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Development of Formal Constructability Review Meeting Guidelines for Transportation Agencies

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Constructability reviews have been used by multiple departments of transportation (DOTs) in the United States for more than a decade to enhance the project design documents by introducing construction knowledge to the design process. Constructability reviews provide the contractors with a complete set of bid documents that have a reduced possibility of encountering any obstacles during project construction phase. The main objective of this research is to provide DOTs and transportation agencies with guidelines to conduct formal constructability review meetings with increased efficiency. Transportation agency personnel, consultants, and contractors were interviewed to collect data relevant to constructability review meetings best practices, advantages, and disadvantages. The analysis of interviews results determined that conducting constructability review meetings before 50% completion of the design phase is recommended. A successful meeting should include project designer, project manager, and a minimum of 3 general contractors. Attendees should receive advanced information regarding the project, and meetings should be held in the construction site to ensure proper communication. The implementation of the research outcomes will increase the constructability review meeting outcomes, minimize cost and schedule overruns, and enhance the overall safety of the construction project.

Key Words: Constructability, Buildability, Constructability Review, Cost Overrun, Schedule Overrun, DOTs

Introduction

The concept of “constructability” in the United States, or buildability in the United Kingdom emerged in the early 1980s. Constructability concept evolved to increase the economic feasibility of construction projects, and maintain construction quality and affordability (Uhlik and Lores, 1998). According to the Construction Industry Institute (CII), constructability is defined as “the optimum use

of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives,” (CII 1986). Similarly, constructability is defined as “a project property that reflects the ease with which a project can be built and the quality of its construction documents,” (Dunston et al., 2003). Various definitions evolved for the term “constructability” according to the project specific conditions, including the following definitions:

- “A measure of the ease or expediency with which a facility can be constructed,” (Hugo et al., 1990)
- “The integration of construction knowledge, resources, technology, and experience into the engineering and design of a project,” (Anderson et al., 1995)
- “The capability of being constructed,” (ASCE, 1991)
- “A Process that utilizes construction personnel with extensive construction knowledge early in the design stages of projects to ensure that the projects are buildable, cost-effective, biddable, and maintainable,” (AASHTO, 2000)

In an attempt to improve project constructability, transportation agencies implemented different measures including peer review of design documents, brain storming sessions, the use of different commercial software packages to improve project coordination (Meadati et al., 2011 and 2012), the use of design checklists, implementing artificial intelligence (AI) in constructability evaluation (Xiao et al., 2018), and conducting constructability review meeting(s) to discuss project constructability (Bonilla et al., 2022, Akhnoukh et al., 2022). In the past decade, departments of transportation (DOTs) and transportation agencies have widely attempted to implement constructability review meetings during different stages of project design stage. However, most constructability review meetings lack formal procedures and outcomes assessment.

Literature Review

The increased complexity of construction projects, and the budget constraints encouraged transportation agencies to optimize the use of their limited resources to maintain the conditions of national infrastructure projects. Decades ago, several research programs investigated the possible of developing durable construction materials to increase the life span of construction projects and minimize the need to maintenance, repairs, and replacement of deteriorated infrastructure projects (Akhnoukh, 2018, 2010). As a result, new materials with superior characteristics were introduced to the local construction market including high grade steel, ultra-high-performance concrete, and large-size prestress strands). Different research programs investigated the reliability of infrastructure projects (Morcoux and Akhnoukh, 2007) and modeled infrastructure deterioration (Morcoux and Akhnoukh, 2006). The research findings were used by transportation agencies increased ability to prioritize the use of their limited resources to maintain infrastructure projects in operating conditions. Recently, DOTs introduced the constructability reviews concept during project design phase to possibly predict any future site issues that may evolve during construction phase. Early detection of construction issues will significantly reduce the project expenditure, reduce cost and schedule overruns, and enhance project safety. During the last 10 years, different DOTs in California, New York, Indiana, North Carolina, Washington, Florida, and Tennessee started to conduct constructability reviews through formal meetings, held in construction site during the project design phase.

Constructability reviews requires a champion to ensure successful implementation. Traditionally, the construction project manager assume the champion role and guide project stakeholders during the meetings designated time.

The main role of the construction project manager is to provide a detailed review of the draft construction plans and specifications. This review, referred to as constructability review, results in improved plans and eliminate multiple problems during different phases of construction. The constructability review meetings provide different stakeholders involved in the construction process including the owner, designer, contractor, and project manager with a detailed process to share their expertise and knowledge to improve the workflow and efficiency of the construction process, while being at the design phase (Gambatese et al., 2012).

In research conducted by Washington State DOT, researchers investigated the possible advantages attained by formal constructability review meetings. The research outcomes provided the DOT personnel with outlines to conduct successful meetings, and a framework to increase the constructability review meetings efficiency (McManus et al., 1996). In a different study, projects executed after incorporating formal constructability review meetings were compared to similar projects where constructability review meetings were ignored. The research study showed that the constructability reviews resulted in significant improvement in project workflow; the benefit/cost ratio of constructability reviews is greater than 2.0 (Dunston et al., 2002). Similar research showed that the effectiveness of constructability review meetings is significantly increased when they are tailored to the project specific conditions. Thus, constructability review process has to be flexible to accommodate different projects (Stamatiadis and Hartman, 2011). The Kentucky Transportation Cabinet (KYTC) has incorporated the constructability review concept in their projects during design phase. The KYTC meetings are performed by four reviewers. However, these meetings represented more of an ad hoc approach which lacked the systematic approach in identifying key-problems and challenges to the project constructability (Stamatiadis, 2013). Similarly, the Florida Department of Transportation (FDOT) has developed formal constructability review procedures for highway construction projects. FDOT constructability review program depends on the utilization of standard checklist during CR meetings (Ellis et al., 1992). Arizona Department of Transportation (ADOT) has developed detailed guidelines on how to conduct a formal CR meeting, record, and implement the recommendations (Wright, 1994). The Wisconsin Department of Transportation (WDOT) investigated the constructability concepts and developed its tools for constructability Implementation in highway construction (Russel and Swiggum, 1994). Louisiana Department of Transportation conducted recent research that showed it may be beneficial to State DOTs to conduct CR meetings and discuss constructability issue regardless of the nature of the project, project delivery, and the portion of the project that may be outsourced. The Louisiana DOT project specified the main important dimensions to be considered in highway construction project management. These project management dimensions are to be articulated in constructability review meetings to ensure project successful implementation. These dimensions include time management, cost management, quality control, project environmental aspects, value engineering, workforce qualifications, project delivery methods, and operation and maintenance (Jafari et al., 2019). In relevant research, the impediments to conducting successful formal constructability review meetings were investigated. The research outcomes showed that staffing and budgetary constraints represent a major challenge that limits the abilities of transportation agencies in conducting formal constructability review meetings for all projects conducted. However, the research findings concluded that formally conducted meeting during early design phase results in 1.25% of project budget savings (Stamatiadis et al., 2017). Thus, the implementation of formal CR in projects with high budget will result in significant cost savings.

The influence of constructability review meetings on budget savings is evaluated according to the time the CR meeting is conducted. The research outcomes showed that budget savings is maximized when project CR process is implemented at early stages of the construction project design phase, as shown in Figure 1.

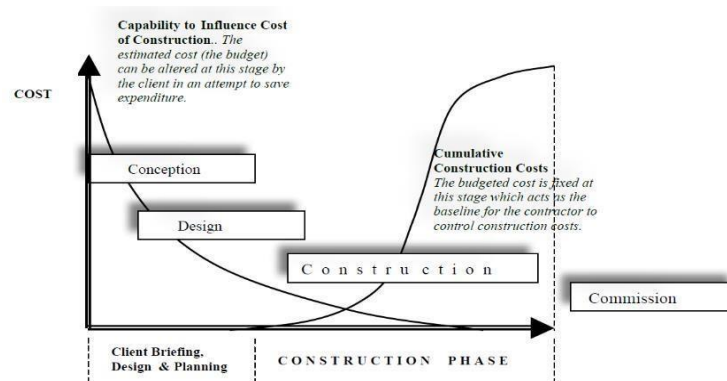


Figure 1. Influence of constructability review meetings on project budget vs. project phase (bahaudin et al., 2012)

Objectives and Methodology

The main objective of this research is to provide DOTs and transportation agencies with guidelines to conduct formal constructability review meetings with increased efficiency, and highlight possible parameters to be used in the assessment of constructability review meetings outcomes. The research objectives are attained through the following methodology:

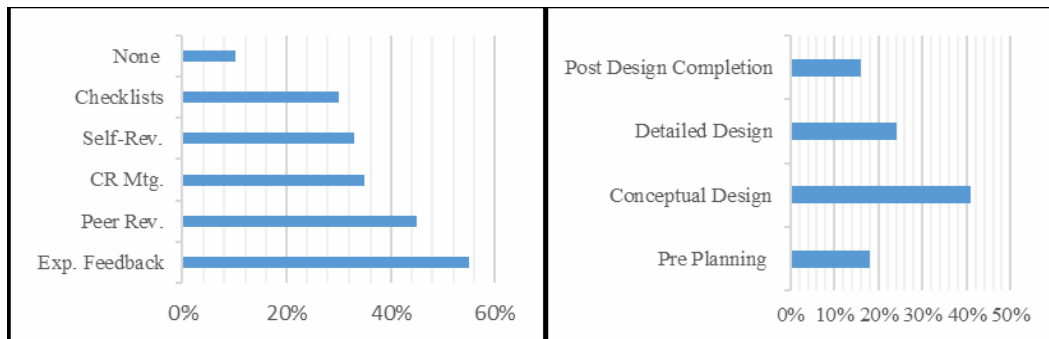
- Conduct interviews with DOT personnel at different states to receive feedback regarding their constructability review meetings practices. Feedback focused on the timing of constructability review meetings, invited project stakeholders and their expertise, the nature of the projects where constructability review meetings are applicable, meetings' location and duration, the main challenges faced by DOT personnel when meetings are conducted, and the possible project parameters to be used in meetings outcomes assessment.
- Developed a questionnaire to survey construction professionals at the State of North Carolina. The questionnaire surveyed the recommendations to formalize successful meetings for future transportation projects within the State. Thirty-five interviews were held, the list of interviewees included 19 NCDOT personnel and 16 general and specialty contractors. The questionnaire was handled through web meetings, phone interviews, and through 6 different on-site constructability review meetings attended by the research team. The following list of questions was included in DOTs and North Carolina construction professionals survey:
 - Does your DOT project require CR?
 - If CR and CR meetings are optional, what are the indicators that a CR meeting is required for a given project?
 - What type of CR meetings do you implement (formal or non-formal)?
 - At what phase of project design do you conduct your CR meetings?
 - Who are the project stakeholders invited to CR meetings?
 - What are the parameters used to assess the efficiency of your CR process?
 - Do you have a specific suggestion for the CR meeting invitation? Number of invitees? Invitee background?

The research team compiled the data received from the questionnaire and DOT interviews to provide transportation agencies with recommendations to conduct efficient formal constructability review meetings, and provide guidelines to assist DOT personnel in optimizing project constructability, avoiding cost and schedule overruns. Detailed outcomes are shown in the following sections.

Research Findings

Departments of Transportation Interviews

State DOTs started to implement different forms of constructability reviews; 35% of interviewed DOTs stated that they conduct constructability review meetings, 55% conduct reviews using checklists, peer revisions, feedback from experts, or through self-revisions; and 10% of surveyed DOTs do not implement constructability reviews in their projects. Constructability review meetings implemented by DOTs are either formally conducted according to predetermined guidelines (52%) or informally (48%). Typically, DOTs plan on conducting constructability review meetings during the design phase to ensure the early detection of constructability issues. The type of constructability reviews and timing for constructability review meetings is shown in Figure 2.



(b) Figure 2. (a) Type of constructability review (b) Timing of constructability review meeting

Stakeholders invited to attend constructability reviews for DOT projects includes DOT construction personnel, design personnel, maintenance staff, external contractors, and other professionals including utility companies’ personnel, material suppliers, and environmental experts. Percentage of attendees according to their professional background is shown in Figure 3.

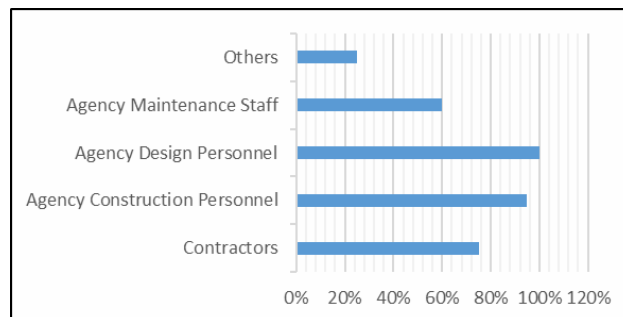


Figure 3. Constructability review meetings attendees according to their professional background

Constructability review meetings could potentially be implemented in any DOT project regardless to the project type, budget, duration, or site conditions. However, constructability review meetings are challenging due to coordination problems, time consuming, and cost associated by conducting on-site meetings. While some states requires constructability review meetings for all projects, other state DOTs restrict the implementation of meetings to specific project types, as shown in Figure 4.

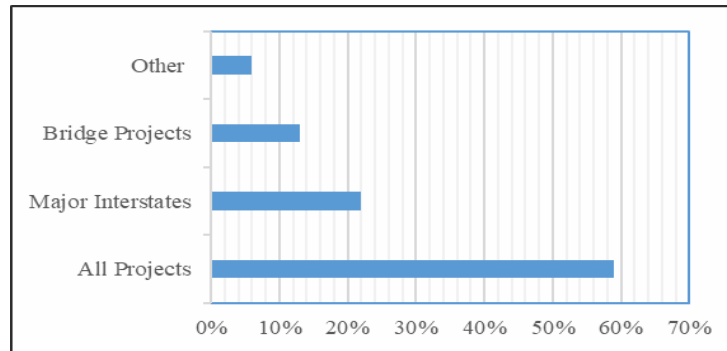


Figure 4. Type of construction projects for constructability review meeting implementation

Constructability reviews in general, and constructability review meetings in particular, provide DOTs and other transportation agencies with the opportunity to predict potential construction projects prior to project execution. The efficiency of constructability review meetings and their outcomes are hard to quantify. DOTs use different approaches to assess meetings outcomes. Constructability review assessment parameters and their corresponding application by different DOTs are shown in Figure 5.

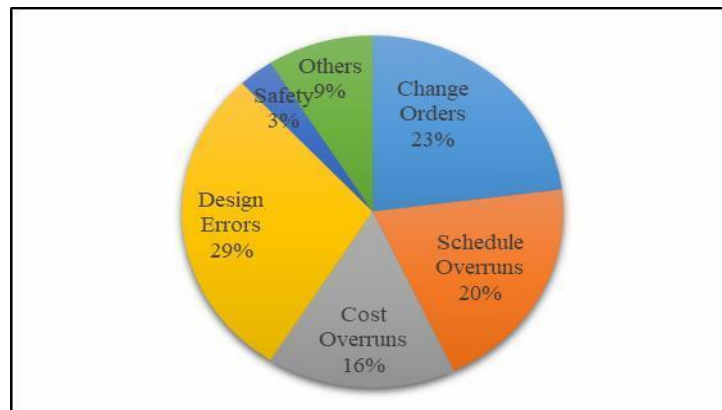


Figure 5. Constructability review meetings assessment parameters

NCDOT Personnel and Contractors Questionnaire

The research team developed a questionnaire to collect feedback to assist in conducting sufficient constructability review meetings at the State of North Carolina. The questionnaire was prepared in light of DOT survey feedback. Thirty-five questionnaire responses were recorded, including 19 responders from NCDOT personnel, and 16 local contractors. According to the feedback provided by the responses, the following suggestions, shown in Table 1, were made regarding future constructability meetings attendance.

Table 1.

Suggestions for future constructability review meetings participation

Suggested Participants	Responses	Percentage
At least 3 contractors	5	14.2%
No more than 15 attendees	4	11.3%
Number of participants should vary according to project complexity	3	8.6%
Maintenance Personnel	1	2.9%
Utility company representatives	2	5.8%
Subcontractors	1	2.9%
No limit on attendees (for successful brainstorming)	1	2.9%
Traffic Management Personnel	1	2.9%
Roadway Personnel	1	2.9%
No Suggestions	16	45.6%

The questionnaire responses suggested that on-site constructability reviews are preferred for increased efficiency. Constructability review meeting duration should range from 2.0 to 4.0 hours to allow for sufficient discussions. According to the feedback obtained, A slight majority of the responders preferred having multiple meetings for constructability reviews to be held prior to the completion of 50% of the design phase, as shown in Table 2.

Table 2.

Constructability review meetings implementation timing

Design Phase Percentage Needed	Multiple Reviews Needed		One Review	
	NCDOT	Contractors	NCDOT	Contractors
20-30%	5	4	4	7
30-40%	0	0	0	0
40-50%	2	2	0	1
50-60%	0	0	1	1
60-70%	6	2	3	2
70-80%	1	0	0	1

NCDO personnel and contractors interviewed have indicated that review meetings are faced with obstacles, and could be cancelled or delayed due to different factors including the absence of constructability champions, participants might not be well prepared for constructability review meetings due to lack of coordination, and work schedule constraints. Finally, contractors raised concerns regarding the financial burdens incurred due to meeting attendance, specially for remote on-site meetings.

Assessment of Constructability Review Meeting Outcomes

The assessment of CR meetings efficiency is challenging due to the inability to quantify the losses avoided due to CR implementation. The following 3 parameters are identified in the DOT practices

survey and construction professional questionnaire feedback: 1) project safety, 2) construction quality, and 3) schedule compliance. The contribution of the CR meeting on the afore-mentioned parameters is evaluated on a scale of through 4, according to Table 3 (a). Project bid items are evaluated using the criteria listed in Table 3(a) to assess the overall impact of the CR on different project activities, as shown in Table 3(b).

Table 3.

(a) Impact scale of project CR, and (b) Assessment of CR total impact on bid items

3(a)		3(b)	
Individual Assessment Scale	Impact Scale	Assessment of Total Impact	
1	No Impact	3-5	Low
2	Minimal	6-8	Minimal
3	Moderate	9-10	Moderate
4	High	11-12	High

CR meeting assessment tool is implemented by NCDOT in recent highway construction project. The outcomes of the assessment criteria for a small component of the project (detour construction) is shown in Table 4.

Table 4.

Assessment of overall impact of CR on NCDOT construction project

	Items Description	Safety	Quality	Schedule	Overall
Bid Item List	Detour signing	4	2	3	9
	Snow Plowable Pavement Markers	4	1	1	6
	Pavement Marking	4	1	1	6
	Temporary Pavement Markings	4	1	1	6

Conclusions

The outcomes of this research project shows that transportation agencies and DOTs are increasing implemented constructability review for their construction projects. The implementation of constructability reviews through formal meetings with predetermined guidelines is favored by 35% of interviewed DOTs. Constructability review meetings held at early stages of project design phase is advantageous due to the ease of revising the project design. Interviews conducted for North Carolina contractors and DOT personnel show that conducting constructability review meetings prior to 50% design completion is suggested by slight majority of interviewees. Suggested participants includes project managers, consultants, general and specialty contractors, maintenance and utility personnel. The advantages of constructability reviews include cost and time savings, reducing the number of

claims and change orders, and improved site safety. Despite their advantages, several DOTs doesn't implement formal constructability review meetings. The major impediments to the meetings implementations includes the lack of funding, hardships in scheduling meetings, and the inability to coordinate concurrent site visits for sufficient number of participants. The assessment of constructability reviews outcomes presents a major challenge. However, the research findings suggests that constructability review effectiveness may be quantified by estimating projects compliance to budget and schedule or reduced OSHA citations for projects where constructability reviews are implemented in comparison to comparable projects that ignored constructability reviews. The implementation of the research findings according to would assist transportation agencies and DOTs in formalizing constructability review meetings and increase meetings efficiency for transportation projects.

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