value Engineering (VE) study assessing conceptual and preliminary design phases of a project offers significant value in impacting the engineering design of a project. However, on large infrastructure projects the effectiveness of VE beyond the 30% design phase begins to wane as many of the key project elements are already worked through with community stakeholders and jurisdictions making them difficult to modify. The value of a VE workshop at 60% or 90% level of design is greatly enhanced by shifting the subject matter expertise focus to the actual construction of the project. Construction focused VE's at the later stages can be very effective in supporting the development of well thought out cost estimates, schedules, contract specifications, and ensuring a solid set of bid documents. The benefits can include reduced change orders during construction, improved risk mitigation/risk management, improved bids and better stakeholder interface and improved follow through on stakeholder commitments.

What is a Constructability Review?

Constructability focuses on how a project will be built including construction means/methods, delivery method, materials, work sequence, phasing, staging, laydown, schedule, contract interface, material delivery, maintenance of traffic/access, plans, construction specifications, contract specifications, and other related elements of construction. While these reviews provide value as early as conceptual and 30% design, they are particularly useful as a design proceeds to 60% and 90% where review of near final bid documents and contract interfaces are defined. By including constructability in a VE study using the six step job process, a function analysis is provided which serves to focus the review team on the purpose and need for the project.

Applicability to Value Engineering

Figure 1 demonstrates the peaking trends for the added value of typical VE and constructability review focused VE. Classic VE is most effective through the 30% design phase, whereas the inclusion of constructability can extend that effectiveness well into the 60 and 90% design phases.

Figure 1: VE and Constructability Effectiveness Peaking

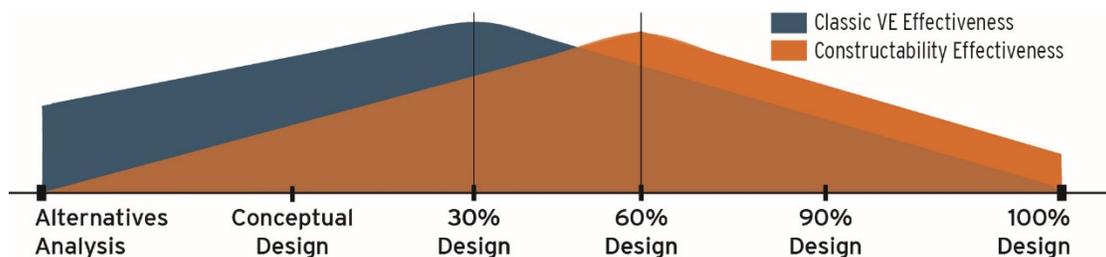


Table 1 outlines the types of constructability considerations that can come into play at various design stages.

Table 1: Constructability Considerations/Design Phase

Project Phase	Potential Review Opportunities
Conceptual Design	<ul style="list-style-type: none"> • Conceptual Cost Estimate • Construction Means and Methods • Lay Down and Staging Requirements • Access/MOT Requirements • Risk Register Items/Updates • Permitting/Environmental
Preliminary Engineering (30% Design) and 60% Design	<ul style="list-style-type: none"> • 30%/60% Cost Estimate • Construction Scheduling • Long Lead Materials • Contract Definition and Packaging • Discipline Interfaces • Procurement Methods (Project Delivery) • Construction means and Methods • Lay Down and Staging Requirements • Access/MOT Requirements • Risk Register Items/Updates • Permitting/Environmental/Noise and Vibration • Access Permissions/Third Parties • Operational needs during Construction • PE Plan Review • Specifications (60%) • ROW Acquisition
90% Design/100% Design/IFB	<ul style="list-style-type: none"> • 90%/100% Cost Estimate • Construction Scheduling (e.g.; sequencing, work windows, production rates, crew size and material flows) • Contract, Package, and Discipline Interfaces • Construction Means and Methods • Lay Down and Staging Requirements • Access/MOT Requirements • Risk Register Items/Updates • Permitting/Environmental/Noise and Vibration • Access Permissions/Third Parties • Operational needs during Construction • ROW Acquisition • Specifications (90 or 100%) • Special Conditions • Handoff Requirements • Bid Document Review

Tools and Methods

Various tools and methods are used to support constructability as an element of a VE workshop. Categories are described below:

Subject Matter Experts (SME's)

The best SME's for VE with focus on constructability are individuals with significant field construction experience on projects similar to the project being reviewed. Former or current contractors are particularly valuable, as they are able to provide the perspective of contractors who will pursue the work. This type of review can be very effective in identifying areas in the project, designs and specifications, or contract documents that contractors will take advantage by requesting change orders or other potentially costly change orders. The focus of their expertise varies with the project. For reviews at the earlier design phases construction cost estimators with knowledge of the project type and current local market work well, and schedulers with knowledge of contractor means and methods and production rates. At the 60% and higher design stages the review would be more focused on construction means and methods, staging, phasing of work, material flows, production rates and contract interfaces.

For projects with major stakeholder interface requirements constructability teams have included independent expertise as well as staff from both the project owner agency (Sound Transit) and the stakeholder agency. These workshops have been very beneficial in supporting the development of consensus between the owner and key stakeholders relative to the construction needs of the project.

Cost Estimate Review

Cost estimate reviews generally fall into two types:

- (1) Independent review of the engineers cost estimate by experts familiar with the local market, material and labor costs and availability and assumed production rates can identify areas of concern in the estimate. These reviews also identify missed items or inaccurate quantities.
- (2) Bottom up independent estimate, used to compare to the engineers estimate, supports both confirmation of the accuracy of the estimate, as well as confirm the understanding of the plans, specifications and other bid documents. Equivalent items priced differently between the two estimates are places for further review and clarification.

Specific methods for the review include simple redlining; side-by-side estimate reconstruction; bottoms-up newly built independent estimates; and written comment summaries, with explanation of issue areas.

Schedule Review

This method involves independent review of the engineers or contractors schedule or the linear schedule including time and project location of work for contract milestones, sequences, production rates, construction access, temporary facilities, work area "ownership", material flows, coordination of handover requirements, and staging and work area constraints. The methods used can include real-time schedule rebuild, or written summaries of areas to modify or consider changing with explanation.

Risk Register Review

Review of a project contract Risk Register by experienced construction subject matter experts can be very effective in understanding risks that contractors might take advantage of. This review can be completed by reviewing the current risk register and providing comments. As an alternative an independent qualitative risk register can be developed prior to review of the existing risk register to support a truly independent thinking about project risks. Done as a qualitative review, this can easily be done within the timeframe of a VE workshop. Methods may include modification/editing of the current risk register or the development of a parallel but independent

qualitative risk register. The risks identified by the independent team may be added to the full risk register for the project and may be included in the risk model for the project.

Construction Plans and Specification Review

Review of the construction plans and specifications supports the identification of items that are not adequately defined, areas of conflict, and areas where a contractor's expertise supports understanding of how a contractor will identify gaps or errors in the plans and specifications and their approach to the construction, reducing potential for costly change orders and potential delay during construction. Methods for these reviews may include the redlining of plans and specifications, potentially paired with a comment log table summarizing the more significant issues. The comment log table may also include suggestions for mitigation or correction of the issue. The comment log may also include a disposition column, allowing the project owner to manage the comments and ensure that the key issues have been adequately addressed.

Contract Specifications

Review of the contract specifications including Special Conditions, Contract Interfaces, Handoff Requirements, Provisional Sums and other similar areas by experienced contractors or construction professionals with field experience additionally supports the identification of gaps or errors in the contract specifications that could result in costly change orders and possible delay during construction. Methods for these reviews may include the redlining of contract specifications, potentially paired with a comment log table summarizing the more significant issues. The comment log table may also include suggestions for mitigation or correction of the issue. The comment log may also include a disposition column, allowing the project owner to manage the comments and ensure that the key issues have been adequately addressed.

Added Value Examples

Below are several added value examples of including constructability review at various project stages.

Tacoma Link VE and Constructability Review

For the Tacoma Link Streetcar project a Constructability Review was completed at the 30% design level for this 2.4 mile extension of the existing active Tacoma Link Streetcar. Construction would be in existing street rights-of-way in a developed urban environment. The review advanced 100 constructability comments many supported by drawing redline comments. Within these comments there were 76 significant constructability comments.

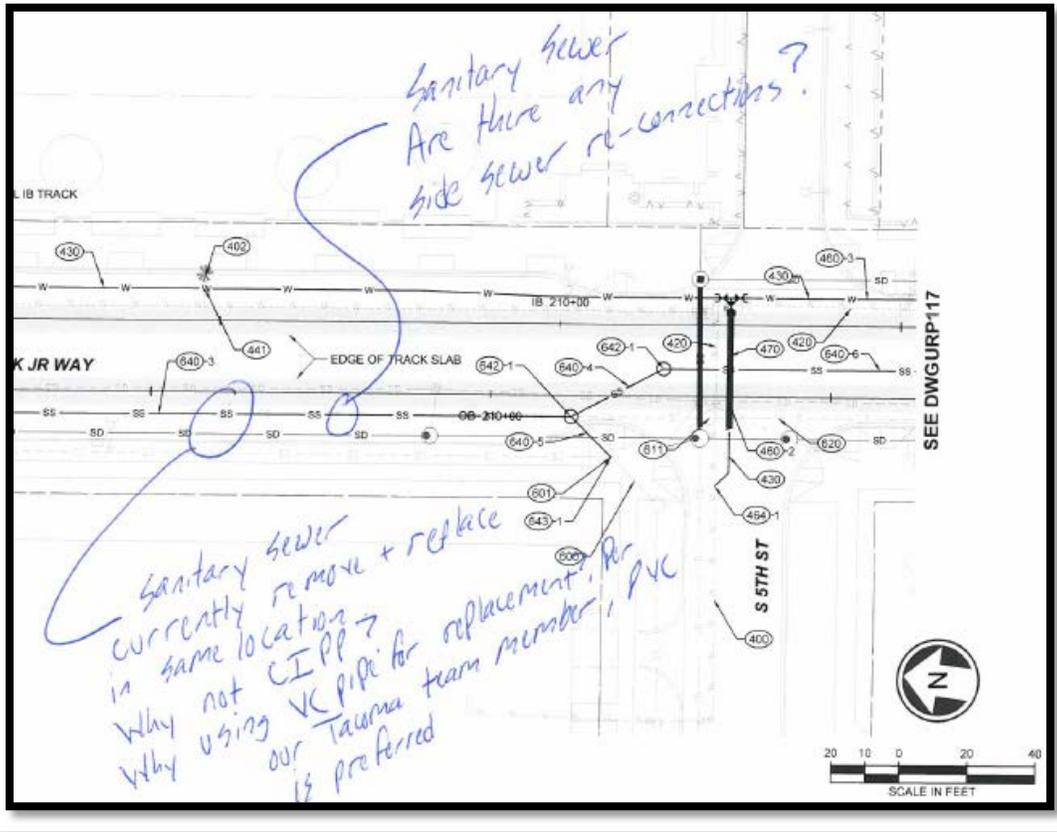
Utility relocation/casing requirements were identified as a significant construction element driving both schedule and cost challenges. Approximately 35% of the project costs were attributed to utility relocation and casing requirements. Deep utility relocations had potential to increase those costs as they would result in excavation depths that would impact adjacent street curbs, forcing reconstruction/replacement of the complete street cross-section (See Figure 2).

Recommendations from the constructability team included the use of reinforced track slab allowing utilities to remain in place, but still allow repair and replacement under and adjacent to the track slab during nighttime/off-peak operational shutdowns; lining older deep sewer lines rather than replacing; casing of only copper lines; and use of offset manholes to allow access to lines from areas adjacent to the trackway.

The constructability team for this project also reviewed the project schedule in depth and reconstructed the schedule to allow rolling four block utility reconstruction/replacement work in combination with track installation that would minimize disruption to the public on busy streets. In addition, the team recommended advance utility relocation for the private utilities along the alignment.

The constructability team for this effort included owner (Sound Transit) staff, City of Tacoma Public Works staff, field construction engineers with significant streetcar construction expertise, and a former construction contractor.

Figure 2: Tacoma Link Utility Redline Drawing



Lynnwood Link VE and Constructability Review

The Lynnwood Link VE and Constructability Review was completed at the 30% design phase and resulted in 180 constructability comments many with supportive plan redline mark-ups (See Figure 3). The Lynnwood project includes 8.5 miles of mostly aerial LRT structure in the heavily travelled WSDOT right-of-way of Interstate 5. Key comments included:

- Early work packages to minimize contractor conflicts for the 130th Street Bridge Realignment, the 145th Street Ramp realignment, 185th Street Bridge widening, 195th Street new Pedestrian Bridge and realignment of the 220th Street interchange and ramps.
- Optimization of Truss Operations for elevated structure construction to reduce equipment relocation and impacts to the traveling public.
- Recommendation for precast segmental columns and deck panels in lieu of cast in place construction to reduce the amount of material delivery to site and disruption to the travelling public.
- The team also reviewed the packaging and procurement options for the project supporting an advanced construction package followed by two General Contractor Construction Management (GCCM – similar to CMGC in other States) packages.

The review team for this project included owner (Sound Transit) and WSDOT staff supported by two independent contractor subject matter experts.

Figure 3: Lynnwood Link Comment Log with Design Team Responses

Code	CR Team Suggestion/Observation	LLE Team Response	Comments	LLE Team Action
GEN01	Consider early works package	Study		ST to discuss during contract packaging & delivery assessment
MOT01	Temp signal at 205 th to allow ramp closures	Accept	Cost already included in MOT allowance	None
MOT02	Sequence construction to allow shoulder closures	Consider in Final Design		None
MOT03	Utilize on/off ramps for construction access	Consider in Final Design		None
MOT04	130 th reconstruction needs a clear sequencing plan	Study	Need to confirm feasibility of completing this work by end of 2018 assuming construction NTP mid-2017	Develop conceptual construction sequencing schedule to discuss with WSDOT
MOT05	185 th reconstruction needs a clear sequencing plan	Consider in Final Design		None
MOT06	Consider permanent signal at 5 th /185 th on east side of I-5	Accept		Add to PE design and cost estimate

I-90 Two-way Transit and HOV Improvements Stage III (R8A)

The R8A Stage 3 was a complex project which involved completion of HOV lanes to and from Seattle, improving the tunnel fire/life safety systems, as well as adjustments to accommodate for the East Link light rail project. The improvements to the tunnel fire/life safety systems for the Mt. Baker Ridge Tunnel (MBRT) and the Mercer Island Tunnel (MIT) included upgrading and replacement of major ventilation fans and motors, new electrical service to support fan motor loads, lighting upgrades, new fire detection and suppression systems, new SCADA control systems, and a new ITS systems. A constructability review was completed at both 60% & 90% design phase allowing a thorough review of the construction means and methods, network and system integration plan as well as commissioning and testing schedule. The study also addressed constraints on work windows mandated by WSDOT and FHWA. The constructability team was able to provide valuable input on the following key issues:

- Coordination of project estimate and schedule
- A detailed review of balancing, testing and commissioning of ventilation, fire suppression, SCADA and ITS systems in order to maintain properly balanced existing systems until transitional and new systems are phased in
- Clarifications to the specification documents to address access permissions, traffic control with limited weekend work windows as well as costs for overtime labor or efficiency loss

The team for this effort included contractors with experience in tunnel ventilation and fire upgrades as well as Electrical, ITS and SCADA expertise.

Northgate Link LRT Trackwork Package

The Northgate Link Trackwork package VE/Constructability Review was completed on the 90% plans, bid documents, construction specification and contract specifications for the project. This team spent significant time testing the assumptions of the project schedule and linear time-

location diagram evaluating the construction means and methods and coordinating the material delivery, handover and work area access specifications, and contract special provisions. A supplemental Qualitative Risk Register was developed. Key findings of the study included:

- Special conditions, specifications, handover requirements and temporary facility provisions required additional clarification – documents were redlined to outline suggested clarifications and improvements.
- The overall schedule for the construction was very tight and required some clarification:
 - Access to two of the work areas will need to be extended to ensure the work can be completed
 - Trainway access through the stations must be assured throughout the construction period to support on time completion of the work
 - Special track work and fixation hardware will require 24 months for production and delivery and should be procured in advance by the owner or early by the selected contractor
 - Floating slab manufacture requires specialize aggregate which is a long lead item which should be acquired by the owner or contractor

The constructability team for this effort was comprised of contractors and agency staff with significant construction engineering expertise for trackway within a tunnel environment.

Conclusions

Including constructability expertise in VE's at each design stage adds significant value to the process. In addition, constructability review at the 60% and 90% phases extends the value of VE into later project phases.