Constructability Effectiveness Review

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16. Abstract

Constructability reviews have been used by multiple departments of transportation (DOTs) in the United States for more than a decade to enhance 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 the project construction phase. The main objective of this research is to provide NCDOT 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 60% completion of the design phase is recommended. A successful meeting should include the project designer, project manager, and a minimum of 3 general contractors. Attendees should receive advanced information regarding the project, and the meetings should be held at 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.

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Executive Summary

Constructability reviews have been used by the NCDOT for more than a decade to enhance the project design documents by introducing construction knowledge to the design process. The main objective of conducting constructability reviews is to ensure the project success by providing the contractors with a complete set of bid documents that have a reduced possibility of encountering any issues during the different phases of project construction. Multiple parties may be considered for their input to enhance the constructability review process of a construction project including experienced construction managers, general contractors with relevant construction experience, design engineers, and finally construction inspectors. The input of the afore-mentioned parties can reduce, or even eliminate, built-in problems and construction flaws that might affect the project activities, and/or result in project delays, or conflicts between different project parties. Thus, the successful implementation of constructability reviews at different design stages will provide a seamless flow of construction activities, which minimize project duration, and results in significant budget savings.

The increased complexity of construction projects, and the staffing and budgetary constraints, encouraged federal and state entities to conduct constructability reviews meetings. During the past two decades, the need and demand for these reviews has exponentially increased among different state departments of transportation. Several state DOTs have conducted research projects to investigate the outcomes of constructability reviews meetings. These research projects assess the outcomes of the constructability review meetings by estimating the reduction in project request for information (RFIs), reduced number of change orders issued during the construction phase, and measuring the conformity of the project with initial project schedule.

Currently, NCDOT conducts constructability reviews meetings through the Value Management Unit that follows a standard meeting format and organization. However, there is no official formal process followed. In addition, the effectiveness of conducted meetings was never investigated or assessed to evaluate their successful implementation. NCDOT has no tools to accurately estimate the cost and time savings for constructability reviews meetings. The lack of meetings formal

process and means of measuring successful implementation may affect the overall project success by missing the opportunity to enhance the efficiency of the project construction activities, with potential inherent cost and time savings.

The main objective of this proposed research is to provide NCDOT with a formal process to conduct successful constructability review meeting to attain relevant benefits to improve the overall efficiency of the construction process, and enable the project stakeholders to accomplish their construction activities within the preplanned schedule and the allocated budget. The project objective is attained by providing specific outlines to follow during the constructability review meetings, determine the optimum time to conduct these meetings (65% design development), and provide the NCDOT personnel with detailed recommendations related to the conduction of follow-up meetings, and tools to measure the effectiveness of the constructability review meetings. The research project outcomes include constructability review meeting action plan for the immediate implementation of successful; reviews, and a checklist to provide NCDOT personnel with a list of project activities to be considered in constructability review meetings.

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List of Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
BIM	Building Information Modelling
CALTRANS	California Department of Transportation
CAPM	Capital Preventative Maintenance
CCIA	Connecticut Construction Industry Association
CI	Construction Institute
CII	Construction Industry Institute
CIIA	Construction Industry Institute Australia
CIRIA	Construction Industry Research Information Association
ConnDOT	Connecticut Department of Transportation
COV	Coefficient of Variation
CR	Constructability Review
DOT	Department of Transportation
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GDP	Gross Domestic Product
HMA	Hot Mix Asphalt
IDOT	Idaho Department of Transportation
INDOT	Indiana Department of Transportation
ICT	Intermediate Contract Time
IoT	Internet of Things
KDOT	Kansas Department of Transportation
MOT	Maintenance of Traffic (aka temporary traffic control)
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program

NYSDOT	New York State Department of Transportation
OSHA	Occupational Health and Safety Administration
PennDOT	Pennsylvania Department of Transportation
PERT	Program Evaluation and Review Technique
PID	Project Initiation Documents
ROW	Right of Way
SD	Standard Deviation
TRB	Transportation Research Board
UAV	Unmanned Aerial Vehicle
VE	Value Engineer
VMO	Value Management Office
WSDOT	Washington State Department of Transportation

List of Symbols

μ	Mean Value
σ	Standard Deviation
σ^2	Variance
$\frac{\sigma}{\mu}$	Coefficient of Variation
E	Expected Value
O	Optimistic Value
P	Pessimistic Value
M	Most Likely Value

1. Introduction

The construction industry represents approximately 9% of the total gross domestic product (GDP) of the United States and has a market size of approximately 2.0 trillion dollar per year (Akhnoukh, 2008). A significant portion of this expenditure is directed at maintaining the US infrastructure inventory including highways, tunnels, and bridges. According to the American Society of Civil Engineers, the United States' infrastructure conditions need additional maintenance, repair, and/or replacement projects to avoid being classified as structurally deficient or functionally obsolete.

Currently, different research programs are investigating possible techniques to increase projects' life span, reduce maintenance intervention, and reduce the overall life cycle cost of new DOT projects. The following techniques are used to minimize state and federal expenditures:

I. Develop and use high performance materials in construction projects including high grade steel, welded wire reinforcement, reactive powder concrete, and large size prestressing strands
II. Introduce advanced technologies in scanning and evaluating conditions of existing projects including remote sensing, uncrewed aerial vehicles, and internet of things (IoT) applications
III. Implementing performance-based specifications in construction projects. Performance-based specifications provide project contractors with sufficient flexibility to use alternative materials and new construction techniques
IV. Use non-traditional project delivery methods to create seamless construction processes with minimized conflicts among different projects stakeholders
V. Use coordination techniques and visual aids like building information modeling (BIM), and different on-site quality control/assurance techniques
VI. Conduct pre-construction meetings with different project stakeholders to investigate the project's constructability and to detect any potential future conflicts that might evolve during the project construction phase

According to current DOT practices, construction projects pass through two different phases prior to the start of project site work. These 2 phases are:

Project Conceptual Design starts mainly with the client (project owner). During this phase, the project progress is limited to the owner and the architect (consulting) firm. There are no construction activities involved, and the project expenditure is limited to the development of a conceptual design to generate specific details to describe the overall project location, size, and function.

Project Design starts with further development of the agreed upon conceptual design to generate a schematic design with further dimensional details. Once the conceptual design is approved, a detailed design generates civil, structural, mechanical, electrical, plumbing, and landscape details. The design phase is concluded by developing detailed design drawings and specifications to be used in the project bid process. During the project design phase, different project stakeholders are required to provide their input to avoid site issues during the subsequent construction phase, and ensure the project constructability, also known as "buildability."

Project constructability is defined as the extent to which the design of a facility provides ease of construction yet meets the overall requirements of the project. The Constructability Committee within the Construction Institute (CI) of the American Society of Civil Engineers (ASCE) defines constructability as "the integration of construction knowledge and experience in the planning, design, procurement, construction, operation, maintenance, and decommissioning phases of projects consistent with overall projects objectives." Similarly, constructability (or buildability) is defined as a project management technique to review construction processes from start to finish during the preconstruction phase. It is used to identify obstacles before a project is constructed or to reduce or prevent errors, delays, and cost overruns. Another definition of constructability is the integration of construction knowledge into the project delivery process and balancing the various project and environmental constraints to achieve the project goals and building performance at the optimal level.

The key to project constructability (or buildability) is the incorporation of construction knowledge and site experience. These encompass the knowledge of construction processes and techniques, project delivery methods, requisition of information needed to efficiently operate the site and efficiently conduct construction activities, and manage the labor, materials, and equipment

necessary to execute the project. The increased complexity, size, and duration of construction projects necessitates addressing project constructability issues through a formalized process to ensure efficient constructability, avoid problems, and eliminate the need for project arbitration and/or litigation.

Various transportation agencies or Departments of Transportation (DOTs) holds project stakeholders meeting(s) during the project design phase to define any potential problems that might occur during the project construction phase. These meetings of stakeholders, also termed a *constructability review (CR) meeting*, has as its main objective to ensure project constructability/buildability through design modification to avoid future problems. Specific CR meeting objectives include desired outcomes of the construction project, such as:

I. Reduce potential conflicts during the construction process
II. Avoid cost overrun
III. Avoid schedule overrun
IV. Avoid construction site work stoppage due to conflicting activities, supply issues, and/or equipment problems
V. Minimize the number of change orders issued during the project construction phase
VI. Increase the overall safety of construction

Traditionally, constructability review meetings are held upon the completion of a specific percentage of the project design phase, ranging from 30% to 70% of the project design phase. Several federal and state agencies have developed standard procedures and guidelines for organizing CR meetings including the meeting format, meeting attendees, and a conclusive checklist of the items to be discussed within the meeting. Some agencies require conducting follow-up meetings to monitor the outcomes of the initial meeting and assess the meeting outcomes. A typical CR meeting requires the attendance of the following project stakeholders:

I. Project designers
II. Project consultant
III. Project engineer
IV. Multiple general contractors to provide feedback relevant to potential site problems or construction activity issues

V. Material vendors and suppliers

Stakeholders attending CR meetings may vary according to the project type, size, location, project owner, and project delivery method. Despite the dynamic nature of construction projects and the continuous change in the construction market, the following list of items are present as common factors that can be included in CR meetings:

I. Project utilities
II. Project right of way
III. Traffic control and detours
IV. Design for projects encountering bodies of water, historical places, parks, recreational areas, and other community assets or areas of interest

The advantages of CR meetings stem from the ability of the involved stakeholders to detect potential construction conflicts during the project design phase. With this knowledge they can then, modify the project's final design are suggested to ensure that potential conflicts are eliminated. Thus, early detection of conflicts results significantly reduced potential risks associated with the project including cost and schedule overruns. According to the Kentucky Department of Transportation, the following schematic diagram, shown in ***Figure 1.1*** describes the transportation project evolution, design, and construction phases.

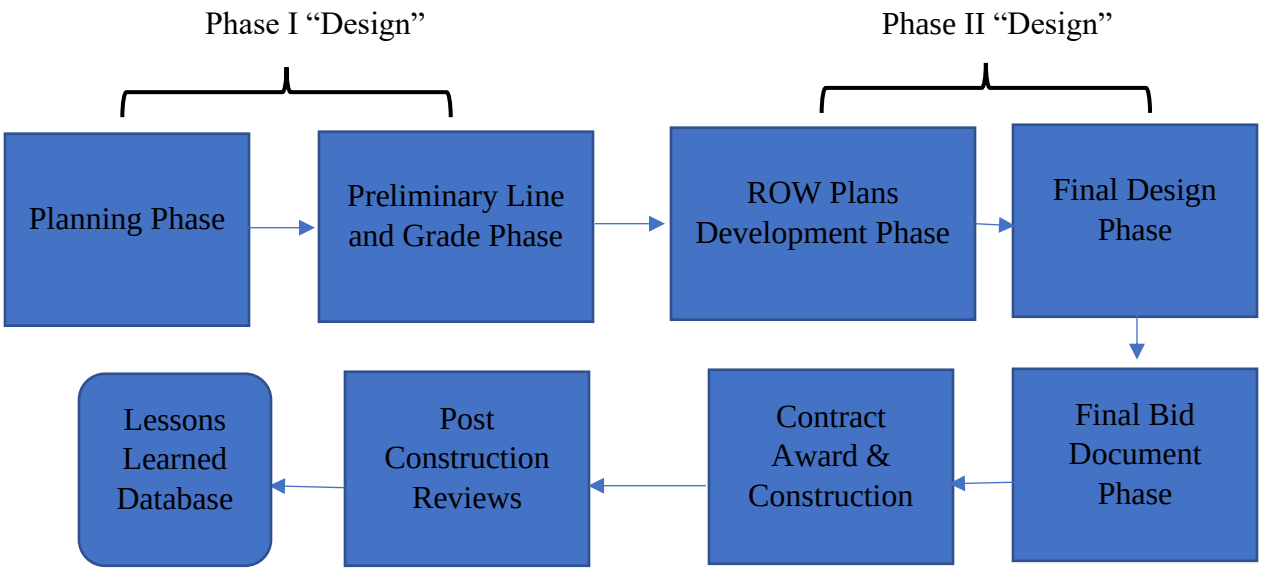

Figure 1.1: Project development phase (Kentucky Department of Transportation)

To maximize the outcome of CR meetings, stakeholders are invited to participate in CR meetings during Phase I and Phase II displayed in the aforementioned schematic diagram for project workflow. Early implementation of CR meetings has a high influence on project savings, as shown in ***Figure 1.2.***

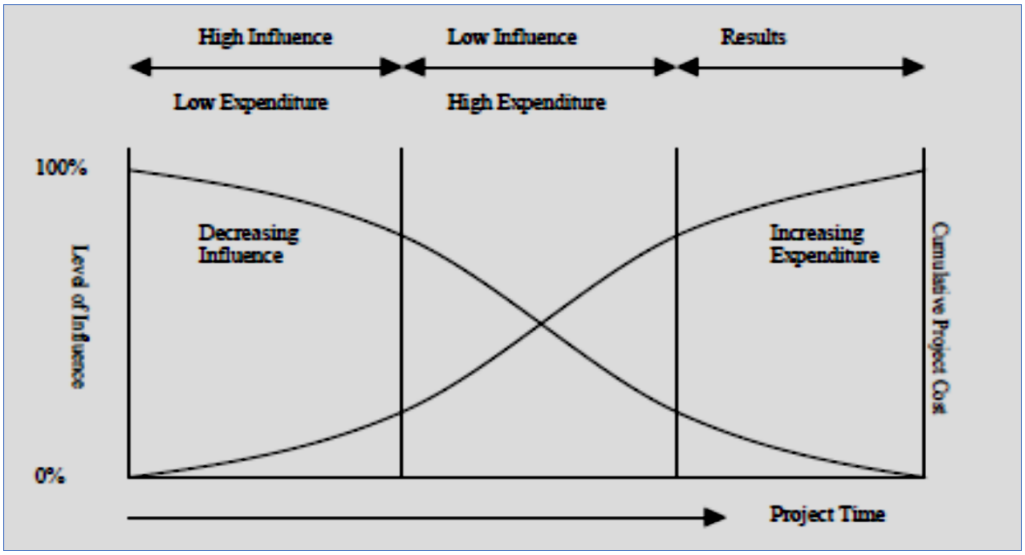

Figure 1.2: Influence of CR meeting on project cost saving versus project phase

The main objective of this research project is to develop specifications and guidelines for conducting formal CR meetings with increased efficiency to be adopted by the North Carolina Department of Transportation (NCDOT). This research project includes four phases:

Phase I: Investigate current CR meetings' practices followed by the Federal Highway Administration (FHWA) and different state DOTs. This phase was accomplished through a comprehensive literature search, conducting a formal survey to obtain recommended practices by architects, engineers, project managers, contractors, and DOT personnel, and attending, or serving, and documenting CR meetings for different projects administered by NCDOT.

Phase II: Develop a detailed checklist to include project activities to be considered in future NCDOT CR meetings. The list of activities was compiled according to the literature outcomes, analyzing previous CR meetings minutes, survey results, and NCDOT personnel feedback.

Phase III: Develop a tool to evaluate the outcomes of CR meetings held at NCDOT for different transportation projects/types.

Phase IV: Evaluate the potential risk of different project activities included in the CR and develop a checklist and assess their impact on the final project budget. The financial risk evaluation will be conducted using a 3-point analysis for activity bid items.

This research report is divided into the following chapters:

Chapter 1. *Introduction:* constructability (buildability) concepts, general CR meeting format, participating stakeholders, and possible CR meeting advantages.

Chapter 2. *Literature review:* to identify and document relevant research projects conducted at federal and state levels. The literature review will highlight different practices followed by other state DOTs, possible CR meeting standards and specifications as outlined by different DOTs, and reported advantages and disadvantages associated with these practices.

Chapter 3. *DOT Constructability Review Practices:* are listed based on surveying and interviewing different State DOTs across the country. These various practices were considered by the project research team when conducting in-state surveys regarding NCDOT CR practices.

Chapter 4. *NCDOT Constructability Review Meetings:* Survey and CR meetings' outcomes, as recorded by the project research team. The outcomes provided detailed feedback on practices recommended by different project stakeholders to be observed by NCDOT in future projects.

Chapter 5. *CR Meeting Checklist Development and CR Meetings Assessment Tools:* The checklist provided in chapter 5 presents the research team finding for common activities discussed in similar CR meetings as reported by different state DOTs, and as per literature review findings (chapter 2), DOT Practices (chapter 3), and the project stakeholders' surveys (in North Carolina) outcomes (chapter 4). A suggested assessment tool is developed to be used in the outcome evaluation of future CR meetings.

Chapter 6. *Risk Assessment for DOT projects:* using 3-point bid/cost analysis for bid items. The outcomes of this chapter provide information on the identification of bid items that have a larger (negative) impact on project budget.

2. Literature Review

The construction industry is infamous for the lack of coordination between the design phase including the development of design drawings and specifications, and the construction phase including the development of construction drawings. During the last three decades, the idea of integrating design and construction procedures has been investigated and implemented in different ways, formally and informally, to avoid site issues, schedule delays, cost overruns, and safety violations.

2.1. Evolution of Constructability Review

The concept of "constructability" in the United States, or "buildability" in the United Kingdom emerged in the early 1980s. The concept of constructability evolved to increase the economic feasibility of construction projects, and to maintain construction quality and affordability (Emmerson, 1962 and Uhlik and Lores, 1998). The importance of inserting construction knowledge into the design process was investigated, and the impact of decisions made in the early phase of a project on the cost and quality of construction was confirmed (Paulson, 1976). Ever since, different research projects investigated project constructability, provided different definitions of constructability, explored constructability advantages, proper CR meetings format, duration, location, and participating stakeholders. In addition, several research projects investigated the possibility of increasing CR meetings' efficiency, limitations to successful CR meetings, and how to quantify and assess the outcomes of CR meetings for construction projects.

2.2. Constructability Definitions and Concepts

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" depending on 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 capability of being constructed" (ASCE, 1991)
- "The integration of construction knowledge, resources, technology, and experience into the engineering and design of a project," (Anderson et al., 1995)
- "A process that utilizes construction personnel with extensive construction knowledge early in the design stages of projects to ensure that the projects are buildable and cost-effective or biddable and maintainable," (AASHTO, 2000)

The Construction Industry Institute (CII) formed a Constructability Task Force to determine principles and concepts that could be used to improve constructability in each phase of the construction project. The task force considered possible principles within the following three project phases:

1. Conceptual planning
2. Design and procurement
3. Field operations

Constructability improvement during the conceptual planning phase is attained through three major principles including the development of a detailed project plan, clear site layout details, and consideration of alternative construction methods (CII, 1986a). In a different study, the CII examined the improvement of constructability during the project engineering and procurement phases. The conclusions of the study (CII, 1986b) were as follows:

- Design and procurement should be construction driven
- Designs should be configured to enable efficient construction
- Designs should be scoped to facilitate fabrication, transport, and installation
- Designs should promote resource utilization
- Specifications should simplify construction operations

Finally, constructability could be enhanced during field operations when innovative constructability methods are utilized (CII 1988). In a relevant study, the CII displays 14 different concepts (principles) to improve constructability; six considerations during conceptual planning, seven for consideration during design, engineering, and procurement stages, and one concept for

consideration during site operations (CII 1992). In 1995, the ASCE proposed 6 principles for constructability including (1) evaluating various design alternatives to optimize owner requirements, (2) knowledge of the various project systems and their interface requirement with other project components, (3) understanding trade skills and practices, construction methods, materials, and sub-contract resources, (4) understanding climate conditions, (5) evaluating site conditions above and below the ground, and (6) determining space and access routes within the construction site.

Similar constructability concepts were developed by researchers outside the United States. The Construction Industry Research Information Association (CIRIA) of the United Kingdom developed seven guidelines for constructability (buildability), which were later expanded into 16 principles for constructability (CIRIA, 1983m and Adams, 1989). Constructability rules/concepts were defined for bespoke buildings in the United Kingdom after a thorough review of existing building design as a source of constructability rules (Fox and Cockerham, 2002). Based on the aforementioned research findings, the following guidelines were followed to enhance the constructability efficiency of bespoke buildings:

I. Focus rules on each design stage in sequence
II. Support rules with self-explanatory strategies and production databases
III. Develop routine and foolproof application methods or rules
IV. Target rules on best available productivity/quality improvement opportunities

In Australia, the Construction Industry Institute of Australia (CIIA) has developed 12 principles of constructability using the principles generated by the CII after tailoring them to the Australian construction industry (CIIA, 1996). The 12 principles include:

1. *Integration*: constructability concepts should be incorporated in an integrated way into the design phase of the project
2. *Construction knowledge*: project design should actively include simultaneous use of knowledge and experience
3. *Team skills*: the project team's abilities, experiences, and skills which should match the goals of the project

4. *Common objectives*: defining and understanding common objectives leads to improving project implementability
5. *Available resources*: applied technologies in the design section should be compatible with available capabilities and resources
6. *External factors*: these factors are effective in project cost and time planning
7. *Schedule*: a detailed project schedule should be implementable, and the project team should be committed to the implementation
8. *Construction methodology*: constructability should be fully considered in project design
9. *Availability*: consideration of the construction phase during the design phase will enhance project implementation
10. *Specifications:* constructability should be considered in the development of project specifications
11. *Technology*: using modern innovations and methods will result in improved implementations
12. *Feedback*: project evaluation by an experienced team, after its completion, will be useful for improving the constructability of similar projects in the future

In Malaysia, the following 23 detailed concepts for constructability have been identified and are recommended during different phases of the construction projects (Nima et al., 2001):

I. Project constructability enhancement during the conceptual planning phase (7 concepts):

Concept 1: The project constructability program should be discussed and documented within the project execution plan, through the participation of all project team members

Concept 2: A project team that includes representatives of the owner, engineer, and contractor should be formulated and maintained to consider the constructability issue from the outset of the project and through all its phases

Concept 3: Individuals with current construction knowledge and experience should achieve the early project planning so that interference between design and construction can be avoided

Concept 4: The construction methods should be taken into consideration when choosing the type and the number of contracts required for executing the project

Concept 5: The master project schedule and the construction completion date should be construction-sensitive and should be assigned as early as possible

Concept 6: To accomplish the field operations easily and efficiently, major construction methods should be discussed and analyzed in-depth as early as possible to direct the design according to these methods

Concept 7: Site layout should be studied carefully so that construction, operation, and maintenance can be performed efficiently, and to avoid interference between the activities performed during these phases

II. Project constructability enhancement during the design and procurement phase (8 concepts):

Concept 8: Design and procurement schedules should be dictated by construction sequence. Thus, the construction schedule must be discussed and developed prior to the design development and procurement schedule

Concept 9: Advanced information technologies are important to any field including the construction industry. Therefore, the use of these technologies will overcome the problem of fragmentation into specialized roles in this field, and enhance constructability

Concept 10: designs, through design simplification by designers and design review by qualified construction personnel, must be configured to enable efficient construction

Concept 11: Project elements should be standardized to an extent that will never affect the project cost negatively

Concept 12: The project technical specifications should be simplified and configured to achieve efficient construction without sacrificing the level or the efficiency of the project performance

Concept 13: The implementation of modularization and preassembly for project elements should be taken into consideration and studied carefully. Modularization and preassembly design should be prepared to facilitate fabrication, transportation, and installation

Concept 14: Project design should take into consideration the accessibility of construction personnel, materials, and equipment to the required position inside the site

Concept 15: Design should facilitate construction during adverse weather conditions. Efforts should be made to plan for the construction of the project under suitable weather

conditions; otherwise, the designer must increase the project elements that could be prefabricated in workshops

III. Project constructability enhancement during the field operation phase (8 concepts):

Concept 16: Field tasks sequencing should be configured to minimize damages or rework of some project elements, minimize scaffolding needs, formwork used, or congestion of construction personnel, material, and equipment

Concept 17: Innovation in temporary construction materials/systems, or implementing innovative ways of using available temporary construction materials/systems that have not been defined or limited by the design drawings and technical specifications will contribute positively to the enhancement of constructability

Concept C18: Incorporating innovation of new methods in using off-the-shelf hand tools, or modification of the available tools, or introducing new hand tools that reduce labor intensity, increase mobility, safety, or accessibility will enhance constructability during the construction phase

Concept C19: Introducing innovative methods for using the available equipment or modification of the available equipment to increase productivity will lead to a better constructability

Concept 20: To increase productivity, reduce the need for scaffolding, or improve the project's constructability under adverse weather conditions, constructors should be encouraged to use any optional preassembly

Concept 21: Constructability will be enhanced by encouraging the constructor to carry out innovation of temporary facilities

Concept 22: Good contractors, based on quality and time, should be documented so that contracts for future construction works would not be awarded based on low bids only, but by considering other project attributes, i.e., quality and time

Concept 23: Evaluation, documentation, and feedback on the issues of the constructability concepts should be maintained throughout the project to be used in later projects as lessons learned

2.3. Implementation of Constructability Review Programs

Constructability implementation by holding constructability review meetings represents a major challenge to project stakeholders. CR meetings require putting all constructability concepts and principles identified in a workable package. Based on the literature search, the successful implementation of constructability principles depends on addressing the following 6 questions:
Question #1: When is the optimum timing for holding a constructability review meeting? At what stage within the project life cycle?
Question #2: Who are the invited stakeholders?
Question #3: What should be the main focus of the constructability review meeting/constructability review program?
Question #4: How should the constructability program be implemented? Should CR meetings have formal guidelines?
Question #5: How many CR meetings are required for a given project?
Question #6: How would the meeting outcomes be assessed?

The Construction Management Committee of the American Society of Civil Engineers states that constructability review meetings should start during the project conceptual planning phase to maximize its impact. The ASCE committee states that all invitees should have relevant construction knowledge that could benefit the project, and have the authority to request revisions of existing designs/specs. Invitees should consider the following points to evaluate the success potential of the CR program:

I. What are the key components of the CR meeting they participate in?
II. What are the standards and format of the CR meeting held?
III. What are the barriers that could face the effective implementation of the outcome of their meeting?
IV. How to assess the existing program, evaluate its outcomes, and make an improvement?

2.4. Implementation of Constructability in Transportation Projects

Over the past decades, there has been a substantial increase in the number and size of construction projects by the Federal Highway Administration and State Departments of Transportation. The

main objective of DOT projects are to maintain and improve the conditions of roadway networks under their supervision. Due to budget constraints, State DOTs have been researching (1) The quality of construction materials for improved projects performance and to lower maintenance expenditure (Akhnoukh and Ekhande, 2022, Akhnoukh and Buckhalter, 2021, Akhnoukh 2020, 2018, 2013a, 2013b, Akhnoukh et al. 2016, Morcous and Akhnoukh, 2007 and 2006, Elia et al., 2018, Akhnoukh and Soares, 2018, and Akhnoukh, 2010), (2) The better coordination of construction projects using artificial intelligence, remote sensing, and commercial software packages (Xiao et al, 2018, Meadati et al., 2012, 2011), and (3) The implementation of constructability review principles (Minerva et al., 2022, Akhnoukh et al., 2022, Stamadiatis et al., 2013, Wong et al., 2007, and Douglas, 2008).

Although the constructability principles and implementation of constructability review meetings were widely investigated by the transportation industry personnel, their implementation is not as widely adopted as in building and industrial construction projects. Among the early constructability studies conducted by State DOTs, the Texas Department of Transportation developed a guide that describes constructability implementation and its relevance to other programs as value engineering. The report introduced when, how, and why to introduce constructability reviews in highway construction projects (Hugo et al., 1990). Similarly, the Florida Department of Transportation (FDOT) has developed constructability implementation guidelines for its highway construction projects (Ellis et al., 1992).

Arizona Department of Transportation (ADOT) has developed detailed guidelines on how to conduct a formal CR meeting, record, and implement its recommendations (Wright, 1994).The Wisconsin Department of Transportation (WDOT) investigated the constructability concepts and developed its tools for constructability implementations in highway construction (Russell and Swiggum, 1994). Kentucky Department of Transportation has conducted a research program that collected relevant information on different potential issues that could interfere with the successful constructability implementation of their highway construction projects (Hancher et al., 2003).

Louisiana Department of Transportation conducted recent research that showed that it may be beneficial to State DOTs to conduct CR meetings and discuss constructability issues 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., 2021).

Idaho Department of Transportation has developed formalized CR meetings to include specific personnel attendance, specific time, and format for conducting the CR meetings (ITD, 2011). Similarly, the New Jersey Department of Transportation has developed guidelines to minimize the risk associated with construction projects. The risk mitigation plans of NJDOT require conducting CR meetings, recording its results, and following the execution of its recommendations (NJDOT, 2011). Finally, Indiana DOT developed a detained constructability guidebook to provide a step-by-step guideline for formalizing constructability review meetings (INDOT, 2010).

Different transportation agencies have researched and developed guidelines to increase the constructability efficiency of highway projects including the Transportation Research Board (TRB), the National Cooperative Highway Research Program (NCHRP), and the American Association of State Highway and Transportation Officials (AASHTO). The AASHTO Subcommittee on Construction developed the Best Practice Guide to provide recommendations, guidelines, and specifications for developing a constructability review process and holding constructability review meetings by different State DOTs. The AASHTO guide presents recommendations for different transportation agencies that could be used to develop specific CR meeting regulations that could best fit the unique needs of the agency. According to the developed AASHTO guidelines, the implementation of constructability in transportation projects requires the following components:

2.4.1. CR Programs and CR Meetings Champion

Although every agency and DOT has its unique organizational structure, and specific needs and demands, it is reported that the successful implementation of any constructability program requires

a supervision and an agency leading the program. For example, it is recommended for DOT to allocate a chief engineer, chief construction officer, senior management personnel, or value management officer to serve as CR program champions. According to the literature, the suggested role of the constructability program champion should include the following:

I. Ensure that all units participate in the implementation of project constructability
II. Ensure that all communications are flowing freely, on a horizontal and vertical level, within the department
III. Authorize the design units to revise plans and specifications in a timely manner to address all CR meetings comments

2.4.2. CR Team Composition

The constructability review team is usually composed at the design concept stage of the construction project. Most agencies, including State DOTs, delegates the responsibility for arranging CR meetings to the design project manager. Few DOTs have a separate team for CR coordination. When developing the CR team, it is important to limit the team size to avoid coordination problems and/or conflicts. The CR team should be focused on critical project issues and may consider the formal steps, if any, for conducting the CR meeting. Most agencies require group CR meetings instead of individual ones for better communication. In general, the review team may be comprised of the following:

I. *Internal Members:* including members from the design and construction units. Support personnel from other units could be brought in as needed. Most State DOTs favor the inclusion of external industry professionals in CR meetings. Industry professional input is required to supplement the experience of the DOT staff members.
II. *Construction Professionals*: are invited by DOTs to assist in constructability review process. Different State DOTs developed their system to invite industry professionals. The Connecticut Department of Transportation (ConnDot) invites professionals who are members of the Connecticut Construction Industries Association (CCIA) to attend CR meetings and provide their feedback. Pennsylvania DOT has hired a retired contractor to perform their constructability reviews, Kansas Department of Transportation formed a joint task force including representatives from the Kansas Contractors Association, Heavy Constructors Association, and Kansas Department of

Transportation (KDOT) to provide feedback on CR meetings. Maine DOT invites professionals from a list of industry personnel prepared and updated by the Maine DOT management office. Current North Carolina CR meetings require the attendance of AGC invited contractors. Typically, the attendance of three contractors is encouraged for NCDOT constructability meetings.

III. *Consultants:* are invited by different DOTs to participate in constructability review meetings. It is encouraged that consultants do not attend CR meetings for projects they designed. Some state DOTs, such as Washington State DOT, provides consultants with CR meetings compensations under a specific CR agreement established at WSDOT.

IV. *Regulatory:* representatives of federal, state, or local regulatory agencies may be involved in constructability meetings. Regulatory personnel can alert the review team if special permits are required, and the possibility of schedule delays incurred due to the time durations required for permit issuance. Regulatory personnel presence is important when projects are built in the vicinity of historical locations, preservatives, or when water bodies and/or railroads are crossed.

V. *Material Suppliers:* are invited where non-standard materials are required to be utilized. This includes special steel sections, the use of ultra-high performance concrete mixes, special insulations, coatings, and finishing. Materials suppliers' input is required to confirm the availability of special materials and to discuss potential problems and delays associated with their supply chains.

VI. *Utilities:* representatives of utility companies that may be affected by the construction project may be invited to the constructability meeting. The utility companies' representatives may provide information regarding the impact of the project on the utility services in the project vicinity. Also, their feedback regarding the possible need to relocate and/or replace specific utilities should be addressed.

VII. *Railroad:* representatives may be invited to constructability meetings if the construction project may cross railroad tracks.

2.4.3. Constructability Review Frequency

The frequency of constructability meetings, length of meetings, and the number of meetings held per project are highly dependent on project size, nature, and location. In addition, the agency resources should be considered when constructability is discussed. The literature results showed that earlier meetings provide optimized results as changes to the design are easily achieved at the initial design stages. Feedback showed that performing constructability reviews past 85% of project completion is not recommended, as changes made at this stage will be costly. The ability to influence the final cost of the project versus the time of conducting constructability review (CR) meetings is shown in ***Figure 2.1.***

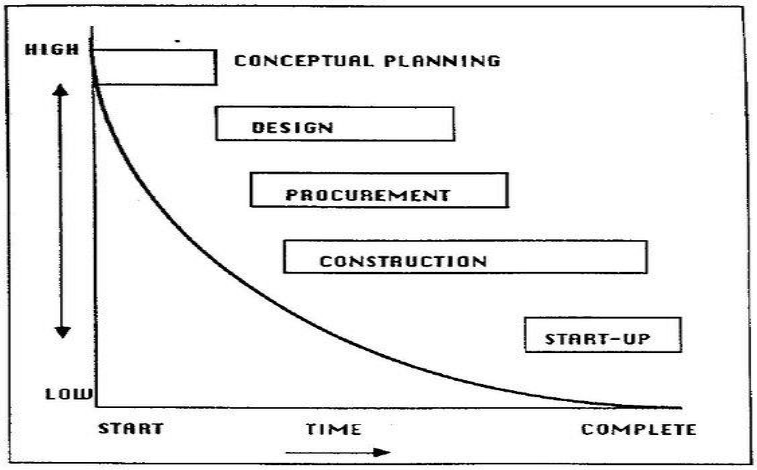

Figure 2.1: Constructability review meeting timing influence on final project budget

Multiple constructability meetings may be required for the same project due to its complex nature, or the need for additional feedback from multiple external experts who may not be available to attend the same meeting. CALTRANS developed a three-level constructability process to be implemented for the agency projects according to the following schedule:

Level 1 Constructability Meeting: to include reviews at the Project Initiation Document (PID) stage, and 30%, 60%, and 95% of the design stage. This 4-meeting constructability is appropriate for the following projects:

- Complex roadway/facility improvement projects
- Complex interchange construction or modifications
- Large rehabilitation projects that require widening, major structure replacement, or significant utility adjustments

Level 2 Constructability Meeting: to include reviews at the PID stage, 30%, and 95% of the design stage. This 3-meeting constructability is appropriate for the following projects:

- Less complex roadway and facility improvement projects
- Less complex structure or interchange projects
- Most rehabilitation projects which include minor widening, drainage, or safety improvement

Level 3 Constructability Meeting: This includes PID stage and 95% design completion meetings. This 2-meeting constructability is appropriate for the following projects:

- Capital Preventative Maintenance (CAPM) overlay projects
- Most non-complex soundwall projects

Florida DOT incorporates its constructability review meetings into its 30% and 60% design review procedures. Connecticut DOT schedules their constructability review meetings at 30-50% of design completion. At this level, modifications for design will not require much work alteration. Thus, the impact of changes made on the project schedule is minimal. Washington State DOT conducts a 4-stage constructability meeting. WSDOT constructability meetings include: (1) 0% CR meeting; (2) 30% CR meetings, which is focused on constructability assessment after the development of the project's primary geometric features; (3) 60% CR meetings, which is set at the critical design stage to review several design features and details and address all items that may be critical during the project execution; and (4) Final constructability review meeting to focus on contract plans and special design provisions. The WSDOT utilizes an in-house checklist to assist in performing their constructability reviews (McManus et al., 1996). Currently, other State DOTs conduct CR meetings with no strict formal schedule or format as in North Carolina, Arkansas, Pennsylvania, and Arizona.

2.4.4. Location of CR Meetings

State DOTs prefer to have constructability review meetings held on the construction site. Site meetings provide CR meeting attendees with sufficient information required to discuss constructability issues including soil conditions, site access, impact on utility lines, right of way, traffic interchanges, detours, and possible drainage/hydrology considerations. Some DOT

feedback highlighted problems associated with site visits including the driving distance and the inability to coordinate site visits concurrently. As an alternative, few DOTs require the CR meeting to be held in an office setup provided that all attendees would conduct individual site visits prior to the meeting time.

The literature review suggests that CR meetings may be held by using nearby public facilities (i.e., state highway garage, school, library conference room, etc.). This allows for a combination of organizing the meeting in an office setting while possibly reviewing the nearby construction as needed to address any issues.

Current research projects are investigating the possible use of advanced technology in supporting project constructability. Among the suggested technologies, are the use of aerial photos, utilizing unmanned aerial vehicles (UAVs) to capture site videos, and conducting web meetings for all CR meeting attendees to cut down on financial expenditure, reduce the time and effort required for travel, and enhance constructability reviews safety. In a recent study, different constructability techniques were surveyed and ranked according to their importance on a scale from 1 to 5 (5 is the highest importance). The feedback from 42 interviewees is shown in ***Table 2.1*** (Amade, 2016).

Table 2.1: Different constructability techniques – reported by 42 interviewees

Constructability Technique	**Response Ranking**					**Total**	**Mean Score**	**Rank**
	5	**4**	**3**	**2**	**1**			
Contract Incentive Clause	6	7	6	13	10	42	2.66	6
Formal Implementation Process	6	6	7	12	11	42	2.61	7
Corporate Lesson Learned File	22	10	3	2	5	42	4.00	1
Constructability Resources	7	6	5	10	14	42	2.57	8
Computer Based Software	16	14	5	3	4	42	3.83	4
Brainstorming	16	14	6	4	2	42	3.90	2
Peer Review	17	13	5	4	3	42	3.88	3
Feedback Systems	5	6	9	10	12	42	2.57	8
Const. Review Meetings	10	12	9	8	3	42	3.42	5

2.4.5. Resource Allocation

Resource availability is a concern for all agencies in charge of formal constructability review meetings, regardless of the meeting number, location, duration, and format. The main resources required to conduct successful CR meetings include: (1) the availability of a program champion; (2) a list of potential attendees among the agency personnel, designers, contractors, project managers, suppliers, etc., (3) funding required to hold the meeting and financially covers site trips, and (4) sufficient time to review designs, conduct site visits, prepare and attend CR meetings.

Agencies are required to tailor their constructability review programs to fit their goals which include improving design, reducing costs associated with delays and/or site stoppage, minimizing claims and change orders, ensuring proper supply chain functionality, and avoiding possible safety problems and accidents. The following variables are to be considered when CR meetings are held:

I. *Manpower:* more resources are typically required in the project's early phase
II. *Funding:* is required at the initial project stages to cover the CR meetings expenditures. Funding may be made available through the savings from reduced change orders and claims
III. *Time:* for review process, conducting site visits, attending CR meetings, and design changes to address constructability review concerns have to be inserted into the schedule to avoid possible delays in the project start date

2.4.6. Constructability Review Process

2.4.6.1. Checklists

Constructability review meeting checklists were developed by some State DOTs to be reviewed by CR meeting attendees. State DOTs use this approach as detecting issues may not be discovered easily through a formal or non-formal CR if it is not included in a detailed checklist. Some DOTs uses a general checklist listing general subjects to be reviewed, while other DOTs has developed a detailed checklist with specific items to be reviewed by CR meeting attendees. Based on the

literature, states with general checklists include New Jersey, New York, and Pennsylvania, while California, Connecticut, Maryland, Florida, Indiana, and Tennessee implement detailed checklists. State DOTs checklist investigated shows that the following areas are commonly present in different DOTs checklists:

I. Traffic operations
II. Right of way
III. Environmental considerations and hazardous waste
IV. Utilities within the project area
V. Construction schedule

Different items included in CR checklists by different State DOTs and the list of states enforcing each item are shown in ***Table 2.2.***

Table 2.2: Sample checklist items for CR meetings by different state DOTs

Checklist Item	State DOT of Implementation
Design	California (CALTRANS), Florida (FDOT), Connecticut (ConnDOT)
Traffic Design	California (CALTRANS), Connecticut (ConnDOT), Florida (FDOT), Maryland DOT, NYSDOT
Construction	California (CALTRANS) and NYSDOT
Hydraulics and Drainage	California (CALTRANS), Connecticut (ConnDOT), Maryland DOT, Pennsylvania DOT (PennDOT)
Right-of-Way	California (CALTRANS), Maryland DOT, NYSDOT,
Surveys	California (CALTRANS), Connecticut (ConnDOT), NYSDOT
Structures	California (CALTRANS), Connecticut (ConnDOT), Florida DOT (FDOT), Maryland DOT, NYSDOT, Pennsylvania (PennDOT)
Construction Schedule	Florida DOT (FDOT), NYSDOT
Clearing and Grubbing	Florida DOT (FDOT), Maryland DOT
Utilities	Connecticut (ConnDOT), Florida DOT (FDOT), Maryland DOT
Landscape Architecture	California DOT (CALTRANS),
Detours	Maryland DOT

To survey the aforementioned items, different state DOTs developed a questionnaire to be handed out and discussed with the CR meeting attendees. Based on the answers provided for the questionnaire, DOT personnel can figure out points of concern for the given project design. A collection of survey questions compiled from different DOTs is shown in ***Appendix (A).***

2.4.6.2. Formal vs. Informal Review Meetings

The formality of a CR meeting is determined according to the existence of a predefined date, meeting location, and a predetermined agenda to guide the meeting attendees. Constructability process can be implemented with different states of formality (Gugel and Russel, 1994; Russel et al., 1994). Most DOTs surveyed has some level of formality in their process including defining the design stage at which the CR meeting is to be conducted, the meeting location, meeting attendees, or format. The aforementioned parameters are defined according to the size of the project and the resources available for the DOT supervising the project.

2.5. Current Constructability Reviews Limitation

Several studies have reported the barriers and limitations to the successful implementation of CR meetings in different projects. The literature shows that some critical issues and barriers target the CR meetings of transportation projects associated with project execution, project planning, and project resources. These issues are relevant to the dynamic nature of construction projects and the impact of external parameters such as environment and human behavior on the success of transportation projects (Anderson et al. 1999).

In a relevant study, Arditi et al. (2002) reported that different issues with faulty, ambiguous, and/or defective work project results in incomplete project documentation, which represents a major challenge to the success of CR meetings. Similarly, Uhlik and Lores (1998) reported that general contractors have always been challenged due to the lack of communication with the project designer during the early stages of design. The incorporation of CR meetings in a later stage during the design results in significant tension between project designers and contractors reviewing the design. Lastly, Goodrum et a. (2003) reviewed constructability barriers and factors obstructing the inclusion of efficient CR meetings during the design phase of DOT projects. Reported

impediments included the lack of time and workforce shortage. In addition, the research findings highlighted the extent of the problem when a constructability champion is not available. CII (1987) has classified the impediments to constructability concept implementation in different construction projects to include general barrier, owner barrier, designer barrier, and contractor barrier. The different barriers can be listed as the following:

A. General Barrier:

- Complacency with the status quo
- Right people, including the champion, are not available
- No documentation for previous constructability reviews, and lack of studies relevant to their efficiency
- Discontinuity of key project team personnel

B. Owner Barrier

- Lack of awareness of benefits, concepts, etc.
- The perception that constructability delays project schedule
- Reluctance to spend money or effort at this early stage of the project
- Lack of construction experience
- Contracting difficulty in selecting contractors and consultants

C. Designer Barrier

- Lack of awareness of benefits
- Lack of construction experience
- Perception of increased designer liability
- Setting company goals over project goals

D. Contractor Barrier

- The reluctance of field personnel to offer preconstruction advice
- Poor timeliness of input
- Poor communication skills
- Lack of involvement in tool and equipment development

3. NCDOT Constructability Review

3.1. Introduction

The NCDOT has been conducting constructability review meetings for more than a decade, with no official or formal format and organization. In addition, there are no follow-up meetings made to verify whether or not the CR meetings have achieved their purpose in increasing the efficiency of the construction process and/or reducing potential problems that might evolve during different phases of the project. The lack of this information and meeting formal guidelines might result in reduced efficiency of the construction and lower the possible return on investment to be attained by the NCDOT should successful implementation of the constructability review meeting is performed. The following section provides the detailed research methodology followed by the research team to provide recommendations for implementing formal CR meetings.

3.2. Research Methodology

To provide NCDOT Value Management Office (VMO) with guidelines for the formal implementation of constructability reviews for NCDOT projects, answers to the following questions were required:

Question #1: what are the advantages of the current informal NCDOT constructability review meetings?

Question #2: what are the disadvantages of the current informal NCDOT constructability review meetings?

Question #3: what are the requirements of a successful formal constructability review meeting including meeting time, duration, list of attendees, location, agenda, etc.?

Question #4: how would NCDOT assess the outcomes and efficiency of constructability review meetings?

A four-phase survey (questionnaire) was developed to address the aforementioned questions and the outcomes of the survey were discussed, tabulated, and tailored to NCDOT's needs to provide guidelines required for implementing efficient constructability reviews. The four-phase survey included:

I. Survey practices at other State DOTs personnel regarding the current practices followed at their agencies for conducting constructability review meetings.

II. Developed a questionnaire to assess current constructability review meetings at NCDOT, and gain insights on their major advantages, disadvantages, and required changes to increase their efficiency.

III. Developed a questionnaire to survey NCDOT personnel and industry professionals on best practices required to be implemented for NCDOT projects given the nature of the projects and the local construction market conditions within the State of North Carolina.

IV. The research team attended multiple constructability review meetings organized by NCDOT VMO and conducted a field study for current constructability review meetings.

The outcomes of the DOTs survey, the two questionnaires for current and possible future practices at NCDOT constructability reviews, and conclusions obtained by attending NCDOT constructability review meetings are compiled to provide guidelines for the implementation of formal constructability review meetings for future NCDOT projects.

3.3. State DOTs Constructability Review Practices

3.3.1 Constructability Review Techniques

Different constructability review techniques are implemented by transportation agencies and DOTs. The selection of the constructability review approach is dependent on the project type, size, location, and resources available at the DOT. According to the feedback received, only 10% of DOTs implement no constructability review for their projects. Other DOTs depend on construction experts' feedback, peer review for project design and tender documents, formal review meetings, self-revisions conducted by the design team, or through the implementation of predefined checklists. The type of constructability reviews and the percentage of implementation by different DOTs is shown in ***Figure 3.1.***

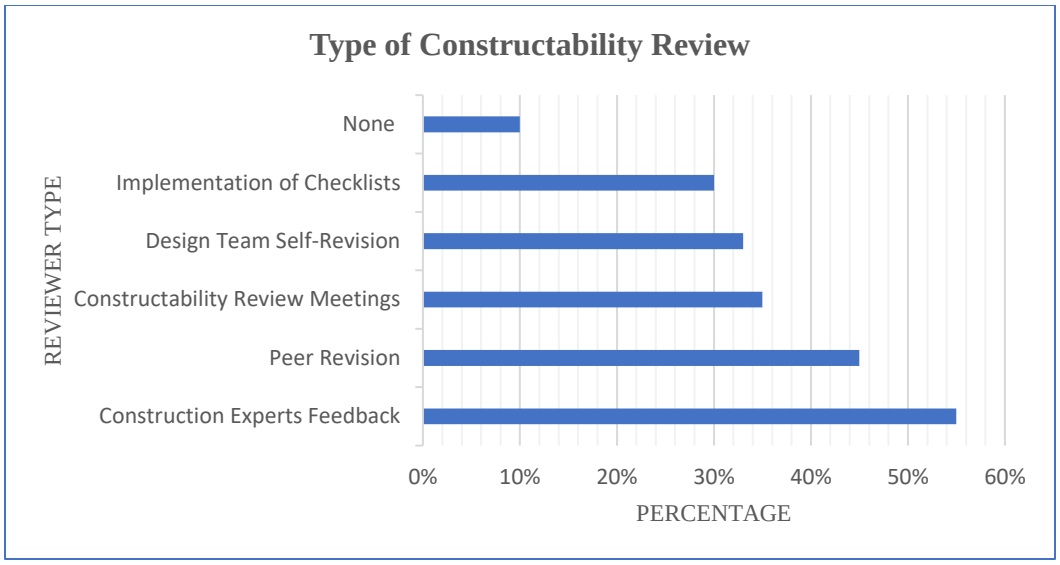

Figure 3.1: Type and percentage of constructability review techniques implemented by different state DOTs

Efficient constructability review technique preference slightly varies according to the profession of the interviewee. DOT survey feedback showed that design engineers' and contractors' preference for constructability review meetings is 61% and 69% respectively. Value engineering and non-formal project meetings are selected as a preferred constructability review approach next to constructability review meetings by both parties. Detailed survey outcomes and feedback of design engineers vs. contractors are shown in ***Figure 3.2***, ***Figure 3.3***, and ***Figure 3.4.***

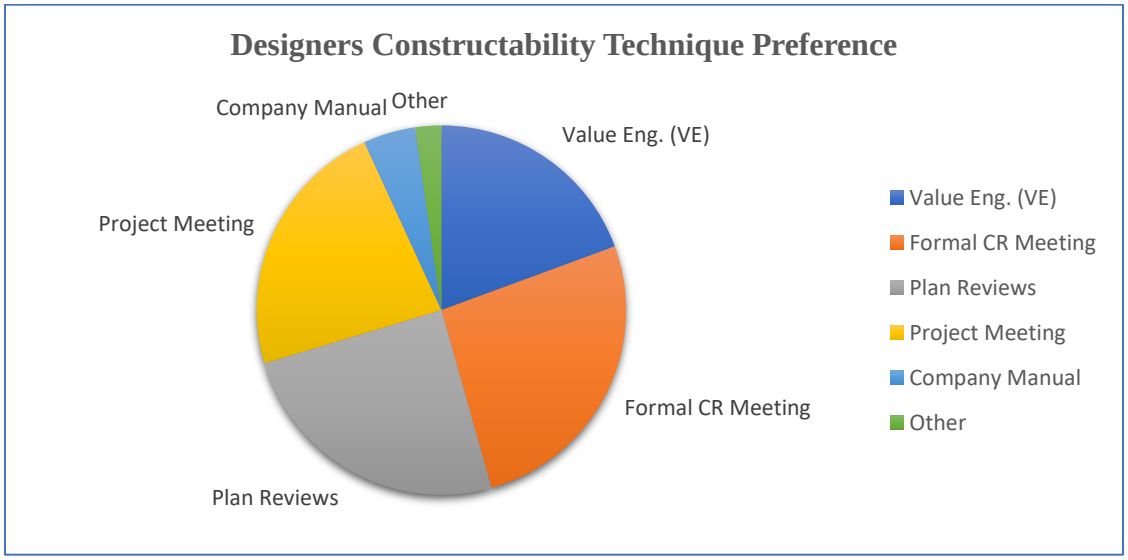

Figure 3.2: Constructability review preference reported by design engineers

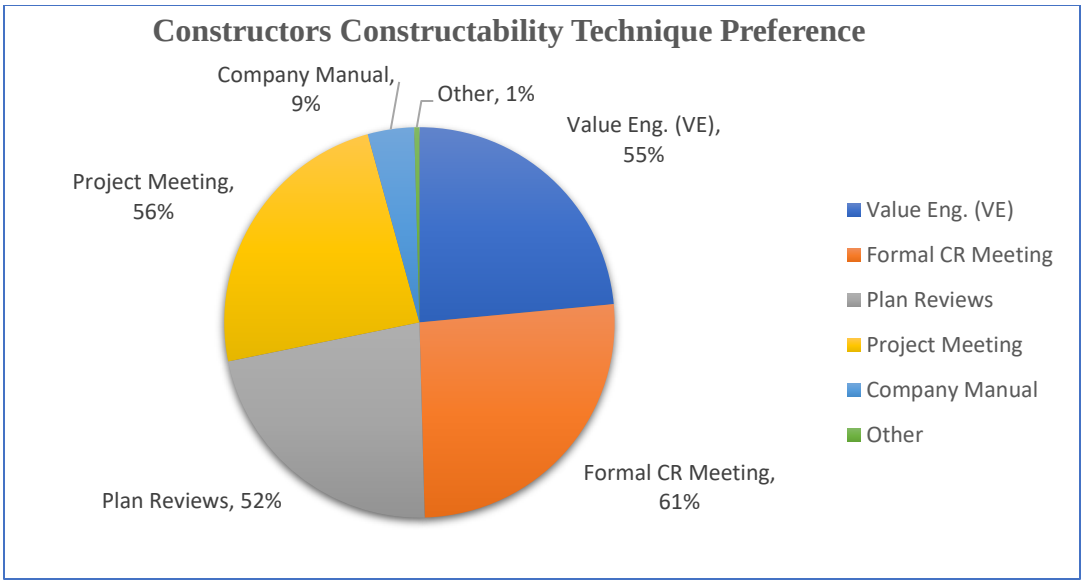

Figure 3.3: Constructability review preference reported by design engineers

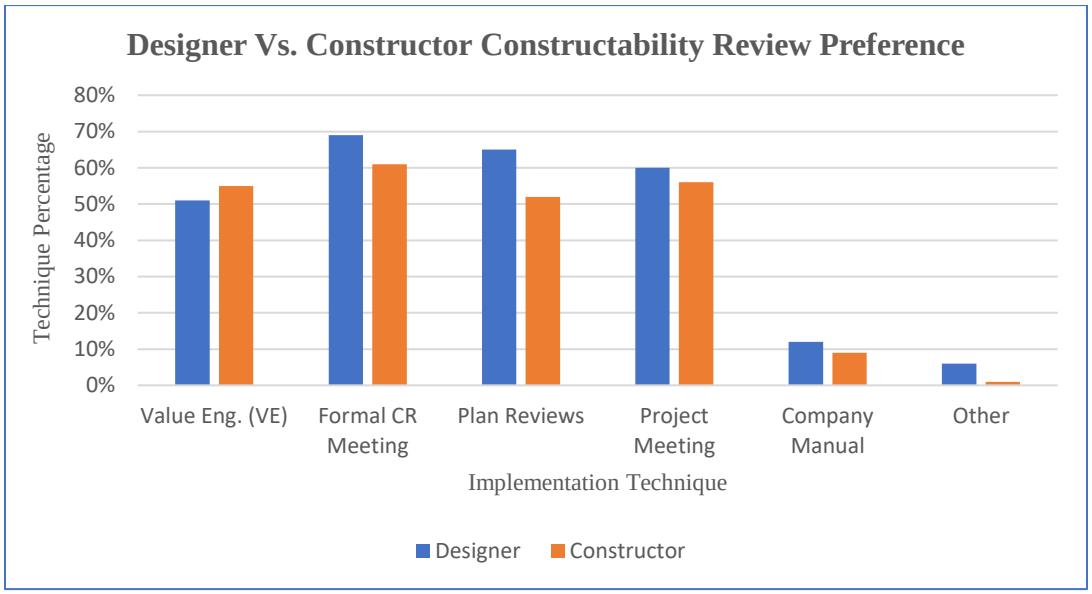

Figure 3.4: Comparison of constructability review preference for design engineers and contractors

DOTs utilizing constructability review meetings perform formal meetings according to the specific manual, or non-formally conduct their meetings without specific guidelines. DOTs in several states including California, Washington, New York, New Jersey, Texas, Florida, Indiana, Tennessee, Arizona, Kentucky, Connecticut, and Maryland conduct constructability review meetings

according to standard procedures developed by the DOT personnel. The aforementioned states developed standard procedures relevant to the timing to conduct their meetings, meeting location, participants, number of meetings, meeting duration, and the documentation required to handle different stages of constructability review meetings. Other state DOTs including the states of Arkansas, North Carolina, and South Carolina conduct non-formal reviews according to the constructability champion request. Despite the overall advantages provided by constructability reviews, several disadvantages are associated with the implementation of non-formal meetings including the reduced efficiency of conducted meetings, and the inability to assess meeting outcomes. In 1997, only 16% of DOTs across the nation implemented formal constructability review meetings (Anderson and Fisher, 1997). Currently, a slight majority of state DOTs implement formal reviews, as shown in ***Figure 3.5.***

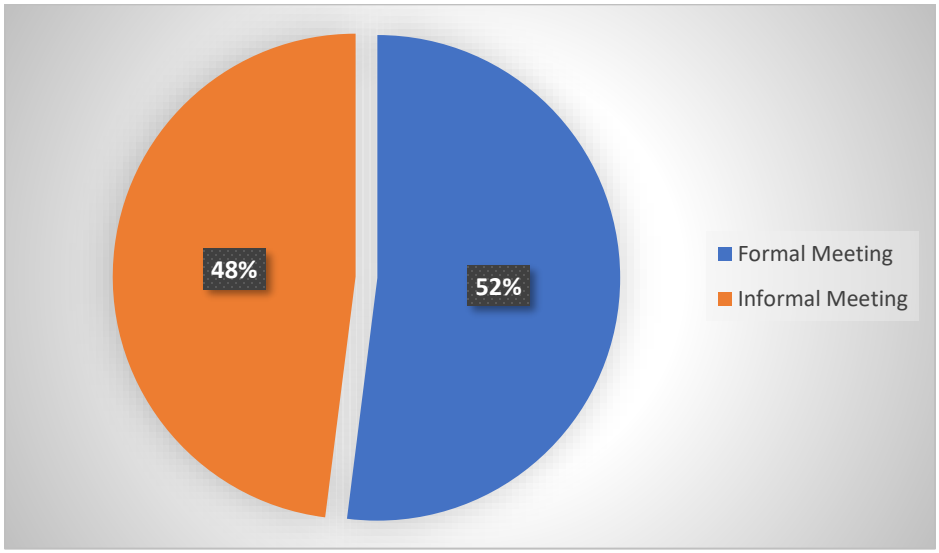

Figure 3.5: Percentage of formal vs. non-formal constructability review meetings implemented by State DOTs

3.3.2. Constructability Review Meetings Timing

The majority of surveyed DOTs (84%) implement constructability review meetings before design phase completion. Early implementation of constructability reviews provides project designers with adequate opportunities to review the project design and comply with feedback received during the review meeting without significant changes to the project design and bid documents. More than 40% of state DOTs require constructability reviews to take place during the conceptual design

phase. Few state DOTs as California and Kentucky developed a multi-step constructability review meeting program for their projects, with initial meetings held at the preplanning stages of the project, and additional meetings held during different design stages. Constructability review meetings should not exceed 3 meetings held per project. The number of meetings is proportional to the project budget and complexity. Timing for constructability review meetings as reported by state DOTs is shown in ***Figure 3.6.***

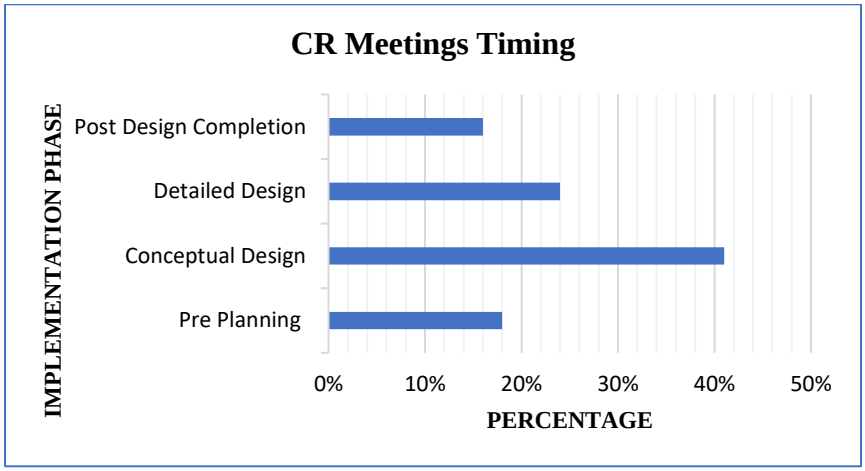

Figure 3.6: Constructability review meeting implementation timing

Constructability review meetings are implemented within the design phase as early as 15% of design completion up to 95% of design phase completion. Detailed DOT feedback is shown in ***Figure 3.7.***

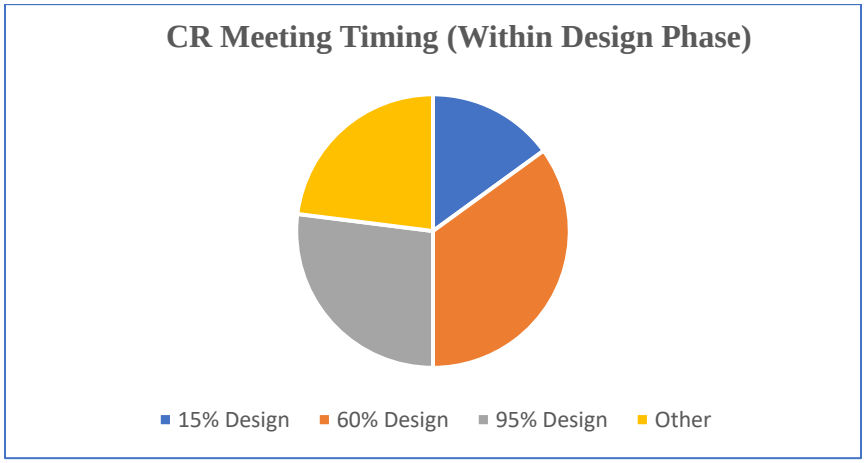

Figure 3.7: Constructability review meeting implementation timing (within design phase)

3.3.3. Constructability Review Champions

The success of any constructability program requires a champion to ensure the successful implementation of different program steps and procedures. Typically, constructability review meetings are initiated and coordinated by an agency-appointed champion. More than 65% of DOTs reported that the project design engineer typically oversees the constructability review process for his project. Other candidates for the constructability review champion position include project managers, resident engineers, value management office personnel, or project coordinator hired specifically to conduct constructability reviews. DOTs feedback and response percentages are shown in ***Figure 3.8.***

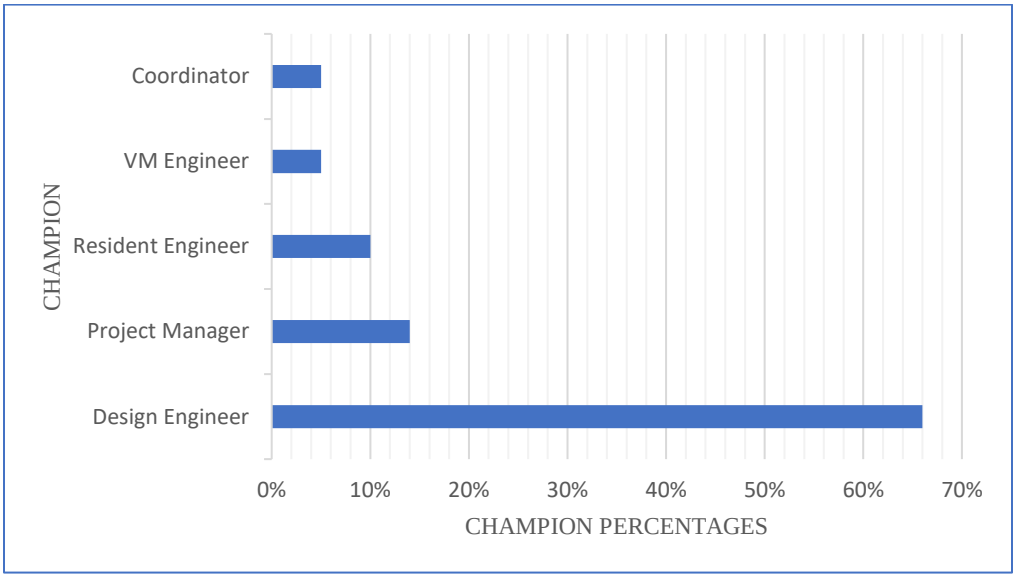

Figure 3.8: Constructability review champion selection for DOT projects

3.3.4. Constructability Review Meetings Participants

The successful implementation of constructability review meetings is dependent on meeting participants, and their ability to review the developed design documents prior to the CR meeting date. A large set of attendees are recommended to attend DOTs constructability review meetings including the DOT design personnel (recommended by 100% of the interviewees, the DOT construction personnel (recommended by almost 95% of the interviewees), a set of general contractors with relevant project expertise (recommended by 75% of the interviewees). Other

project stakeholders' attendance is recommended including the DOT maintenance staff, utility company representatives, material suppliers, and environmental experts. The list of other stakeholders depends mainly on the nature, size, location, and duration of the project. Detailed DOT feedback is shown in ***Figure 3.9.***

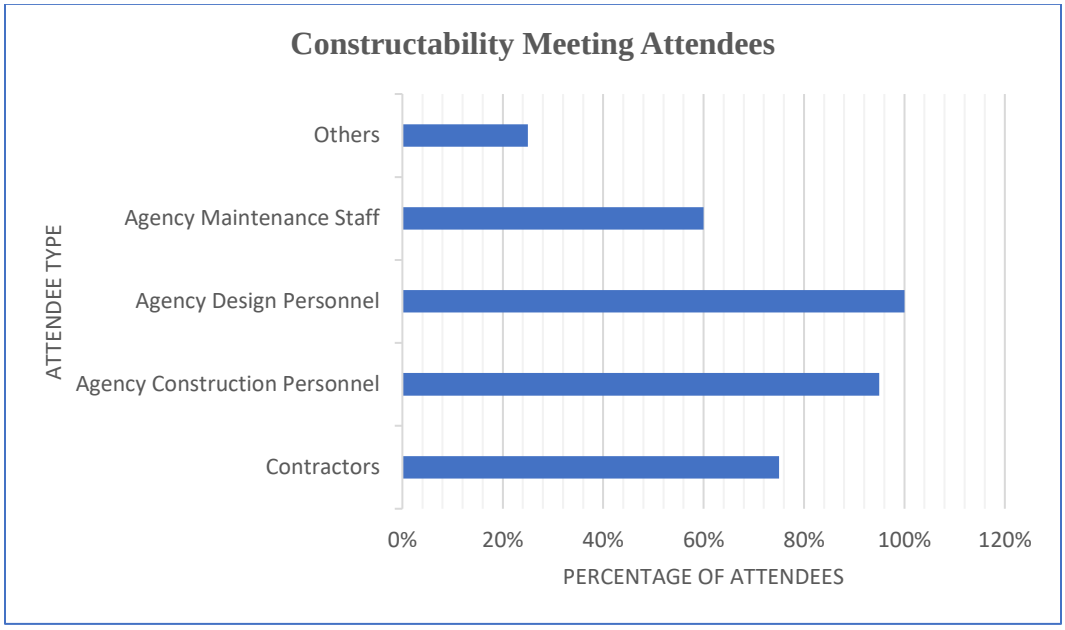

Figure 3.9: Constructability Review Meetings Attendees

3.3.5. Constructability Review Assessment Parameters

Different parameters are used by different DOTs for measuring the efficiency of constructability review meetings and their impact on infrastructure projects. According to DOTs surveyed, The major advantage of CR meetings is to reduce the percentage of design errors (as reported by 29% of the interviewees). CR meetings result in a reduced number of change orders (23% of feedback). Schedule and cost overruns are reduced due to the seamless flow of work when successful CR meetings are implemented. Schedule and cost overruns are reported by 20% and 16% of the interviews, respectively. Additional parameters used in the assessment of CR meetings' efficiency include increased job site safety and reduced OSHA citations. Detailed feedback by state DOTs is reported in ***Figure 3.10.***

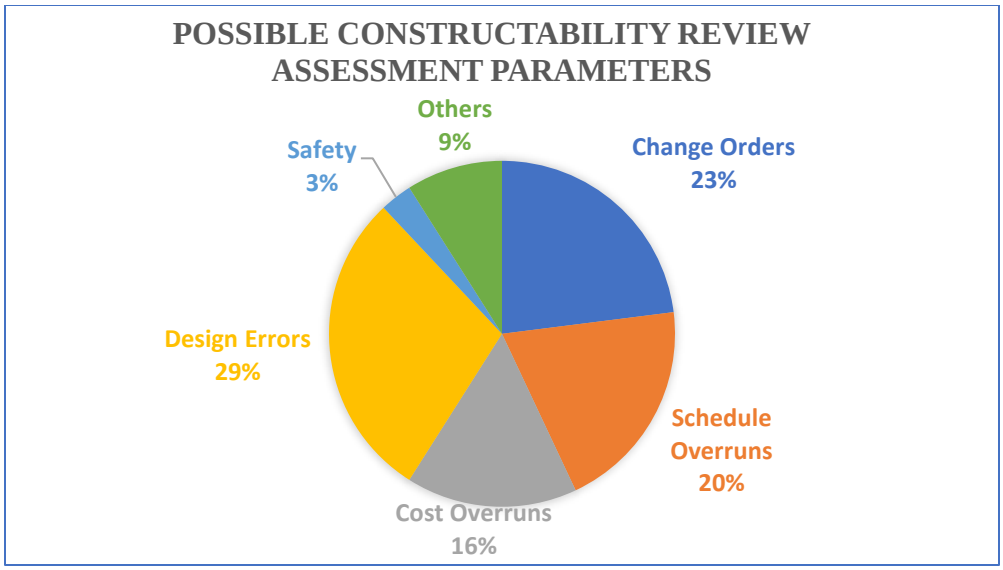

Figure 3.10: CR meetings efficiency assessment parameters

3.3.6. Constructability Impediments

Multiple impediments have been reported by different state DOTs that could affect the implementation of CR meetings. Feedback from state DOTs survey included lack of time, lack of manpower, lack of available experience, and contractor reluctance to participate in CR meetings. The feedback provided by the DOTs is grouped under three main categories, as shown in ***Figure 3.11.***

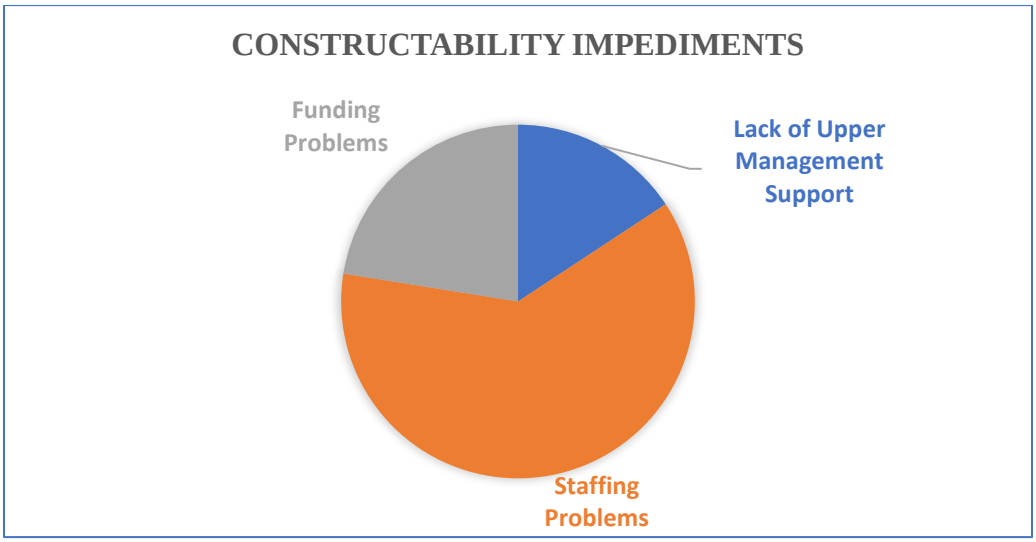

Figure 3.11: Constructability review meetings impediments

3.3.7. Types of Projects Selected for CR Meetings

Constructability review implementation has documented advantages for all types of construction projects. However, due to the limited resources, schedule conflicts, and to alleviate the financial burden, some state DOTs strictly applies CR meetings when conducting specific types of construction projects. The feedback for the DOTs survey showed that less than 60% of the interviewees would recommend CR meetings for all projects. Approximately 22% apply CR review meetings for major interstate construction projects, while 13% consider CR meetings in bridge construction projects. Detailed results are shown in ***Figure 3.12.***

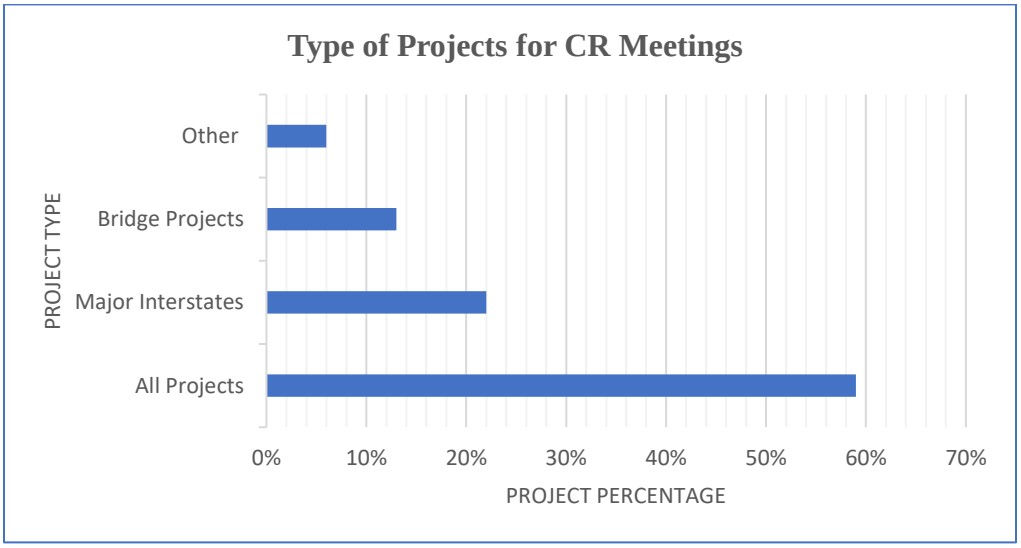

Figure 3.12: Types of projects selected for CR meetings

4. NCDOT Constructability Review Meetings Evaluation

5. CR Meeting Checklist and Assessment Tools Development

5.1. CR Meetings Checklist

The formal constructability review questionnaire and the literature review of state DOTs guidelines in conducting CR meetings suggested that at least one formal CR meeting is required at early stages of design phase (30% of design completion), and a follow-up meeting is required prior to the completion of project design phase.

Due to the shortage in resources, and the possibility of overlooking fine design details at early stages of the design phase, different DOTs found that it is imperative to incorporate checklist in CR meetings to avoid overlooking project details, and/or minimize the chances of excluding important project activities and/or bid items from constructability discussions. The use of checklists serve as a "reminder" or a "to-do list" for reviewing project activities that may result in potential design or construction conflicts. Despite the advantages of checklists, it has to be noted that checklists do not always cover all aspects of work, and may not be applicable to all possible areas of concern in the construction project.

Based on DOT survey results regarding the format of implemented constructability review, it was found that a small number of state DOTs include general checklists to consider during their CR meetings. These states, as New Jersey, Pennsylvania, Arkansas, and Nebraska doesn't use specific checklists due to the large variations in the nature of construction projects. On the contrary, the majority of surveyed states incorporates detailed checklists, with specific items to be considered in the review meeting regardless to the nature, shape, size, and expected budget or duration of the project under-design. These states, including Florida, New York, Connecticut, Indiana, and California depends on detailed standard checklist to be filled by CR meeting attendees including engineers, inspectors, designers, project managers, and contractors to compile a list of potential items to be considered before proceeding the completion of the design. A detailed list of items included in different DOTs checklists is listed in ***Appendix (A).***

5.2. Development of NCDOT Constructability Review Checklist

A multiple criteria selection process was used in determining the project activities to be included in the NCDOT constructability review checklist. First, the project work breakdown structure is examined to select main project categories that are included in different DOT checklists. Second, the literature search included the detailed investigation of detailed list of activities as developed by different states DOTs. A special consideration was given to the project activities repeated in different DOT checklists. Finally, standard project bid items, as developed by NCDOT, is checked by the research team, and specific activities were selected to be included in the development of NCDOT checklist. Detailed activities included in NCDOT checklist were validated by input from NCDOT Value Management Office personnel, NCDOT internal surveys, and feedback obtained from different project stakeholders attending constructability review meetings organized for future NCDOT projects.

5.2.1. State DOTs Categories for Checklist Development based on Project Work Breakdown Structure (WBS)

Different project categories, based on projects WBS, is investigated by the research team. The WBS items investigated are based on similar findings for a relevant research project conducted by Kentucky DOT. The following list of project categories are included in KY DOT:

a) **General**: addressing general constructability issues that may impact all aspects of the construction project

b) Drainage: includes all issues pertinent to temporary or permanent drainage of the construction project

c) Earthwork: which includes all issues relevant to clearing the project construction site (removal of trees and bushes), grubbing (root removing), excavation, hauling materials, backfilling, compaction, and leveling of construction site

d) Environmental: aspects of a project that affect the environment including runoff quality, life of endangered species, soil and underground water quality, and air quality

e) Traffic Maintenance: including all issues relevant to traffic quality and traffic control plan, including traffic signs, signals, detours, barricades, and signage boards

f) **Hazardous Waste:** issues concerning the removal and hauling of hazardous waste in the project vicinity according to the regulations of the designated project county

g) **Railroad:** issues concerning existing railroads, and possible future construction nearby or relevant to railroads

h) **Structures:** including all issues relevant to existing structures, activities followed in new structure projects, and inspection, and maintenance of existing projects

i) **Right of Way (ROW):** issues that arise from obtaining the necessary land needed to construct the project are addressed

j) **Surveying:** includes site surveying and the verification of site boundaries

k) **Utilities:** issues with coordinating underground or overhead utilities in the project area including pipes for water, sewage, gas lines, and electric/phone/internet cables

l) **Pavement:** issues concerning the quantity and quality of the pavement to be used in the construction site or during the project lifetime

m) **Phasing:** issues concerning the step-by-step construction activities

n) **Pedestrians:** issues relevant to pedestrian mobility within the construction site

Ten state DOTs provided feedback for the afore-mentioned categories to identify if the CR meetings at their end requires special attention to these categories. Eleven state DOTs WBS for construction projects were assessed. State DOTs Include the following:

- New York Department of Transportation (NYSDOT)
- Florida Department of Transportation (FDOT)
- New Jersey Department of Transportation (NJDOT)
- Connecticut Department of Transportation (CTDOT)
- California Department of Transportation (CALTRANS)
- Indiana Department of Transportation (INDOT)
- Pennsylvania Department of Transportation (PENNDOT)
- Washington State Department of Transportation (WSDOT)
- Kentucky Department of Transportation (KYDOT)
- Arizona Department of Transportation (AZDOT)
- South Carolina Department of Transportation (SCDOT)

Table 5.1 is developed to incorporate the feedback received from the afore-mentioned DOTs regarding the categorization of their projects. A numerical value of "1" is assigned to DOTs feedback when the category is used by the State DOT in their CR meetings, and a value of "0" is assigned to the category if not included in the DOT feedback. The frequency of feedback is separated into 3 groups: greater than 50% indicates high importance, between 25% and 50% indicates moderate importance, and less than 25% indicates low importance.

Table 5.1: Category frequency according to state DOTs survey outcomes

Categories	**NY**	**FL**	**NJ**	**CT**	**CA**	**IN**	**PA**	**WA**	**KY**	**AZ**	**SC**	**Total**	**Freq.**
General	1	1			1				1	1	1	6	55%
Drainage		1	1	1	1	1	1	1			1	8	73%
Earthwork		1	1		1		1	1				5	45%
Environ.		1			1	1		1				4	36%
Traffic M.	1	1	1	1	1	1	1	1	1	1	1	11	100%
H. Waste					1							1	9%
Railroads				1		1						2	18%
Structures		1	1	1			1	1	1	1		7	64%
ROW	1		1		1	1	1	1		1	1	8	73%
Surveying		1		1	1							3	27%
Utilities		1	1		1	1	1	1	1	1	1	9	82%
Pavement			1					1	1			3	27%
Phasing	1	1	1			1	1					6	46%
Pedestrians				1								1	9%

According to the outcomes of WBS survey, additional consideration is provided to general project aspects, drainage, traffic maintenance, structures, right of way, and utilities. The detailed activities

considered under the afore-mentioned categories are gathered from different state DOTs to form the general guidelines for the development of NCDOT project checklist.

5.2.2. State DOTs Checklist based on Selected Categories

According to the feedback received, detailed checklists of different state DOTs are investigated to outline common project activities included in other DOTs constructability reviews. The interpretation of DOTs checklists is mapped according to the bid items included in NCDOT standard bid document format. The following section displays different checklist items included in current DOTs practice:

5.2.2.1. General Items

A list of general items are included in NCDOT developed checklist to be considered by different project stakeholders participating in CR meetings. The general list is shown in ***Table 5.2.***

Table 5.2: General items for DOTs constructability checklist

Item	Item Description	OK	Not OK	N/A
A-1a	If there is a Local Agreement, is it related to the construction footprint, construction hours, hauling routes, or another construction impact? i.e., holiday events that may result in road closures.			
A-1b	If there is a Local Agreement, is it related to a unique feature to be construction - i.e., pedestrian bridge never constructed in the State?			
A-1c	Does the MPO/RPO etc. not understand the construction impacts? A CR can be helpful to provide back-up documentation.			
A-1d	Overall -were any agreements made with the town that may impact Construction?			
A-2	Is it anticipated that this project construction will need to be accelerated?			

5.2.2.2. Traffic Management

Traffic management is the single criteria included in the checklists and feedback of all State DOTs due to its significant importance in DOT construction projects. Maintenance of traffic and traffic

management are reviewed to confirm the compatibility with the current site conditions. For instance, lane closures should be compatible with expected traffic volumes. In addition, access for local residences and businesses should not be interrupted. Different alternatives should be evaluated to ensure the flow of traffic during the work hours, and avoid lengthy detours or traffic delays. Finally, safety of construction workers, pedestrians, and all commuters through the construction area is to be ensured. ***Table 5.3*** includes main items included for traffic management checklists.

Table 5.3: Traffic management item description for DOTs constructability checklist

Item	**Item Description**	**OK**	**Not OK**	**N/A**
1	Traffic control plan, clear, and complete			
2	Is temporary safety devices available?			
3	Locations of traffic control signs are made clear on plans			
4	Is traffic operation adequately addressed?			
5	Detours are required to be checked			
6	Locations of flashing arrow boards and their numbers			
7	Are traffic lanes kept open adequate for traffic?			
8	Adequate accommodations for intersections and crossing traffic			
9	Are pedestrians and bike users' needs addressed?			
10	Entrances and exits to project site are adequate			
11	Methods of containing bridge slopes during phased construction			
12	Are all traffic restrictions included in plans?			
13	Does work hours restrictions allow for work completion?			
14	Has consideration been given to malls and businesses?			

5.2.2.3. Structures

This category considers the inspection of existing structures, potential remodeling, recycling of any current or existing project members, and to revise designs of new structures. ***Table 5.4*** provides a list of items included in structures checklist.

Table 5.4: Structures item description for DOTs constructability checklist

Item	**Item Description**	**OK**	**Not OK**	**N/A**
1	Timber Structures			
2	Bridges a) Concrete mix/steel grade b) Bearings c) Bridge drainage & railings			
3	Pedestrian Structures			
4	Habitats (fish/animal passage)			
5	Tunnels			
6	Pavements			
7	Special structural sections and material grades			
8	Are all as-builts for existing structures available?			
9	Is geotechnical report available?			
10	Any items available for recycling?			
11	Is minimum vertical clearance available on plans?			
12	Is there a need for cofferdams and/or temporary structures?			
13	Is there need to protective compounds?			
14	Is sequence of construction explained?			
15	Is there any fractured main members?			
16	Conditions of paints			
17	Is substructure designed for potential scour?			
18	Will construction result in any site contamination?			

5.2.2.4. Right of Way

All state DOT constructability review meetings and checklists displayed major concerns regarding the consideration of right of way and potential problems that could be associated if ROW is not considered during the project design phase. ROW for equipment, materials, and hazardous waste storage should be considered during the CR discussions of future DOT projects. CALTRANS suggests that all construction and foundations easements should be identified. WSDOT suggests that at the design report stage, the ROW estimate and purchasing costs are to be identified for probable decision making at project early stages. A detailed list of ROW items is shown in ***Table 5.5.***

Table 5.5: Right of way item description for DOTs constructability checklist

Item	Item Description	OK	Not OK	N/A
1	Is sufficient ROW available for all operations?			
2	Is their sufficient space for equipment & materials storage?			
3	Sufficient access to the construction site			
4	Field offices space availability?			
5	Sufficient disposal of hazardous waste			

5.2.2.5. Utilities

This category includes the existing and proposed utilities. It covers current problems, potential problems, and possible conflicts resulting from lack of design details, conflicts or lack of design coordination, and potential problems evolving during the construction phase. The main objective of this category is to mark any utility conflict that might occur when the construction starts, possibly relocate utilities prior to construction if this relocation will avoid conflicts and site stoppage, and confirm that overhead utilities will not provide obstruction to the access and work of large construction equipment. Detailed items are included in the ***Table 5.6***

Table 5.6: Utilities item description for DOTs constructability checklist

Item	Item Description	OK	Not	N/A
1	List of utility owners and contact information			
2	Utility locations marked on project plans			
3	Disruption of utilities during construction phase			
4	Connectivity of new and old utilities			
5	Heights of overhead utilities and conflict with high equipment			
6	Need to special utility connections during construction phase			
7	Conflicts or lack of coordination in utilities			
8	Locations for power sources			
9	Sewer lines			
10	Power poles locations, heights, and possible relocation			

5.2.3. NCDOT Checklist Development

The afore-mentioned categories and individual items for DOTs checklists are assessed, and compared to the activities listed in NCDOT general bid list provided by NCDOT value management office. The afore-mentioned effort resulted in a draft checklist for NCDOT future projects. The draft checklist was further assessed via external interviews and feedback obtained by general contractors attending CR meetings for NCDOT projects, and internal evaluation conducted by the NCDOT VMO. According to the external interviews feedback and internal evaluation by NCDOT personnel, a final checklist is prepared for adoption in future constructability review meetings organized by NCDOT VMO. NCDOT checklist included 8 main categories for CR meetings consideration, as follows:

1) **General:** to assess general project circumstances, constraints, and special considerations. General items included in CR checklist are shown in ***Table 5.7.***

Table 5.7: General items included in NCDOT CR checklist

A	General
A-1a	If there is a Local Agreement, is it related to the construction footprint, construction hours, hauling routes, or another construction impact? i.e., holiday events that may result in road closures.
A-1b	If there is a Local Agreement, is it related to a unique feature to be construction - i.e., pedestrian bridge never constructed in the State?
A-1c	Does the MPO/RPO etc. not understand the construction impacts? A CR can be helpful to provide back-up documentation.
A-1d	Overall -were any agreements made with the town that may impact Construction?
A-2	Is it anticipated that this project construction will need to be accelerated?

2) **Traffic Management:** to evaluate different aspects within the construction project that may impact the continuity of traffic during the construction phase, entrance and exit from construction site, and accommodation of residence, commuters, and businesses in the construction site vicinity. Traffic management items are shown in ***Table 5.8.***

Table 5.8: Traffic management items included in NCDOT CR checklist

B	Traffic Management
B-1	Has sufficient construction easement been obtained for temporary work zone? Including traffic shifts, temporary bridges, temporary signage, etc.
B-2a	Do bike and pedestrians need to be accommodated during construction?
B-2b	Has this safety measure been taken into consideration?
B-3	Has the phasing of the earthwork, hydraulics, etc. been reviewed to consider the construction phasing?
B-4a	Are detours required?
B-4b	If so, have the detours been approved by the town?
B-4c	Is justification needed for the easements?
B-5a	Timing of highway closure for blasting and clearing?
B-5b	Does this project include blasting?
B-6a	Is the ground water level high?
B-6b	Will this impact the construction?
B-6c	Has how it will be handled been addressed?
B-7	Is specialized equipment needed to complete any part of the project?
B-8	If shoulders are required to carry traffic during staging, are shoulders sufficiently designed for that?
B-9	Is there sufficient room to install shoring for the maintenance of traffic and construct the project?
B-10	If no reasonable detour is available, will lane closures result in significant backups and/or create safety issues?

3) **Project Complexity:** to address any non-usual aspects during the project construction phase. Project complexity items are shown in ***Table 5.9.***

Table 5.9: Project complexity items included in NCDOT projects checklist

C	Project Complexity
C-1a	Will businesses or residences have impacted during construction?
C-1b	Has access been provided?
C-1c	Will this impact the construction footprint and access?
C-2a	Will construction impact emergency services, schools, etc.?
C-2b	Have access roads been provided for these and will it impact the construction access?
C-3a	Will detour be required?
C-3b	Has traffic analysis been conducted on the traffic for the detour?
C-3c	Have the construction impacts been considered for the detour?
C-4	Has the phasing of the earthwork, hydraulics, etc. been reviewed to consider the construction phasing?
C-5	Is the project located in an area with limited laydown and staging areas?
C-6	Can easements be obtained for detours?
C-7a	Is there sufficient construction easement?
C-7b	Are there locations where sufficient construction easement will not be able to be found?
C-8	Are the potential hauling routes acceptable to carry the loads of the construction equipment?
C-9	Is site-access for hauling materials an issue?
C-10	Are the potential hauling routes acceptable to carry the loads of the construction equipment?
C-11	Are there any deep excavations that require special site considerations?
C-11a	Sufficient ROW for staging?
C-12	Will project create any long-term maintenance issues?
C-13	Is there any directional drilling required for drainage or ITS?
C-13a	Is there sufficient room for TDE and bore pit locations?
C-14a	Will the construction methods likely to be used impact the environment in a way that would need to be included in the permitting?
C-14b	Will this require barge work in an area with moratoriums or will the detour route cross a jurisdictional stream?

4) **Structural Issues:** to accommodate any special provisions related to the design and construction of structures. This includes strength of construction materials, availability of non-traditional construction sections, and the need to temporary structures to serve traffic and pedestrians. Structure issues items are shown in ***Table 5.10.***

Table 5.10: Structure issues items included in NCDOT CR checklist

D	Structure Issues
D-1	Does this project include any special provisions that would impact the construction means and methods?
D-2	Is there a need, based on the permitting, for any cofferdams, submerged pumping, or specialized construction means?
D-3	Does the structure consider an innovative approach - i.e., unusually long spans, special material, etc. ?
D-4	Are there any materials that may require a long lead time or advanced delivery consideration?
D-5	Is the structure subject to any historic preservation?
D-6	Will barges be required for any reason during Construction?
D-7	Will the project require a temporary structure?
D-8	Will the structure be constructed adjacent or above traffic?
D-9	Are as built of the existing structure available?
D-10	Do railroad or coast guard permits include the impacts of construction and not just the permanent structure?
D-11	Does the project require structural remove over protected waterways, during certain times of the year, adjacent to OH utilities or any utilities?
D-12a	Does the structure cross any navigable waters requiring a FERC permit?
D-12b	Does the FERC regulated entity(i.e., power company) have any requirements?
D-13	Is there sufficient access available to construct the bridges, sufficient room to stage cranes for construction, is top-down construction required?
D-14	Are there any in-water moratoriums that will extend the construction schedule?
D-15	Are areas available for crane operations and their swing diameters?
D-16	Does your structure include two of the following? Skew less than 75 degrees or more than 105 degrees, a vertical curve, transitioning superelevation, or crown?

5) **Right of Way:** to evaluate the existing design provisions and measures taken to avoid problems in entering or exiting the construction site, and to ensure a seamless traffic flow during the construction phase. Right of way items are shown in ***Table 5.11.***

Table 5.11: Right of way items included in NCDOT CR checklist

E	Right of Way (ROW)
E-1a	Have all ROW purchases and negotiations been made?
E-1b	Has this considered the construction impact (versus the permanent impact)?
E-1c	Will any negotiations not be complete prior to construction?
E-2a	Are there any complex relocations within proposed ROW?
E-2b	Does business relocations involve moving specialized equipment, very large equipment, or lengthy move times that would adversely disrupt the business?
E-3	Are there any contaminated sites within the ROW that would require remediation?
E-4	Are there any unusually high ROW estimates for property that may warrant a design change?

6) **Unfamiliar Construction Practices:** to evaluate and assess items not included in other categories, and may evolve due to the special nature of the project. A list of unfamiliar construction practices items are included in ***Table 5.12.***

Table 5.12: Unfamiliar construction practices items included in NCDOT CR checklist

F	Unfamiliar Construction Practices
F-1a	Are there protected environmental species (flora or fauna) that need to be considered during construction?
F-1b	Will the clearing adversely impact wetlands?
F-1c	Or cause slope stabilization issues?
F-2	Does the project require specialized disposal per the environmental permit??
F-3	Is there anything that might require a specialized construction safety plan?
F-4a	Are there any moratoriums to consider?
F-4b	Are any ICTs (Intermediate Contract Times) needed for portions of the work?
F-5	Are there any time restrictions for work to stop at (holidays, storm/hurricane season, etc.)
F-6	Is noise ordinance (heavy equipment) respected (specific working hours)?
F-7	Are sediment and erosion control devices designed and located correctly during different phases of construction?

7) **Cost:** this category is created based on feedback attained from NCDOT personnel and surveyed construction professionals within NC. Based on feedback received, projects with budget in excess of $10 million dollar should be subjected to special CR scrutiny. Items listed are shown in ***Table 5.13.***

Table 5.13: Cost items included in NCDOT CR checklist

G	Cost
G-1	Construction cost of 10 Million Dollar Cost?
G-2	Are all the utility costs known?

8) **Utility Issues and Relocation:** to evaluate items relevant to existing or future utilities. Utility items are considered in any DOT construction project to avoid disruption to utility in the project vicinity. Utility items are included in ***Table 5.14.***

Table 5.14: Utility items included in NCDOT CR checklist

H	Utility Issues or Relocation
H-1a	Are utilities being done by others?
H-1b	Have they been scheduled?
H-1c	Will utilities be relocated prior to letting?
H-2	If utilities will not be relocated before construction starts, has the phasing been included in the contract?
H-3a	Does any soil need to be removed from site due to contamination?
H-3b	Do the soil conditions require an unusual construction method?
H-4a	Is boring or drilling (trenchless technology) a part of the project?
H-4b	Has sufficient construction easement been included?
H-5a	Are utility relocations going to impact the construction?
H-5b	Are temporary utilities needed?
H-6	Any close-by high voltage lines?
H-7	Has sufficient construction easement been obtained for temporary work zone the is needed? Including traffic shifts, temporary bridges, temporary signage, etc.
H-8	Have utility relocation plans been completed and is sufficient PUE shown to accommodate the relocation?
H-9	Do utility owners need specialized equipment or permits to complete their work?
H-10a	Does project cross any power transmission easements/RW?
H-10b	Does plans meet utility owner's requirements regarding slopes, walls, excavation limits, etc.
H-11a	Does project cross any transcontinental gas lines?
H-11b	Can utility owner's conditions be satisfied regarding excavation, loading, etc.
H-13a	Do any wet utilities require complex or phased installation?
H-13b	Has this been accounted for in TMP?
H-14	Will grading work need to be performed before water and sewer line relocation can occur?
H-15	Does phasing need to consider delayed utility relocation? Can delays in relocation be mitigated through phasing?

5.3. Assessment Tool Development

The assessment of CR meetings effectiveness is a challenging task due to the inability to evaluate the losses or issues avoided due to CR implementation in an accurate manner. Based on extensive surveys, literature search, and CR meetings attended for NCDOT projects, the following 3 individual assessment criteria were determined:

1) Project Safety: where possible reduction in accidents or OSHA citations could be used to assess the outcomes and efficiency of constructability review meetings

2) Construction Quality: is considered when evaluating the outcomes of CR meetings efficiency. The quality of construction includes the ability to avoid site conflicts between different engineering trades, the project environmental compliance, and reduced waste in construction materials
3) Schedule Compliance: where actual activities duration is compared with initial project schedule to determine if site stoppages or delays in construction due to supply chain issues has occurred and/or resulted in possible violations to initial schedule

The impact of the CR meeting on the safety, quality, and schedule of different project activities listed in the CR checklist is evaluated. A scale of 1 through 4 is proposed for activities evaluations is shown in ***Table 5.15.***

Table 5.15: Scale for CR checklist activities assessment

Individual Assessment Scale	Impact Scale
1	No Impact
2	Minimal
3	Moderate
4	High

The overall impact of any given activity within the CR checklist is evaluated after adding the assigned rating for the three evaluation criteria (safety, quality, and schedule). The minimum overall scale to be assigned to any activity is 3 and the maximum overall scale is 12. The interpretation of total impact of activities is shown in ***Table 5.16.***

Table 5.16: Assessment (rating) of activities based on overall impact calculated

Assessment of Total Impact	
3-5	Low
6-8	Minimal
9-10	Moderate
11-12	High

An example of the overall rating of a given list of CR checklist activities is shown in ***Table 5.17.***

Table 5.17: Example of overall assessment of project activities included in CR checklist

	Unit	Item Class	Items Description	Safety	Quality	Schedule	Overall
Pay Item List	LS	FA	Detour signing	4	2	3	9
	LS	FA	Snow Plowable Pavement Markers	4	1	1	6
	LS	FA	Pavement Marking	4	1	1	6
	LS	FA	Temporary Pavement Markings	4	1	1	6
	LS	FA	Traffic Control	4	1	1	6
	LS	FA	Warning Flags	4	1	1	6
	LS	FA	Type A Signs	4	1	1	6
	LS	FA	Type B Signs	4	1	1	6

6. Risk Assessment for NCDOT Project

6.1.Introduction

The assessment of construction projects risks is a lengthy procedure. Three primary steps are considered when evaluating construction projects risks for NCDOT projects. These steps are as follows:

I. Analysis

To analyze the risk associated with a construction projects, integral effort should be provided by the project stakeholders during different phases including conceptual design, detailed design, construction, and operation and maintenance. Expertise required per project discipline is shown in ***Table 6.1*** (Ashley et al., 2006).

Table 6.1: Expertise required for risk analysis vs. project phase

Discipline	Conceptual Design	Preliminary Design	Final Design	Construction
Implementation Planning	●	●	○	
Environmental Planning	●	●	○	○
Funding Approval	●	●	○	
Project Management	●	●	●	●
Civil, Structural, Systems		○	●	●
Architectural Design		●	●	○
Cost Estimating	○	●	●	●
Scheduling	○	●	●	●
Budget Control		○	●	○
Constructability			○	●
Operations	●	●	●	●
(legal, permits, etc.)	○	●	●	●

- ● Highly desirable
- ○ Desirable but optional

II. Identification and Assessment of Risk based on Project Cost Estimates

In this research project, where constructability is considered, efforts are made to identify and assess risks associated during construction phase. In the previous chapter, a list of activities are compiled, and a checklist is presented (as shown in ***Appendix (B)***) to provide the constructability review meeting attendees with an inclusive list of items to check during the project design phase to avoid potential site issues. In order to estimate the cost of every work item, the three-point estimation technique is utilized with different project activities. This technique involves three different estimates that are obtained from project bids provided by NCDOT VMO. The three cost estimates obtained are:

- Optimistic estimate: that represents the expected expenditure associated with a given activity assuming no impediments occurred. The optimistic estimate is denoted by "O"
- Pessimistic estimate: that represents the expected expenditure when major impediments are present. The pessimistic estimate is denoted by "P"
- Most likely estimate that represents the expenditure associated with the most realistic construction scenario. The most likely estimate is denoted by "M"

6.2. Benefits of using Three-Point Estimates

The three-point estimate provides a guideline for contractors when providing a bid for a given project. Contractors would use the likelihood of different project events to price given items. Contractor's pricing depends on the project circumstances and their ability to take risk. Similarly, project managers could rely on three-point estimates to foresee any potential risks associated with bid items. A higher variation among the O, M, and P cost estimates should trigger a flag and may require additional scrutiny for a given bid item. The main benefits of the three-point estimating are:

6.2.1. Better Estimates and lesser risk

By using a three-point estimate on DOT projects, the chances of risk (budget overrun) decreases, as it allows the project stakeholders to plan ahead for future events and factors in potential risks

that may result in budget overruns including potential site stoppage due to inclement weather, disruption of supply chain, increase in construction material cost, inflation, etc.

6.2.2. Better Planning

The three-point estimate presents potential outcomes and their cost implications in a less biased manner and provides a near accurate forecast. There are numerous ways to adopt the three-point estimate in project management for bid estimation and to assess the potential risk associated with cost overrun. The two main methods to calculate a three-point estimate are: (1) triangular distribution, and (2) the PERT beta distribution:

6.2.2.1. Triangular Distribution

Bid values for different project activities are obtained and expected cost is calculated according to the following equation:

$$E = \frac{(O+M+P)}{6} \qquad \textit{Equation 1}$$

Where:

E= expected cost for an activity

O= optimistic estimate for the activity

M = most likely estimate for the activity

P = pessimistic estimate for the activity

6.2.2.2. PERT beta Distribution

Bid values for different project activities are calculated using a weighted average method. More weight is given to the most likely value, as compared to equal distribution given to the mean value when linear triangular distribution is used.

In Pert beta distribution, the most likely value is considered to have 4 times more occurrence likelihood as compared to the pessimistic and optimistic values. In order to calculate the most likely (expected) value for a given bid item, the following steps are taken:

-Calculate the expected value (E) using the following formula:

$$E = \frac{(O+6M+P)}{6} \qquad \textit{Equation 2}$$

Where:

E= expected cost for an activity

For example, assume a project bid item that has the following estimated cost:

Optimistic (O) = $10K

Most likely (M) = $13K

Pessimistic (P) = $25K

Based on the afore-mentioned bid values, the expected value for the project activity is calculated using equation #2, as follows:

E = (O+4M+P)/3 = (10+4x13+25)/6 = $14.5K (rounded to $15K in ***Figure 6.1)***

Figure 6.1: Pert beta distribution for bid values

Based on the attained values, there is a dollar difference between the expected value E ($14.5K) and the most likely bid value attained M ($13K), as shown in ***Figure 6.1***. The difference between the expected value and the most likely value results from the variation between the optimistic and pessimistic values calculated, which represents a level of uncertainty in pricing. The difference between the expected values of project activities, and most likely values is directly proportional to the risk associated with project activities.

6.3. Risk Analysis Case study (using NCDOT Project Bid Tabs)

(a) Obtain 3 bids for your project

(b) List the bid items (as received) in project spreadsheet as shown in ***Table 6.2*** **(Data obtained from NCDOT projects bid tabs, listed in *Appendix (C)*-Project #1).**

Table 6.2: Bid items as received by contractors A, B, and C

Item*	Project Activity - Bid Items	Contractor A	Contractor B	Contractor C
1	Mobilization	108,500.00	110,000.00	131,000.00
2	Mill Asphalt (depth = 1.5")	62,494.20	100,685.10	152,763.60
3	Incident Milling	111,452.75	105,700.35	93,476.50
4	Asphalt Conc Surf (CRS S9.5B)	465,452.00	597,479.25	742,933.00
5	Asphalt Conc Surf (CRS S9.5C)	376,465.00	368,714.25	425,184.00
6	ASP for Plant Mix	694,200.00	467,250.00	712,000.00
7	Patching Exist Pavement	76,300.00	140,337.50	100,825.00
8	Milled Rumble Strips	9,789.30	9,245.45	5,656.04
9	ADJ Manholes	6,600.00	3,000.00	3,400.00
10	ADJ Meter or Valve Boxes	4,950.00	1,875.00	2,250.00
11	Work Zone Adv	8,705.52	8,705.52	10,170.00
12	Temp Traffic Control (SP)	137,000.00	177,375.00	154,235.00
13	Law Enforcement	5,610.00	7,650.00	9,690.00
14	Thermo PVT MKG Lines 4 90	18,601.00	18,601.00	21,137.50
15	Thermo PVT MKG Lines 6 90	10,947.00	10,947.00	12,771.50
16	Thermo PVT MKG Lines 8 90	4,366.00	4,366.00	5,130.05
17	12" Wide Thermo 90 MILS	6,543.00	6,543.00	10,359.75
18	24" Wide Thermo 90 MILS	2,820.00	2,820.00	2,209.00
19	Thermo PVT MKG Character90	400.00	400.00	500.00
20	Thermo PVT Symbol 90MILs	7,950.00	7,950.00	12,614.00
21	Paint PVMT Markings 4"	21,500.58	21,500.58	25,294.80
22	Paint PVMT Markings 6"	2,116.42	2,116.42	2,554.30
23	Paint PVMT Markings 8"	1,091.50	1,091.50	1,790.06
24	Paint PVMT Markings 12"	1,635.75	1,635.75	2,508.15
25	Paint PVMT Markings 24"	750.00	750.00	375.00
26	Paint PVT MKG Character	120.00	120.00	140.00
27	Paint PVT MKG Symbol	1,590.00	1,590.00	1,855.00
28	Non-Cast Iron SnoPLB PVMT	16,650.00	16,650.00	14,985.00
29	Portable Lighting	14,400.00	10,675.00	14,000.00
		2,179,000.02	2,205,773.67	2,671,807.25

(c) Using spreadsheet functions, categorize the price of bid items according to their optimistic (O), Pessimistic (P), and Most Likely (M) values

(d) Calculate the Expected Value (E) for project activities using Pert beta distribution equation (Equation #2). The O, P, M, and E values for project activities are shown in ***Table 6.3.***

Table 6.3: Bid items categorized according to their O, P, M, and E values

Item	Project Activity - Bid Items	O	P	M	E
1	Mobilization	108,500.00	131,000.00	110,000.00	113,250.00
2	Mill Asphalt (depth = 1.5")	62,494.20	152,763.60	100,685.10	102,999.70
3	Incident Milling	93,476.50	111,452.75	105,700.35	104,621.78
4	Asphalt Conc Surf (CRS S9.5B)	465,452.00	742,933.00	597,479.25	599,717.00
5	Asphalt Conc Surf (CRS S9.5C)	368,714.25	425,184.00	376,465.00	383,293.04
6	ASP for Plant Mix	467,250.00	712,000.00	694,200.00	659,341.67
7	Patching Exist Pavement	76,300.00	140,337.50	100,825.00	103,322.92
8	Milled Rumble Strips	5,656.04	9,789.30	9,245.45	8,737.86
9	ADJ Manholes	3,000.00	6,600.00	3,400.00	3,866.67
10	ADJ Meter or Valve Boxes	1,875.00	4,950.00	2,250.00	2,637.50
11	Work Zone Adv	8,705.52	10,170.00	8,705.52	8,949.60
12	Temp Traffic Control (SP)	137,000.00	177,375.00	154,235.00	155,219.17
13	Law Enforcement	5,610.00	9,690.00	7,650.00	7,650.00
14	Thermo PVT MKG Lines 4 90	18,601.00	21,137.50	18,601.00	19,023.75
15	Thermo PVT MKG Lines 6 90	10,947.00	12,771.50	10,947.00	11,251.08
16	Thermo PVT MKG Lines 8 90	4,366.00	5,130.05	4,366.00	4,493.34
17	12" Wide Thermo 90 MILS	6,543.00	10,359.75	6,543.00	7,179.13
18	24" Wide Thermo 90 MILS	2,209.00	2,820.00	2,820.00	2,718.17
19	Thermo PVT MKG Character90	400.00	500.00	400.00	416.67
20	Thermo PVT Symbol 90MILs	7,950.00	12,614.00	7,950.00	8,727.33
21	Paint PVMT Markings 4"	21,500.58	25,294.80	21,500.58	22,132.95
22	Paint PVMT Markings 6"	2,116.42	2,554.30	2,116.42	2,189.40
23	Paint PVMT Markings 8"	1,091.50	1,790.06	1,091.50	1,207.93
24	Paint PVMT Markings 12"	1,635.75	2,508.15	1,635.75	1,781.15
25	Paint PVMT Markings 24"	375.00	750.00	750.00	687.50
26	Paint PVT MKG Character	120.00	140.00	120.00	123.33
27	Paint PVT MKG Symbol	1,590.00	1,855.00	1,590.00	1,634.17
28	Non-Cast Iron SnoPLB PVMT	14,985.00	16,650.00	16,650.00	16,372.50
29	Portable Lighting	10,675.00	14,400.00	14,000.00	13,512.50
		1,909,138.76	2,765,520.26	2,381,921.92	2,367,057.78

(e) Based on ***Table 6.3***, the following conclusions can be listed:

- Minimum project cost (in case of optimistic pricing for all activities) is $1,909,138.76
- Maximum project cost (in case of pessimistic pricing for all activities) is $2,765,520.26
- Total project cost (in case Most Likely pricing is used) is $2,381,921.92
- Expected cost pricing for project activities is $2,367,057.78

The variation of total pricing results from the possible risk factors assessed and included in every contractor's activity pricing. The minimum (optimistic) pricing is based on optimum site conditions during the whole project duration, which is not a likely scenario. Similarly, the maximum (pessimistic) pricing is based on worst case scenario for all project activities, which is also a low possibility. The project cost (expected cost) is the most probable scenario, where expected cost of all project activities are added. There is minimal differences between the calculated expected cost and most likely pricing due to the variation within every project activity.

The standard deviation, denoted as SD, for the cost of project activities is calculated as follows:

$$6 = \sqrt{\frac{(P-M)^2}{6}} \qquad \textit{Equation 3}$$

Where:

Ϭ = Standard Deviation

P = Pessimistic (maximum) bid value

O = Optimistic (minimum) bid value

The standard deviation of bid items, denoted as Ϭ, is used to estimate the variation in prices obtained for project activities. The risk in item pricing is directly proportional to the value of the standard deviation for the given item. In order to compare standard deviation impact, the standard deviation value is divided on the mean value (the expected value) to calculate the coefficient of variation for every activity, which is a direct measure to the risk associated with the activity bid. The bid items, their standard deviation, and the coefficient of variation are shown in ***Table 6.4***

Table 6.4: Variations in bid items (activities) pricing

Item	Project Activity - Bid Items	E	б	б/E
1	Mobilization	113,250.00	3750.0	3.3%
2	Mill Asphalt (depth = 1.5")	102,999.70	15044.9	14.6%
3	Incident Milling	104,621.78	2996.0	2.9%
4	Asphalt Conc Surf (CRS S9.5B)	599,717.00	46246.8	7.7%
5	Asphalt Conc Surf (CRS S9.5C)	383,293.04	9411.6	2.5%
6	ASP for Plant Mix	659,341.67	40791.7	6.2%
7	Patching Exist Pavement	103,322.92	10672.9	10.3%
8	Milled Rumble Strips	8,737.86	688.9	7.9%
9	ADJ Manholes	3,866.67	600.0	15.5%
10	ADJ Meter or Valve Boxes	2,637.50	512.5	19.4%
11	Work Zone Adv	8,949.60	244.1	2.7%
12	Temp Traffic Control (SP)	155,219.17	6729.2	4.3%
13	Law Enforcement	7,650.00	680.0	8.9%
14	Thermo PVT MKG Lines 4 90	19,023.75	422.8	2.2%
15	Thermo PVT MKG Lines 6 90	11,251.08	304.1	2.7%
16	Thermo PVT MKG Lines 8 90	4,493.34	127.3	2.8%
17	12" Wide Thermo 90 MILS	7,179.13	636.1	8.9%
18	24" Wide Thermo 90 MILS	2,718.17	101.8	3.7%
19	Thermo PVT MKG Character90	416.67	16.7	4.0%
20	Thermo PVT Symbol 90MILs	8,727.33	777.3	8.9%
21	Paint PVMT Markings 4"	22,132.95	632.4	2.9%
22	Paint PVMT Markings 6"	2,189.40	73.0	3.3%
23	Paint PVMT Markings 8"	1,207.93	116.4	9.6%
24	Paint PVMT Markings 12"	1,781.15	145.4	8.2%
25	Paint PVMT Markings 24"	687.50	62.5	9.1%
26	Paint PVT MKG Character	123.33	3.3	2.7%
27	Paint PVT MKG Symbol	1,634.17	44.2	2.7%
28	Non-Cast Iron SnoPLB PVMT	16,372.50	277.5	1.7%
29	Portable Lighting	13,512.50	620.8	4.6%

Based on Table 6.4, the (б/E) values greater than 10% is highlighted to be further considered when bid prices are revised. It is a common industry practice for funding agencies to consider 10% as a threshold for additional bid items scrutiny. According to bid items analysis procedures, the following procedures, shown in

Figure 6.2, are recommended for risk analysis of bid items:

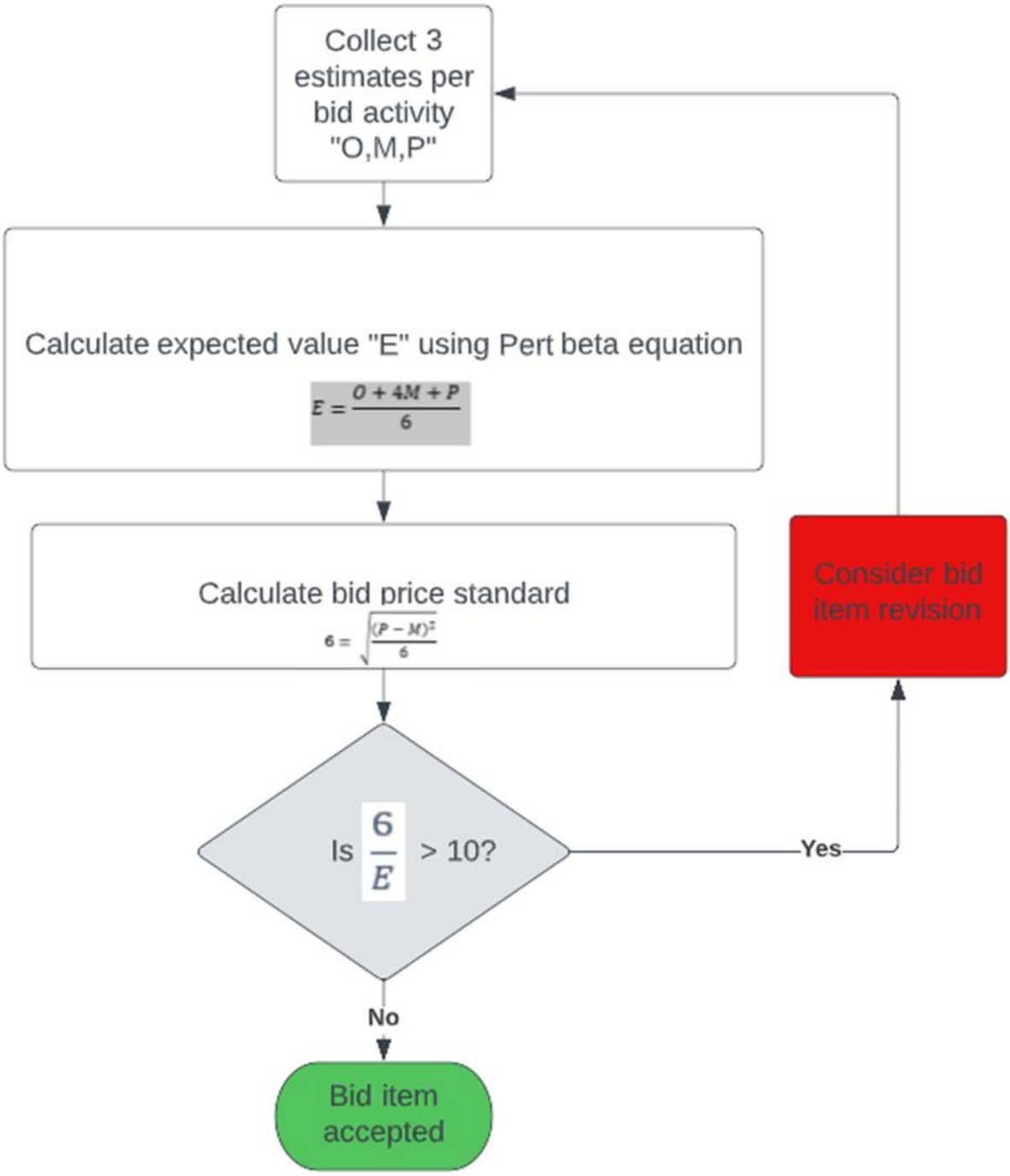

Figure 6.2: Flow chart for project risk analysis

6.4. Risk Analysis Study for Categorized NCDOT Bid Items

Risk analysis for NCDOT bid items according to their category is conducted. The purpose of this investigation is to assess the risk associated with different projects categories for additional scrutiny during constructability review process, and during the bid process. Five highway projects with different budget ranges were selected for the risk analysis study. Bid items are provided by three bidders for every project. Total project budgets (as included in bids received) are shown in ***Table 6.5.***

Table 6.5: Projects bid values

Project	No. of Bid Items	Contractor A	Contractor B	Contractor C
Project #1	35	4,790,931.02	4,924,701.10	5,875,429.00
Project #2	29	2,179,000.02	2,205,773.67	2,671,807.25
Project #3	252	61,497,777.30	62,462,442.00	65,517,430.69
Project #4	28	4,500,014.62	4,540,786.22	4,791,456.30
Project #4	133	11,095,482.80	14,528,442.00	14,652,000.00

The coefficient of variation (σ/E), denoted as COV, is calculated for different bid activities using available bids. Coefficient of variation calculated represents the possible risk associated with activity pricing, as shown in the following section.

6.4.1. Mobilization

The COV for project mobilization, shown in ***Table 6.6***, has an overall variation of 5.34%. The average COV indicates a low bid item risk.

Table 6.6: Risk analysis of bid items - Mobilization

Bid Items	Proj. #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	σ/E
Mobilization	1	1	108500	110000	131000	108,500	131,000	110,000	113,250	3.3%
Mobilization	2	1	144640	141799	292500	141,799	292,500	144,640	168,810	14.9%
Mobilization	3	1	3074885	3100000	3275921	3,074,885	3,275,921	3,100,000	3,125,134	1.1%
Mobilization	4	1	265000	220000	235000	220,000	265,000	235,000	237,500	3.2%
Mobilization	5	1	555000	725000	732000	555,000	732,000	725,000	697,833	4.2%
									Average	5.34%

6.4.2. Surveying

The COV for surveying, shown in ***Table 6.7*** , has an overall variation of 28.7%. Only 2 projects had a surveying bid item included (Projects #3 and #5). The high COV for surveying, as compared to all evaluated activities, indicates that project surveying has a very high impact on the final project budget as a volatile activity.

Table 6.7: Risk analysis of bid items - Surveying

Bid Items	Proj. #	Bid Item #	Cont. A	Cont. B	*Cont. C*	*O*	P	M	E	б/E
Const. Surveying	3	2	500,000.	55,000	1,250,000	55,000	1,250,000	500,000	550,833	36.2%
Const. Surveying	5	2	95,000	180,000	50,000	50,000	180,000	95,000	101,666	21.3%
									Average	28.7%

6.4.3. Excavation

The COV for excavation, shown in ***Table 6.8 ,*** has an overall variation of 14.2%. The value of the COV indicates that the variation of bid pricing for excavation is high, and could potentially impact the final project budget.

Table 6.8: Risk analysis of bid items - Excavation

Project Activity	Proj #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	б/E
6.Borrow Excavation	1	2	114,790	96,494	88,300	88,300	114,790	96,494	98,178	4.5%
Unclassified Excavation	2	5	2,653,200	2,653,200	2,211,000	2,211,000	2,653,200	2,653,200	2,579,500	2.9%
Undercut Excavation	2	6	650,700	723,000	964,000	650,700	964,000	723,000	751,117	7.0%
Borrow Excavation	2	7	7,680,600	635,200	9,036,000	635,200	9,036,000	7,680,600	6,732,267	20.8%
EMBT Settlement Gauge	2	8	2,580	1,560	10,000	1,560	10,000	2,580	3,647	38.6%
Drainage Ditch Excavation	2	9	67,625	70,330	54,100	54,100	70,330	67,625	65,822	4.1%
Undercut Excavation	5	4	32400	19200	7200	7200	32400	19200	19400	21.6%
									Average	14.2%

6.4.4. Asphalt Milling

The COV for asphalt milling activities has an average of 7.6%. The COV per individual milling activity ranges from a minimum of 2.9% and a maximum of 14.6%, as shown in ***Table 6.9.*** The COV for asphalt milling activities suggests a moderate impact on final bid value.

Table 6.9: Risk analysis of bid items - Milling

Bid Item	Proj. #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	б/E
Asphalt Milling	1	2	62,494	100,685	15,2763	62,494	152,763	100,685	103,000	14.6%
Incidental Milling	1	3	111,452	105,700	93,476	93,476	111,452	105,700	104,621	2.9%
Mill Asp Pav. 1.5"	2	5	277,274	373,122	427,892	277,274	427,892	373,122	366,276	6.9%
Mill Asp Pav. 5.5"	2	6	10,220	9,982	8,400	8,400	10,220	9,982	9,758	3.1%
Mill Asp Pav. 0"-1.5"	2	7	4928	7,584	11,636	4,928	11,636	7,584	7,817	14.3%
Mill Asp Pav. 0"-2.5"	2	8	4704	7,570	8,820	4,704	8,820	7,570	7,301	9.4%
Incidental Milling	2	9	80,802	89,892	86,574	80,802	89,892	86,574	86,165	1.8%
Incidental Milling	3	44	23,355	20,760	17,300	17,300	23,355	20,760	20,616	4.9%
Incidental Milling	4	5	41,268	30,645	26,442	26,442	41,268	30,645	31,715	7.8%
Incidental Milling	5	19	12,150	12,420	5,373	5,373	12,420	12,150	11,066	10.6%
									Average	7.6%

6.4.5. Asphalt Patching

The COV for asphalt patching activities has an average of 12.7%. The COV per individual patching activities ranges from a minimum of 4.3% and a maximum of 20.7%, as shown in ***Table 6.10***. The COV for asphalt milling activities suggests a high impact on final bid value.

Table 6.10: Risk analysis of bid items – Asphalt Patching

Project Activity	Project #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	б/E
Patching Exist. Pav.	1	7	76300	140337	100825	76300	140337	100825	103323	10.3%
Patching Exist. Pav.	2	14	255915	247455	316192	247455	316192	255915	264551	4.3%
Patching Exist. Pav.	4	8	130200	139965	282100	130200	282100	139965	162027	15.6%
ASP PLT Mix PVT Repair	5	23	8920	10000	24000	8920	24000	10000	12153	20.7%
									Average	12.7%

6.4.6. Asphalt Pavement

The COV for asphalt pavement activities has an average of 4.9%. The COV per individual activity ranges from a minimum of 2.9% and a maximum of 18.8%, as shown in ***Table 6.11***. The COV for asphalt milling activities suggests a very low impact on final bid value.

Table 6.11: Risk analysis of bid items – Asphalt Pavement

Project Activity	Project #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	б/E
ASP Conc. Surf. S9.5B	1	4	465,452	587,497	742,933	465,452	742,933	587,497	593,062	7.8%
ASP Conc. Surf. S9.5C	1	5	376,465	368,714	425,184	368,714	425,184	376,465	383,293	2.5%
ASP for Plant Mix	1	6	694,200	467,250	712,000	467,250	712,000	694,200	659,342	6.2%
ASP Conc. Base CRS B25.0C	2	10	16,013	16,091	18,881	16,013	18,881	16,091	16,543	2.9%
ASP Conc. Surf CRS S9.5B	2	11	130,872	125,870	151,905	125,870	151,905	130,872	133,544	3.2%
ASP Conc Surf CRS S9.5C	2	12	1,522,638	1,407,312	1,861,002	1,407,312	1,861,002	1,522,638	1,55,9811	4.8%
ASP for Plant Mix	2	13	1,450,400	1,569,626	156,800	156,800	1,569,626	1,450,400	1,254,671	18.8%
ASP Conc Base CRS B25.0C	3	45	828,977	1,031,370	836,075	828,977	1,031,370	836,075	867,441	3.9%
ASP Conc INTR CRS I9.0C	3	46	3,074,280	3,726,400	3,100,364	3,074,280	3,726,400	3,100,364	3,200,356	3.4%
ASP Conc. Surf CRS S9.5B	3	47	436,177	589,050	439,880	436,177	589,050	439,880	464,125	5.5%
ASP Conc Surf CRS S9.5C	3	48	2,405,970	3,231,900	2,426,438	2,405,970	3,231,900	2,426,438	2,557,270	5.4%
ASP Conc Surf CRS S9.5C	4	6	1,605,239	1,591,673	1,894,634	1,591,673	1,894,634	1,605,239	1,651,211	3.1%
ASP for Plant Mix	4	7	1,154,560	1,337,600	1,232,000	1,154,560	1,337,600	1,232,000	1,236,693	2.5%
ASP Conc Base CRS B25.0C	5	20	69,030	74,295	60,255	60,255	74,295	69,030	68,445	3.4%
ASP Conc INTR CRS I9.0C	5	21	54,870	59,055	47,895	47,895	59,055	54,870	54,405	3.4%
ASP Conc Surf CRS S9.5C	5	22	97,200	103,680	84,240	84,240	103,680	97,200	96,120	3.4%
ASP for Plant Mix	5	23	83,400	89,500	72,500	72,500	89,500	83,400	82,600	3.4%
									Average	4.9%

6.4.7. Manhole Construction

The COV for Manhole construction ranges from 6.0% to 19.4%, with an average of 10.5%, as shown in ***Table 6.12*** . This COV suggests a high impact on final bid.

Table 6.12: Risk analysis of bid items – Manhole Construction

Project Activity	Proj. #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	б/E
ADJ Manholes	1	17	73,786	79,588	108,625	73,786	108,625	79,588	83,461	7.0%
ADJ Meter or Valve Box	1	18	57,980	62,440	81,250	57,980	81,250	62,440	64,832	6.0%
ADJ Manholes	2	9	6,600	3,000	3,400	3,000	6,600	3,400	3,867	15.5%
ADJ Meter or Valve Box	2	10	4,950	1,875	2,250	1,875	4,950	2,250	2,638	19.4%
4" DIA Utility Manhole	3	153	38,000	28,000	50,532	28,000	50,532	38,000	38,422	9.8%
Abandon Utility Manhole	3	159	3,500	1,650	4,032	1,650	4,032	3,500	3,280	12.1%
									Average	10.5%

6.4.8. Temporary Traffic Regulation

The COV for Manhole construction ranges from 1.0% to 15.9%, with an average of 4.1%%, as shown in ***Table 6.13.*** This COV suggests a low impact on final bid.

Table 6.13: Risk analysis of bid items – Temporary Traffic Regulation

Project Activity	Proj. #	Bid Item #	Cont. A	Cont. B	Cont. C	O	P	M	E	б/E
Work Zone Adv/Gen Warn Sign	1	19	13,172	13,136	13,973	13,136	13,973	13,172	13,300	1.0%
Temp Traffic Control (SP)	1	20	103,000	106,315	165,000	103,000	165,000	106,315	115,543	8.9%
Portable Lighting	1	33	10,000	31,348	37,500	10,000	37,500	31,348	28,815	15.9%
Work Zone Adv/Gen Warn Sign	2	12	8,705	8,705	10,170	8,705	10,170	8,705	8,949	2.7%
Portable Lighting	2	29	16,650	16,650	14,985	14,985	16,650	16,650	16,373	1.7%
Work Zone Signs (STAT)	4	10	4,277	4,602	4,897	4,277	4,897	4,602	4,597	2.2%
Generic Traffic Control Item	4	11	9,200	9,200	10,600	9,200	10,600	9,200	9,433	2.5%
Generic Traffic Control Item	4	13	85,750	85,750	98,245	85,750	98,245	85,750	87,833	2.4%
Generic Traffic Control Item	4	14	13,200	13,200	15,200	13,200	15,200	13,200	13,533	2.5%
Temporary Crash Cushions	5	134	12,500	12,000	10,850	10,850	12,500	12,000	11,892	2.3%
									Average	4.1%

7. Conclusions and Recommendations for Future Research

The objective of this research project is to develop guidelines for NCDOT formal constructability review meetings. Specific objectives include:

1. Investigate constructability review meetings format as implemented by different state DOTs
2. Evaluate the current practices associated with NCDOT constructability review meetings
3. Survey different NCDOT personnel and industry professionals within the state of North Carolina to develop a better understanding of current review meetings advantages, disadvantages, and potential changes and adjustments required to develop a formal review process for implementation in future NCDOT projects
4. Develop a mechanism to evaluate the efficiency of constructability review process
5. Evaluate the financial risks associated with NCDOT projects through the 3-point analysis of bid items included in NCDOT projects

7.1. Formal Constructability Review Process Guidelines for NCDOT Projects

Recommendation for formal constructability review meetings for NCDOT includes the following guidelines:

A. Initial constructability review meeting is recommended at an early stage of the project design phase (20%-30% of design phase completion)

B. A follow-up constructability review meeting is recommended at 60% -70% of design phase completion. The follow-up meeting is recommended to ensure the successful implementation of the recommendations made during the initial review meeting

C. Formal constructability review meetings are recommended for different types of infrastructure projects. However, the following project indicators require additional CR meetings discussions:

- Traffic management
- Complex structural component
- Right of way
- Impact on public
- Utilities relocation

D. The majority of interviewed stakeholders indicates that they prefer to work with NCDOT Value Management Office (VMO) to conduct and supervise CR review meetings.

E. Constructability review meetings are more efficient when combination of field and office meetings are conducted

F. CR meetings should include a formal agenda and requires a checklist to be reviewed by the meetings attendees. Detailed NCDOT constructability review checklist is developed by the project research team, and attached in ***Appendix (B)***

G. CR meetings duration should vary according to the project type and complexity. A 2–4-hour duration is recommended by the majority of the interviewees.

H. Constructability review meetings should include the following project stakeholders: NCDOT engineers. construction managers, minimum of 3 contractors, utility company representative, and material suppliers

The overall suggestions for NCDOT constructability review meetings as a result of NCDOT personnel and construction experts at the state of North Carolina are shown in ***Table 7.1.***

Table 7.1: List of suggestions for future NCDOT constructability review meetings

Suggestions
Conduct follow up meetings. Utilize CRs on high volume and traffic-related types of projects.
The meetings should be better structured and have objectives, schedule, an indication of the issues, etc.
Identify a proper time when CRs should be held
Do more formal CRs and call people with experience (this is based on the complexity of the project). The current CRs process has issues identifying problems and communicates this to people.
Require CR for all projects. Space constraints are a real issue and safety is getting out of control.
Focus on formal meetings. The objective of the CR meetings is to have a meaningful and productive outcome.
NCDOT is experiencing some turnover issues. New personnel does not know about the program, VMO needs to advertise the meetings and identify when a CR is needed.
VMO should meet with the Division and design team to go through the project and discuss potential constructability issues prior to the formal constructability review. It is important to identify potential issues and create clear objectives for the CR meetings.
CR meetings should be held close to the project site. A site visit should be mandatory.
Build a database of change orders to identify the benefits of CRs.
DOT should have more control over who should be invited to the CR meetings.
All informal and formal CRs and follow up meetings should be documented and available to divisions.
More contractors need to be present at the CR meetings. The documents need to be sent ahead of time.
Need to involve young staff in the CRs. It would be useful to have professionals can bring different inputs.

7.2. Risk Analysis for Bid Items

The risk analysis process for bid items was based on the financial analysis of different categories of bid activities for a selected list of 5 NCDOT projects. The coefficient of variation of each activity is calculated using the PERT beta equation. The average coefficient of variation for every category is calculated. Average coefficient of variation calculations show that surveying has the highest variation in bid items pricing, while temporary traffic regulation has the lowest variation. Detailed co-efficient of variation for bid items are shown in ***Figure 7.1.***

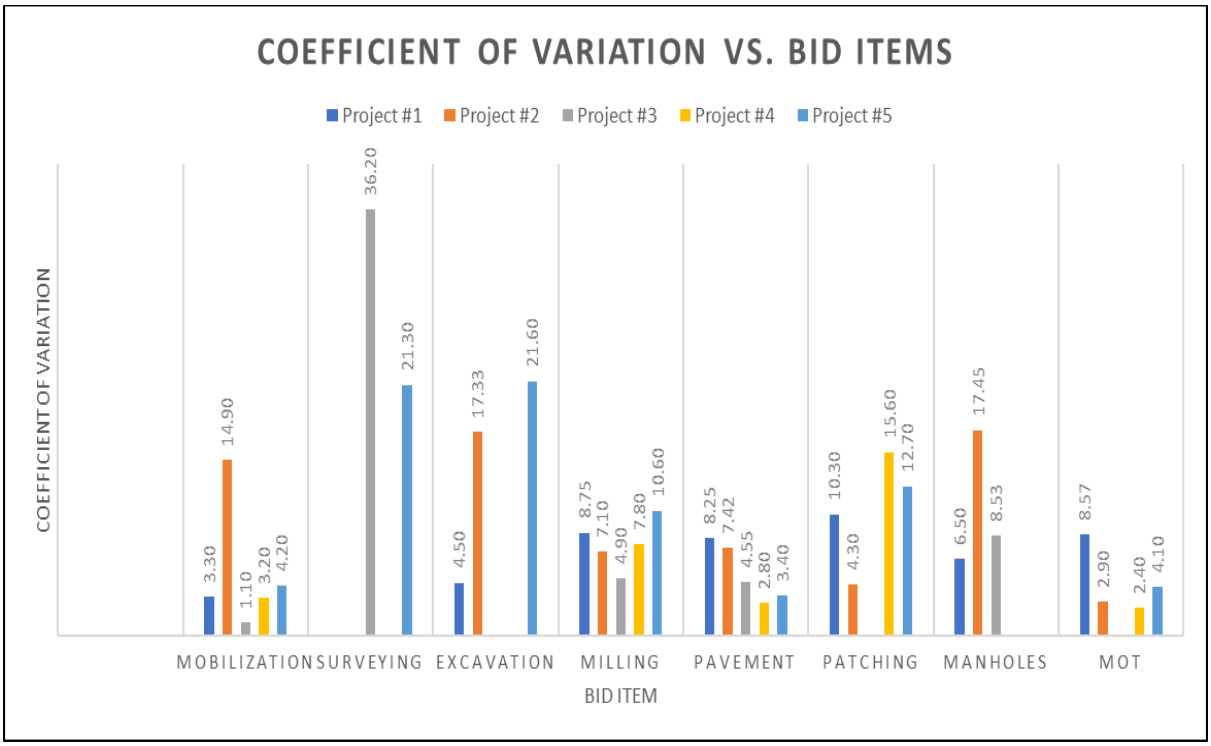

Figure 7.1: Average coefficient of variation for projects bid items

Constructability Review recommendations and risk analysis calculation for project conducted by NCDOT targets increasing the efficiency of NCDOT future projects, eliminating work redundancy, avoid site conflicts, potential schedule and cost overruns. Recommended workflow for NCDOT projects is shown in ***Figure 7.2.***

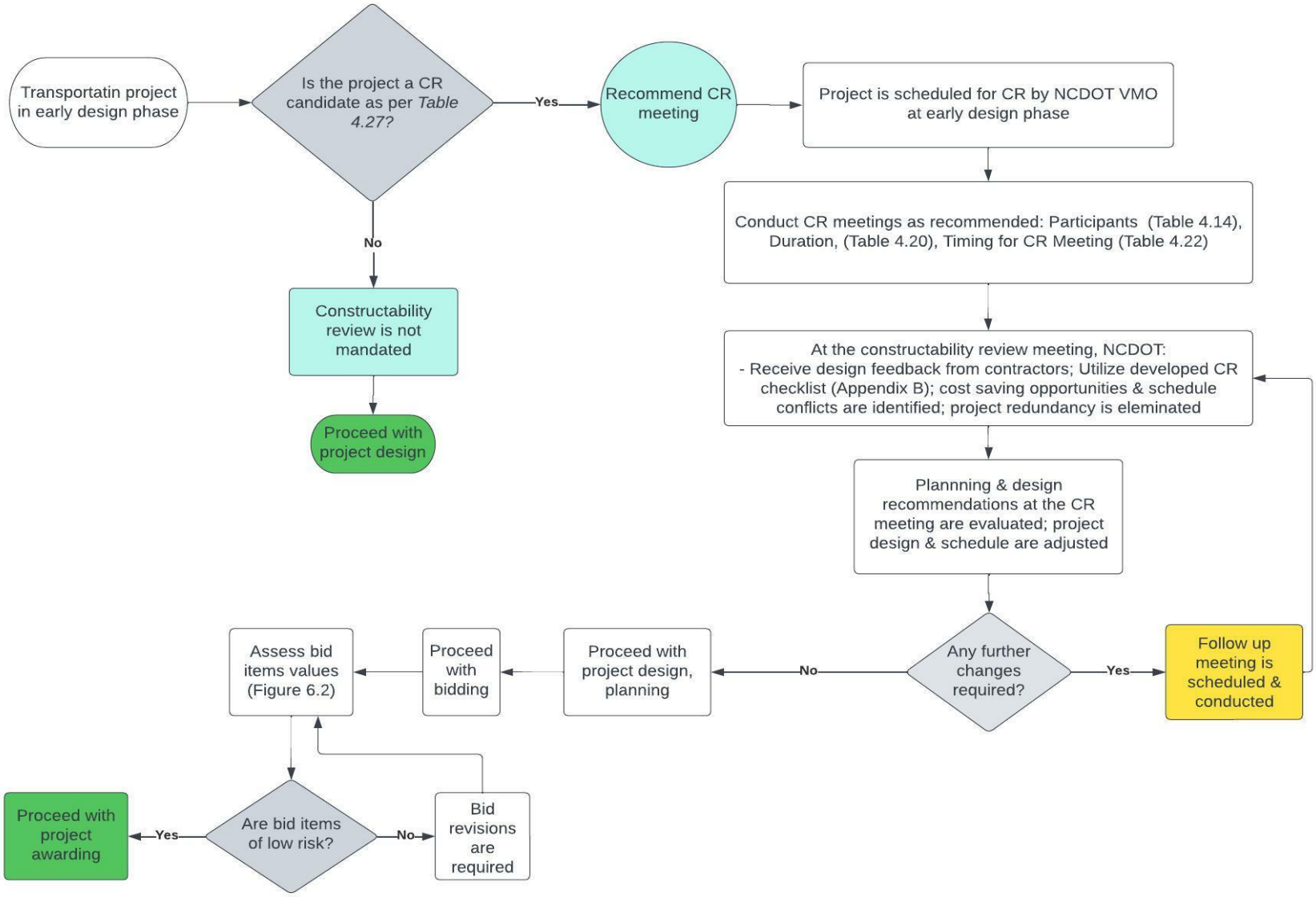

Figure 7.2: Recommended constructability review process for NCDOT

7.3. Recommendations for Future Research

Additional research is required to evaluate the effectiveness of constructability review meetings through the possible development of mathematical equations to quantify the cost savings and the possible time saving in the overall project schedule. The research team suggests the possible use of neural networks and Markov chains in this study. Additional research is required for further consideration of risk in project bids considering the project circumstances including project location, size, duration, and any restrictions imposed by logistics and/or permits.

Appendix (A)- Constructability Reviews Checklists Items (Other State DOTs)

A. Roadway

1. Is general topography of areas as indicated on plans?
2. Any subdivisions of commercial/industrial areas not indicated>
3. Is there sufficient geometry, horizontal and vertical to properly locate and construct project? Are baseline ties shown? Benchmarks?
4. If survey baseline and centerline are different and test pits taken, are they plotted correctly?
5. Are sufficient control points and curve data shown?
6. Do we need additional right-of-way to construct?
7. Are widths and grade of reconstructed driveways reasonable?
8. Is point of application of grade being changed? If so, have proper sections been developed?
9. Existing pavement conditions – Are replacements required? Condition of concrete or bituminous. Are appropriate specifications included?
10. Does existing pavement have concrete base not shown?
11. Is transition from structure sufficient? Is pavement overlay keyed into existing? Are details provided?
12. Are paving limits shown? Pavement composition? Joint sealing? Does specs address over filling joint on sealing item and cleaning and sealing joints and cracks item. Saw cutting?
13. If pressure relief joints are to be constructed, are they wide enough? I.e.: 10’ minimum
14. Have existing overlays been taken into consideration?
15. Are temporary roadways or pavements required to complete the construction? If so, details are required.
16. On overlay projects, are leveling courses required in some areas to correct existing problems?
17. Plans or specifications must indicate no longitudinal joints allowed at completion of days paving.

B. Structures

1. Are all as-builts of existing structure available and referenced in the specifications?

2. Have all subsurface or underwater investigations been performed to verify existing conditions?
3. Is sufficient boring data available? Were borings taken at location of temporary and permanent sheet piling, piles and structures?
4. If piles or sheeting are required, can they be driven or do conflicts exist, additional borings may be required. Are necessary permits in place?
5. Are railroad requirements and Coast Guard regulations in place? Allowable time frames?
6. Any salvageable material? If so, is it noted? Ensure if maintenance or stores has a need for it.
7. Are provisions and items in contract to maintain not only the lighting on and under the bridge but also the circuits running through the parapets during deck replacements and / or jacking, etc.? Are there provisions for temporary lighting, if existing is to be removed and new lighting does not get installed until the latter stages of the project.
8. Ensure that when cofferdam and pumping is an item in the contract, structure excavation is also an item. Is underwater (tremie) concrete required?
9. Is an index sheet included? This is required for projects with more than one structure.
10. Is a summary of quantities sheet included for each structure?
11. Ensure that the structure reference numbers are correct.
12. Is hydrologic data shown for waterway structures?
13. Is minimum vertical clearance shown on the plans?
14. If structure is on Merritt Parkway, does it conform to parkway guidelines? (i.e.: replication of original).
15. If cofferdams required, is size and location shown on plans and allowed by permit?
16. Do we have sufficient unassigned quantity of repair work items to cover unforeseen conditions?
17. If existing structures nearby, are they on timber mats? This is prevalent along the shoreline.
18. Are abutments and piers in sound condition? If not, are proper repair procedures in place?
19. Are deck grades furnished on replacement project? Are deflections of existing beams shown?
20. If structure is structural steel, are replacement members required? If so, is replacement procedure in place and is it adequate? Are additional members deteriorated to a point of replacement not noted?

21. Are bearings to remain? If so, are they in good condition? If not, is there a suggested jacking procedure along with associated quantities? Is jacking acceptable under live load? If yes, are parameters established?
22. Are bearing pads sound or do they display deterioration or cracking? Is so, are repair procedures in place? Access available for elevated structures?
23. If structure is prestressed, are units in good shape?
24. Does the contract require a suggested erection sequence? Particular attention should be given to structures with curved girders or tubs, and skewed abutments for differential deflection and/ or rotation,
25. All Fracture Critical Members (FCM) should be indicated with requirements for fabrication.
26. Condition of Paint – Adhesion Tests and Toxicity Tests must be performed. Are current containment, cleaning, and disposal specifications in place? Does contract contain lates LHPP Specifications?
27. Will containment cause height restrictions (i.e., Waterway, railroad)?
28. Are painting specifications complete and current? Note any special problems (access, environmental)?
29. Has the substructure been examined for scour?
30. Underside of deck, are map cracking, efflorescence or chlorides visible?
31. Are “pop-outs” evident on underside of deck? If so, are they addressed in repair procedures?
32. Condition of deck surface – is deck overlaid? If so, is type known?
33. If deck exposed, what is its condition? Are partial and / or full depth patches required? Are specifications in place? Check removal procedures.
34. If stage construction, will deck have cantilevered sections that require support? If so, is support concept noted on plans and criteria as to when required given for both existing and new decks?
35. Type of deck joints / headers – can they be constructed in fashion to eliminate “Bumps”? If nor, recommend possible solution.
36. How is wearing surface to be removed? Item provided?
37. Does deck have existing membrane waterproofing? If so, is type known?
38. If at all possible, new bridge decks on existing roadways should be raised to meet the new roadway profile created by an overlay.
39. Is transition, roadway to bridge, sufficient?

40. Have provisions been made to maintain navigational lighting throughout construction?
41. If bridge is to be closed, are there enough safety barriers and protection in place?
42. Protective Compound – is preferred material indicated (not linseed oil)?
43. Bridge rail (protective fence) is it properly indicated? If over railroad, is latest railroad specifications utilized? If on moveable span, is kickplate required?
44. Do specifications contain an item for protective sealing / coating for completed structures? This item is no longer required.
45. If temporary structures are specified, responsibilities for design and appropriate details should be furnished.
46. Are existing utilities under structure or in parapets? If so, how are they maintained throughout contract period? Are items provided to maintain them?
47. Is all repair work noted on the plans as built?
48. For box culvert installations, the sequence of installation should be from outlet to inlet.

C. Utilities – Feature to be Checked

1. List of all utility owners and contact numbers
2. Existing utility location marked in the plan.
3. Utility conflicts and their relocation indicated in design.
4. Disruptions of other utilities and provisions for restoration.
5. Responsibility to relocate utility and provisions.
6. Verification of new utilities connecting with existing.
7. Adequate description of connection and reconnection points.
8. Availability of indicated existing utility ducts and their proximity to highway facility and traffic.
9. Other utilities which new underground ducts intersect or traverse.
10. Utility crossings resolved via scheduling restrictions (i.e., weekends, after hours) or temporary structures.
11. Overhead utilities, guy wires for potential conflict with operations and access of large equipment.
12. Utilities required for construction operation and field offices.
13. Sewer lines below water mains and gas lines above other utilities.

14. Space between R/W line and drainage structure to allow for construction.
15. Utility conflicts with drainage.

D. Maintenance for Traffic – Feature to be Checked

1. TCP (Traffic Control Plan) clear, complete, approved and conform to FDOT Standard Index.
2. Temporary safety devices requirements and provision (i.e., guard rail, attenuators, earth mounds, etc.).
3. Location of traffic control signs, warning devices and barricades. Check if they are encroaching on lanes.
4. Detour facility, of any, and maintenance of traffic. Traffic addressed on side streets as per Index 600 of Standard Index.
5. Traffic operation requirements properly addressed (i.e., signing, pavement markings, signal, etc.).
6. Relocation item for barrier wall or fence.
7. Location of flashing arrow boards, if needed, at appropriate places.
8. Lanes on which traffic is to be maintained compatible to local conditions and intended to be paved.
9. Is there sufficient clearance within the work zone for the operation (such as crane swing room)?
10. Adequate accommodations for intersecting and crossing traffic.
11. Address pedestrian and bicycle accommodations.
12. Are exits and entrances to the work zone adequate and safe?
13. Method of containing bridge slopes during phased construction (at end bent) and approach grade separations.
14. Restrictions (e.g., lane closure, general construction or peak-hour restrictions in urban areas) indicated in plan.

E. Re-constructability – Feature to be Checked

1. Earthwork design (e.g., “temporary” borrow, “additional excess,” detour material, embankment, etc.).

2. Right-of-way acquisition (e.g., for signal and lighting foundations, redesigned radii of drainage structures, utility relocation, construction easements, adequate workspace, desirable clear zone, etc.).
3. Geometrics and roadway alignment (e.g., curve data, sight distance, vertical datum, centerline, etc.).
4. Utilities (e.g., accuracy of location, proposed relocation, conflicts with other structures, future MOT impact, etc.).
5. Pavement (e.g., design criteria, flexibility to change, material alternatives, etc.,).
6. Drainage structures (e.g., new and standardized structures, size of pipe, low head piping, interim drainage).
7. Lighting and signs (e.g., conduit size service point locations, design of structures, compatibility, power source, etc.).
8. Other structures (e.g., mix design, strength, pile information, finishes, concrete and steel requirements, etc.).

F. MOT Items

1. Are quantities sufficient for lane markings, both tape and paint (multiple HMA lifts, MOT phases); Traffic Manager; flagger hours; drums; concrete barriers, MOT asphalt; signs; VMS and arrow panels, etc.
2. Will project go through winter? How will this affect quantities if duration is longer than scheduled?
3. Is there enough room for sand cushions at the actual roadway speed, or should GREAT systems be utilized?
4. Have appropriate types and quantities of temporary connections of traffic barrier been identified?
5. Have minimum numbers of lanes and widths of lanes been shown on both MOT plans and x-sections and typical sections? Do they match?
6. Have MOT & temporary widenings been calculated into excavation quantities? Will borrow have to be brought in & cause a waste of material at end of job?
7. Have replacement items been setup for items such as drums, attenuators, barrier, etc.?
8. Is there an indication that the RCE worked time through phases of construction?

9. Was the project value-engineered?
10. Can embarkment materials be accessed from Class 1 or is traffic being maintained on top of it?
11. Can work be accessed safely? (Median work especially)
12. Is clearance sufficient under bridge to allow MOT before final work phases?
13. Is access required for pedestrians?
14. Is an alternate route required?

G. Problems with Phasing

1. How do you get from one phase into the next? Are there any safety issues between phasing?
2. Are there drainage problems between phases? Can water get to inlets or drainage structures while changing phases and during each phase?
3. Can residents and customers use driveways and entrances safely? Are tie-ins reasonable? Are they too steep or will water lay in them?
4. Are drop-offs adequately protected?

H. Hours for Lane Closures

1. Are hours on project and location on project specific? Has consideration been given to shopping centers and malls, churches, schools, military installations, seasonal traffic constraints, sports arenas and events, etc.?
2. Do work hour restrictions allow time to perform work?
3. Can hours be determined based on directional traffic flow?

I. Detour Routes

1. Has the appropriate jurisdiction approved them?
2. Has duration of detours been identified? Will it run through winter? If so, has plowing of snow or maintenance of detour included?

J. Right of Way

1. Is sufficient right-of-way available for all operations?
2. Equipment, material, and hazardous waste storage?

3. Staging?
4. Field office?
5. Access requirements?
6. Are there special facilities within the R.O.W. that need to be addressed?
7. Are there R.O.W. constraints that may impact the contractor work execution

Appendix (B) – Detailed NCDOT Checklist

Overall Checklist	**If you answer yes to any of these questions and are unsure of how to address the construction impacts, please contact the Area Construction Engineer for your division. https://apps.ncdot.gov/dot/directory/authenticated/UnitPage.aspx?id=2821 Yes - on any of these items may warrant an internal or external CR. Contact your ACE and/or VMO.**

Item	Description	Yes	No	Not Yet Defined
A	**General**			
A-1a	If there is a Local Agreement, is it related to the construction footprint, construction hours, hauling routes, or another construction impact? i.e, holiday events that may result in road closures.			
A-1b	If there is a Local Agreement, is it related to a unique feature to be construction - i.e., pedestrian bridge never constructed in the State?			
A-1c	Does the MPO/RPO etc not understand the construction impacts? A CR can be helpful to provide back-up documentation.			
A-1d	Overall -were any agreements made with the town that may impact Construction?			
A-2	Is it anticipated that this project construction will need to be accelerated?			
B	**Traffic Management**			
B-1	Has sufficient construction easement been obtained for temporary work zone? Including traffic shifts, temporary bridges, temporary signage, etc.			
B-2a	Do bike and pedestrians need to be accommodated during construction?			
B-2b	Has this safety measure been taken into consideration?			
B-3	Has the phasing of the earthwork, hydraulics, etc been reviewed to consider the construction phasing?			
B-4a	Are detours required?			
B-4b	If so, have the detours been approved by the town?			
B-4c	Is justification needed for the easements?			

B-5a	Timing of highway closure for blasting and clearing?			
B-5b	Does this project include blasting?			
B-6a	Is the ground water level high?			
B-6b	Will this impact the construction?			
B-6c	Has how it will be handled been addressed?			
B-7	Is specialized equipment needed to complete any part of the project?			
B-8	If shoulders are required to carry traffic during staging, are shoulders sufficiently designed for that?			
B-9	Is there sufficient room to install shoring for the maintenance of traffic and construct the project?			
B-10	If no reasonable detour is available, will lane closures result in significant backups and/or create safety issues?			
C	**Project Complexity**			
C-1a	Will businesses or residences impact during construction?			
C-1b	Has access been provided?			
C-1c	Will this impact the construction access?			
C-2a	Will construction impact emergency services, schools, etc?			
C-2b	Have access roads been provided for these and will it impact the construction access?			
C-3a	Will detour be required?			
C-3b	Has traffic analysis been conducted on the traffic for the detour?			
C-3c	Have the construction impacts been considered for the detour?			
C-4	Has the phasing of the earthwork, hydraulics, etc been reviewed to consider the construction phasing?			
C-5	Is the project located in an area with limited laydown and staging areas?			
C-6	Can easements be obtained for detours?			

C-7a	Is there sufficient construction easement?			
C-7b	Are there locations where sufficient construction easement will not be able to be found?			
C-8	Are the potential hauling routes acceptable to carry the loads of the construction equipment?			
C-9	Is site-access for hauling materials an issue?			
C-10	Are the potential hauling routes acceptable to carry the loads of the construction equipment?			
C-11	Are there any deep excavations that require special site considerations?			
C-11a	Sufficient ROW for staging?			
C-12	Will project create any long-term maintenance issues?			
C-13	Is there any directional drilling required for drainage or ITS?			
C-13a	Is there sufficient room for TDE and bore pit locations?			
C-14a	Will the construction methods likely to be used impact the environment in a way that would need to be included in the permitting?			
C-14b	Will this require barge work in an area with moratoriums or will the detour route cross a jurisdictional stream?			
D	**Structure Issues**			
D-1	Does this project include any special provisions that would impact the construction means and methods?			
D-2	Is there a need, based on the permitting, for any cofferdams, submerged pumping, or specialized construction means?			
D-3	Does the structure consider an innovative approach - i.e. unusually long spans, special material, etc. ?			
D-4	Are there any materials that may require a long lead time or advanced delivery consideration?			
D-5	Is the structure subject to any historic preservation?			
D-6	Will barges be required for any reason during Construction?			
D-7	Will the project require a temporary structure?			
D-8	Will the structure be constructed adjacent or above traffic?			

D-9	Are as built of the existing structure available?			
D-10	Do railroad or coast guard permits include the impacts of construction and not just the permanent structure?			
D-11	Does the project require structural remove over protected waterways, during certain times of the year, adjacent to OH utilities or any utilities?			
D-12a	Does the structure cross any navigable waters requiring a FERC permit?			
D-12b	Does the FERC regulated entity(i.e. power company) have any requirements?			
D-13	Is there sufficient access available to construct the bridges, sufficient room to stage cranes for construction, is top-down construction required?			
D-14	Are there any in-water moratoriums that will extend the construction schedule?			
D-15	Are areas available for crane operations and their swing diameters?			
D-16	Does your structure include two of the following? Skew less than 75 degrees or more than 105 degrees, a vertical curve, transitioning superelevation, or crown?			
E	**Right of Way (ROW)**			
E-1a	Have all ROW purchases and negotiations been made?			
E-1b	Has this considered the construction impact (versus the permanent impact)?			
E-1c	Will any negotiations not be complete prior to construction?			
E-2a	Are there any complex relocations within proposed ROW?			
E-2b	Does business relocations involve moving specialized equipment, very large equipment, or lengthy move times that would adversely disrupt the business?			
E-3	Are there any contaminated sites within the ROW that would require remediation?			
E-4	Are there any unusually high ROW estimates for property that may warrant a design change?			
F	**Unfamiliar Construction Practices**			
F-1a	Are there protected environmental species (flora or fauna) that need to be considered during construction?			
F-1b	Will the clearing adversely impact wetlands?			

F-1c	Or cause slope stabilization issues?			
F-2	Does the project require specialized disposal per the environmental permit??			
F-3	Is there anything that might require a specialized construction safety plan?			
F-4a	Are there any moratoriums to consider?			
F-4b	Are any ICTs (Intermediate Contract Times) needed for portions of the work?			
F-5	Are there any time restrictions for work to stop at (holidays, storm/hurricane season, etc.)			
F-6	Is noise ordinance (heavy equipment) respected (specific working hours)?			
F-7	Are sediment and erosion control devices designed and located correctly during different phases of construction?			
G	**Cost**			
G-1	Construction cost of 10 Million Dollar Cost?			
G-2	Are all the utility costs known?			
H	**Utility Issues or Relocation**			
H-1a	Are utilities being done by others?			
H-1b	Have they been scheduled?			
H-1c	Will utilities be relocated prior to letting?			
H-2	If utilities will not be relocated before construction starts, has the phasing been included in the contract?			
H-3a	Does any soil need to be removed from site due to contamination?			
H-3b	Do the soil conditions require an unusual construction method?			
H-4a	Is boring or drilling (trenchless technology) a part of the project?			
H-4b	Has sufficient construction easement been included?			
H-5a	Are utility relocations going to impact the construction?			
H-5b	Are temporary utilities needed?			

H-6	Any close-by high voltage lines?			
H-7	Has sufficient construction easement been obtained for temporary work zone the is needed? Including traffic shifts, temporary bridges, temporary signage, etc.			
H-8	Have utility relocation plans been completed and is sufficient PUE shown to accommodate the relocation?			
H-9	Do utility owners need specialized equipment or permits to complete their work?			
H-10a	Does project cross any power transmission easements/RW?			
H-10b	Does plans meet utility owner's requirements regarding slopes, walls, excavation limits, etc.			
H-11a	Does project cross any transcontinental gas lines?			
H-11b	Can utility owner's conditions be satisfied regarding excavation, loading, etc.			
H-13a	Do any wet utilities require complex or phased installation?			
H-13b	Has this been accounted for in TMP?			
H-14	Will grading work need to be performed before water and sewer line relocation can occur?			
H-15	Does phasing need to consider delayed utility relocation? Can delays in relocation be mitigated through phasing?			
Comments				

Appendix (C) – NCDOT Projects Bid Tabs

Project #1

Nov 30, 2022 9:18 AM LEE 2:00 PM 1 / 1 009

2023CPT.08.05.10531, 2023CPT.08.05.20531 Nov 15, 2022 C204791

TIP NO 7.230 MILES

FED AID NO STATE FUNDED
MILLING, AND RESURFACING.
2 SECTIONS OF US-1 BUS, 2 SECTIONS OF US-15-501, 2 SECTIONS OF US-1, AND 6 SECTIONS OF SECONDARY ROADS.

					FSC II LLC DBA FRED SMITH COMPANY		S T WOOTEN CORPORATION		BOGGS CONTRACTING INC	
						RALEIGH, NC		WILSON, NC		MONROE, NC
		ROADWAY ITEMS								
0001	0000100000-N	MOBILIZATION	Lump Sum			108,500.00		110,000.00		131,000.00
0002	1297000000-E	MILL ASP PVMT "***" DTH (1-1/2")	34,719	SY	1.80	62,494.20	2.90	100,685.10	4.40	152,763.60
0003	1330000000-E	INCIDENTAL MILLING	14,381	SY	7.75	111,452.75	7.35	105,700.35	6.50	93,476.50
0004	1519000000-E	ASP CONC SURF CRS S9.5B	8,951	TON	52.00	465,452.00	66.75	597,479.25	83.00	742,933.00
0005	1523000000-E	ASP CONC SURF CRS S9.5C	4,429	TON	85.00	376,465.00	83.25	368,714.25	96.00	425,184.00
0006	1575000000-E	ASP FOR PLANT MIX	890	TON	780.00	694,200.00	525.00	467,250.00	800.00	712,000.00
0007	1704000000-E	PATCHING EXIST PAVEMENT	545	TON	140.00	76,300.00	257.50	140,337.50	185.00	100,825.00
0008	1840000000-E	MILLED RUMBLE STRIPS	10,877	LF	0.90	9,789.30	0.85	9,245.45	0.52	5,656.04
0009	2830000000-N	ADJ MANHOLES	4	EA	1,650.00	6,600.00	750.00	3,000.00	850.00	3,400.00
0010	2845000000-N	ADJ METER OR VALVE BOXES	3	EA	1,650.00	4,950.00	625.00	1,875.00	750.00	2,250.00
0011	4413000000-E	WORK ZONE ADV/GEN WARN SIGN	1,017	SF	8.56	8,705.52	8.56	8,705.52	10.00	10,170.00
0012	4457000000-N	TEMP TRAFFIC CONTROL (SP)	Lump Sum			137,000.00		177,375.00		154,235.00
0013	4510000000-N	LAW ENFORCEMENT	102	HR	55.00	5,610.00	75.00	7,650.00	95.00	9,690.00
0014	4685000000-E	THERMO PVT MKG LINES 4"90	16,910	LF	1.10	18,601.00	1.10	18,601.00	1.25	21,137.50
0015	4688000000-E	THERMO PVT MKG LINES,6"90 MILS	7,298	LF	1.50	10,947.00	1.50	10,947.00	1.75	12,771.50
0016	4695000000-E	THERMO PVT MKG LINES 8"90 MILS	2,183	LF	2.00	4,366.00	2.00	4,366.00	2.35	5,130.05
0017	4700000000-E	12"WIDE THERMO 90 MILS	2,181	LF	3.00	6,543.00	3.00	6,543.00	4.75	10,359.75
0018	4709000000-E	24"WIDE THERMO 90 MILS	188	LF	15.00	2,820.00	15.00	2,820.00	11.75	2,209.00
0019	4720000000-E	THERMO PVT MKG CHARACTER 90	4	EA	100.00	400.00	100.00	400.00	125.00	500.00
0020	4725000000-E	THERMO PVT SYMBOL 90MILS	53	EA	150.00	7,950.00	150.00	7,950.00	238.00	12,614.00
0021	4810000000-E	PAINT PVMT MARKINGS 4"	126,474	LF	0.17	21,500.58	0.17	21,500.58	0.20	25,294.80
0022	4815000000-E	PAINT PVMT MARKINGS 6"	7,298	LF	0.29	2,116.42	0.29	2,116.42	0.35	2,554.30
0023	4820000000-E	PAINT PVMT MARKINGS 8"	2,183	LF	0.50	1,091.50	0.50	1,091.50	0.82	1,790.06
0024	4825000000-E	PAINT PVMT MARKINGS 12"	2,181	LF	0.75	1,635.75	0.75	1,635.75	1.15	2,508.15
0025	4835000000-E	PAINT PVT MKG LINES 24"	250	LF	3.00	750.00	3.00	750.00	1.50	375.00
0026	4840000000-N	PAINT PVT MKG CHARACTER	4	EA	30.00	120.00	30.00	120.00	35.00	140.00
0027	4845000000-N	PAINT PVT MKG SYMBOL	53	EA	30.00	1,590.00	30.00	1,590.00	35.00	1,855.00
0028	4905100000-N	NON-CAST IRON SNOWPLB PVMT MRKER	333	EA	50.00	16,650.00	50.00	16,650.00	45.00	14,985.00
0029	5255000000-N	PORTABLE LIGHTING	Lump Sum			14,400.00		10,675.00		14,000.00
		CONTRACT TOTAL			TOTAL	2,179,000.02	TOTAL	2,205,773.67	TOTAL	2,671,807.25
		ROADWAY ITEMS			SUB-TOTAL	2,179,000.02	SUB-TOTAL	2,205,773.67	SUB-TOTAL	2,671,807.25

BIDDERS IN ORDER **CONTRACT TOTAL**

FSC II LLC DBA FRED SMITH COMPANY	1	2,179,000.02
S T WOOTEN CORPORATION	2	2,205,773.67
BOGGS CONTRACTING INC	3	2,671,807.25

Project #2

TIP NO 16.153 MILES
FED AID NO STATE FUNDED
MILLING, RESURFACING, AND SHOULDER RECONSTRUCTION.
8 SECTIONS OF SECONDARY ROADS.

					APAC ATLANTIC INC THOMPSON ARTHUR DIVISION GREENSBORO, NC		VECELLIO & GROGAN INC DBA SHARPE BROTHERS BECKLEY, WV		J T RUSSELL & SONS INC ALBEMARLE, NC	
		ROADWAY ITEMS								
0001	0000100000-N	MOBILIZATION	Lump Sum			144,640.00		141,799.16		292,500.00
0002	0106000000-E	BORROW EXCAVATION	1,766	CY	65.00	114,790.00	54.64	96,494.24	50.00	88,300.00
0003	1220000000-E	INCIDENTAL STONE BASE	440	TON	1.00	440.00	1.00	440.00	0.01	4.40
0004	1245000000-E	SHOULDER RECONSTRUCTION	29.5	SMI	2,140.00	63,130.00	1,964.74	57,959.83	1,600.00	47,200.00
0005	1297000000-E	MILL ASP PVMT *****" DTH (1-1/2")	171,157	SY	1.62	277,274.34	2.18	373,122.26	2.50	427,892.50
0006	1297000000-E	MILL ASP PVMT *****" DTH (5-1/2")	700	SY	14.60	10,220.00	14.26	9,982.00	12.00	8,400.00
0007	1308000000-E	MILLN ASPHALT PVMT ***** - ***** (0" TO 1-1/2")	2,738	SY	1.80	4,928.40	2.77	7,584.26	4.25	11,636.50
0008	1308000000-E	MILLN ASPHALT PVMT ***** - ***** (0" TO 2-1/2")	1,470	SY	3.20	4,704.00	5.15	7,570.50	6.00	8,820.00
0009	1330000000-E	INCIDENTAL MILLING	14,429	SY	5.60	80,802.40	6.23	89,892.67	6.00	86,574.00
0010	1491000000-E	ASP CONC BASE CRS B25.0C	239	TON	67.00	16,013.00	67.33	16,091.87	79.00	18,881.00
0011	1519000000-E	ASP CONC SURF CRS S9.5B	2,337	TON	56.00	130,872.00	53.86	125,870.82	65.00	151,905.00
0012	1523000000-E	ASP CONC SURF CRS S9.5C	28,197	TON	54.00	1,522,638.00	49.91	1,407,312.27	66.00	1,861,002.00
0013	1575000000-E	ASP FOR PLANT MIX	1,960	TON	740.00	1,450,400.00	800.83	1,569,626.80	800.00	1,568,000.00
0014	1704000000-E	PATCHING EXIST PAVEMENT	2,115	TON	121.00	255,915.00	117.00	247,455.00	149.50	316,192.50
0015	1775500000-E	AST, MAT COAT, #*** STONE (#67)	92,111	SY	1.15	105,927.65	0.58	53,424.38	1.80	165,799.80
0016	1838000000-E	EMULSION FOR AST	36,844	GAL	2.52	92,846.88	2.86	105,373.84	2.80	103,163.20
0017	2830000000-N	ADJ MANHOLES	79	EA	934.00	73,786.00	1,007.45	79,588.55	1,375.00	108,625.00
0018	2845000000-N	ADJ METER OR VALVE BOXES	65	EA	892.00	57,980.00	960.62	62,440.30	1,250.00	81,250.00
0019	4413000000-E	WORK ZONE ADV/GEN WARN SIGN	1,780	SF	7.40	13,172.00	7.38	13,136.40	7.85	13,973.00
0020	4457000000-N	TEMP TRAFFIC CONTROL (SP)	Lump Sum			103,000.00		106,315.20		165,000.00
0021	4510000000-N	LAW ENFORCEMENT	165	HR	55.00	9,075.00	74.90	12,358.50	110.00	18,150.00
0022	4685000000-E	THERMO PVT MKG LINES 4"90	128,302	LF	0.50	64,151.00	0.48	61,584.96	0.57	73,132.14
0023	4687000000-E	THERMO PVT MKG LINES 4"240	120	LF	0.60	72.00	14.98	1,797.60	0.68	81.60
0024	4688000000-E	THERMO PVT MKG LINES,6"90 MILS	219,797	LF	0.55	120,888.35	0.68	149,461.96	0.63	138,472.11
0025	4695000000-E	THERMO PVT MKG LINES 8"90 MILS	1,454	LF	2.00	2,908.00	1.77	2,573.58	2.27	3,300.58
0026	4704000000-E	THERMO LINES 16" 90MILS	100	LF	7.00	700.00	12.84	1,284.00	7.96	796.00
0027	4709000000-E	24"WIDE THERMO 90 MILS	1,835	LF	8.00	14,680.00	8.56	15,707.60	9.10	16,698.50
0028	4720000000-E	THERMO PVT MKG CHARACTER 90	77	EA	60.00	4,620.00	107.00	8,239.00	68.22	5,252.94
0029	4725000000-E	THERMO PVT SYMBOL 90MILS	237	EA	100.00	23,700.00	128.40	30,430.80	113.68	26,942.16
0030	4810000000-E	PAINT PVMT MARKINGS 4"	152,191	LF	0.10	15,219.10	0.18	27,394.38	0.11	16,741.01
0031	4815000000-E	PAINT PVMT MARKINGS 6"	250	LF	0.15	37.50	4.28	1,070.00	0.17	42.50
0032	4835000000-E	PAINT PVT MKG LINES 24"	754	LF	1.00	754.00	4.65	3,506.10	1.14	859.56
0033	5255000000-N	PORTABLE LIGHTING	Lump Sum			10,000.00		31,348.27		37,500.00
0034	6000000000-E	TEMPORARY SILT FENCE	5,877	LF	0.10	587.70	1.00	5,877.00	2.00	11,754.00
0035	6071010000-E	WATTLE	587	LF	0.10	58.70	1.00	587.00	1.00	587.00
		CONTRACT TOTAL			TOTAL	4,790,931.02	TOTAL	4,924,701.10	TOTAL	5,875,429.00
		ROADWAY ITEMS			SUB-TOTAL	4,790,931.02	SUB-TOTAL	4,924,701.10	SUB-TOTAL	5,875,429.00

	APAC ATLANTIC INC THOMPSON ARTHUR DIVISION	VECELLIO & GROGAN INC DBA SHARPE BROTHERS	J T RUSSELL & SONS INC
	GREENSBORO, NC	BECKLEY, WV	ALBEMARLE, NC

BIDDERS IN ORDER		CONTRACT TOTAL
APAC ATLANTIC INC THOMPSON ARTHUR DIVISION	1	4,790,931.02
VECELLIO & GROGAN INC DBA SHARPE BROTHERS	2	4,924,701.10
J T RUSSELL & SONS INC	3	5,875,429.00

Project #3

TIP NO R-5705B 4.536 MILES
FED AID NO STATE FUNDED
GRADING, DRAINAGE, PAVING, SIGNALS, AND CULVERTS.
NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
		ROADWAY ITEMS								
0001	0000100000-N	MOBILIZATION	Lump Sum			3,074,885.00		3,100,000.00		3,275,921.00
0002	0000400000-N	CONSTRUCTION SURVEYING	Lump Sum			500,000.00		550,000.00		1,250,000.00
0003	0001000000-E	CLEARING & GRUBBING	Lump Sum			2,500,000.00		3,776,000.00		1,350,000.00
0004	0008000000-E	SUPP CLEARING & GRUBBING	3	ACR	9,255.00	27,765.00	6,500.00	19,500.00	12,000.00	36,000.00
0005	0022000000-E	UNCLASSIFIED EXCAVATION	221,100	CY	12.00	2,653,200.00	12.00	2,653,200.00	10.00	2,211,000.00
0006	0036000000-E	UNDERCUT EXCAVATION	48,200	CY	13.50	650,700.00	15.00	723,000.00	20.00	964,000.00
0007	0106000000-E	BORROW EXCAVATION	451,800	CY	17.00	7,680,600.00	14.00	6,325,200.00	20.00	9,036,000.00
0008	0127000000-N	EMBM'T SETTLEMENT GAUGE	2	EA	1,290.00	2,580.00	780.00	1,560.00	5,000.00	10,000.00
0009	0134000000-E	DRAINAGE DITCH EXCAVATION	5,410	CY	12.50	67,625.00	13.00	70,330.00	10.00	54,100.00
0010	0156000000-E	REMOVAL OF EXT ASPHALT PVMT	46,000	SY	11.00	506,000.00	6.30	289,800.00	3.98	183,080.00
0011	0192000000-N	PROOF ROLLING	40	HR	285.00	11,400.00	110.00	4,400.00	300.00	12,000.00
0012	0194000000-E	SELECT GRANULAR MATL, CLASS III	52,900	CY	32.00	1,692,800.00	14.00	740,600.00	75.00	3,967,500.00
0013	0196000000-E	GEOTEXTILE SOIL STABILIZATION	92,090	SY	1.70	156,553.00	1.15	105,903.50	5.00	460,450.00
0014	0199000000-E	TEMPORARY SHORING	1,020	SF	84.00	85,680.00	70.00	71,400.00	100.00	102,000.00
0015	0223000000-E	ROCK PLATING	1,460	SY	100.00	146,000.00	60.00	87,600.00	100.00	146,000.00
0016	0255000000-E	GENERIC GRADING ITEM (TON) HAULING AND DISPOSAL OF PETROLEUM CONTAMINATED SOIL	650	TON	69.00	44,850.00	400.00	260,000.00	70.00	45,500.00
0017	0318000000-E	FND CONDIT MATL MINOR STRS	3,799	TON	50.00	189,950.00	42.00	159,558.00	36.00	136,764.00
0018	0320000000-E	FND CONDIT GEOTEXTILE	17,699	SY	5.00	88,495.00	1.00	17,699.00	5.00	88,495.00
0019	0335200000-E	15" DRAINAGE PIPE	709	LF	70.00	49,630.00	82.00	58,138.00	125.00	88,625.00
0020	0335300000-E	18" DRAINAGE PIPE	160	LF	85.00	13,600.00	92.00	14,720.00	150.00	24,000.00
0021	0390000000-E	36" RC PIPE CULV III	127	LF	180.00	22,860.00	234.00	29,718.00	200.00	25,400.00
0022	0448000000-E	***" RCP CULV CLASS IV (48")	1,760	LF	350.00	616,000.00	355.00	624,800.00	420.00	739,200.00
0023	0448000000-E	***" RCP CULV CLASS IV (54")	63	LF	445.00	28,035.00	565.00	35,595.00	600.00	37,800.00
0024	0448000000-E	***" RCP CULV CLASS IV (60")	564	LF	525.00	296,100.00	580.00	327,120.00	650.00	366,600.00
0025	0448000000-E	***" RCP CULV CLASS IV (66")	180	LF	735.00	132,300.00	800.00	144,000.00	750.00	135,000.00
0026	0448200000-E	15" RCP CULV CLASS IV	17,476	LF	70.00	1,223,320.00	105.00	1,834,980.00	125.00	2,184,500.00
0027	0448300000-E	18" RCP CULV CLASS IV	3,498	LF	85.00	297,330.00	125.00	437,250.00	150.00	524,700.00
0028	0448400000-E	24" RCP CULV CLASS IV	3,215	LF	125.00	401,875.00	160.00	514,400.00	175.00	562,625.00
0029	0448500000-E	30" RCP CULV CLASS IV	1,112	LF	165.00	183,480.00	190.00	211,280.00	225.00	250,200.00
0030	0448600000-E	36" RCP CULV CLASS IV	622	LF	225.00	139,950.00	252.00	156,744.00	250.00	155,500.00
0031	0448700000-E	42" RCP CULV CLASS IV	240	LF	310.00	74,400.00	332.00	79,680.00	330.00	79,200.00
0032	0582000000-E	15" CS PIPE CULV 0.064"	912	LF	80.00	72,960.00	61.00	55,632.00	100.00	91,200.00
0033	0588000000-E	18" CS PIPE CULV 0.064"	336	LF	95.00	31,920.00	70.00	23,520.00	115.00	38,640.00
0034	0636000000-E	**" CS ELBOW *****" THICK (15", 0.064")	27	EA	750.00	20,250.00	200.00	5,400.00	300.00	8,100.00
0035	0636000000-E	**" CS ELBOW *****" THICK (18", 0.064")	4	EA	1,000.00	4,000.00	240.00	960.00	325.00	1,300.00

TIP NO R-5705B 4.536 MILES
FED AID NO STATE FUNDED
GRADING, DRAINAGE, PAVING, SIGNALS, AND CULVERTS.
NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
0036	0995000000-E	PIPE REMOVAL	4,041	LF	35.00	141,435.00	34.00	137,394.00	50.00	202,050.00
0037	1011000000-N	FINE GRADING	Lump Sum			4,367,474.00		3,572,278.50		1,607,684.31
0038	1099500000-E	SHALLOW UNDERCUT	7,750	CY	17.00	131,750.00	20.00	155,000.00	12.00	93,000.00
0039	1099700000-E	CLASS IV SUBGRD STABILIZATION	22,220	TON	38.00	844,360.00	29.00	644,380.00	35.00	777,700.00
0040	1111000000-E	CLASS IV AGGREGATE STABILIZATION	250	TON	44.00	11,000.00	46.00	11,500.00	70.00	17,500.00
0041	1121000000-E	AGGREGATE BASE COURSE	84,300	TON	37.00	3,119,100.00	43.00	3,624,900.00	45.00	3,793,500.00
0042	1220000000-E	INCIDENTAL STONE BASE	450	TON	45.00	20,250.00	36.00	16,200.00	100.00	45,000.00
0043	1275000000-E	PRIME COAT	1,080	GAL	7.60	8,208.00	8.00	8,640.00	8.07	8,715.60
0044	1330000000-E	INCIDENTAL MILLING	1,730	SY	13.50	23,355.00	12.00	20,760.00	10.00	17,300.00
0045	1491000000-E	ASP CONC BASE CRS B25.0C	11,090	TON	74.75	828,977.50	93.00	1,031,370.00	75.39	836,075.10
0046	1503000000-E	ASP CONC INTR CRS I19.0C	46,580	TON	66.00	3,074,280.00	80.00	3,726,400.00	66.56	3,100,364.80
0047	1519000000-E	ASP CONC SURF CRS S9.5B	5,610	TON	77.75	436,177.50	105.00	589,050.00	78.41	439,880.10
0048	1523000000-E	ASP CONC SURF CRS S9.5C	35,910	TON	67.00	2,405,970.00	90.00	3,231,900.00	67.57	2,426,438.70
0049	1575000000-E	ASP FOR PLANT MIX	5,270	TON	812.00	4,279,240.00	730.00	3,847,100.00	844.74	4,451,779.80
0050	1693000000-E	ASPH PLT MIX PVMT REPAIR	2,500	TON	300.00	750,000.00	105.00	262,500.00	300.00	750,000.00
0051	2000000000-N	RIGHT-OF-WAY MARKERS	178	EA	102.00	18,156.00	55.00	9,790.00	230.00	40,940.00
0052	2022000000-E	SUB DRAIN EXCAVATION	5,511	CY	35.00	192,885.00	38.00	209,418.00	50.00	275,550.00
0053	2026000000-E	GEOTEXTILE FOR SUBSURF DRNS	16,400	SY	11.00	180,400.00	1.25	20,500.00	1.50	24,600.00
0054	2036000000-E	SUB DRAIN COARSE AGGREGATE	2,760	CY	75.00	207,000.00	53.00	146,280.00	50.00	138,000.00
0055	2044000000-E	6" PERF SUBDRN PIPE	16,400	LF	16.00	262,400.00	15.00	246,000.00	5.00	82,000.00
0056	2070000000-N	SUB DRN PIPE OUTLET	33	EA	400.00	13,200.00	420.00	13,860.00	750.00	24,750.00
0057	2077000000-E	6" OUTLET PIPE	198	LF	45.00	8,910.00	25.00	4,950.00	35.00	6,930.00
0058	2209000000-E	ENDWALLS	52.6	CY	1,000.00	52,600.00	1,700.00	89,420.00	2,500.00	131,500.00
0059	2220000000-E	REINFORCED ENDWALLS	28.3	CY	1,500.00	42,450.00	1,800.00	50,940.00	5,000.00	141,500.00
0060	2264000000-E	PIPE PLUGS	0.045	CY	10,500.00	472.50	120,000.00	5,400.00	75,000.00	3,375.00
0061	2286000000-N	MASNRY DRAINAGE STRUCT	328	EA	3,500.00	1,148,000.00	3,200.00	1,049,600.00	4,200.00	1,377,600.00
0062	2308000000-E	MASNRY DRAINAGE STRUCT	75.3	LF	500.00	37,650.00	470.00	35,391.00	350.00	26,355.00
0063	2364000000-N	FRAME W/2GRTS 840.16 STD	18	EA	2,000.00	36,000.00	1,220.00	21,960.00	1,250.00	22,500.00
0064	2364200000-N	FRAME W/2GRTS 840.20 STD	29	EA	1,700.00	49,300.00	1,210.00	35,090.00	1,250.00	36,250.00
0065	2365000000-N	FRAME W/2GRTS 840.22 STD	7	EA	1,950.00	13,650.00	1,230.00	8,610.00	1,250.00	8,750.00
0066	2366000000-N	FRAME W/2GRTS 840.24 STD	17	EA	2,000.00	34,000.00	1,250.00	21,250.00	1,250.00	21,250.00
0067	2367000000-N	FRAME W/2GRTS 840.29 STD	100	EA	2,000.00	200,000.00	1,230.00	123,000.00	1,250.00	125,000.00
0068	2374000000-N	FRAME-GRT-HD 840.03 ** (E)	16	EA	2,100.00	33,600.00	1,315.00	21,040.00	1,250.00	20,000.00
0069	2374000000-N	FRAME-GRT-HD 840.03 ** (F)	60	EA	2,200.00	132,000.00	1,315.00	78,900.00	1,250.00	75,000.00
0070	2374000000-N	FRAME-GRT-HD 840.03 **	77	EA	2,200.00	169,400.00	1,315.00	101,255.00	1,250.00	96,250.00

TIP NO R-5705B
FED AID NO STATE FUNDED
4.536 MILES
GRADING, DRAINAGE, PAVING, SIGNALS, AND CULVERTS.
NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
0074	2542000000-E	1'-6" CONC CURB & GUTTER	21,030	LF	23.80	500,514.00	30.00	630,900.00	56.00	1,177,680.00
0075	2549000000-E	2'-6" CONC CURB & GUTTER	24,800	LF	28.40	704,320.00	38.00	942,400.00	27.00	669,600.00
0076	2556000000-E	SHOULDER BERM GUTTER	4,870	LF	25.15	122,480.50	44.00	214,280.00	27.00	131,490.00
0077	2591000000-E	4" CONCRETE SIDEWALK	9,660	SY	49.55	478,653.00	60.00	579,600.00	57.00	550,620.00
0078	2605000000-N	CONCRETE CURB RAMPS	80	EA	2,500.00	200,000.00	2,900.00	232,000.00	2,416.00	193,280.00
0079	2612000000-E	6" CONCRETE DRIVEWAY	620	SY	79.25	49,135.00	105.00	65,100.00	95.00	58,900.00
0080	2619000000-E	4" CONCRETE PAVED DITCH	800	SY	135.00	108,000.00	140.00	112,000.00	97.00	77,600.00
0081	2655000000-E	5" MONO CONC ISLDS (KEY IN)	10,010	SY	70.50	705,705.00	90.00	900,900.00	80.00	800,800.00
0082	2905000000-N	CONVERT DI TO JB	1	EA	3,500.00	3,500.00	2,400.00	2,400.00	2,500.00	2,500.00
0083	2920000000-N	CONVERT DI TO CB	1	EA	3,500.00	3,500.00	2,300.00	2,300.00	2,800.00	2,800.00
0084	3030000000-E	STL BEAM GUARDRAIL	5,725	LF	26.00	148,850.00	30.00	171,750.00	26.39	151,082.75
0085	3045000000-E	SBGR SHOP CURVED	262.5	LF	27.00	7,087.50	32.00	8,400.00	27.40	7,192.50
0086	3150000000-N	ADDIT GUARDRAIL POSTS	5	EA	55.00	275.00	60.00	300.00	55.83	279.15
0087	3195000000-N	GR END TYPE AT-1	1	EA	900.00	900.00	950.00	950.00	913.50	913.50
0088	3210000000-N	GR END TYPE CAT-1	13	EA	950.00	12,350.00	1,300.00	16,900.00	964.25	12,535.25
0089	3287000000-N	GR END TYPE TL-3	12	EA	3,450.00	41,400.00	3,900.00	46,800.00	3,501.75	42,021.00
0090	3360000000-E	REMOVE EXISTING GUARDRAIL	3,951	LF	1.00	3,951.00	1.65	6,519.15	1.01	3,990.51
0091	3503000000-E	WOVEN WIRE FENCE 47" FAB	26,850	LF	4.25	114,112.50	7.00	187,950.00	4.31	115,723.50
0092	3509000000-E	4" TIMBER POSTS 7'-6"LONG	1,630	EA	32.00	52,160.00	36.00	58,680.00	32.48	52,942.40
0093	3512000000-E	5" TIMBER POSTS ****LONG (7'-6")	480	EA	38.00	18,240.00	50.00	24,000.00	38.57	18,513.60
0094	3575000000-E	GENERIC FENCING ITEM (LF) PEDESTRIAN SAFETY RAIL	152	LF	250.00	38,000.00	280.00	42,560.00	253.75	38,570.00
0095	3628000000-E	RIP RAP, CLASS I	4,350	TON	79.00	343,650.00	65.00	282,750.00	58.80	255,780.00
0096	3649000000-E	RIP RAP, CLASS B	1,755	TON	68.00	119,340.00	60.00	105,300.00	52.80	92,664.00
0097	3656000000-E	GEOTEXTILE FOR DRAINGE	14,545	SY	3.50	50,907.50	1.65	23,999.25	3.84	55,852.80
0098	4072000000-E	SUPPORT, 3-LB STL U-CHAN	4,052	LF	7.15	28,971.80	12.00	48,624.00	10.00	40,520.00
0099	4096000000-N	SIGN ERECTION, TYPE D	1	EA	295.00	295.00	220.00	220.00	200.00	200.00
0100	4102000000-N	SIGN ERECTION, TYPE E	146	EA	245.00	35,770.00	85.00	12,410.00	75.00	10,950.00
0101	4108000000-N	SIGN ERECTION, TYPE F	34	EA	285.00	9,690.00	220.00	7,480.00	200.00	6,800.00
0102	4116100000-N	SIGN ERECT, RELOC ** GRD MTD (D)	7	EA	225.00	1,575.00	220.00	1,540.00	200.00	1,400.00
0103	4116100000-N	SIGN ERECT, RELOC ** GRD MTD (F)	1	EA	245.00	245.00	220.00	220.00	200.00	200.00
0104	4155000000-N	DISPOSE SIGN SYST U-CHAN	46	EA	10.00	460.00	1.10	50.60	1.00	46.00
0105	4192000000-N	DISPOSE SUPPORT, U-CHAN	11	EA	10.00	110.00	1.10	12.10	1.00	11.00
0106	4238000000-N	DISPOSE SIGN, D, E, F	1	EA	10.00	10.00	1.10	1.10	1.00	1.00

TIP NO R-5705B 4.536 MILES
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GRADING, DRAINAGE, PAVING, SIGNALS, AND CULVERTS.
NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
0112	4445000000-E	BARRICADES (TYPE III)	376	LF	40.00	15,040.00	45.00	16,920.00	25.00	9,400.00
0113	4447000000-E	PED CHANNEL DEVICES	1,350	LF	60.00	81,000.00	60.00	81,000.00	64.35	86,872.50
0114	4455000000-N	FLAGGER	120	DAY	440.00	52,800.00	320.00	38,400.00	250.00	30,000.00
0115	4465000000-N	TEMPORARY CRASH CUSHIONS	2	EA	9,600.00	19,200.00	8,250.00	16,500.00	7,650.00	15,300.00
0116	4470000000-N	REM & RES CRASH CUSHION	2	EA	3,500.00	7,000.00	3,200.00	6,400.00	2,950.00	5,900.00
0117	4485000000-E	PORT CONC BARRIER	1,826	LF	42.00	76,692.00	54.00	98,604.00	43.75	79,887.50
0118	4500000000-E	REM & RES PORT CONC BARRIER	1,446	LF	15.50	22,413.00	4.40	6,362.40	4.00	5,784.00
0119	4510000000-N	LAW ENFORCEMENT	24	HR	65.00	1,560.00	44.00	1,056.00	62.00	1,488.00
0120	4516000000-N	SKINNY DRUM	50	EA	60.00	3,000.00	36.00	1,800.00	38.61	1,930.50
0121	4650000000-N	TEMP RAISED PVMT MRKS	1,061	EA	5.00	5,305.00	5.75	6,100.75	6.18	6,556.98
0122	4685000000-E	THERMO PVT MKG LINES 4"90	86,561	LF	0.85	73,576.85	1.05	90,889.05	0.88	76,173.68
0123	4695000000-E	THERMO PVT MKG LINES 8"90 MILS	7,257	LF	1.50	10,885.50	1.75	12,699.75	2.83	20,537.31
0124	4700000000-E	12"WIDE THERMO 90 MILS	600	LF	3.00	1,800.00	3.55	2,130.00	4.89	2,934.00
0125	4709000000-E	24"WIDE THERMO 90 MILS	1,728	LF	12.00	20,736.00	14.00	24,192.00	13.13	22,688.64
0126	4720000000-E	THERMO PVT MKG CHARACTER 90	20	EA	100.00	2,000.00	120.00	2,400.00	128.75	2,575.00
0127	4725000000-E	THERMO PVT SYMBOL 90MILS	134	EA	150.00	20,100.00	165.00	22,110.00	245.14	32,848.76
0128	4810000000-E	PAINT PVMT MARKINGS 4"	102,948	LF	0.25	25,737.00	0.30	30,884.40	0.15	15,442.20
0129	4820000000-E	PAINT PVMT MARKINGS 8"	7,255	LF	0.75	5,441.25	0.85	6,166.75	0.57	4,135.35
0130	4835000000-E	PAINT PVT MKG LINES 24"	756	LF	5.00	3,780.00	5.65	4,271.40	2.58	1,950.48
0131	4840000000-N	PAINT PVT MKG CHARACTER	22	EA	60.00	1,320.00	70.00	1,540.00	36.05	793.10
0132	4845000000-N	PAINT PVT MKG SYMBOL	97	EA	60.00	5,820.00	70.00	6,790.00	56.65	5,495.05
0133	4850000000-E	LINE REMOVAL 4" WIDE	24,341	LF	0.40	9,736.40	0.50	12,170.50	0.77	18,742.57
0134	4870000000-E	LINE REMOVAL 24" WIDE	133	LF	6.00	798.00	6.85	911.05	5.67	754.11
0135	4905100000-N	NON-CAST IRON SNOWPLB PVMT MRKER	1,435	EA	42.00	60,270.00	50.00	71,750.00	50.00	71,750.00
0136	5325800000-E	8" WATER LINE	2,144	LF	95.00	203,680.00	155.00	332,320.00	134.31	287,960.64
0137	5326200000-E	12" WATER LINE	2,980	LF	150.00	447,000.00	200.00	596,000.00	180.19	536,966.20
0138	5327000000-E	20" WATER LINE	2,496	LF	275.00	686,400.00	340.00	848,640.00	324.00	808,704.00
0139	5329000000-E	DI H2O PIPE FITTINGS	43,890	LB	8.50	373,065.00	14.00	614,460.00	13.02	571,447.80
0140	5540000000-E	6" VALVE	6	EA	2,300.00	13,800.00	2,600.00	15,600.00	2,710.12	16,260.72
0141	5546000000-E	8" VALVE	7	EA	3,300.00	23,100.00	3,500.00	24,500.00	3,721.91	26,053.37
0142	5558000000-E	12" VALVE	11	EA	6,100.00	67,100.00	6,400.00	70,400.00	6,826.51	75,091.61
0143	5559000000-E	20" VALVE	5	EA	20,000.00	100,000.00	34,000.00	170,000.00	36,459.14	182,295.70
0144	5606000000-E	2" BLOW OFF	3	EA	6,500.00	19,500.00	4,200.00	12,600.00	8,878.04	26,634.12
0145	5648000000-N	RELOCATE WATER METER	9	EA	1,200.00	10,800.00	1,870.00	16,830.00	2,402.49	21,622.41
0146	5649000000-N	RECONNECT WATER METER	5	EA	1,000.00	5,000.00	1,600.00	8,000.00	1,604.94	8,024.70
0147	5672000000-N	RELOCATE FIRE HYDRANT	5	EA	9,000.00	45,000.00	4,200.00	21,000.00	5,135.55	25,677.75

TIP NO R-5705B 4.536 MILES
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NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
0153	5775000000-E	4' DIA UTILITY MANHOLE	4	EA	9,500.00	38,000.00	7,000.00	28,000.00	12,633.12	50,532.48
0154	5800000000-E	ABANDON 6" UTILITY PIPE	2,044	LF	10.00	20,440.00	13.00	26,572.00	23.22	47,461.68
0155	5801000000-E	ABANDON 8" UTILITY PIPE	3,795	LF	12.00	45,540.00	16.00	60,720.00	24.43	92,711.85
0156	5804000000-E	ABANDON 12" UTILITY PIPE	1,453	LF	17.00	24,701.00	20.00	29,060.00	28.31	41,134.43
0157	5812000000-E	ABANDON 20" UTILITY PIPE	2,478	LF	38.00	94,164.00	27.00	66,906.00	40.11	99,392.58
0158	5816000000-N	ABANDON UTILITY MANHOLE	1	EA	2,500.00	2,500.00	2,050.00	2,050.00	2,026.93	2,026.93
0159	5828000000-N	REMOVE UTILITY MANHOLE	1	EA	3,500.00	3,500.00	1,650.00	1,650.00	4,032.12	4,032.12
0160	5835000000-E	"" ENCASEMENT PIPE (42")	110	LF	530.00	58,300.00	910.00	100,100.00	1,166.27	128,289.70
0161	5835600000-E	12" ENCASEMENT PIPE	395	LF	235.00	92,825.00	290.00	114,550.00	460.12	181,747.40
0162	5835700000-E	16" ENCASEMENT PIPE	462	LF	275.00	127,050.00	300.00	138,600.00	459.32	212,205.84
0163	5836000000-E	24" ENCASEMENT PIPE	512	LF	340.00	174,080.00	400.00	204,800.00	510.18	261,212.16
0164	5872500000-E	BORE & JACK "" (12")	235	LF	510.00	119,850.00	442.00	103,870.00	496.01	116,562.35
0165	5872500000-E	BORE & JACK "" (16")	102	LF	650.00	66,300.00	491.00	50,082.00	651.76	66,479.52
0166	5872500000-E	BORE & JACK "" (24")	332	LF	875.00	290,500.00	510.00	169,320.00	535.74	177,865.68
0167	5872500000-E	BORE & JACK "" (42")	90	LF	1,500.00	135,000.00	990.00	89,100.00	1,156.46	104,081.40
0168	5882000000-N	GENERIC UTILITY ITEM (EA) 8" INSERTION VALVE	1	EA	30,000.00	30,000.00	26,000.00	26,000.00	17,680.35	17,680.35
0169	6000000000-E	TEMPORARY SILT FENCE	65,630	LF	3.30	216,579.00	3.50	229,705.00	3.32	217,891.60
0170	6006000000-E	EROS CNTRL STONE CL A	2,900	TON	68.00	197,200.00	54.00	156,600.00	49.80	144,420.00
0171	6009000000-E	EROS CNTRL STONE CL B	19,850	TON	68.00	1,349,800.00	55.00	1,091,750.00	52.80	1,048,080.00
0172	6012000000-E	SEDIMENT CONTROL STONE	9,935	TON	48.00	476,880.00	44.00	437,140.00	40.19	399,287.65
0173	6015000000-E	TEMPORARY MULCHING	124	ACR	1,200.00	148,800.00	1,300.00	161,200.00	1,224.00	151,776.00
0174	6018000000-E	SEED FOR TEMP SEEDING	4,800	LB	3.50	16,800.00	3.75	18,000.00	3.57	17,136.00
0175	6021000000-E	FERT FOR TEMP SEEDING	25.5	TON	1,200.00	30,600.00	1,300.00	33,150.00	1,224.00	31,212.00
0176	6024000000-E	TEMPORARY SLOPE DRAINS	8,760	LF	25.00	219,000.00	16.00	140,160.00	18.14	158,906.40
0177	6029000000-E	SAFETY FENCE	13,600	LF	2.10	28,560.00	2.20	29,920.00	2.14	29,104.00
0178	6030000000-E	SILT EXCAVATION	29,260	CY	13.25	387,695.00	8.00	234,080.00	11.27	329,760.20
0179	6036000000-E	MATTING FOR EROS CONTROL	192,229	SY	1.65	317,177.85	1.95	374,846.55	1.68	322,944.72
0180	6037000000-E	COIR FIBER MAT	585	SY	3.95	2,310.75	4.50	2,632.50	4.03	2,357.55
0181	6042000000-E	1/4" HARDWARE CLOTH	16,265	LF	3.15	51,234.75	3.15	51,234.75	3.06	49,770.90
0182	6043000000-E	LOW PERMEABILITY GEOTEXTILE	860	SY	7.10	6,106.00	6.50	5,590.00	16.27	13,992.20
0183	6070000000-N	SPECIAL STILLING BASINS	10	EA	1,120.00	11,200.00	330.00	3,300.00	1,660.53	16,605.30
0184	6071012000-E	COIR FIBER WATTLE	4,550	LF	18.00	81,900.00	20.00	91,000.00	18.36	83,538.00

TIP NO R-5705B 4.536 MILES
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NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
0188	6071050000-E	"" SKIMMER (2")	3	EA	1,855.00	5,565.00	110.00	330.00	1,057.33	3,171.99
0189	6071050000-E	"" SKIMMER (2-1/2")	1	EA	2,185.00	2,185.00	110.00	110.00	1,309.51	1,309.51
0190	6084000000-E	SEEDING AND MULCHING	87	ACR	2,675.00	232,725.00	2,900.00	252,300.00	2,728.50	237,379.50
0191	6087000000-E	MOWING	99	ACR	185.00	18,315.00	195.00	19,305.00	188.70	18,681.30
0192	6090000000-E	SEED FOR REPAIR SEEDING	1,250	LB	13.00	16,250.00	14.00	17,500.00	13.26	16,575.00
0193	6093000000-E	FERT FOR REPAIR SEEDING	4.25	TON	1,300.00	5,525.00	1,400.00	5,950.00	1,326.00	5,635.50
0194	6096000000-E	SEED FOR SUPP SEEDING	2,075	LB	11.00	22,825.00	12.00	24,900.00	11.22	23,281.50
0195	6108000000-E	FERTILIZER TOPDRESSING	62.25	TON	1,275.00	79,368.75	1,350.00	84,037.50	1,300.50	80,956.13
0196	6111000000-E	IMPERVIOUS DIKE	445	LF	190.00	84,550.00	40.00	17,800.00	108.21	48,153.45
0197	6114500000-N	SPECIALIZED HAND MOWING	30	MHR	105.00	3,150.00	115.00	3,450.00	107.10	3,213.00
0198	6114800000-N	MANUAL LITTER REMOVAL	55	MHR	60.00	3,300.00	55.00	3,025.00	100.00	5,500.00
0199	6114900000-E	LITTER DISPOSAL	9	TON	440.00	3,960.00	95.00	855.00	200.00	1,800.00
0200	6117000000-N	RESPONSE FOR EROS CONTROL	150	EA	550.00	82,500.00	600.00	90,000.00	561.00	84,150.00
0201	6117500000-N	CONC WASHOUT STRUCTURE	20	EA	825.00	16,500.00	900.00	18,000.00	2,469.89	49,397.80
0202	6120000000-E	CULVERT DIVERSION CHANNEL	285	CY	62.85	17,912.25	24.00	6,840.00	63.79	18,180.15
0203	6132000000-N	GENERIC EROSION CONTROL ITEM (EA) FABRIC INSERT INLET PROTECTION DEVICE	123	EA	195.00	23,985.00	175.00	21,525.00	150.00	18,450.00
0204	6132000000-N	GENERIC EROSION CONTROL ITEM (EA) FABRIC INSERT INLET PROTECTION DEVICE CLEANOUT	369	EA	160.00	59,040.00	55.00	20,295.00	149.35	55,110.15
0205	7048500000-E	16" PEDEST SIG HEAD 1 SEC W/CD	20	EA	825.00	16,500.00	1,300.00	26,000.00	825.00	16,500.00
0206	7060000000-E	SIGNAL CABLE	10,650	LF	3.50	37,275.00	3.30	35,145.00	3.50	37,275.00
0207	7120000000-E	VEHICLE SIGNAL HD (12", 3 SECT)	37	EA	825.00	30,525.00	1,300.00	48,100.00	825.00	30,525.00
0208	7132000000-E	VEHICLE SIGNAL HD (12", 4 SECT)	4	EA	1,025.00	4,100.00	1,600.00	6,400.00	1,025.00	4,100.00
0209	7252000000-E	MESSENGER CABLE (1/4")	2,331	LF	3.30	7,692.30	6.00	13,986.00	3.30	7,692.30
0210	7264000000-E	MESSENGER CABLE (3/8")	600	LF	4.00	2,400.00	3.00	1,800.00	4.00	2,400.00
0211	7279000000-E	TRACER WIRE	1,232	LF	1.00	1,232.00	1.15	1,416.80	1.00	1,232.00
0212	7300000000-E	UNPAVED TRENCH (********) (1, 2")	2,850	LF	8.25	23,512.50	13.00	37,050.00	8.25	23,512.50
0213	7300000000-E	UNPAVED TRENCH (********) (2, 2")	967	LF	9.25	8,944.75	18.00	17,406.00	9.25	8,944.75
0214	7301000000-E	DIRECT DRILL (********) (1, 2")	1,020	LF	18.00	18,360.00	22.00	22,440.00	18.00	18,360.00
0215	7301000000-E	DIRECT DRILL (********) (2, 2")	100	LF	32.00	3,200.00	26.00	2,600.00	32.00	3,200.00
0216	7312000000-N	JUNCTION BOX (**********) (SPECIAL OVERSIZED HEAVY DUTY)	3	EA	1,350.00	4,050.00	1,950.00	5,850.00	1,350.00	4,050.00

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NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

					HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
0222	7420000000-E	2" RISER WITH WEATHERHEAD	1	EA	675.00	675.00	872.00	872.00	675.00	675.00
0223	7432000000-E	2" RISER WITH TUBING	3	EA	810.00	2,430.00	1,120.00	3,360.00	810.00	2,430.00
0224	7444000000-E	INDUCTIVE LOOP SAWCUT	2,520	LF	7.95	20,034.00	9.00	22,680.00	7.95	20,034.00
0225	7456000000-E	LEAD-IN CABLE(********) (14-2)	10,550	LF	1.75	18,462.50	2.25	23,737.50	1.75	18,462.50
0226	7481000000-N	SITE SURVEY	2	EA	100.00	200.00	1,900.00	3,800.00	100.00	200.00
0227	7481240000-N	CAMERA W/O INT LOOP EMUL PROCESS	4	EA	2,175.00	8,700.00	6,300.00	25,200.00	2,175.00	8,700.00
0228	7481260000-N	EXT LOOP EMULATOR PROCESS UNIT	1	EA	4,500.00	4,500.00	11,500.00	11,500.00	4,500.00	4,500.00
0229	7516000000-E	COMMUNICATIONS CABLE (** FIBER) (24)	3,636	LF	3.15	11,453.40	4.00	14,544.00	3.15	11,453.40
0230	7528000000-E	DROP CABLE	570	LF	3.85	2,194.50	5.00	2,850.00	3.85	2,194.50
0231	7540000000-N	SPLICE ENCLOSURE	3	EA	1,500.00	4,500.00	2,100.00	6,300.00	1,500.00	4,500.00
0232	7552000000-N	INTERCONNECT CENTER	3	EA	2,100.00	6,300.00	2,700.00	8,100.00	2,100.00	6,300.00
0233	7566000000-N	DELINEATOR MARKER	6	EA	200.00	1,200.00	200.00	1,200.00	200.00	1,200.00
0234	7588000000-N	SGNL MAST ARM WITH METAL POLE	6	EA	22,750.00	136,500.00	32,000.00	192,000.00	22,750.00	136,500.00
0235	7613000000-N	SOIL TEST	6	EA	975.00	5,850.00	2,400.00	14,400.00	975.00	5,850.00
0236	7614100000-E	DRILLED PIER FOUND	36	CY	1,300.00	46,800.00	1,400.00	50,400.00	1,300.00	46,800.00
0237	7631000000-N	MAST ARM W/ MTL POLE DES	6	EA	100.00	600.00	400.00	2,400.00	100.00	600.00
0238	7636000000-N	SIGN FOR SIGNALS	17	EA	270.00	4,590.00	380.00	6,460.00	270.00	4,590.00
0239	7642100000-N	TYPE I POST W/ FOUNDATION	2	EA	1,500.00	3,000.00	3,200.00	6,400.00	1,500.00	3,000.00
0240	7642200000-N	TYPE II PED W/ FOUNDATION	26	EA	2,500.00	65,000.00	3,400.00	88,400.00	2,500.00	65,000.00
0241	7684000000-N	SIGNAL CABINET FOUNDATION	12	EA	1,500.00	18,000.00	1,100.00	13,200.00	1,500.00	18,000.00
0242	7744000000-N	DETECTOR CARD (TYPE 170)	14	EA	170.00	2,380.00	250.00	3,500.00	170.00	2,380.00
0243	7756000000-N	CONTLR WITH CBNT, 2070L BASE MTD	6	EA	18,900.00	113,400.00	29,000.00	174,000.00	18,900.00	113,400.00
0244	7901000000-N	CABINET BASE EXTENDER	6	EA	575.00	3,450.00	770.00	4,620.00	575.00	3,450.00
0245	7980000000-N	GENERIC SIGNAL ITEM (EA) ETHERNET EDGE SWITCH	3	EA	2,105.00	6,315.00	5,400.00	16,200.00	2,105.00	6,315.00
		CULVERT ITEMS								
0247	8065000000-N	ASBESTOS ASSESSMENT	Lump Sum			2,000.00		2,250.00		1,200.00
0248	8126000000-N	CULV EXCAV @ ********** (313+23.00 -L-)	Lump Sum			44,215.00		13,900.00		56,000.00
0249	8133000000-E	FND CONDIT MAT, BOX CULV	297	TON	63.00	18,711.00	54.00	16,038.00	65.00	19,305.00
0250	8196000000-E	CLASS A CONCRETE (CULV)	483.8	CY	715.00	345,917.00	1,100.00	532,180.00	1,100.00	532,180.00
0251	8245000000-E	REINF STEEL (CULVERT)	50,086	LB	2.50	125,215.00	2.15	107,684.90	2.54	127,218.44
0253	8021000000-N	REMV EXIST STR ********** (472+00.00 -L-)	Lump Sum			218,000.00		146,000.00		125,000.00
		WALL ITEMS								

46377.3.2 Oct 18, 2022 C204745

TIP NO R-5705B 4.536 MILES
FED AID NO STATE FUNDED
GRADING, DRAINAGE, PAVING, SIGNALS, AND CULVERTS.
NC-55 FROM NC-210 TO SR-4809 (JICARILA LANE).

		HIGHLAND PAVING CO LLC FAYETTEVILLE, NC		CONTI CIVIL LLC EDISON, NJ		ZACHRY CONSTRUCTION CORPORATION SAN ANTONIO, TX	
CULVERT ITEMS	SUB-TOTAL	754,058.00	SUB-TOTAL	818,052.90	SUB-TOTAL	860,903.44	
WALL ITEMS	SUB-TOTAL	125,560.00	SUB-TOTAL	70,080.00	SUB-TOTAL	127,750.00	

BIDDERS IN ORDER		**CONTRACT TOTAL**
HIGHLAND PAVING CO LLC	1	61,497,777.30
CONTI CIVIL LLC	2	62,462,442.00
ZACHRY CONSTRUCTION CORPORATION	3	65,517,430.69

Project #4

Nov 01, 2022 11:22 AM RUTHERFORD 2:00 PM 1 / 1 008

2023CPT.13.06.10811 Oct 18, 2022 C204776

TIP NO 10.990 MILES

FED AID NO STATE FUNDED

MILLING AND RESURFACING.

1 SECTION OF US-74.

					BLYTHE CONSTRUCTION INC CHARLOTTE, NC		APAC ATLANTIC INC DBA HARRISON CONSTRUCTION COMPANY ASHEVILLE, NC		ROGERS GROUP INC NASHVILLE, TN	
		ROADWAY ITEMS								
0001	0000100000-N	MOBILIZATION	Lump Sum			265,000.00		220,000.00		235,000.00
0002	1245000000-E	SHOULDER RECONSTRUCTION	3	SMI	8,950.00	26,850.00	7,000.00	21,000.00	8,750.00	26,250.00
0003	1260000000-E	AGGREGATE SHOULDER BORROW	384	TON	55.00	21,120.00	28.00	10,752.00	32.80	12,595.20
0004	1297000000-E	MILL ASP PVMT *****" DTH (1-1/2")	262,399	SY	3.10	813,436.90	2.80	734,717.20	2.10	551,037.90
0005	1330000000-E	INCIDENTAL MILLING	2,724	SY	15.15	41,268.60	11.25	30,645.00	9.70	26,422.80
0006	1523000000-E	ASP CONC SURF CRS S9.5C	22,609	TON	71.00	1,605,239.00	70.40	1,591,673.60	83.80	1,894,634.20
0007	1575000000-E	ASP FOR PLANT MIX	1,408	TON	820.00	1,154,560.00	950.00	1,337,600.00	875.00	1,232,000.00
0008	1704000000-E	PATCHING EXIST PAVEMENT	1,085	TON	120.00	130,200.00	129.00	139,965.00	260.00	282,100.00
0009	1840000000-E	MILLED RUMBLE STRIPS	117,688	LF	0.20	23,537.60	0.30	35,306.40	0.45	52,959.60
0010	4400000000-E	WORK ZONE SIGNS (STAT)	590	SF	7.25	4,277.50	7.80	4,602.00	8.30	4,897.00
0011	4600000000-N	GENERIC TRAFFIC CONTROL ITEM (EA) CONNECTED LANE CLOSURE DEVICE	4	EA	2,300.00	9,200.00	2,300.00	9,200.00	2,650.00	10,600.00
0012	4600000000-N	GENERIC TRAFFIC CONTROL ITEM (EA) RAMP/LOOP CLOSURES	11	EA	1,100.00	12,100.00	1,100.00	12,100.00	1,260.00	13,860.00
0013	4600000000-N	GENERIC TRAFFIC CONTROL ITEM (EA) SINGLE LANE CLOSURE	49	EA	1,750.00	85,750.00	1,750.00	85,750.00	2,005.00	98,245.00
0014	4600000000-N	GENERIC TRAFFIC CONTROL ITEM (EA) WORK ZONE DIGITAL SPEED LIMIT SIGNS	4	EA	3,300.00	13,200.00	3,300.00	13,200.00	3,800.00	15,200.00
0015	4688000000-E	THERMO PVT MKG LINES,6"90 MILS	164,240	LF	0.74	121,537.60	0.74	121,537.60	0.85	139,604.00
0016	4695000000-E	THERMO PVT MKG LINES 8"90 MILS	10,839	LF	1.55	16,800.45	1.55	16,800.45	1.75	18,968.25
0017	4700000000-E	12"WIDE THERMO 90 MILS	5,679	LF	7.00	39,753.00	7.00	39,753.00	7.90	44,864.10
0018	4704000000-E	THERMO LINES 16" 90MILS	1,386	LF	9.00	12,474.00	9.00	12,474.00	10.15	14,067.90
0019	4709000000-E	24"WIDE THERMO 90 MILS	180	LF	15.00	2,700.00	15.00	2,700.00	16.95	3,051.00
0020	4720000000-E	THERMO PVT MKG CHARACTER 90	4	EA	175.00	700.00	175.00	700.00	197.25	789.00
0021	4725000000-E	THERMO PVT SYMBOL 90MILS	25	EA	250.00	6,250.00	250.00	6,250.00	281.80	7,045.00
0022	4810000000-E	PAINT PVMT MARKINGS 4"	175,079	LF	0.18	31,514.22	0.18	31,514.22	0.20	35,015.80
0023	4825000000-E	PAINT PVMT MARKINGS 12"	5,267	LF	1.50	7,900.50	1.50	7,900.50	1.70	8,953.90
0024	4835000000-E	PAINT PVT MKG LINES 24"	180	LF	3.50	630.00	3.50	630.00	3.95	711.00
0025	4840000000-N	PAINT PVT MKG CHARACTER	4	EA	75.00	300.00	75.00	300.00	84.55	338.20
0026	4845000000-N	PAINT PVT MKG SYMBOL	25	EA	100.00	2,500.00	100.00	2,500.00	112.75	2,818.75
0027	4850000000-E	LINE REMOVAL 4" WIDE	190	LF	3.00	570.00	3.00	570.00	3.40	646.00
0028	4905100000-N	NON-CAST IRON SNOWPLB PVMT MRKER	1,107	EA	45.75	50,645.25	45.75	50,645.25	53.10	58,781.70
		CONTRACT TOTAL			TOTAL	4,500,014.62	TOTAL	4,540,786.22	TOTAL	4,791,456.30
		ROADWAY ITEMS			SUB-TOTAL	4,500,014.62	SUB-TOTAL	4,540,786.22	SUB-TOTAL	4,791,456.30

BIDDERS IN ORDER		CONTRACT TOTAL
BLYTHE CONSTRUCTION INC	1	4,500,014.62
APAC ATLANTIC INC DBA HARRISON CONSTRUCTION COMPANY	2	4,540,786.22
ROGERS GROUP INC	3	4,791,456.30

Project #5

TIP NO B-4786 0.237 MILES
FED AID NO 0013069
GRADING, DRAINAGE, PAVING, AND STRUCTURE.
BRIDGE #38 OVER THE TAR RIVER ON US-13 IN GREENVILLE.

							W C ENGLISH INCORPORATED LYNCHBURG, VA		CONTI CIVIL LLC EDISON, NJ		SANFORD CONTRACTORS INC LEMON SPRINGS, NC	
			ROADWAY ITEMS									
0001	0000100000-N	800	MOBILIZATION	Lump Sum			555,000.00		725,000.00			732,600.00
0002	0000400000-N	801	CONSTRUCTION SURVEYING	Lump Sum			95,000.00		180,000.00			50,000.00
0003	0028000000-N	SP	TYPE I STANDARD APPR ********* (28+03.00 -L-)	Lump Sum			55,000.00		30,000.00			100,000.00
0004	0036000000-E	225	UNDERCUT EXCAVATION	600	CY	54.00	32,400.00	32.00	19,200.00	12.00		7,200.00
0005	0043000000-N	226	GRADING	Lump Sum			560,000.00		165,000.00			300,000.00
0006	0050000000-E	226	SUPP CLEARING & GRUBBING	1	ACR	10,200.00	10,200.00	5,000.00	5,000.00	100.00		100.00
0007	0195000000-E	265	SELECT GRANULAR MATERIAL	600	CY	95.00	57,000.00	45.00	27,000.00	20.00		12,000.00
0008	0196000000-E	270	GEOTEXTILE SOIL STABILIZATION	1,100	SY	5.50	6,050.00	1.00	1,100.00	4.60		5,060.00
0009	0223000000-E	275	ROCK PLATING	1,150	SY	130.00	149,500.00	66.00	75,900.00	95.00		109,250.00
0010	0318000000-E	300	FND CONDIT MATL MINOR STRS	154	TON	57.00	8,778.00	46.50	7,161.00	45.00		6,930.00
0011	0320000000-E	300	FND CONDIT GEOTEXTILE	820	SY	5.00	4,100.00	1.00	820.00	5.00		4,100.00
0012	0335200000-E	305	15" DRAINAGE PIPE	48	LF	125.00	6,000.00	130.00	6,240.00	35.00		1,680.00
0013	0448200000-E	310	15" RCP CULV CLASS IV	522	LF	102.00	53,244.00	106.00	55,332.00	75.00		39,150.00
0014	0582000000-E	310	15" CS PIPE CULV 0.064"	84	LF	106.00	8,904.00	200.00	16,800.00	65.00		5,460.00
0015	0636000000-E	310	**" CS ELBOW *****" THICK (15", 0.064")	4	EA	659.00	2,636.00	340.00	1,360.00	600.00		2,400.00
0016	0995000000-E	340	PIPE REMOVAL	63	LF	27.50	1,732.50	88.00	5,544.00	15.00		945.00
0017	1220000000-E	545	INCIDENTAL STONE BASE	500	TON	48.50	24,250.00	30.00	15,000.00	38.00		19,000.00
0018	1297000000-E	607	MILL ASP PVMT *****" DTH (1-1/2")	3,030	SY	16.00	48,480.00	7.70	23,331.00	3.95		11,968.50
0019	1330000000-E	607	INCIDENTAL MILLING	540	SY	22.50	12,150.00	23.00	12,420.00	9.95		5,373.00
0020	1491000000-E	610	ASP CONC BASE CRS B25.0C	585	TON	118.00	69,030.00	127.00	74,295.00	103.00		60,255.00
0021	1503000000-E	610	ASP CONC INTR CRS I19.0C	465	TON	118.00	54,870.00	127.00	59,055.00	103.00		47,895.00
0022	1523000000-E	610	ASP CONC SURF CRS S9.5C	810	TON	120.00	97,200.00	128.00	103,680.00	104.00		84,240.00
0023	1575000000-E	620	ASP FOR PLANT MIX	100	TON	834.00	83,400.00	895.00	89,500.00	725.00		72,500.00
0024	1693000000-E	654	ASPH PLT MIX PVMT REPAIR	40	TON	223.00	8,920.00	250.00	10,000.00	600.00		24,000.00
0025	2022000000-E	815	SUBDRAIN EXCAVATION	112	CY	26.00	2,912.00	65.00	7,280.00	20.00		2,240.00
0026	2026000000-E	815	GEOTEXTILE FOR SUBSURF DRNS	500	SY	8.00	4,000.00	2.25	1,125.00	6.00		3,000.00
0027	2036000000-E	815	SUBDRAIN COARSE AGGREGATE	84	CY	93.00	7,812.00	30.00	2,520.00	90.00		7,560.00
0028	2044000000-E	815	6" PERF SUBDRN PIPE	500	LF	20.00	10,000.00	3.50	1,750.00	8.00		4,000.00
0029	2070000000-N	815	SUBDRN PIPE OUTLET	1	EA	700.00	700.00	400.00	400.00	600.00		600.00
0030	2077000000-E	815	6" OUTLET PIPE	6	LF	56.00	336.00	40.00	240.00	25.00		150.00
0031	2190000000-N	828	TEMP STL PLT COVER FOR MDS	1	EA	1,680.00	1,680.00	1,100.00	1,100.00	3,000.00		3,000.00
0032	2286000000-N	840	MASNRY DRAINAGE STRUCT	9	EA	3,654.00	32,886.00	3,000.00	27,000.00	2,000.00		18,000.00
0033	2364200000-N	840	FRAME W/2GRTS 840.20 STD	2	EA	1,085.00	2,170.00	1,250.00	2,500.00	450.00		900.00
0034	2365000000-N	840	FRAME W/2GRTS 840.22 STD	1	EA	1,085.00	1,085.00	1,250.00	1,250.00	450.00		450.00
0035	2366000000-N	840	FRAME W/2GRTS 840.24 STD	1	EA	1,085.00	1,085.00	1,250.00	1,250.00	450.00		450.00
0036	2367000000-N	840	FRAME W/2GRTS 840.29 STD	5	EA	965.00	4,825.00	1,250.00	6,250.00	450.00		2,250.00
0037	2549000000-E	846	2'-6" CONC CURB & GUTTER	20	LF	113.00	2,260.00	75.00	1,500.00	20.00		400.00
0038	2556000000-E	846	SHOULDER BERM GUTTER	480	LF	73.00	35,040.00	50.00	24,000.00	20.00		9,600.00
0039	3030000000-E	862	STL BEAM GUARDRAIL	887.5	LF	30.50	27,068.75	32.00	28,400.00	26.50		23,518.75
0040	3150000000-N	862	ADDIT GUARDRAIL POSTS	10	EA	13.00	130.00	70.00	700.00	11.00		110.00

TIP NO B-4786 0.237 MILES
FED AID NO 0013069
GRADING, DRAINAGE, PAVING, AND STRUCTURE.
BRIDGE #38 OVER THE TAR RIVER ON US-13 IN GREENVILLE.

						W C ENGLISH INCORPORATED LYNCHBURG, VA		CONTI CIVIL LLC EDISON, NJ		SANFORD CONTRACTORS INC LEMON SPRINGS, NC	
0041	3287000000-N	SP	GR END TYPE TL-3	5	EA	4,025.00	20,125.00	4,300.00	21,500.00	3,500.00	17,500.00
0042	3317000000-N	SP	GR ANCHOR TYPE B-77	4	EA	3,105.00	12,420.00	4,150.00	16,600.00	2,600.00	10,400.00
0043	3360000000-E	863	REMOVE EXISTING GUARDRAIL	1,350	LF	1.15	1,552.50	3.00	4,050.00	1.00	1,350.00
0044	3389150000-N	SP	TEMP GDRL END UNITS ***** (TL-3)	2	EA	2,875.00	5,750.00	3,400.00	6,800.00	2,500.00	5,000.00
0045	3595000000-E	869	RELAPPING GUARDRAIL	262.5	LF	4.60	1,207.50	10.00	2,625.00	4.00	1,050.00
0046	3649000000-E	876	RIP RAP, CLASS B	5	TON	285.00	1,425.00	95.00	475.00	80.00	400.00
0047	3656000000-E	876	GEOTEXTILE FOR DRAINGE	1,775	SY	5.00	8,875.00	2.50	4,437.50	4.00	7,100.00
0048	4025000000-E	901	CONTR FURN, TYPE ***SIGN (E)	65	SF	32.00	2,080.00	34.00	2,210.00	28.00	1,820.00
0049	4072000000-E	903	SUPPORT, 3-LB STL U-CHAN	15	LF	17.25	258.75	9.50	142.50	15.00	225.00
0050	4082000000-E	903	SUPPORT, WOOD	155	LF	28.75	4,456.25	32.00	4,960.00	25.00	3,875.00
0051	4102000000-N	904	SIGN ERECTION, TYPE E	8	EA	230.00	1,840.00	200.00	1,600.00	200.00	1,600.00
0052	4116100000-N	904	SIGN ERECT, RELOC ** GRD MTD (D)	8	EA	287.50	2,300.00	425.00	3,400.00	250.00	2,000.00
0053	4141000000-N	907	DISPOSE SUPPORT, WOOD	4	EA	57.50	230.00	45.00	180.00	50.00	200.00
0054	4158000000-N	907	DISPOSE SIGN SYST WOOD	6	EA	57.50	345.00	30.00	180.00	50.00	300.00
0055	4400000000-E	1110	WORK ZONE SIGNS (STAT)	192	SF	17.25	3,312.00	14.00	2,688.00	15.00	2,880.00
0056	4410000000-E	1110	WORK ZONE SIGNS (BARR)	20	SF	9.20	184.00	15.50	310.00	8.00	160.00
0057	4415000000-N	1115	FLASHING ARROW BOARD	2	EA	3,650.00	7,300.00	2,500.00	5,000.00	4,400.00	8,800.00
0058	4420000000-N	1120	PORTABLE CHANGE MSG SIGN	2	EA	13,500.00	27,000.00	8,500.00	17,000.00	17,500.00	35,000.00
0059	4430000000-N	1130	DRUMS	343	EA	81.00	27,783.00	60.00	20,580.00	46.50	15,949.50
0060	4445000000-E	1145	BARRICADES (TYPE III)	48	LF	34.50	1,656.00	34.00	1,632.00	30.00	1,440.00
0061	4480000000-N	1165	TMA	2	EA	12,500.00	25,000.00	40,000.00	80,000.00	50,000.00	100,000.00
0062	4490000000-E	1170	PORT CONC BARRIER(ANCHRD)	1,747	LF	68.00	118,796.00	66.00	115,302.00	59.00	103,073.00
0063	4685000000-E	1205	THERMO PVT MKG LINES 4"90	6,020	LF	2.88	17,337.60	2.75	16,555.00	2.50	15,050.00
0064	4709000000-E	1205	24"WIDE THERMO 90 MILS	60	LF	17.25	1,035.00	16.50	990.00	15.00	900.00
0065	4725000000-E	1205	THERMO PVT SYMBOL 90MILS	12	EA	189.75	2,277.00	175.00	2,100.00	165.00	1,980.00
0066	4810000000-E	1205	PAINT PVMT MARKINGS 4"	5,775	LF	1.75	10,106.25	1.65	9,528.75	1.50	8,662.50
0067	4890000000-E	SP	GENERIC PAVEMENT MARKING ITEM (LF) POLYUREA PAVEMENT MARKING LINES (4", 20 MILS) (STANDARD GLASS BEADS)	2,580	LF	5.75	14,835.00	5.50	14,190.00	5.00	12,900.00
0068	4905100000-N	SP	NON-CAST IRON SNOWPLB PVMT MRKER	105	EA	115.00	12,075.00	123.00	12,915.00	100.00	10,500.00
0069	5325800000-E	1510	8" WATER LINE	793	LF	114.00	90,402.00	150.00	118,950.00	175.00	138,775.00
0070	5326200000-E	1510	12" WATER LINE	838	LF	160.00	134,080.00	170.00	142,460.00	215.00	180,170.00
0071	5329000000-E	1510	DI H2O PIPE FITTINGS	4,300	LB	10.50	45,150.00	14.50	62,350.00	15.00	64,500.00
0072	5546000000-E	1515	8" VALVE	2	EA	4,600.00	9,200.00	3,000.00	6,000.00	2,450.00	4,900.00
0073	5558000000-E	1515	12" VALVE	2	EA	6,800.00	13,600.00	4,000.00	8,000.00	4,200.00	8,400.00

TIP NO B-4786 0.237 MILES
FED AID NO 0013069
GRADING, DRAINAGE, PAVING, AND STRUCTURE.
BRIDGE #38 OVER THE TAR RIVER ON US-13 IN GREENVILLE.

						W C ENGLISH INCORPORATED LYNCHBURG, VA		CONTI CIVIL LLC EDISON, NJ		SANFORD CONTRACTORS INC LEMON SPRINGS, NC	
0078	6000000000-E	1605	TEMPORARY SILT FENCE	1,445	LF	4.00	5,780.00	3.85	5,563.25	4.25	6,141.25
0079	6006000000-E	1610	EROS CONTRL STONE CL A	125	TON	70.00	8,750.00	65.00	8,125.00	65.00	8,125.00
0080	6009000000-E	1610	EROS CONTRL STONE CL B	5	TON	310.00	1,550.00	95.00	475.00	60.00	300.00
0081	6012000000-E	1610	SEDIMENT CONTROL STONE	640	TON	55.00	35,200.00	35.00	22,400.00	50.00	32,000.00
0082	6015000000-E	1615	TEMPORARY MULCHING	1.5	ACR	1,725.00	2,587.50	1,650.00	2,475.00	1,400.00	2,100.00
0083	6018000000-E	1620	SEED FOR TEMP SEEDING	100	LB	8.00	800.00	7.70	770.00	4.00	400.00
0084	6021000000-E	1620	FERT FOR TEMP SEEDING	0.5	TON	2,300.00	1,150.00	2,200.00	1,100.00	1,600.00	800.00
0085	6024000000-E	1622	TEMPORARY SLOPE DRAINS	200	LF	19.00	3,800.00	31.00	6,200.00	20.70	4,140.00
0086	6029000000-E	SP	SAFETY FENCE	1,320	LF	3.45	4,554.00	3.30	4,356.00	3.25	4,290.00
0087	6030000000-E	1630	SILT EXCAVATION	70	CY	0.01	0.70	43.00	3,010.00	15.00	1,050.00
0088	6036000000-E	1631	MATTING FOR EROS CONTROL	1,260	SY	2.30	2,898.00	2.20	2,772.00	4.00	5,040.00
0089	6037000000-E	SP	COIR FIBER MAT	1,200	SY	9.00	10,800.00	8.80	10,560.00	8.31	9,972.00
0090	6042000000-E	1632	1/4" HARDWARE CLOTH	250	LF	7.00	1,750.00	6.50	1,625.00	4.50	1,125.00
0091	6048000000-E	SP	FLOAT TURBIDITY CURTAIN	755	SY	44.00	33,220.00	30.00	22,650.00	16.00	12,080.00
0092	6070000000-N	1639	SPECIAL STILLING BASINS	28	EA	1,110.00	31,080.00	420.00	11,760.00	400.00	11,200.00
0093	6071012000-E	SP	COIR FIBER WATTLE	300	LF	15.00	4,500.00	14.00	4,200.00	22.00	6,600.00
0094	6071020000-E	SP	POLYACRYLAMIDE (PAM)	15	LB	115.00	1,725.00	110.00	1,650.00	20.00	300.00
0095	6084000000-E	1660	SEEDING AND MULCHING	3	ACR	4,025.00	12,075.00	3,800.00	11,400.00	3,000.00	9,000.00
0096	6087000000-E	1660	MOWING	3	ACR	345.00	1,035.00	330.00	990.00	100.00	300.00
0097	6090000000-E	1661	SEED FOR REPAIR SEEDING	50	LB	17.25	862.50	16.00	800.00	8.00	400.00
0098	6093000000-E	1661	FERT FOR REPAIR SEEDING	0.25	TON	2,300.00	575.00	2,200.00	550.00	1,600.00	400.00
0099	6096000000-E	1662	SEED FOR SUPP SEEDING	50	LB	34.50	1,725.00	33.00	1,650.00	6.00	300.00
0100	6108000000-E	1665	FERTILIZER TOPDRESSING	1	TON	2,300.00	2,300.00	2,200.00	2,200.00	1,400.00	1,400.00
0101	6114500000-N	1667	SPECIALIZED HAND MOWING	10	MHR	74.75	747.50	72.00	720.00	75.00	750.00
0102	6114800000-N	SP	MANUAL LITTER REMOVAL	2	MHR	220.00	440.00	65.00	130.00	75.00	150.00
0103	6114900000-E	SP	LITTER DISPOSAL	1	TON	492.00	492.00	550.00	550.00	450.00	450.00
0104	6117000000-N	SP	RESPONSE FOR EROS CONTROL	13	EA	690.00	8,970.00	660.00	8,580.00	1,500.00	19,500.00
0105	6117500000-N	SP	CONC WASHOUT STRUCTURE	2	EA	2,400.00	4,800.00	400.00	800.00	642.00	1,284.00
0106	6123000000-E	1670	REFORESTATION	0.1	ACR	11,500.00	1,150.00	11,000.00	1,100.00	5,000.00	500.00
0134	4465000000-N	1160	TEMPORARY CRASH CUSHIONS	1	EA	12,500.00	12,500.00	12,000.00	12,000.00	10,850.00	10,850.00
			STRUCTURE ITEMS								
0107	8017000000-N	SP	CM&R TEMP ACCESS ********** (28+03.00-L-)	Lump Sum			1,179,000.00		1,696,580.24		2,750,000.00
0108	8021000000-N	SP	REMV EXIST STR ********** (28+03.00-L-)	Lump Sum			757,000.00		2,250,000.00		1,950,000.00
0109	8065000000-N	SP	ASBESTOS ASSESSMENT	Lump Sum			2,875.00		1,350.00		2,500.00
0110	8105500000-E	411	**'-**" DRILLD PIER IN SOIL	1,966.25	LF	707.00	1,390,138.75	900.00	1,769,625.00	573.85	1,128,332.56

TIP NO B-4786 0.237 MILES
FED AID NO 0013069
GRADING, DRAINAGE, PAVING, AND STRUCTURE.
BRIDGE #38 OVER THE TAR RIVER ON US-13 IN GREENVILLE.

						W C ENGLISH INCORPORATED LYNCHBURG, VA		CONTI CIVIL LLC EDISON, NJ		SANFORD CONTRACTORS INC LEMON SPRINGS, NC	
0115	8115000000-N	411	CSL TESTING	7	EA	2,335.00	16,345.00	1,250.00	8,750.00	2,000.00	14,000.00
0116	8121000000-N	412	UNCL STR EXCAV STA ***** (28+03.00-L-)	Lump Sum			7,000.00		40,000.00		10,000.00
0117	8147000000-E	420	REINF CONCRETE DECK SLAB	22,585	SF	48.20	1,088,597.00	50.00	1,129,250.00	65.00	1,468,025.00
0118	8161000000-E	420	GROOVING BRIDGE FLOORS	20,835	SF	0.70	14,584.50	0.90	18,751.50	1.79	37,294.65
0119	8182000000-E	420	CLASS A CONCRETE (BRIDGE)	482.1	CY	1,310.00	631,551.00	1,450.00	699,045.00	1,450.00	699,045.00
0120	8210000000-N	422	BRG APPR SLAB ********** (28+03.00-L-)	Lump Sum			70,000.00		70,000.00		109,170.80
0121	8217000000-E	425	REINF STEEL (BRIDGE)	220,030	LB	1.57	345,447.10	1.90	418,057.00	1.71	376,251.30
0122	8238000000-E	425	SPIRAL COL REINF STL BRG	67,749	LB	2.11	142,950.39	2.55	172,759.95	3.62	245,251.38
0123	8262000000-E	430	45" PRESTR CONCRETE GIRDR	2,700.83	LF	317.00	856,163.11	340.00	918,282.20	381.31	1,029,853.49
0124	8328200000-E	450	PILE DRV EQUIP SETUP ** STEEL PILES (HP 12 X 53)	19	EA	750.00	14,250.00	1,500.00	28,500.00	3,556.94	67,581.86
0125	8364000000-E	450	HP12X53 PILES	1,425	LF	85.00	121,125.00	82.00	116,850.00	44.16	62,928.00
0126	8393000000-N	450	PILE REDRIVES	10	EA	500.00	5,000.00	1,800.00	18,000.00	0.01	0.10
0127	8503000000-E	460	CONCRETE BARRIER RAIL	1,136.77	LF	135.00	153,463.95	143.00	162,558.11	161.69	183,804.34
0128	8608000000-E	876	RIP RAP II (2'-0")	330	TON	72.00	23,760.00	53.00	17,490.00	85.39	28,178.70
0129	8622000000-E	876	GEOTEXTILE FOR DRAINAGE	370	SY	4.00	1,480.00	1.00	370.00	3.75	1,387.50
0130	8657000000-N	430	ELASTOMERIC BEARINGS	Lump Sum			100,000.00		110,000.00		26,041.13
0131	8706000000-N	SP	EXPANSION JOINT SEALS	Lump Sum			77,000.00		80,000.00		144,068.02
0132	8727000000-N	SP	ELEC CONDUIT SYS SIGNAL ****** (28+03.00-L-)	Lump Sum			132,000.00		130,000.00		189,976.72
0133	8897000000-N	SP	GENERIC STRUCTURE ITEM (EA) THERMAL INTEGRITY PROFILER TESTING	7	EA	1,725.00	12,075.00	3,500.00	24,500.00	10,944.00	76,608.00
			CONTRACT TOTAL			TOTAL	11,095,482.80	TOTAL	14,528,442.00	TOTAL	14,652,000.00
			ROADWAY ITEMS			SUB-TOTAL	3,684,982.30	SUB-TOTAL	4,017,713.00	SUB-TOTAL	3,734,984.50
			STRUCTURE ITEMS			SUB-TOTAL	7,410,500.50	SUB-TOTAL	10,510,729.00	SUB-TOTAL	10,917,015.50

BIDDERS IN ORDER		**CONTRACT TOTAL**
W C ENGLISH INCORPORATED	1	11,095,482.80
CONTI CIVIL LLC	2	14,528,442.00
SANFORD CONTRACTORS INC	3	14,652,000.00

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