Understanding Alternative Quality Assurance Program in Innovative Project Delivery Environment

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by

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Understanding Alternative Quality Assurance Program in Innovative Project Delivery Environment

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LIST OF ABBREVIATIONS

DB	Design-build
P3	Public–private partnership
QAP	Quality assurance program
CQAF	Construction quality acceptance firm
IQF	Independent quality firm
DOT	Department of Transportation
CEI	Construction engineering and inspection
QA	Quality assurance
FHWA	Federal Highway Administration
RFP	Requests for proposals
RFQ	Requests for qualifications
DBIA	Design–Build Institute of America
GDOT	Georgia Department of Transportation
DBB	Design–bid–build
DBF	Design–build–finance
DBFOM	Design–build–finance–operate–maintain
QC	Quality control
RII	Relative importance index
DBE	Disadvantaged business enterprise

SUMMARY

High quality transportation infrastructure carries great value to society and economy in the United States. To attain better quality of the infrastructure, innovative project delivery methods have been applied by many projects, such as design–build (DB) and public–private partnership (P3), thereby requiring a new model for ensuring overall quality management. The innovative quality management model has been adopted by a lot of states to serve as an essential element of a quality assurance program (QAP), where a construction quality acceptance firm (CQAF), also named as an independent quality firm (IQF) is required. Despite the increasing acceptance of the new model, many states' Department of Transportation (DOT) agencies, which are responsible for maintenance and development, still utilize a traditional project delivery method. A deeper and more comprehensive understanding is desired about how these innovative approaches of conducting quality assurance (QA) have developed in the construction engineering and inspection (CEI) industry. The objective of this research is to identify discrepancies in understanding the new model between CEI understanding and DOT expectations and offer guidance to promote the QA process in the innovative project delivery environment.

To accomplish such goals, this research started with a comprehensive literature analysis of current studies in traditional and new project delivery methods, quality management and quality assurance. The literature resources included reports from the Federal Highway Administration (FHWA), DOT documents including requests for proposals (RFPs) and requests for qualifications (RFQs), and a few other records from professional organizations such as the Design–Build Institute of America (DBIA).

Following the in-depth literature analysis, the research method continued with the distribution of survey among professional associations. The survey results were analyzed to identify large levels of discrepancies and similarity in respondents' understanding. A further step was conducting in-depth interviews with a subsample of survey respondents. Their perspectives on the questions raised from survey results and advice on how to ensure effective QA were gathered during each 1-hour long virtual interview. The narratives from interviews offer fruitful information on how to minimize the gaps between CEI industry understanding and DOT's expectations. A final step was to hold a virtual focus group workshop among Georgia Department of Transportation (GDOT) professionals and their owner's representatives, where the research topic was presented, and results of survey and interviews were dynamically discussed. The findings of this study offer a more thorough understanding of the innovative project delivery method and contribute to using the new QAP and ensuring effective quality delivery.

CHAPTER 1: INTRODUCTION

As the responsibilities fall on state DOTs across the nation to meet the increasing demand for maintenance and development of projects, still, there are many DOTs that keep using traditional project delivery approaches (ASCE 2013, USDOT 2013). A series of internal issues such as communications, funding, and complexity of tasks make the traditional design–bid–build (DBB) systems not very appropriate in some cases (An et al. 2018, Kingsley et al. 2017, Mallett and Luther 2011). These problems result in consequences like cost overruns or schedule delays for project delivery. The FHWA, in response, has allowed and encouraged the use of innovative project delivery methods for more effective and efficient infrastructure development (Ashuri and Kashani 2012, FHWA 2019). Many state DOTs are accepting new methods, such as the use of CQAF by GDOT which plays a vital role as an integrated part of project QA. The new quality management model is also known as the independent quality firm. The DB project delivery provides considerable benefits in comparison with the traditional DBB approach, where reduced costs, shortened schedules, and enhanced quality are involved (Allen et al. 2002, Gransberg et al. 2003, Liang et al. 2019). Besides, there is less administrative burden and decreased transaction expenses related to high-standard infrastructure maintenance and development within the DB environment. Similar to this innovative and increasingly popular system, there are other public-private partnership (P3) systems such as design–build–finance (DBF) and design–build–finance–operate–maintain (DBFOM) (Mostaan and Ashuri 2016). In these systems, contracts tend to be longer-term and favorable for both private and public sectors, and therefore, shorter schedules and reduced budgets can be easier to attain (Brown et al. 2009).

While these new approaches offer considerable benefits, they also introduce a series of uncertainties and challenges. Within the DB system, a higher level of flexibility is allowed, where the design-builder is allowed to simultaneously proceed through different stages of project development. However, such flexibility can lead to the unclarity of project's final budget and design and create ambiguity over quality control (QC) tasks, making the QA process more challenging (Beard et al. 2001). Additional challenges arise when roles and responsibilities shift to the design-builder from the project owner in the DB environment. The design-builders take on additional tasks for the project design, while becoming responsible for quality acceptance and QC (Lee et al. 2020). In the transition of roles and responsibilities, CQAF, as an independent party, is increasingly involved in the quality acceptance tasks, as the project owners lose some control in the QA process (Lee and Arditi 2006). In some cases, inadequate and ineffective communication also leads to misunderstanding in the status of CQAF and their new expectations of tasks in the QA process. To prevent the effective QA from being undermined by the new project delivery approaches, the ambiguity from the shift in roles and responsibilities needs further attention and studies. An in-depth exploration and analysis of QA practices are needed for consistent high-standard infrastructure maintenance and development in the DB environment. Another challenge is the use of Disadvantaged Business Enterprise (DBE) program in DB projects. Existing literature has specified some key DBE challenges for DB and some alternative project delivery. Challenges include the hardship with limited information when establishing contract objectives and confusion from the new process of alternative project delivery for proposers (Amekudzi-Kennedy et al 2016).

Lastly, different state DOTs have non-identical QA standards, leading to extra ambiguity over expectations of tasks for personnel engaging in DB projects across many states. The heterogeneous QA standards from different DOTs allow a higher level of flexibility in accordance with their specific project requirements in QA processes (Gransberg and Molenaar 2004). The flexibility can cause inconsistent understanding of QA roles and responsibilities and varying requirements for key personnel and design-builders when expectations of tasks are not clearly conveyed by state DOTs. It is therefore critical to comprehend these typical challenges in the DB environment such that the high-quality infrastructure development will not be weakened by the innovative project delivery approaches. The innovative delivery methods come with many benefits, yet the corresponding challenges demand deeper understanding, to ensure new roles and responsibilities are well informed and DOT expectations of tasks are properly communicated.

CHAPTER 2: RESEARCH METHODOLOGY

Following is a detailed review of existing literature in which the current state of quality management practices in new project delivery systems is discussed. Changes from the traditional to the innovative project delivery approaches and typical challenges within the innovative approaches are identified. In this chapter, further steps of this research are introduced.

With the knowledge from existing literature, a survey was created and distributed on the Qualtrics platform. Professionals and experts were contacted for follow-up. A focus group was later established consisting of DOT personnel and their owner's representatives for a workshop. The overarching goal was to obtain useful comments and identified differences between the understanding of the traditional and the innovative quality management program. The mixed use of the survey quantitative analysis and the qualitative analysis from the interview and workshop narratives in a single study adds up richness and confidence of this research. These three methods, survey, interviews and workshop were sequentially used, where interviews and a focus group workshop were performed after survey to compliment quantitative survey results. These three research methods were approved by institutional review board IRB. [1]

A survey associated with the CEI industry was created to examine quality management practices in the traditional and the DB environment. The survey was

[1] IRB Approval Protocol: H19562

distributed online to a wide range of professional engineering associations to gather high-quality responses, and the associations participating in the survey were as follows.

- American Council of Engineering Companies of Georgia.
- American Council of Engineering Companies of Georgia Partnership for Transportation Quality (GPTQ) Task Force.
- American Society of Civil Engineering Claims Avoidance and Resolution Committee.
- American Society of Civil Engineering Construction Institute Board of Governors.
- American Society of Highway Engineers.
- DBIA Transportation and Aviation Markets Committee.
- DBIA P3 Committee.
- Transportation Research Board Committee on Quality Assurance Management (AFH20).
- Transportation Research Board Joint Subcommittee on Quality Management for Alternative Project Delivery (AFH20 (1)).

From the professional associations above, experts and professionals from different professions in 25 states around the nation participated in the survey, which built up the robustness and validity of this research. A set of 106 responses were received in total. Participants' backgrounds included agency employee (DOT staff), CEI specialist, design consultant, general contractor, and owner's representative. Figure 1 below shows profession composition of survey participants. The metric relative importance index (RII) was used to analyze survey data included a gap analysis of CEI understanding and DOT

expectations for QA tasks, roles, and responsibilities. Questions used for this quantitative analysis are "*How frequently is the CEI firm responsible for the following tasks in federal-aid design-build projects?*" and "*How frequently is the CEI firm responsible for ensuring the following aspects of the contract in federal-aid design-build projects?*" These two questions were designed to offer a 5-point Likert scale answer, including "*Always", "Often", "Sometimes", "Rarely",* and *"Never*".

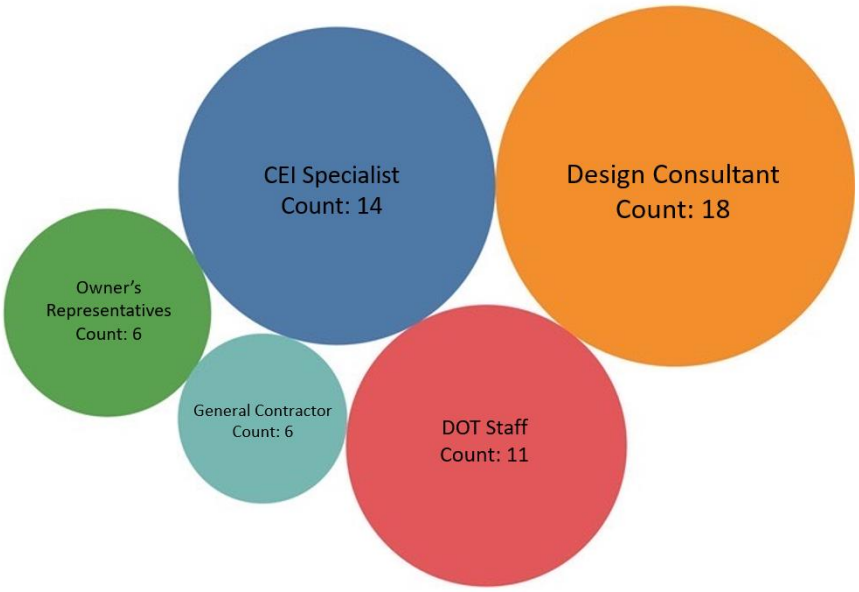

Figure 1. Professions of survey respondents

First, a simple statistical summary and RII were first completed to investigate patterns and trends in survey responses and to identify CEI tasks with great consistency or variance, representing agreement and discrepancies among SMEs regarding their understanding of CEI firms' common tasks. The analysis also looked for variance originated from contracting structures where the CEI firm is employed by different entities. This quantitative analysis with a couple of metrics aimed at identifying agreement or

discrepancies between how experts and professionals view CEI firms' common tasks and DOT's expectations from them in the DB environment.

Second, after the quantitative survey analysis, in-depth interviews were conducted with an embedded qualitative analysis of experienced CEI perspectives. Such a research step built off of the survey analysis by researching its key topics more in depth. Survey respondents who expressed their willingness to participate in further research steps were contacted and scheduled for follow-up interviews. The profession composition of interview participants was nearly consistent with the survey. Critical topics in the survey and analysis of survey results were presented and their understanding of these questions was revealed. The semi-structured interviews were virtually conducted based on the interview protocol with a list of prepared topics and questions to be covered in a specific order. All interviews lasted approximately for an hour and were recorded and transcribed to collect useful information. Narratives from experienced interviewees offered the chance to explore key survey topics in detail and solve questions raised from survey results. This qualitative analysis with data coded from interviews, increased the depth of understanding about QA topics.

Third, a professional from GDOT was contacted and helped to distribute the request to other GDOT professionals and experts and their owner's representatives and a focus group was established. The focus group workshop was virtually conducted, where research content and survey results were presented and an interactive and open conversation among 9 GDOT personnel and owner's representatives from GDOT. The goal of this workshop was to obtain more informative narratives regarding results of survey and collect constructive advice on how to ensure effective QA in the DB environment.

CHAPTER 3: RESULTS

The survey responses were first analyzed and visualized using Tableau and Excel to examine CEI practices and determine gaps between CEI understanding and DOT expectations in the DB environment. Among the 106 responses received, 53 responses were complete and useful relatively for further statistical analysis. The results revealed more than 90% of survey participants mentioned their previous experience and familiarity with DB project delivery methods and about a third of them have been on their current roles for over 10 years. All participants had experience in quality management services for federal-aid DB projects and around 50% of them have been engaged in projects of more than one state across the country. Figure 2 below shows prior experience of survey respondents, and about half specified their experience in both traditional quality management model (hired by DOTs) and the CQAF model (hired by design–builder). Figure 3 shows respondents' preferences when performing quality management services, whether they prefer working for design-builder or for state DOT. Around half of survey respondents specified their preference of working with state DOTs to working for the design–builder, when performing quality management services. Their preference of working with state DOTs is much higher than working for the design–builder, suggesting that survey participants had better contracting experiences with state DOTs. Survey participants' prior professional experience, diverse backgrounds, and familiarity with the research topic ensure the robustness of survey responses.

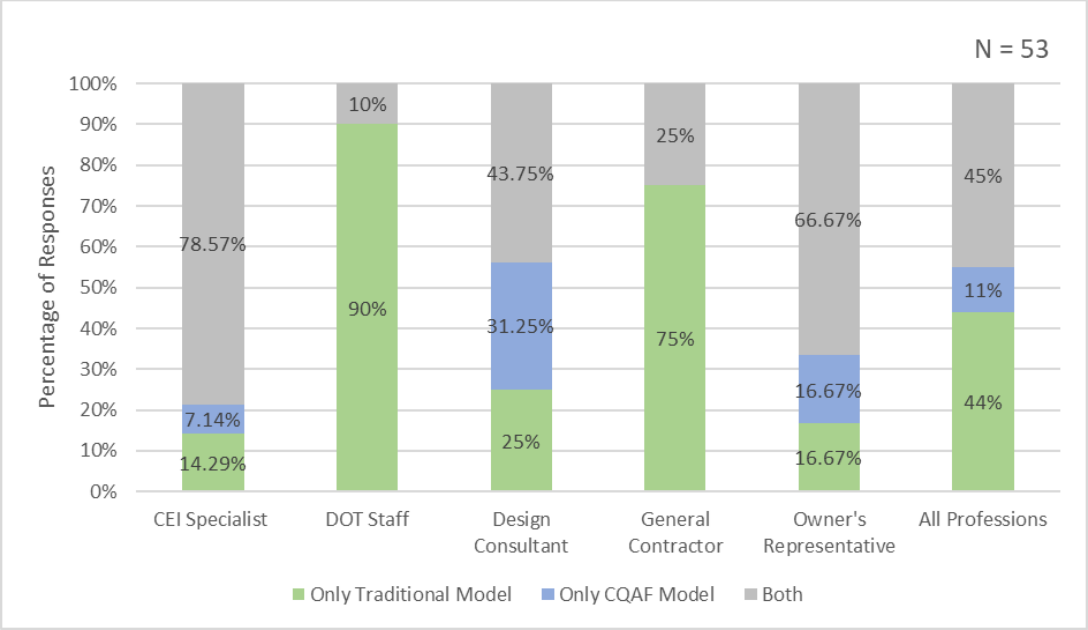

Figure 2. Prior experience of respondents.

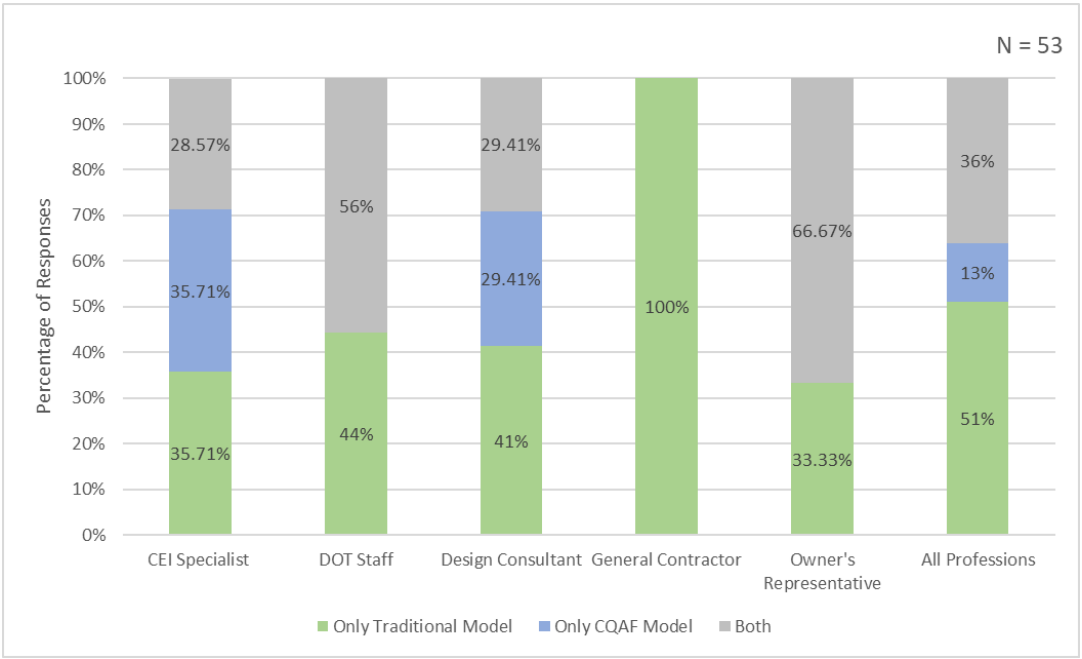

Figure 3. Preferences of respondents regarding quality management models.

Responses to question 15 in the survey were first analyzed, "*How frequently is the CEI firm responsible for the following tasks in federal-aid design-build projects?*" and the provided eight tasks of CEI firms include:

- Notifying the DOT of key times in the quality management schedules;
- Issuing noncompliance reports (NCRs) to address deficiencies in the materials;
- Exercising the approved engineering judgment to accept deficiencies in the material test results;
- Auditing quality management procedures and records;
- Ensuring compliance of project payroll;
- Ensuring compliance of report submission;
- Ensuring contract compliance;
- Conducting construction measurements to certify payments to the design–builder.

This question was analyzed to investigate consistency and variance from 53 sets of survey responses. Survey choices were formatted in a 5-point Likert rating scale, and choices ranging from "*Always"* to *"Often", "Sometimes", "Rarely",* and *"Never*", where survey respondents' choices indicated the frequency of CEI's tasks. Among the 8 tasks above, inconsistent responses were observed from 4 of them, indicating that survey respondents had inconsistent beliefs over CEI firms' roles and responsibilities. Figure 4 below demonstrates such discrepancies in the understanding among respondents of CEI's typical tasks, "*auditing quality management procedures and records", "ensuring project payroll compliance", "ensuring contract compliance",* and *"conducting construction measurements to certify payments to the design–builder*". Variant opinions on CEI firms' roles and responsibilities from the industry revealed a gap in understanding

between different contracting structures when hired by DB or DOT. Interviewees, including designers and DOT staff, explained the understanding discrepancy discovered in survey results, that confusion in the contract can be a source of the different understanding of CEI's roles. In some cases, the contract does not explicitly specify requirements for CEI firms as well as the expected efforts from CEI firms. In addition, misunderstanding may be created when the scope of work is translated to individual contractor.

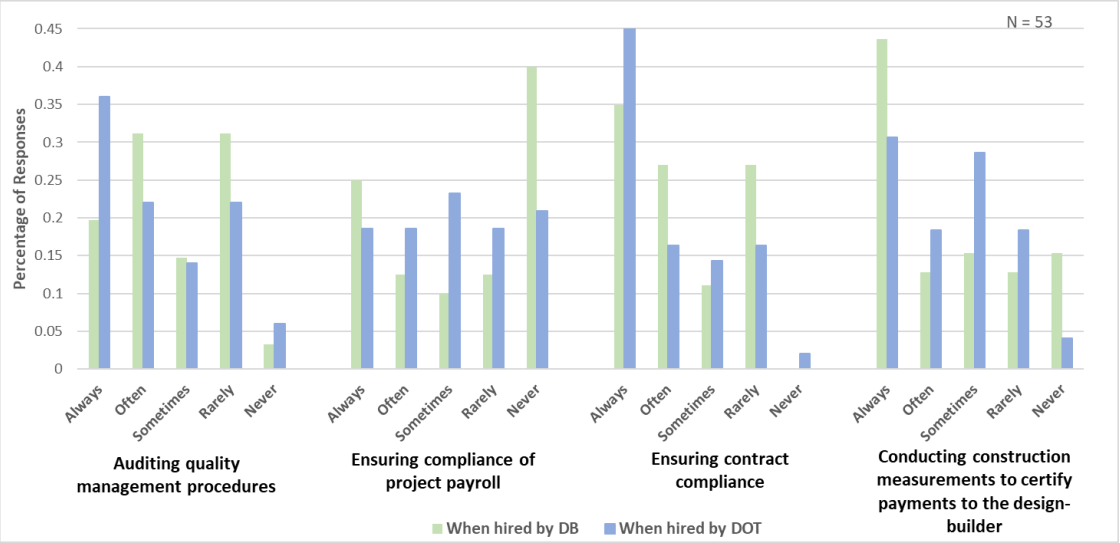

Figure 4. Understanding discrepancy regarding CEI firms' tasks.

Interview participants also believed CEI firms are responsible for the tasks, "*Auditing quality management procedures and records, ensuring project payroll compliance, and ensuring contract compliance*". Nevertheless, contractors and CEI professionals expressed their disagreement of another task, "*Exercising approved engineering judgment to accept deficiencies in the material test results*". They were unsure about this task because, in some cases, owner's representatives engage in exercising engineering judgment to tackle incidents that occurred in the construction phase. This may not be included in the contract, yet owner's representatives take on the

task as they are accustomed to it in the traditional project delivery. A CEI specialist further explained that, in Florida, where the task of QC testing falls on the contractor for both DB and traditional projects. CEI firms, on the other hand, oversee the testing procedures and document certification of materials, responsible for fewer testing and certification tasks.

Per requirement in the contract, public owners have the responsibility to achieve the objective of disadvantaged business enterprise (DBE) (Amekudzi-Kennedy et al. 2016). In another survey question asking, "*How frequently is the CEI firm responsible for ensuring the following aspects of the contract in federal-aid design-build projects?*", whether survey respondents believe CEI firms are responsible for ensuring DBE requirements and the Davis-Bacon Act, were observed. This question was also organized with 5-point Likert scale response options, where respondents were able to rate the frequency of CEI firm's roles in the contract. Inconsistent views were observed in the task of "*ensuring the design-builder's compliance to the contract requirement for paying the local prevailing wages on public works projects for laborers and mechanics".* Figure 5 presents such discrepant responses from the survey regarding CEI firms' responsibilities in the contract under different contracting structures (when hired by DB or DOT). To further identify variance in responses from different profession groups, CEI specialists' answers were separated and visualized in figure 6. The results indicate that CEI specialists understood their responsibilities in the contract differently dependent on whom they are hired by the design–builder or DOT. When comparing figure 5 and figure 6, it can be concluded that CEI personnel also interpreted their roles differently compared to all professions as a whole. A larger portion of CEI specialists believed CEI firms are

frequently responsible for these two aspects in the contract. Similar comments were obtained from the followed-up interviews, where interviewees with CEI background agreed with their roles in the two aspects.

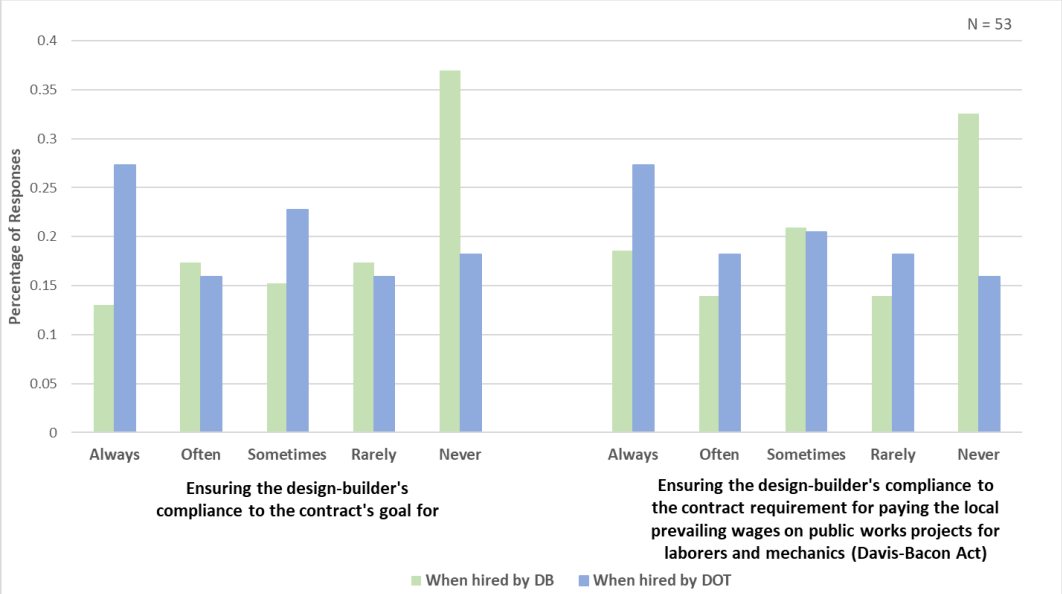

Figure 5. Understanding the inconsistency regarding CEI firms' responsibilities.

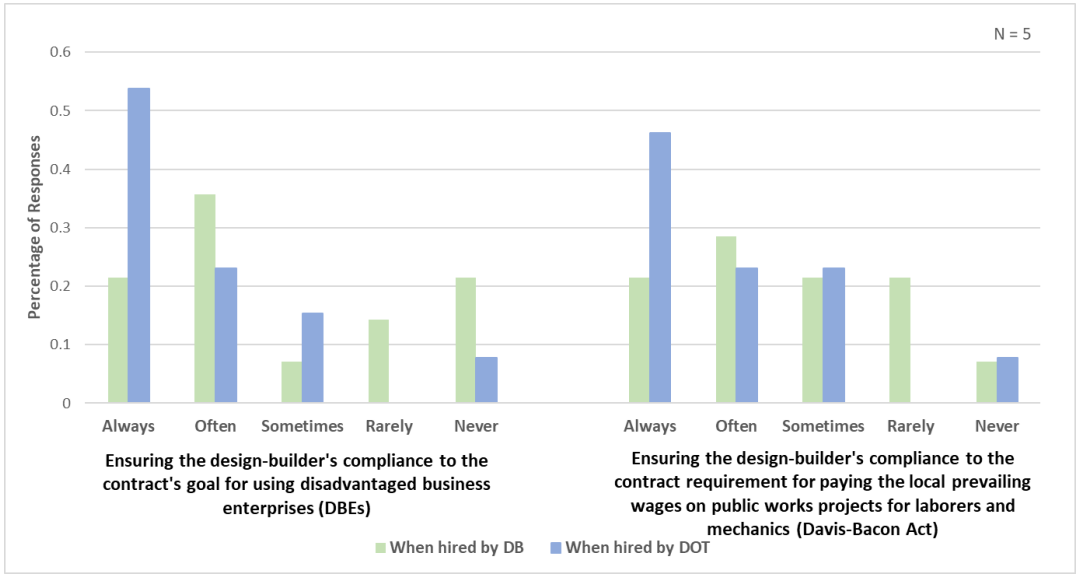

Figure 6. CEI professionals' different views on CEI firm's responsibilities when hired by DB versus DOT.

Next, the metric of RII was used to identify the most significant CEI tasks under different contracting structures, where relative importance of every task of CEI firms were calculated and ranked. Equation 1 presents calculation of RII particularly structured for responses of this survey:

$$RII = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \quad (1)$$

where, n_1, n_2, n_3, n_4, and n_5 stand for responses selected by survey respondents "*Never," "Rarely," "Sometimes," "Often,"* and *"Always*," respectively, and *N* represents the number of survey participants. A CEI task is considered more significant when it is paired with a higher RII value. RII values of 8 CEI tasks were computed and ranked from the lowest to highest. As shown in figure 7, the top three significant CEI tasks "*issuing noncompliance reports (NCRs) to address deficiencies in the materials*," "*ensuring contract compliance*," and "*ensuring compliance of report submission*," are the similar despite the actor that hires CEI firms, while the remaining five tasks were slightly differently ranked. These three tasks were considered most common and important tasks that CEI firms are responsible for, and were ranked 52% higher than one of the task "*ensuring compliance of project payroll".*

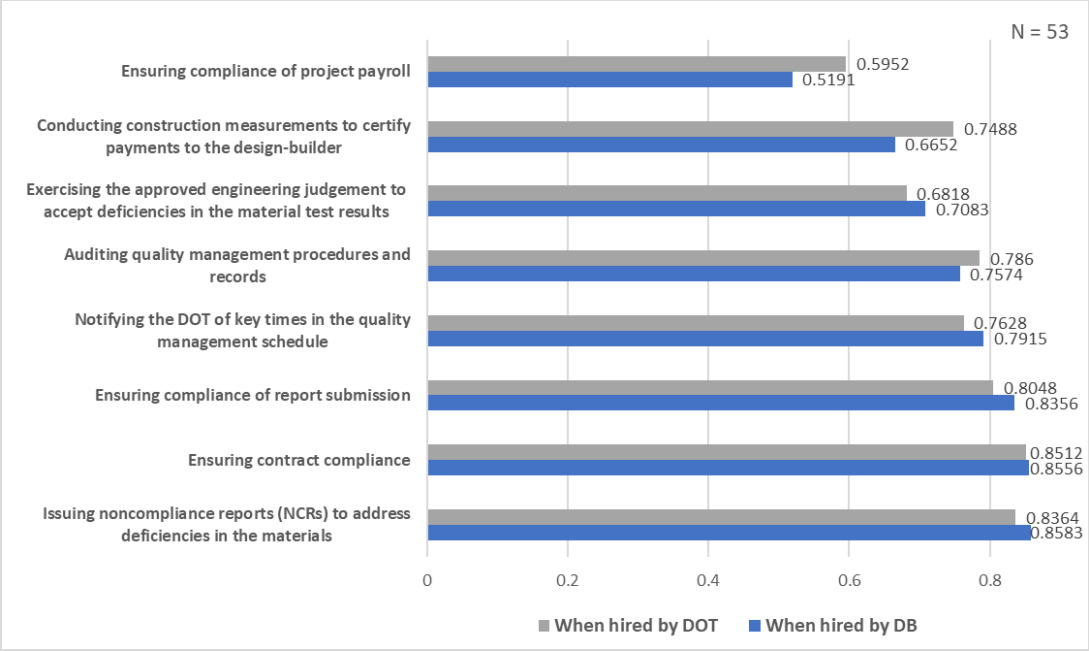

Figure 7. Ranking of relative significance of CEI tasks.

CHAPTER 4: DISCUSSION

As inconsistent perspectives were identified regarding CEI firms' common tasks and the understanding gap was observed between the traditional model and the CQAF model, semi-structured interviews and a virtual focus group workshop were conducted to obtain their recommendations. The virtual interviews and focus group workshop also allowed further exploration of research topics. A great portion of interview and workshop participants has over 10 years of professional experience and mentioned their familiarity with both traditional and DB project delivery methods. Useful insights were obtained on how the understanding gap of CEI's roles and responsibilities can be minimized.

Workshop participants, consisting of DOT personnel and their owner's representatives were on the same mind of CEI firms' common tasks from the survey. On top of the 8 CEI tasks and included in the survey, interviewees added a few other important tasks. For instance, CEI professionals specified their tasks of taking care of balances and checks, while owner's representatives described CEI's roles of having awareness of deficiencies. Some DOT personnel mentioned the need for risk-based inspection for DB projects, which is to dedicate time to critical items. The significance of CEI's tasks in inspection has been discussed in plenty of existing literature. CEI's tasks can include supervising material testing, arranging inspection activities, and conducting quality assurance testing (Li et al. 2019). The task of inspection for CEI firms was also confirmed by state transportation agencies (STAs), particularly for large and complicated projects (Al-Haddad 2020, Torres et al. 2015).

Interviewees provided a set of advice regarding the inconsistent belief of CEI's roles and responsibilities. To ensure CEI firms' solid understanding of their expected roles and responsibilities, design consultants, general contractors and owner's representatives recommended having explicit expectations for each aspect of work and specifying minimum requirements. Owner representatives during interviews suggested performing an oversight process to enhance mutual understanding between CEI firms and DOT. Additionally, CEI professionals offered some advice to have a proactive mind, be more engaged and communicative.

Recommendations on how DOTs can assist in reducing understanding discrepancies of CEI tasks were discussed during interviews and a focus group workshop. For example, DOT personnel suggested during the workshop having clear requirements and responsibilities since federal requirements in the contract, similar to other provisions, are supposed to be more explicit. During interviews, DOT staff recommended having detailed RFP and RFQ, quality management plans, daily reports, and especially requirements and responsibility of roles. From the standpoint of owner's representatives, they suggested having an independent quality firm like the application of CQAF.

CHAPTER 5: CONCLUSION

In the innovative project delivery environment, the CQAF model acts as an essential element for the owner for high-quality project development in the United States, and the CEI firms have responsibilities to help project owners achieve high-quality projects. Given that a lot of state DOTs are transitioning to new methods of project delivery, from the traditional system, it is significant for CEI firms to obtain a solid comprehension of these innovative quality management methods and new expectations and requirements for them in quality assurance. This research included quantitative analysis with survey results combined with qualitative analysis with narratives from interviews and workshop. The aim was to first identify understanding discrepancies between CEI understanding and DOT's expectations, and then offer constructive advice on how to lessen this understanding gap. From the survey results, discrepancies regarding CEI's roles and responsibilities were observed among views from professionals and experts who participated in the survey. Explanations and recommendations were later offered in the interviews and focus group workshop, on how to reduce the understanding gaps between the CEI industry and state DOTs. More awareness is needed regarding this understanding gap to maintain high-quality public project development. Advice from both interview and the workshop discussed in the previous section was beneficial for a better understanding of CEI's roles and responsibilities in innovative project delivery. This research offered a valuable lesson on enhancing QAP in innovative environment. Further values of this research can be foreseen, that the CQAF model can be reinforced as the misunderstanding regarding

CQAF's function between the CEI industry and DOT's expectations can be largely avoided for the current and future DB projects.

APPENDIX

Q15. How frequently is the CEI firm responsible for the following tasks in federal-aid design-build projects?

Notifying the DOT of key times in the quality management schedule (1)

Issuing noncompliance reports (NCRs) to address deficiencies in the materials (2)

Exercising the approved engineering judgement to accept deficiencies in the material test results (3)

Auditing quality management procedures and records (4)

Ensuring compliance of project payroll (5)

Ensuring compliance of report submission (6)

Ensuring contract compliance (7)

Conducting construction measurements to certify payments to the design-builder (8)

	When the CEI firm is directly hired by the design-builder					When the CEI firm is directly hired by the state DOT				
	Never	Rarely	Sometimes	Often	Always	Never	Rarely	Sometimes	Often	Always
(1)										

(2)										
(3)										
(4)										
(5)										
(6)										
(7)										
(8)										

Q16 How frequently is the CEI firm responsible for ensuring the following aspects of the contract in federal-aid design-build projects?

Ensuring the design-builder's compliance to the contract's goal for using disadvantaged business enterprises (DBEs) (1)

Ensuring the design-builder's compliance to the contract requirement for paying the local prevailing wages on public works projects for laborers and mechanics (Davis-Bacon Act) (2)

	When the CEI firm is directly hired by the design-builder					When the CEI firm is directly hired by the state DOT				
	Never	Rarely	Sometimes	Often	Always	Never	Rarely	Sometimes	Often	Always

(1)										
(2)										

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