

Impact of Construction Document Deficiencies on Heavy/Civil Low-Bid Infrastructure
Projects and the Introduction of a Contractor Document Review Assessment

by

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ABSTRACT

The objective of the study was to examine the impact construction document deficiencies have on heavy/civil low-bid infrastructure projects. It encompasses the expertise of 202 heavy/civil construction professionals comprised of contactors and public project owners. The study was designed to determine the frequency and timing of when a contractor discovers construction document deficiencies on heavy/civil low bid projects. The information was correlated with further study data of when a contractor ultimately reports the discovered construction document deficiencies to the public project owner. This research data was compiled and analyzed to determine if contractors are withholding construction document deficiencies from public owners until after the project contract has been executed. The withholding of document deficiencies can benefit contractors by resulting in additional owner incurred costs and potential justification for project time extensions. As a result, further research was required to examine the impact construction document deficiencies have on project cost and schedule. Based on the study findings, it has led to the development of a Contractor Document Review Assessment. The Contractor Document Review Assessment is a risk mitigation device in which contractors and public project owners can identify construction document deficiencies on heavy/civil low-bid construction projects before the project contract has been executed.

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CHAPTER 1

INTRODUCTION

Heavy/civil construction is a category of construction comprising projects related to site development and infrastructure. This category includes construction projects associated with earthwork, highways, bridges, aviation, and railways, to name a few. Heavy/civil infrastructure projects are primarily owned and managed by public entities at various levels of government. To procure construction projects, public entities traditionally apply the most commonly used project delivery method: a price-based selection model known as *low bid*.

The ideology of low-bid procurement for heavy/civil construction projects was first implemented by the New York State in 1898 (Harp, 1991). The original low-bid procurement principles remain prevalent today. The primary objectives of competitive bidding are to encourage competition, eliminate favoritism, and diminish fraud while securing low-bid contracts (Cohen, 1961). In the low-bid process, the public entity develops a set of construction documents, including drawings, plans, and specifications, that detail the requirements for the proposed project (Gransberg & Ellicott, 1997), and contractors use these documents to generate project estimates.

These construction documents are assumed to be entirely accurate and complete (Harbuck, 2004). However, document deficiencies are discovered in the majority of construction projects. A construction document deficiency is any error or omission in the construction drawings, documents, or specifications. Examples include design plan inaccuracies, constructability issues, plan-quantity discrepancies, and project specification conflicts. This study examined the frequency of document deficiencies, the

timing of discovery and communication of deficiencies, and the impact of deficiencies on low-bid heavy/civil construction projects.

CHAPTER 2

PROBLEM STATEMENT AND RESEARCH HYPOTHESES

2.1 PROBLEM STATEMENT

When a price-based procurement model is applied to select contractors for heavy/civil design-bid-build projects, contractors generally do not notify the project owner of construction document deficiencies until after the contract has been executed. By waiting to report the deficiencies, it can result in additional owner-incurred project costs and contractors can justify project time extensions.

2.2 RESEARCH OBJECTIVE

The objective of the study was to examine the priced-based procurement method and assess how construction document deficiencies affect low-bid heavy/civil construction projects. A construction document deficiency is any error or omission in the construction drawings, documents, or specifications. To assess the impact of document deficiencies, data was collected from heavy/civil construction professionals from the contractor and project owner perspectives. In order to evaluate how frequently construction document deficiencies are discovered, the timing of when (before or after contract execution) contractors discover the deficiencies, when contractors report the deficiencies to the project owner representatives, and when the deficiencies are ultimately resolved.

Additionally, heavy/civil contractors were asked to identify the most financially profitable time to inform owners of document deficiencies. Project owners reported the ideal time to learn of document deficiencies in order to maximize project value. Further,

data was collected to determine which construction document deficiencies are most common in heavy/civil construction projects.

The data was analyzed in order to create a Contractor Document Review Assessment (CDRA) model for recognizing potential construction document deficiencies on heavy/civil low-bid projects. This model complements the price-based procurement method for selecting contractors because the model aligns with the foundational principles for selecting contractors for heavy/civil low-bid projects.

2.3 RESEARCH HYPOTHESIS

Heavy/civil construction documents contain a significant amount of document deficiencies that will go on to impact the project outcome. Contractors discover construction document deficiencies during all phases of the construction process (bidding, preconstruction, and construction phases). The information exchange timing varies from when contractors identify deficiencies compared to when they ultimately report those deficiencies to the project owner.

Generally, contractors do not always inform the project owner of construction document deficiencies immediately after discovering the deficiencies. In some instances, contractors will withhold document deficiencies from the project owner until after the contract is executed, resulting in additional owner-incurred costs and enabling the contractors to justify time extensions in the project schedule. Conversely, project owners do not learn of construction document deficiencies until after the low-bid contract is executed, but rather during the preconstruction or construction phase. For this reason, contractors and owners will be open to possibility of reviewing construction document deficiencies prior to the contract being executed.

CHAPTER 3

LITERATURE REVIEW

3.1 LOW-BID CONTRACT PROCUREMENT

Competitive bidding, commonly known as the low-bid approach, is a longstanding procurement method in the United States and is intended to ensure careful use of funds in public projects (Harbuck, 2004). Harp (1988) reported that low bidding has been the procurement method of choice in New York since 1847, with state legislation requiring this method starting in 1898. The low-bid approach discourages government officials and contractors from making corrupt deals that increase the cost of a project (Herbsman, 1992). Statutes requiring competitive bidding are intended to preclude collusion or fraud, prevent favoritism, and “secure the best values for the (public) at the lowest possible expense” (Cohen, 1961, p. 3). The low-bid approach offers a definitive selection process. The transparency of the lowest bidder’s submission makes the challenging of the winning bidder’s submission difficult (Gransberg & Ellicott, 1997).

Low-bid procurement is typically employed in the design-bid-build project delivery method. With this method, the owner retains two separate contracts: (a) a contract with a design firm and (b) a contract with a construction company (Lopez Del Puerto, Gransberg, & Shane, 2008). “The design firm prepares comprehensive, detailed plans and specifications that outline not only what to build but how to build it” (Gransberg & Ellicott, 1997, p. 31). During the bidding phase, the contractor uses the construction plans and specifications to generate a project bid. In theory, the bid consists of the project cost plus profit and overhead. The low-bid method forces contractors to

develop bids that incorporate cost savings via effective project management and technological innovations (Ioannou & Leu, 1993).

With low-bid procurement projects, all contractors have access to the same construction plans, documents, and specifications, which are assumed to be completely accurate (Harbuck, 2004). However, as early as the bidding phase, contractors may discover document deficiencies. When these deficiencies occur, project representatives are tasked with developing solutions. If a solution modifies the drawings and specifications, a contract change order may be needed to properly compensate the contractor (Russel, 2012).

It is common practice for all construction bids to be opened and read aloud in a public setting, with attendance open to all. Before the contract is awarded, all bids are thoroughly examined to ensure they comply with the bidding requirements and instructions. If the lowest bid complies with the requisites, the lowest bidder will be awarded the contract and the public entity will issue an award notice. A contract will then be executed between the public entity and the lowest-bid contractor.

Table 3.1 contains an example of how the low-bid procurement method works. In the example, five contractors submit bid: \$50 million, \$80 million, \$87 million, \$95 million, and \$107 million. The contract is awarded to Contractor A, which submitted the lowest bid. Contractor A's bid of \$50 million is 37.5% lower than the next lowest bidder; the immense variance could be attributed to various reasons. Contractor A may have a unique advantage in building the project, such as an innovative approach or being located close to the project location, creating in a substantial cost advantage. Further, Contractor A may have bid very low to provide work for employees and keep the business operating.

Or, the contractor may have inadvertently underbid certain aspects of the project. In this case, “a contractor cannot adhere to such a price and at the same time expect to complete the project according to plans and specifications, and also make a reasonable profit” (Ioannou & Leu, 1993, p. 131). In this case, the contractor may be hoping for costly change orders or may be forced to forfeit the bid bond.

Table 3.1

Low-Bid Example

Contractor	Bid submission
Contractor A	\$50 million*
Contractor B	\$80 million
Contractor C	\$87 million
Contractor D	\$95 million
Contractor E	\$107 million

* Winning bid.

3.2 PUBLIC RELIANCE ON LOW BIDDING

The low-bid approach is the most commonly used procurement method in the public sector (Walraven & Vries, 2009). Many public entities are attracted to this method because it eliminates external pressure to select a certain contractor, making the selection process an objective decision based on price (Herbsman, 1992). As Reed and Swain (1997) asserted, “in all cases, the goal of a purchasing system for any public organization is to obtain the most appropriate and highest quality good or service possible for the least cost” (p. 184). In public procurement, the objective is to select the lowest responsive bid (Bartle & LaCourse Korosec, 2003). Public entities rely on the competitive-price approach because of extreme pressure—arising from budgetary constraints and public

accountability—to ensure projects are of high value. The public sector can increase project value through selecting contractors with high productivity and distinctive efficiencies (Keisler & Buehring, 2005).

Public agencies must employ a bidding protocol that adheres to state and federal laws; the low-bid approach satisfies the requirements. As Harp (1991) noted the principles of competitive bidding generally require the following actions: public advertisement to bidders inviting submission of proposals; preparation of plan specifications for the work; formal submission of proposals to the contracting agency; submission of financial security by the low bidder guaranteeing his acceptance of the award; consideration of proposals under uniform criteria; and award to successful bidders. (p. 43)

However, the traditional low-bid selection approach has disadvantages. Most notably, the selection process is based on price criteria only (Herbsman & Ellis, 1992). Consequently, the approach ignores possible weaknesses related to overall project quality and longevity (Harp, 1991). Using this procurement method can lead to substantial cost increases, large project delays, and work-quality issues (Herbsman & Ellis, 1992). According to a study by the Florida Department of Transportation (2000), time overruns occur in 30.7% of low-bid contracts, compared to 7.1% of nontraditional contracts; cost overruns occur in 12.4% of low-cost contracts, compared to 3.6% of nontraditional contracts. Because of the disadvantages, the public is facing increasing pressure to substantially improve their procurement methods (Egan, 1998).

Alternatives to the low-bid approach are used in other countries. For example, public entities in Italy and Taiwan use variations of the average-bid approach. Taiwan's

transportation department calculates the average job price of all bids and then awards the contract to the contractor whose bid package price is closest to the average (Ioannou & Awwad, 2010). In Italy, the contract is awarded to the contractor with the bid that is closest to but does not exceed the average (Shrestha, 2014).

In contrast with the traditional low-bid method, the average-bid approach considers all bids together before determining a winner. Table 3.2 contains an example of this process, using the same bid amounts as in Table 3.1. The average bid is \$83.8 million. Contractor B’s bid of \$80 million is the closest to the average and is also below the average; therefore, Contractor B would receive the contract in Taiwan and Italy.

Table 3.2

Average-Bid Example

Contractor	Bid submission
Contractor A	\$50 million
Contractor B	\$80 million*
Contractor C	\$87 million
Contractor D	\$95 million
Contractor E	\$107 million
Average bid	\$83.8 million

*Winning bid.

Because award selection in the average-bid approach is based on the mean bid, an outlier bid will skew the mean and therefore might affect which contractor is selected. Consequently, some variations of this approach exclude the highest and lowest bids when a plethora of contractors have submitted bids. In Switzerland, for instance, the highest and lowest bids are excluded before the average is calculated. The contract is then awarded to the contractor with the bid closest to the average (Shrestha, 2014). This

variation is illustrated in Table 3.3. The bids of Contractor A (lowest) and Contractor E (highest) are eliminated. The bids of Contractors B, C, and D are then averaged (\$87.3 million). The winner is Contractor C, whose bid of \$87 million is closest to the average bid.

Table 3.3

Outlier-Elimination Bid Example

Contractor	Bid submission
Contractor A	\$50 million
Contractor B	\$80 million
Contractor C	\$87 million*
Contractor D	\$95 million
Contractor E	\$107 million
Adjusted average bid	\$87.3 million

Because the lowest bidder is not selected in variations of the average-bid approach, using this approach may lead to a less adversarial relationship between the project owner and the winning contractor, with fewer change orders, less litigation, and fewer contract defaults (Grogan, 1992). Despite this benefit of average-bid approaches, the traditional low-bid approach remains the most frequently used procurement method in the United States. The question then becomes: If the United States continues to use the low-bid model, how can it be improved to mitigate risk?

3.3 CONSTRUCTION DOCUMENT DEFICIENCIES

When a public owner releases the bid solicitation package, contractors use the bid package documents to generate project estimates. Though the documents are assumed to be accurate, they may have numerous design errors (Han, Love, & Pena-Mora, 2011).

Errors that are not detected before construction commences often result in serious consequences, including rework (Haydl & Nikiel, 2000). Rework “is an epidemic feature of the construction procurement process and is a primary factor that contributes to time and cost overruns in projects” (Love, Mandal, Smith, & Li, 2000, p. 567). Rework is the cause of 52% of total project cost overruns, and rework increases the project timeline by approximately 22% (Han et al., 2011). Reducing design errors minimizes the need for rework, which in turn can increase the profitability of the design firm, as well as the performance of those performing the construction work (Love et al., 2000). Despite the negative consequences of document deficiencies, contractors may not notify project owners of deficiencies during the bid phase. As Sandquist (2007) explained, bidders may utilize discrepancies in the drawings and specifications in order to generate change orders.

Rosenfeld (2014) conducted a root-cause analysis of 146 potential causes of cost overruns. One of the goals of the study was to determine which cost overrun had the greatest impact or was the most significant. The majority (87%) of study participants stated that premature tender documents were the main cause of project cost overrun. Premature tender documents include drawings, bills of quantities, specifications, contracts, and other legal documents (Rosenfeld, 2014). Participants indicated that premature tender documents are replete with ambiguous and unclear terms and that design documents feature designs that cannot be constructed (Rosenfeld, 2014). Rosenfeld concluded that to make the greatest overall improvements, the most important root causes need to be addressed first (Rosenfeld, 2014).

3.4 RISK MANAGEMENT ON HEAVY/CIVIL CONSTRUCTION PROJECTS

Project risks pose great challenges to contractors when bidding or performing the construction work. Highway project risks encompass uncertain conditions or events that would have a positive or negative effect on project objectives, such as time, cost, scope, and quality (California Department of Transportation, 2012). The larger and more complex a construction project is, the more risks associated with the project. These risks can lead to significant cost overruns, time delays, and rework. Stakeholders in highway construction projects tend to shift the risk to each other, rather than collaborating to identify and mitigate the risk a project presents (Hanna, Blasier, & Aoun, 2015). Project risk can be mitigated prior to work beginning by ensuring that project stakeholders, including contractors, owners, and engineers, engage in timely and effective communication.

In a study conducted by Diab, Varma, and Nassar (2012), the majority of respondents (80%) considered risk management to be important, very important, or extremely important in highway construction projects. However, only 36% of respondents employed risk assessments in all of their projects (Diab et al., 2012). The researchers concluded that transportation departments need to focus on learning about and implementing formal risk management techniques.

Akinci and Fischer (1998) asserted that “the first step of a systematic approach to the management of project risks is the identification of major risk sources in a project” (p. 67). After risks are identified, they are assessed to determine project impact. Then the best method to control each risk is determined (Akinci & Fischer, 1998).

Organizations use various methods to mitigate risk. Pre-project planning is the “process for developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project” (Construction Industry Institute, 2016). The cost-estimating validation process is a risk-based approach that the Washington State Department of Transportation uses to objectively evaluate cost and schedule estimates for city infrastructure projects (Reilly, Laird, Sangrey, & Gabel, 2011). With this approach, experts in engineering, estimating, environmental analysis, and other areas brainstorm to discern risks in a proposed project. Including a multidisciplinary team of professionals is vital to the success of the cost-estimating validation process in large projects (Molenaar, 2005). Although Reilly et al. (2011) did not present a cost-benefit analysis of this risk mitigation module, the researchers asserted that having a multidisciplinary group validate project cost and identify risks leads to structured “risk-sharing in contract documents to better deliver projects at or under authorized budgets” (p. 14).

CHAPTER 4

METHODOLOGY

4.1 RESEARCH METHODOLOGY

The methodology for this study was formulated based on the researcher's heavy/civil construction experiences, guidance from the dissertation committee, and input from contractors and project owner representatives. The research approach was developed to (a) determine when contractors discover construction document deficiencies and at what point in time does the contractor report those deficiencies to the project owners, (b) identify the point in time the project owners learns of the deficiencies and when a resolution to the deficiencies is achieved, and lastly (c) determine whether document deficiencies affect project cost and or project time duration. Figure 4.1 contains a high-level overview of the study.

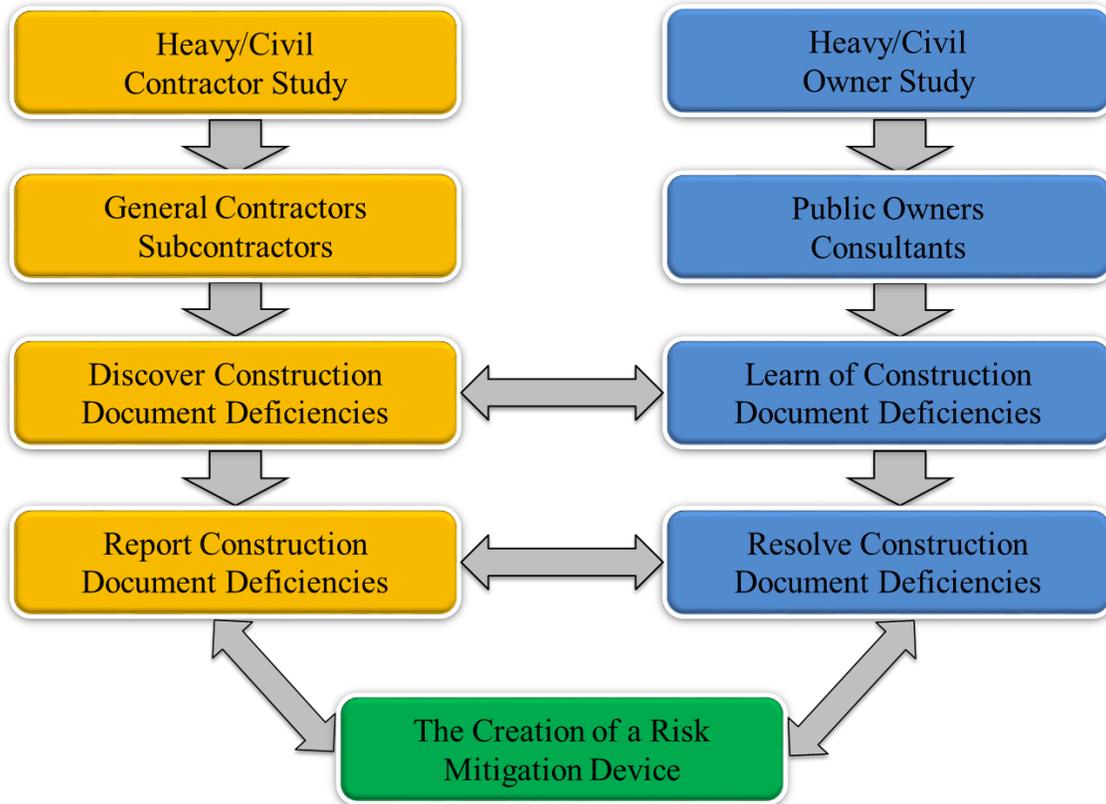


Figure 4.1. Overview of study structure.

4.2 STUDY DEVELOPMENT

This study was developed to gather data regarding how construction document deficiencies affect the heavy/civil construction sector. Data were collected from contractors and project owners through a survey. The first portion of the survey was designed to collect data regarding the respondents, including their construction experience, current positions, and the geographic regions of their heavy/civil projects.

The second portion of the survey was designed to obtain information about the respondents' experiences related to construction document deficiencies. The survey items for contractors differed from the survey items for project owners. Contractors were asked about when they identified and informed project owners about document deficiencies.

Project owners were asked about when deficiencies were resolved and how the deficiencies affected project cost and schedule.

4.3 SURVEY TRIAL

After revising the survey several times based on the input of the dissertation committee, the final draft was ready for testing. Fifteen construction professionals were selected for the survey trial. The individuals agreed to complete the survey and document their thoughts and any questions or problems that arose. Based on the trial respondents' feedback, the survey was further refined to achieve greater clarity. For instance, several respondents stated that they were uncomfortable identifying their organizations' annual construction revenue and the total employee staff size. The respondents believed that this information was confidential or that the information could be used to identify the respondents' organizations. Consequently, the questions regarding this information were removed from the survey.

4.4 STUDY SAMPLE

The target population for the study consisted of U.S. contractors and public project owners with experience in the heavy/civil construction sector. The focus on this specific construction sector necessitated cautious sampling to ensure that the respondents met the participation criteria. The researcher employed a variety of methods to recruit applicable participants. First, he conducted in-person meetings and discussions to introduce the study, including its importance, and to invite individuals to participate. Next, he implemented an online survey collection and tracking system through Qualtrics. The site contained a description of the study and a link to the survey. On the first page of the survey, it contained a detailed description of the survey participation qualifications

prior to allowing potential respondents starting the survey. It specifically noted that individuals were to only participate in the study, if they met the criteria.

4.5 SAMPLE SIZE

The sample consisted of 202 heavy/civil construction professionals. Of the total number, 147 were general contractors or subcontractors. The remaining 55 study participants were public project owner representatives or owner consultants.

4.6 LIMITATIONS

Every effort was made to ensure that only contractors and public project owners with direct experience in the heavy/civil construction sector participated in the study. The survey defined the heavy/civil construction sector and instructed individuals to participate only if they met the participation criteria. It is possible that survey respondents also had construction experiences outside of the heavy/civil construction sector and that these experiences influenced the participants' survey responses.

CHAPTER 5

RESEARCH RESULTS

5.1 STUDY DATA

Study data were collected through a survey, which was available to construction professionals through online data collection software and in hard copy format. A link to the online survey was e-mailed to over 1,500 individuals. Surveys were included in the final data set if each survey item was completed; 202 of the 246 surveys that were started met this requirement.

5.2 RESPONDENTS' BACKGROUNDS

The study sample comprised contractors and project owner with experience in the heavy/civil construction sector. This sector includes projects related to site development and infrastructure, such as earthwork, roads, highways, bridges, aviation, railway, and utilities.

5.2.1 Respondents' Roles in Heavy/Civil Construction

The purpose of the first survey question was to identify the role of the construction professional. If the respondent selected the general contractor or subcontractor role, the respondent was taken to the contractor survey. If the respondent selected the project owner role or the consultant to the project owner role, the respondent was taken to the owner survey. As detailed in Table 5.1 and Figure 5.1, of the 202 study respondents, 54.95% ($n = 111$) identified themselves as general contractors, while 17.82% ($n = 36$) identified themselves as subcontractors. The general contractors and subcontractors composed 73.23% ($n = 147$) of the study sample. Of the remaining 27.23% ($n = 55$) of respondents, 8.91% ($n = 18$) self-identified as project owners, while

18.32% ($n = 37$) self-identified as consultants to owners. The ratio of contractor-survey respondents to owner-survey respondents was approximately 3:1. This ratio may represent the ratio in the overall construction industry, as there are multiple contractors for every project owner.

Table 5.1

Respondents' Roles in Heavy/Civil Construction

Role	% of respondents
General contractor	54.95%
Consultant to the project owner	18.32%
Subcontractor	17.82%
Project owner	8.91%

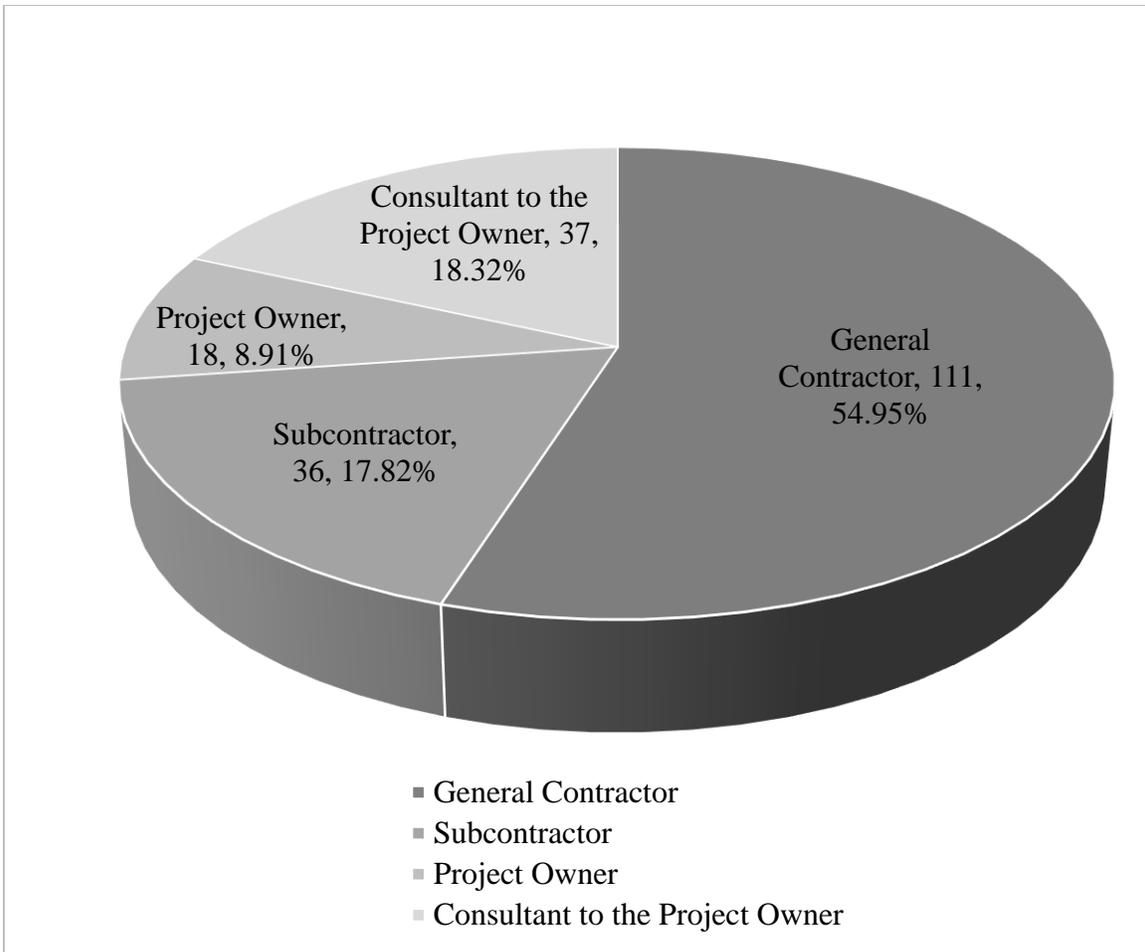


Figure 5.1. Respondents' roles in heavy/civil construction.

5.2.2 Respondents' Years of Experience in Heavy/Civil Construction

Respondents were also asked to indicate how many years they had worked in the heavy/civil construction sector: (a) fewer than 4 years, (b) 5–9 years, (c) 10–14 years, (d) 15–19 years, (e) 20–24 years, or (f) 25 years of experience or more. The results are summarized in Table 5.2 and Figure 5.2. The highest frequency category was 25 years of experience or more (31.68%, $n = 64$), followed by fewer than 4 years (19.31%, $n = 39$). Combined, these two categories represented more than 51% of the study respondents. The remaining 49% of respondents had 5–24 years of experience.

Table 5.2

Participants' Years of Experience in Heavy/Civil Construction

Years of experience	% of respondents
25 years of experience or more	31.68%
Fewer than 4 years of experience	19.31%
20–24 years of experience	16.34%
15–19 years of experience	13.36%
10–14 years of experience	10.40%
5–9 years of experience	8.91%

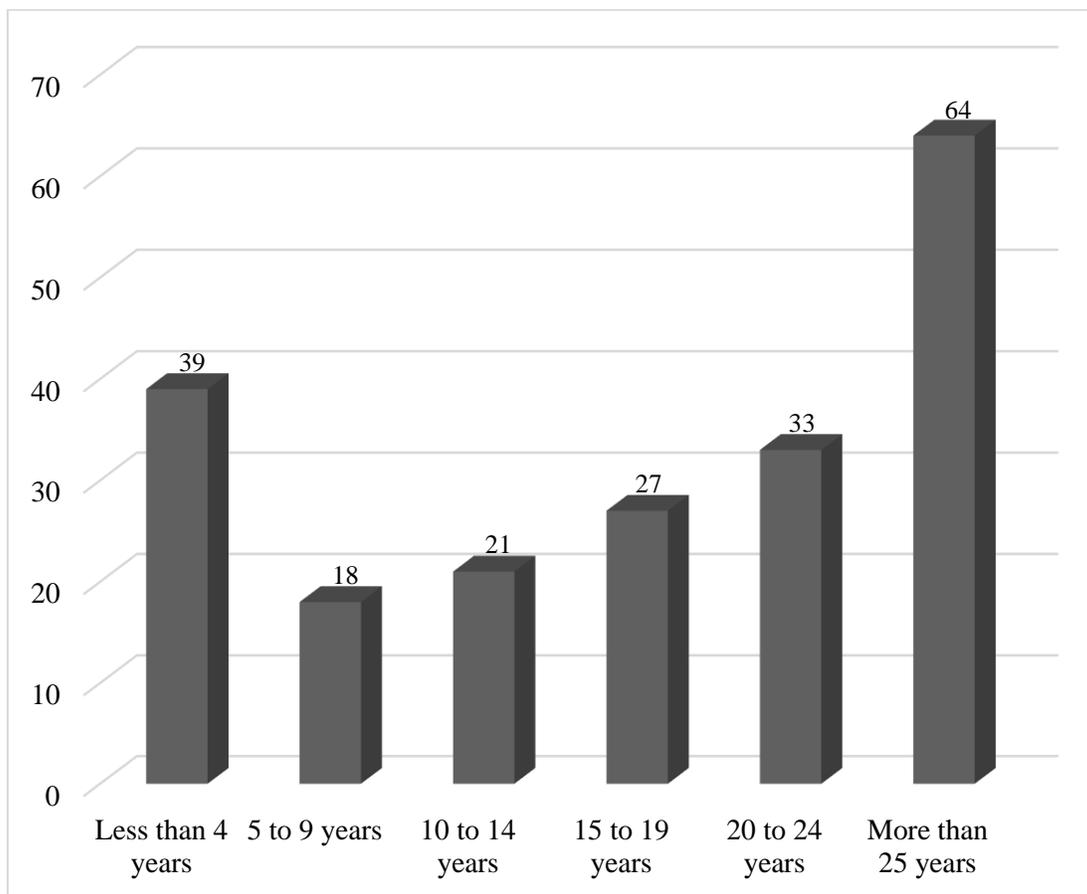


Figure 5.2. Respondents' years of experience in heavy/civil construction.

5.2.3 Respondents' Areas of Experience in the Heavy/Civil Construction Sector

Respondents were also asked to identify which of the following areas of the heavy/civil construction sector they had experience in: earthwork, mining, roads and highways, bridges, aviation, railway, marine, water, sewer, energy, communications, and other. Respondents who selected “other” had the option to specify which other sectors they had worked in. As depicted in Table 5.3 and Figure 5.3, the study sample represented a wide range of experience in the heavy/civil construction sector. At least 18 respondents had experience in a given area of the sector. The most well-represented categories were earthwork (62.38%, $n = 126$), roads and highways (57.43%, $n = 116$), water (49%, $n = 98$), and sewer (50%, $n = 101$). The least-represented categories were mining (8.91%, $n = 18$), marine (8.91%, $n = 18$), and communications (12.38%, $n = 25$).

Table 5.3

Respondents' Areas of Experience in the Heavy/Civil Construction Sector

Area	% of respondents
Earthwork	62.38%
Roads and highways	57.43%
Sewer	50.00%
Water	49.00%
Bridges	34.16%
Railway	19.31%
Aviation	18.81%
Other	16.83%
Energy	16.34%
Communications	12.38%
Mining	8.91%
Marine	8.91%

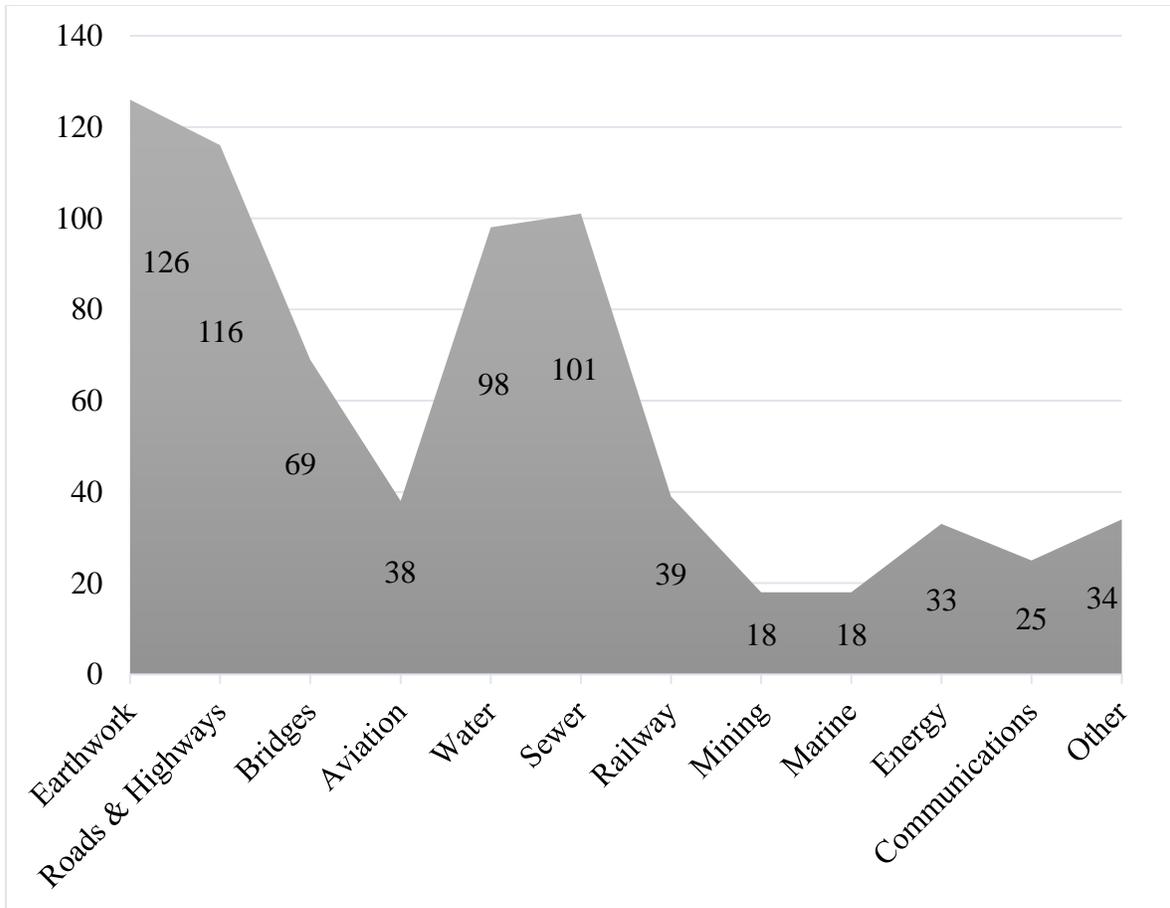


Figure 5.3. Respondents' areas of experience in heavy/civil construction.

5.2.4 Respondents' Heavy/Civil Job Positions

The survey asked about the respondents' job positions at the time of the study. Of the response options, respondents were limited to selecting the one that best reflected their current jobs. The options were project manager, site superintendent, field operations, estimator, designer/engineer, quality control, owner/developer, division manager, president/senior executive, or other. Respondents who selected "other" had the opportunity to specify a different job. The 19 respondents who chose this option reported working in positions such as project coordinator, chief estimator, director of planning and construction, and construction manager.

As shown in Table 5.4 and Figure 5.4, 26.73% ($n = 54$) of respondents indicated they were project managers, 19.31% ($n = 39$) were presidents or senior executives, 10.40% ($n = 21$) were estimators, and 8.42% ($n = 17$) were division managers. Of the remaining respondents, 4.95% ($n = 10$) were site superintendents, 5.94% ($n = 12$) had field operations roles, 5.94% ($n = 12$) were designers/engineers, 1.98% ($n = 4$) had quality control positions, 6.93% ($n = 14$) were owners/developers, and 9.41% ($n = 19$) indicated they had other positions.

Table 5.4

Respondents' Heavy/Civil Job Positions

Job	% of respondents
Project manager	26.73%
President/senior executive	19.31%
Estimator	10.40%
Other	9.41%
Division manager	8.42%
Owner/developer	6.93%
Field operations	5.94%
Designer/engineer	5.94%
Site superintendent	4.95%
Quality control	1.98%

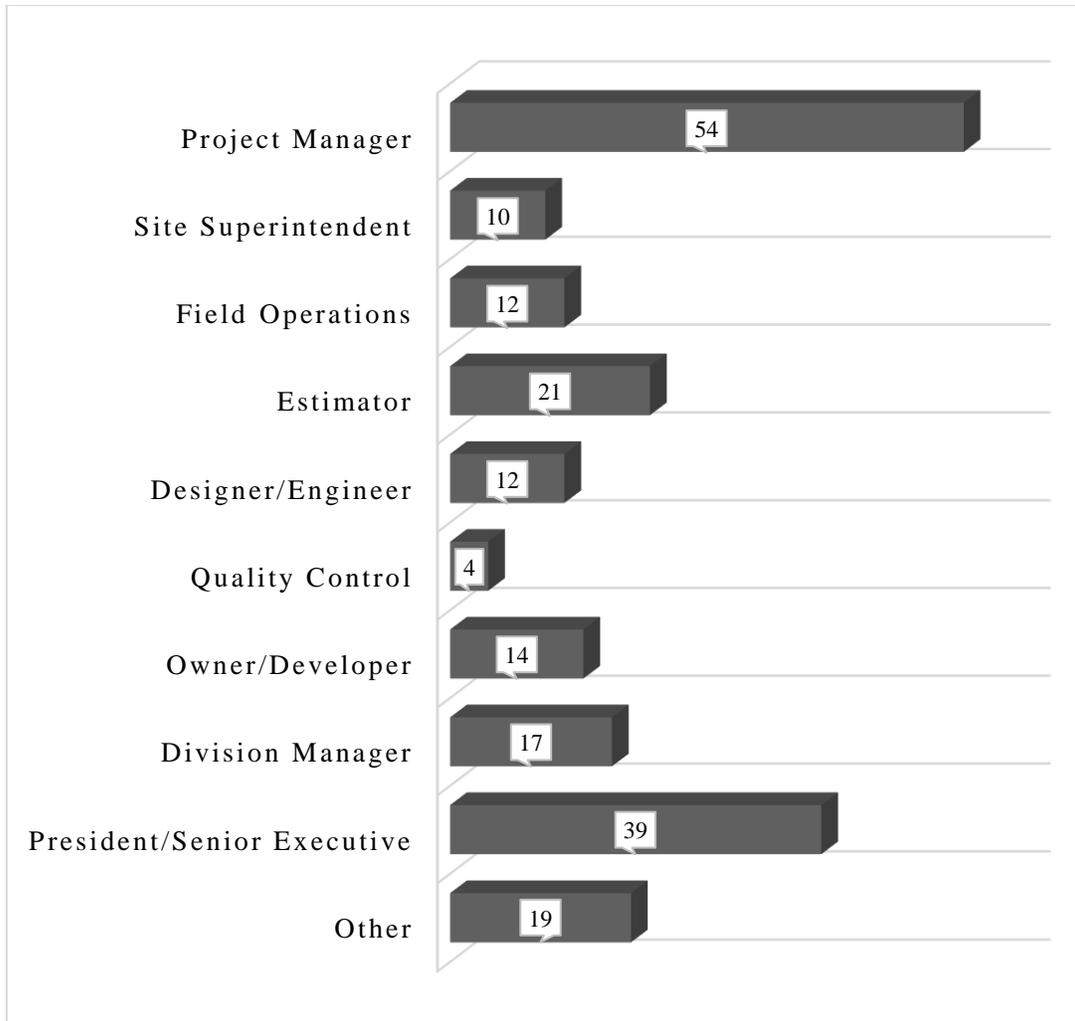


Figure 5.4. Respondents' heavy/civil job positions.

5.2.5 Geographic Regions in Which Respondents Had Heavy/Civil Construction Experience

Respondents were asked to identify which geographic regions their heavy/civil construction experience had occurred in. The respondents had the option to select multiple regions: West, Southwest, Midwest, Southeast, and Northeast. Table 5.5 and Figure 5.5 show that the largest number of respondents (26.91%, $n = 74$) had experience in the Midwest; almost as many respondents (24.73%, $n = 68$) had experience in the Southwest. Regarding the other regions, 18.55% ($n = 51$) had experience in the West,

18.18% ($n = 50$) had experience in the Southeast, and 11.64% ($n = 32$) had experience in the Northeast. The responses indicate that all geographic regions in the United States were represented.

Table 5.5

Geographic Regions in Which Respondents Had Heavy/Civil Construction Experience

Geographic region	% of Respondents
Midwest	26.91
Southwest	24.73
West	18.55
Southeast	18.18
Northeast	11.64

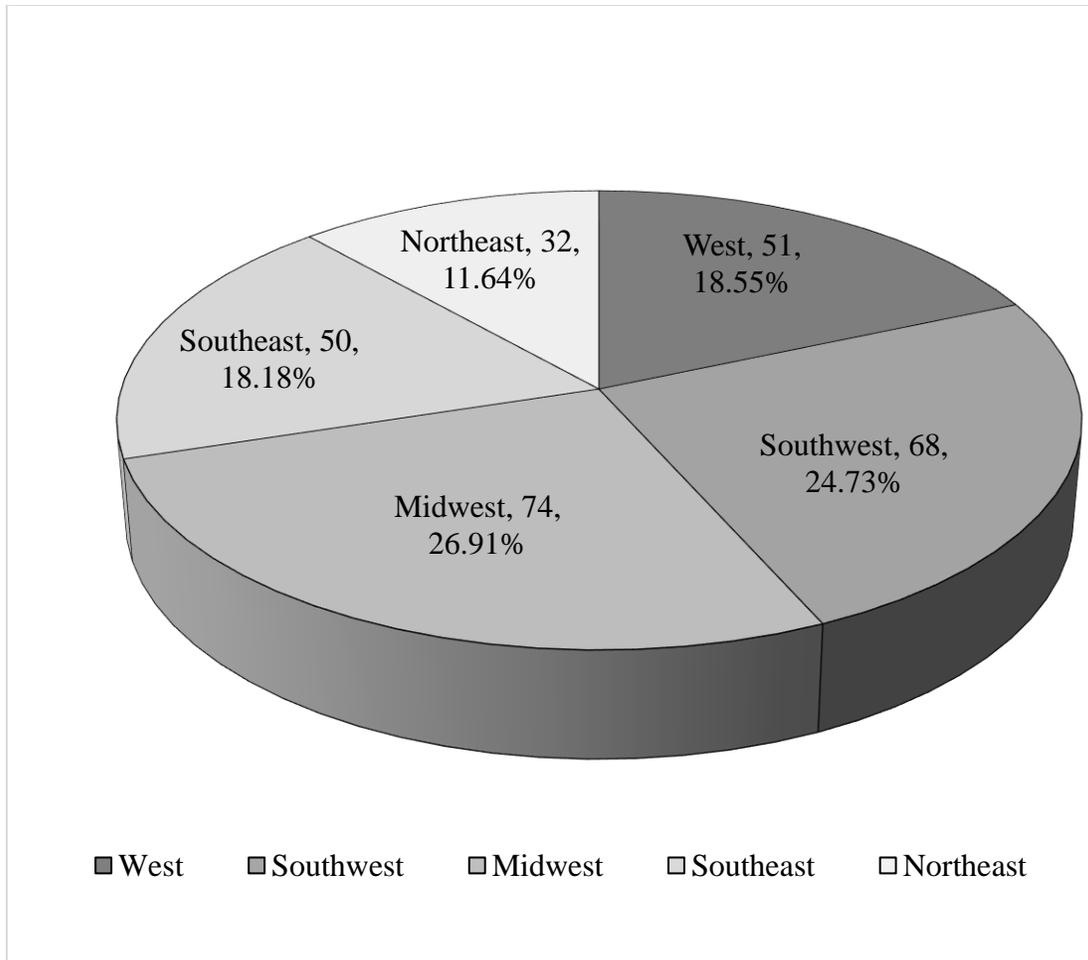


Figure 5.5. Geographic regions in which respondents had heavy/civil construction experience.

5.3 RESPONDENTS' EXPERIENCES WITH DOCUMENT DEFICIENCIES

As previously stated, a construction document deficiency is an error or omission in construction drawings, documents, or specifications. The deficiencies include design plan inaccuracies, constructability issues, plan quantity discrepancies, project specification conflicts, and material applicability issues. The deficiency may or may not result in project time and/or costs that extend beyond the originally contracted amounts.

In the survey, respondents were asked to identify the most common construction document deficiencies. The respondents were allowed to select up to three of the following document deficiencies:

- Design drawings containing plan errors, inaccuracies, and omissions
- Constructability concerns arising because the plan drawings conflict with the actual field conditions
- Project specification provisions that are inaccurately specified or not relevant to the project
- Quantity discrepancies (a substantially higher or lower number than specified in the plan)
- Construction material issues in which the specified materials are not applicable or readily available
- Pay items that have been omitted or incorrectly specified in the contract
- Other (Respondents who selected “other” had the option to specify document deficiencies not already listed.)

Figure 5.6 displays the document deficiencies the respondents identified. The most prevalent category was design drawings containing plan errors, inaccuracies, and omissions ($n = 151$), followed by constructability concerns arising because the plan drawings conflict with the actual field conditions ($n = 131$), project specifications provisions that are inaccurately specified or not relevant to the project ($n = 97$), and quantity discrepancies ($n = 73$). These categories compose 89.10% of all responses, indicating that these four categories represent the vast majority of construction document deficiencies in heavy/civil construction projects. Consequently, contractors and owners

should carefully examine construction documents for these issues in order to reduce project delays and avoid additional costs.

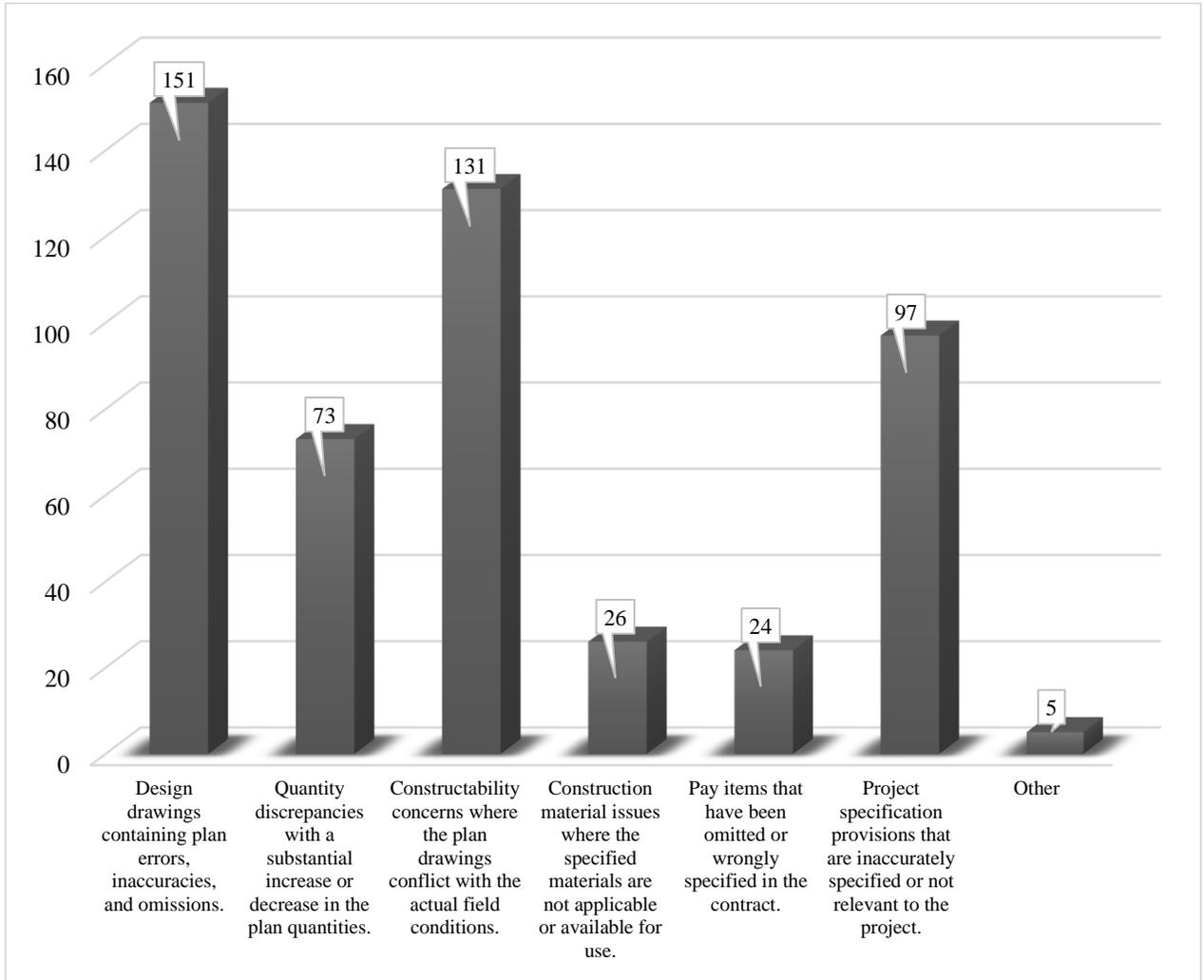


Figure 5.6. Most common document deficiencies in heavy/civil projects.

5.4 CONTRACTORS' EXPERIENCES WITH DOCUMENT DEFICIENCIES

Contractor respondents were asked about the timing of discovering document deficiencies—specifically, whether the discoveries were made during the bidding,

preconstruction, or construction phase. The bidding phase consists of the timeframe before a low-bid contract has been executed. The preconstruction phase starts when the contract is executed and ends immediately before construction activities begin. The construction phase starts when construction activities begin. The contractor respondents were also asked to identify the phase during which they reported their discoveries to project owners.

5.4.1 Contractors' Discovery of Document Deficiencies

As illustrated in Figure 5.7, the contractor respondents discovered document deficiencies during all three phases of low-bid heavy/civil construction projects. Discoveries were most frequent during the construction phase 39.46% (n=58) of the time, followed by the bidding phase 38.10% (n=56) of the time and then the preconstruction phase 22.45% (n=33) of the time. The data indicate that almost the same percentage of document deficiencies are discovered while the contractor is developing a bid as when the contractor is engaged in the construction. It is vital to recognize that nearly 40% of all construction document deficiencies are discovered before the owner has executed a contract with a low-bid contractor. This finding indicates that owners can mitigate numerous construction issues by examining documents and amending deficiencies before the bidding phase begins.

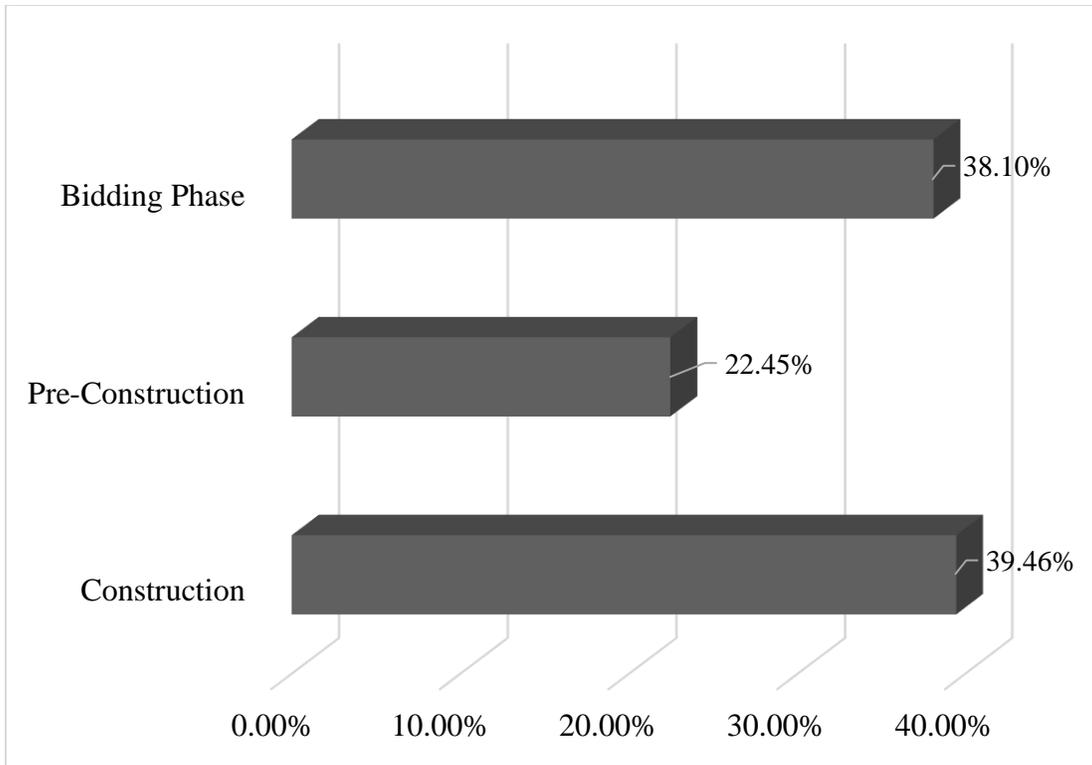


Figure 5.7. Phase in which respondents discovered document deficiencies.

5.4.2 Contractors' Disclosure of Document Deficiencies—Bidding and Construction Phases

As Figure 5.8 shows, 85.03% ($n = 125$) of contractor respondents always or almost always reported document deficiencies to the project owner during the construction phase of heavy/civil projects. In contrast, only 52.38% ($n = 77$) of contractor respondents always or almost always reported document deficiencies to the project owner during the bidding phase of heavy/civil projects. This difference of 32.65% indicates that contractors have specific reasons for not reporting document deficiencies to the project owner before the contract is executed. This conclusion is supported by the finding that

31.29% of contractors rarely or never reported document deficiencies to the project owner during the bidding phase.

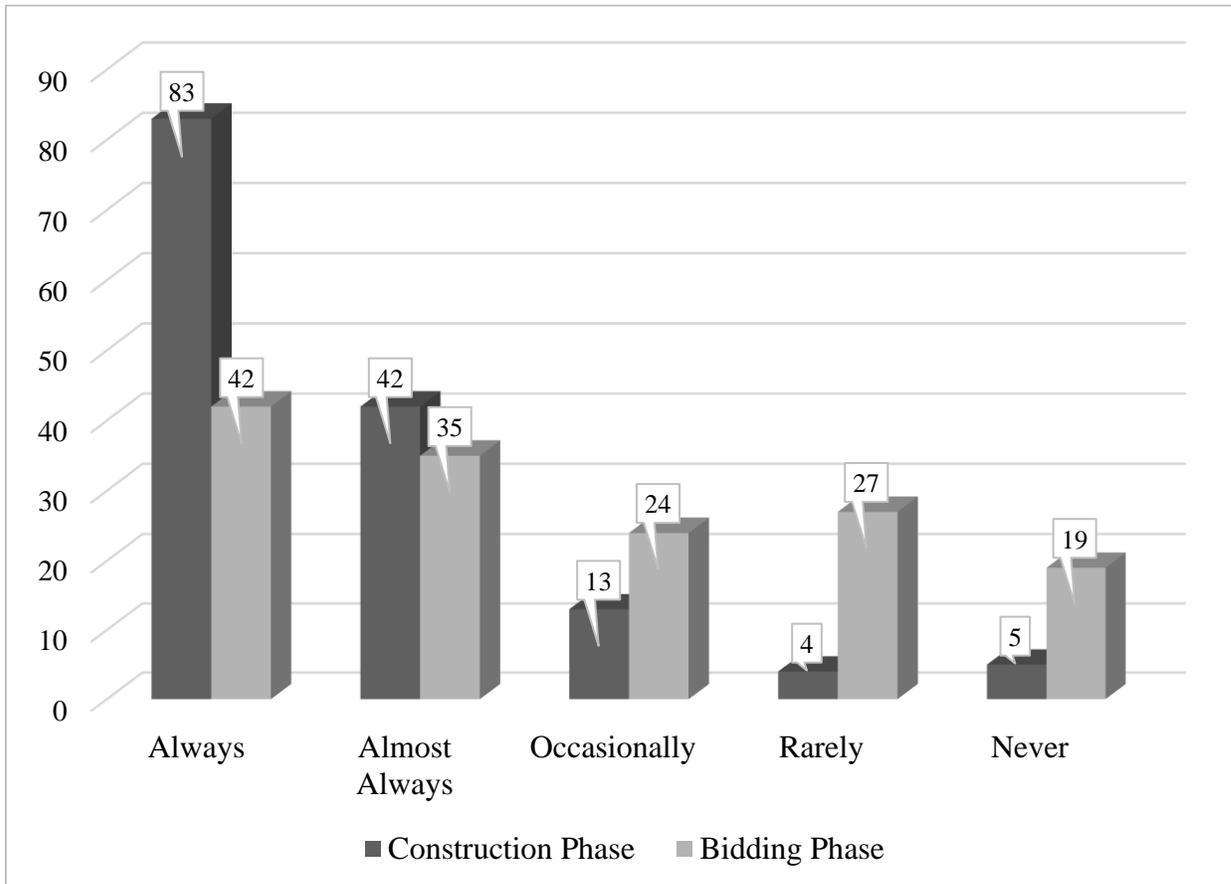


Figure 5.8. Phase in which contractors reported document deficiencies to project owners.

5.5 PROJECT OWNERS' EXPERIENCES WITH DOCUMENT DEFICIENCIES

Project owner respondents were asked about the phase during which they learned of construction document deficiencies—during the bidding, preconstruction, or construction phase. To reiterate, the bidding phase consists of the timeframe before a low-bid contract has been executed. The preconstruction phase starts when the contract is

executed and ends immediately before construction activities begin. The construction phase starts when construction activities begin. The project owner respondents were also asked to identify when they resolved the document deficiencies.

5.5.1 Phase in Which Project Owners Learned of Document Deficiencies

As illustrated in Figure 5.9, the project owners learned of document deficiencies in low-bid heavy/civil construction projects during all three phases of construction projects—18.18% (n=10) of the time during the bidding phase, 20.00% (n=11) of the time during the preconstruction phase, and 61.82% (n=34) of the time during the construction phase. These findings indicate that nearly two-thirds of the time, project owners do not learn about document deficiencies until after construction has begun. Learning of document deficiencies during the construction phase places extreme pressure on the project owner to expeditiously resolve potential issues to prevent project costs and the project timeline from increasing. The results indicate that more than 80% of the time, project owners learn of document deficiencies after the contract has been signed.

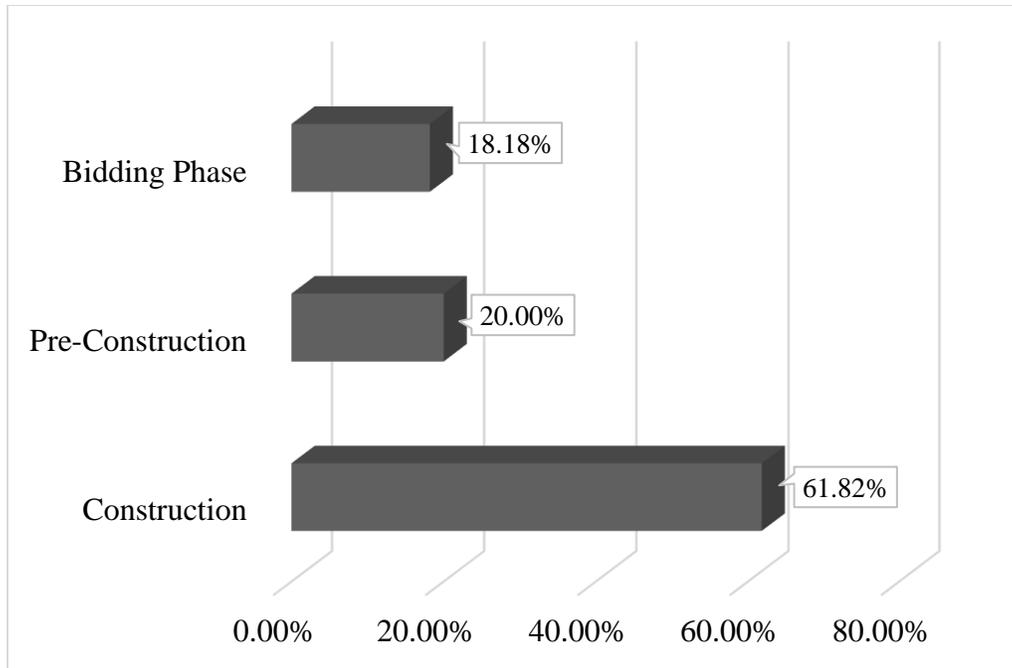


Figure 5.9. Phase in which project owners learned of document deficiencies.

5.5.2 Phase in Which Project Owners Resolved Document Deficiencies—Bidding and Construction Phases

As Figure 5.10 shows, 76.36% ($n = 42$) of project owner respondents always or almost always resolved document deficiencies during the construction phase of heavy/civil projects. An additional 29.09% ($n = 16$) stated they always or almost always resolved document deficiencies during the bidding phase. This equates to a 47.27% variance in achieving a resolution for the construction document deficiencies between the two phases. Figure 5.10 also illustrates that 43.64% ($n = 24$) of project owner respondents rarely or never resolved document deficiencies during the bidding phase. In comparison, only 10.91% ($n = 6$) of project owner respondents rarely or never resolved document deficiencies during the construction phase.

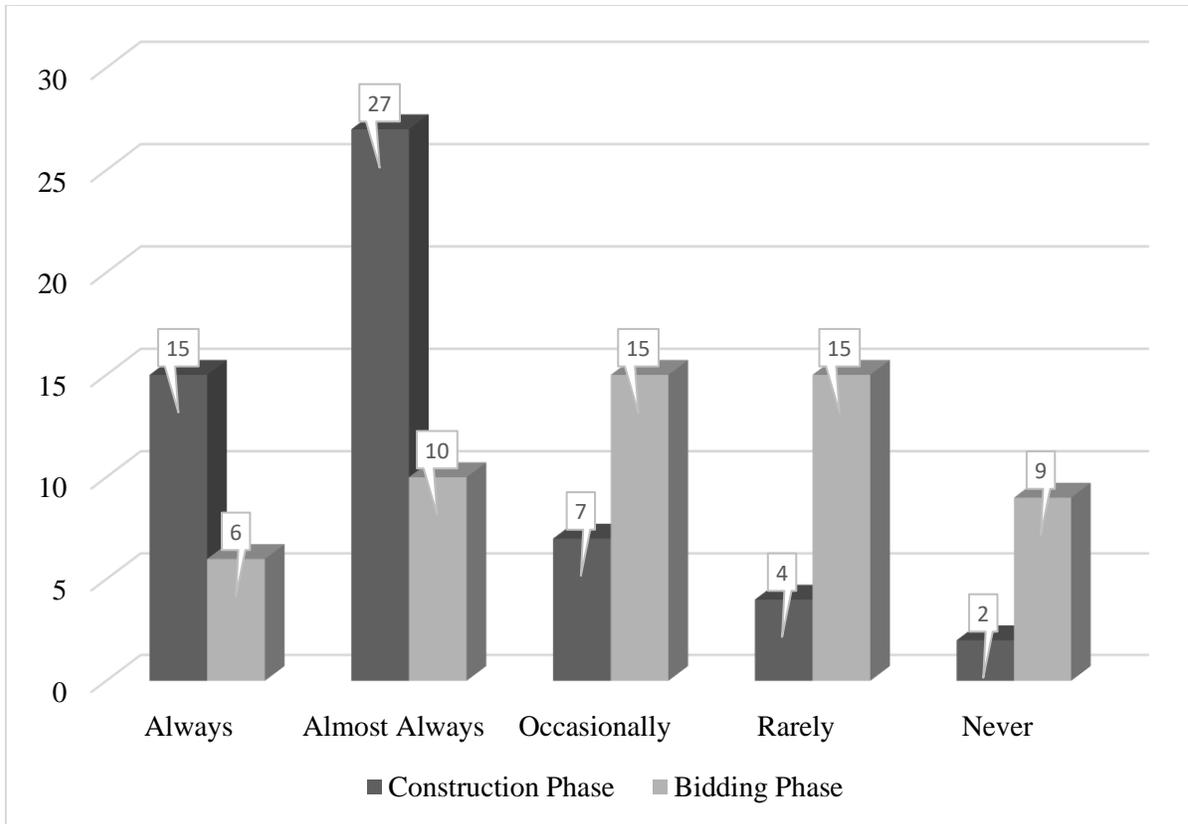


Figure 5.10. Phase in which project owner respondents resolved document deficiencies.

5.6 PHASE TO REPORT DOCUMENT DEFICIENCIES FOR PROFIT AND VALUE MAXIMIZATION

Data were also collected from the participants to understand their perceptions of document deficiencies in relation to project profit and value. Contractor respondents were asked to identify the phase in which notifying project owners of document deficiencies resulted in the greatest profit for the contractors' companies. Project owner respondents were asked to identify the phase in which learning about document deficiencies resulted in the greatest project value.

5.6.1 Profit Maximization

As depicted in Figure 5.11, 45.58% ($n = 67$) of contractor respondents stated that it was most financially profitable to report document deficiencies to the project owner after the low-bid contract was executed. An additional 31.29% ($n = 46$) of contractor respondents believed the bidding phase was the most profitable time to report document deficiencies. The remaining 23.13% ($n = 34$) of contractor respondents stated that the timing did not affect profits.

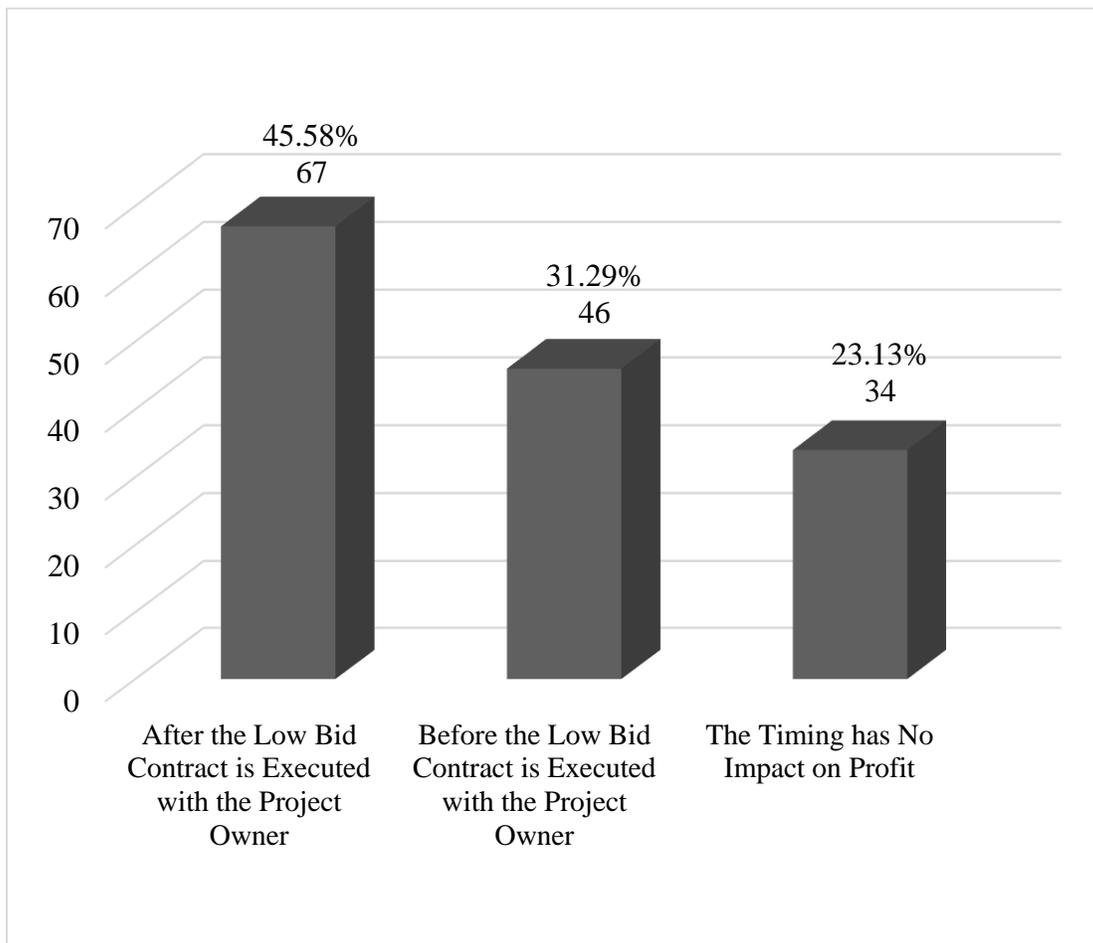


Figure 5.11. Most profitable phase in which to report document deficiencies.

5.6.2 Project Value Maximization

As illustrated in Figure 5.12, 96.36% ($n = 53$) of the project owner respondents stated that project value was the highest when they learned of document deficiencies during the bidding phase. Only 3.64% ($n = 2$) of project owner respondents believed project value was higher if they learned of document deficiencies after the bidding phase. None of the project owner respondents stated that the timing did not affect project value. These findings indicate that almost all project owner respondents wanted to learn about document deficiencies before executing a low-bid contract.

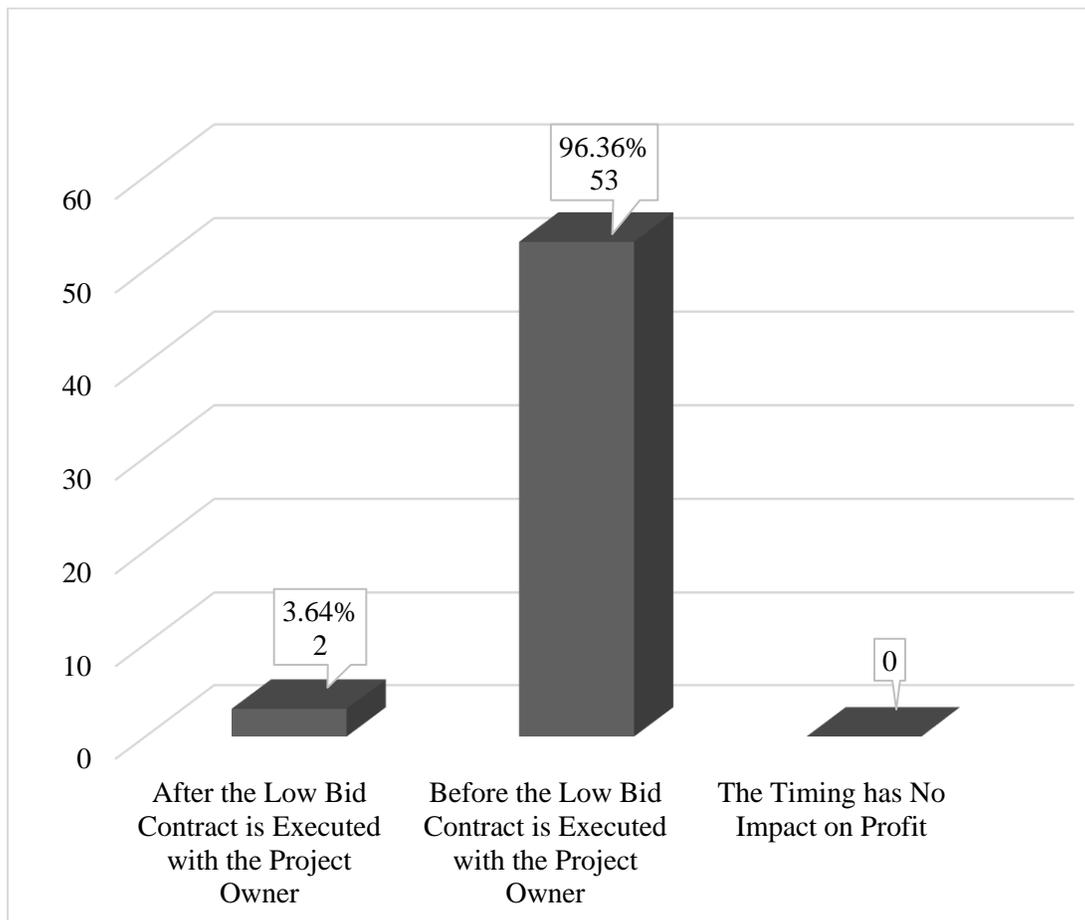


Figure 5.12. Phase in which learning about document deficiencies results in maximum project value.

5.7 EFFECT OF DOCUMENT DEFICIENCIES ON CONTRACT PRICE

All survey respondents were asked to identify how often document deficiencies resulted in a contract price increase. The cost increases arise from project change orders, new unit prices, and time and material billings, among other factors related to document deficiencies. The respondents answered in terms of their overall construction experience and in terms of their most recent heavy/civil project.

5.7.1 Frequency of Contract Price Increasing Because of Document Deficiencies

In identifying how often document deficiencies resulted in contract price increases, respondents chose from the following options: 0%, 1%–9%, 10%–19%, 20%–29%, 30%–39%, 40%–49%, 50%–59%, 60%–69%, 70%–79%, 80%–89%, and greater than 90%. As illustrated in Figure 5.13, the majority (68.31%, $n = 138$) of contractors and project owners believed that document deficiencies caused the contract price to escalate more than 50% of the time. Of this group, 19.81% ($n = 38$) believed document deficiencies resulted in project price increases more than 90% of the time. Conversely, 10.40% ($n = 21$) of respondents stated that document deficiencies cause contract price increases less than 20% of the time.

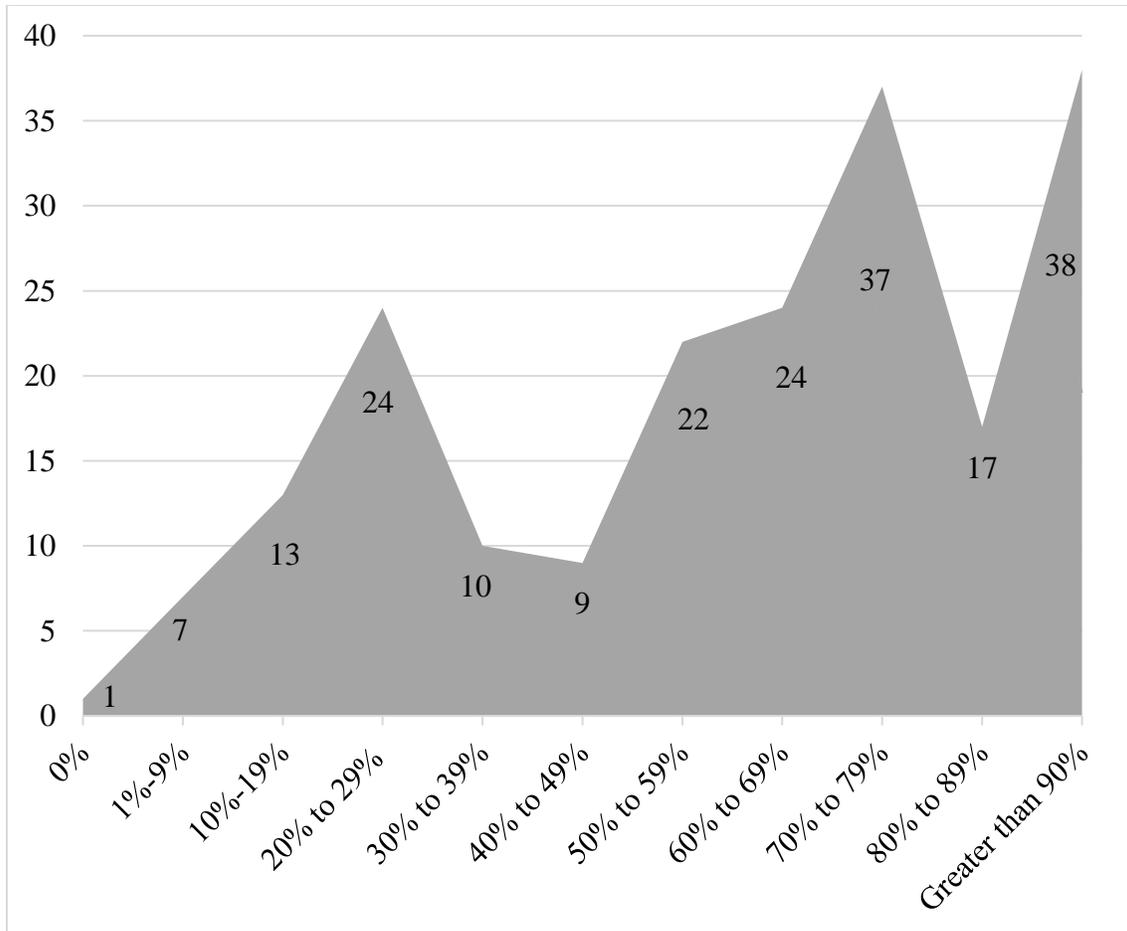


Figure 5.13. Frequency with which document deficiencies increase the project contract price.

5.7.2 Impact of Document Deficiencies on Contract Price

Respondents indicated whether their most recent heavy/civil project had any document deficiencies and, if so, what impact the deficiencies had on the project cost.

The respondents chose from the following options:

- No construction document deficiencies were discovered on my last project.

- At least one construction document deficiency was discovered, and it had no impact on project cost.
- At least one construction document deficiency was discovered, and it had an impact of \$1,000 to \$10,000 on the project cost.
- At least one construction document deficiency was discovered, and it had a major impact of greater than \$10,000 on the project cost.

As Figure 5.14 indicates, 81.68% ($n = 165$) of respondents reported that document deficiencies were discovered in their most recent project and that the deficiencies had a major or minor impact on the project cost. Only 7.92% ($n = 16$) stated that document deficiencies were discovered but did not affect the project cost. This data indicates that in more than 80% of heavy/civil projects with document deficiencies, project costs does increase.

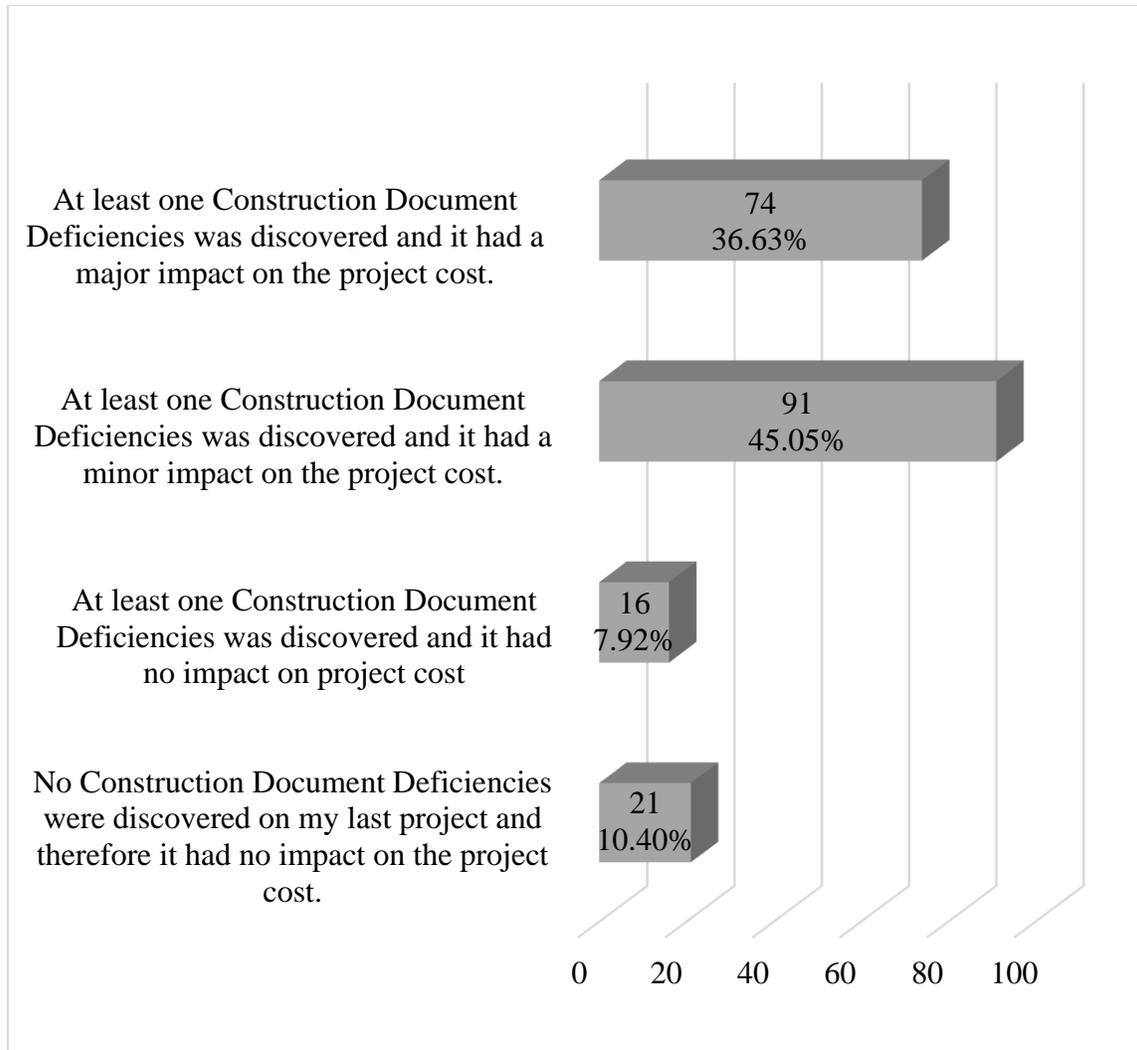


Figure 5.14. Impact of document deficiencies on project contract cost.

5.8 EFFECT OF DOCUMENT DEFICIENCIES ON PROJECT DURATION

Study respondents also identified how document deficiencies affected the duration of heavy/civil construction projects. The respondents provided information about their experiences overall and about their most recent heavy/civil project.

5.8.1 Frequency of Project Duration Increasing Because of Document Deficiencies

Based on their overall experience, participants identified how often project duration increased because of document deficiencies. The respondents chose from the following categories: 0%, 1%–9%, 10%–19%, 20%–29%, 30%–39%, 40%–49%, 50%–59%, 60%–69%, 70%–79%, 80%–89%, and greater than 90%. As Figure 5.15 illustrates, only 2% ($n = 4$) reported that document deficiencies did not increase project duration, whereas 48.02% ($n = 97$) believed document deficiencies increases project duration at least 50% of the time. Of this latter group, 9.40% ($n = 19$) believed that document deficiencies increased project duration more than 90% of the time. An additional 16.83% ($n = 34$) of respondents perceived that document deficiencies increased project duration 1–19% of the time.

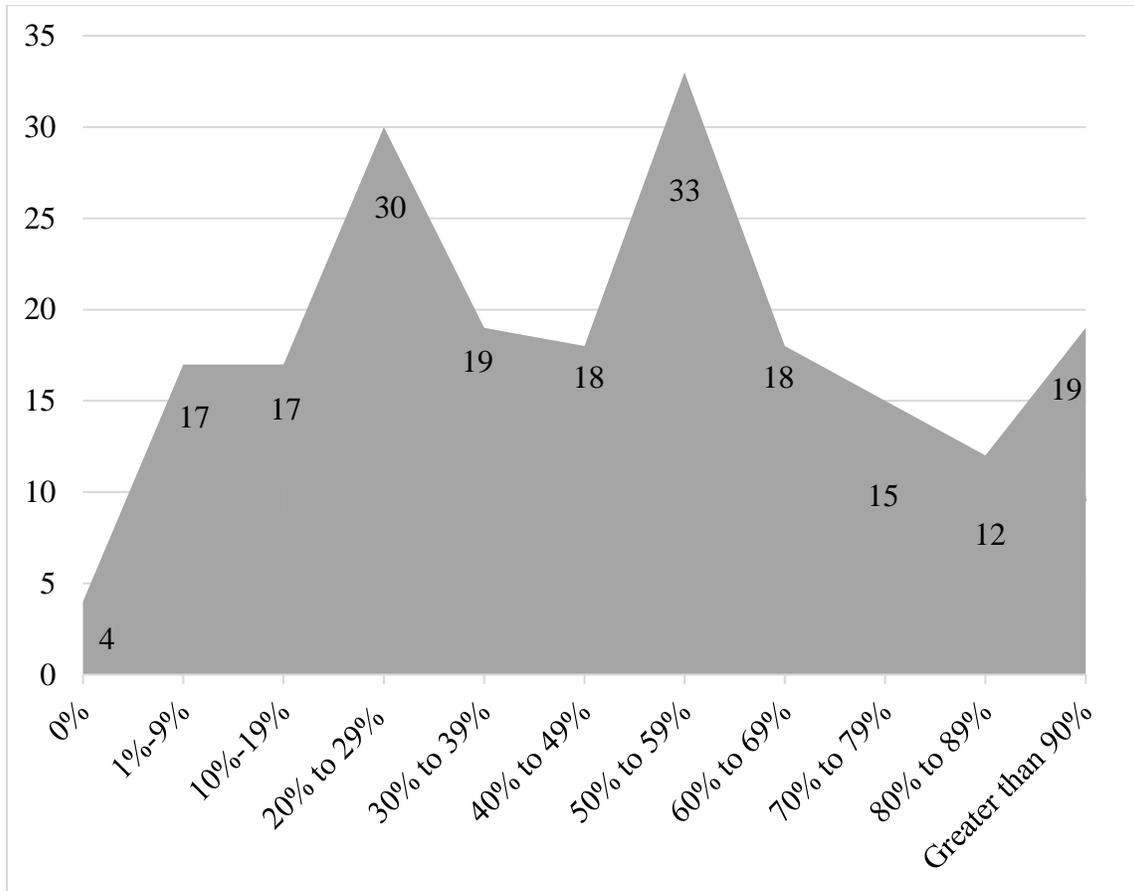


Figure 5.15. Frequency that document deficiencies increased project time duration.

5.8.2 Impact of Document Deficiencies on Project Duration

The respondents were asked to identify whether any document deficiencies had occurred in their most recent heavy/civil project and, if so, the degree of the impact on project duration. The respondents selected one of the following answers:

- No construction document deficiencies were discovered on my last project.
- At least one construction document deficiency was discovered, and it had no impact on the overall project time duration.

- At least one construction document deficiency was discovered, and it had an impact of 1 to 10 days on the overall project time duration.
- At least one construction document deficiency was discovered, and it had a major impact of greater than 10 days on the overall project time duration.

The results, presented in Figure 5.16, indicate that 75.25% ($n = 152$) of the respondents experienced document deficiencies in their most recent project and that the deficiencies had a major or minor impact on the overall project duration. In contrast, 12.87% ($n = 26$) stated that document deficiencies in their most recent project did not affect the overall project duration.

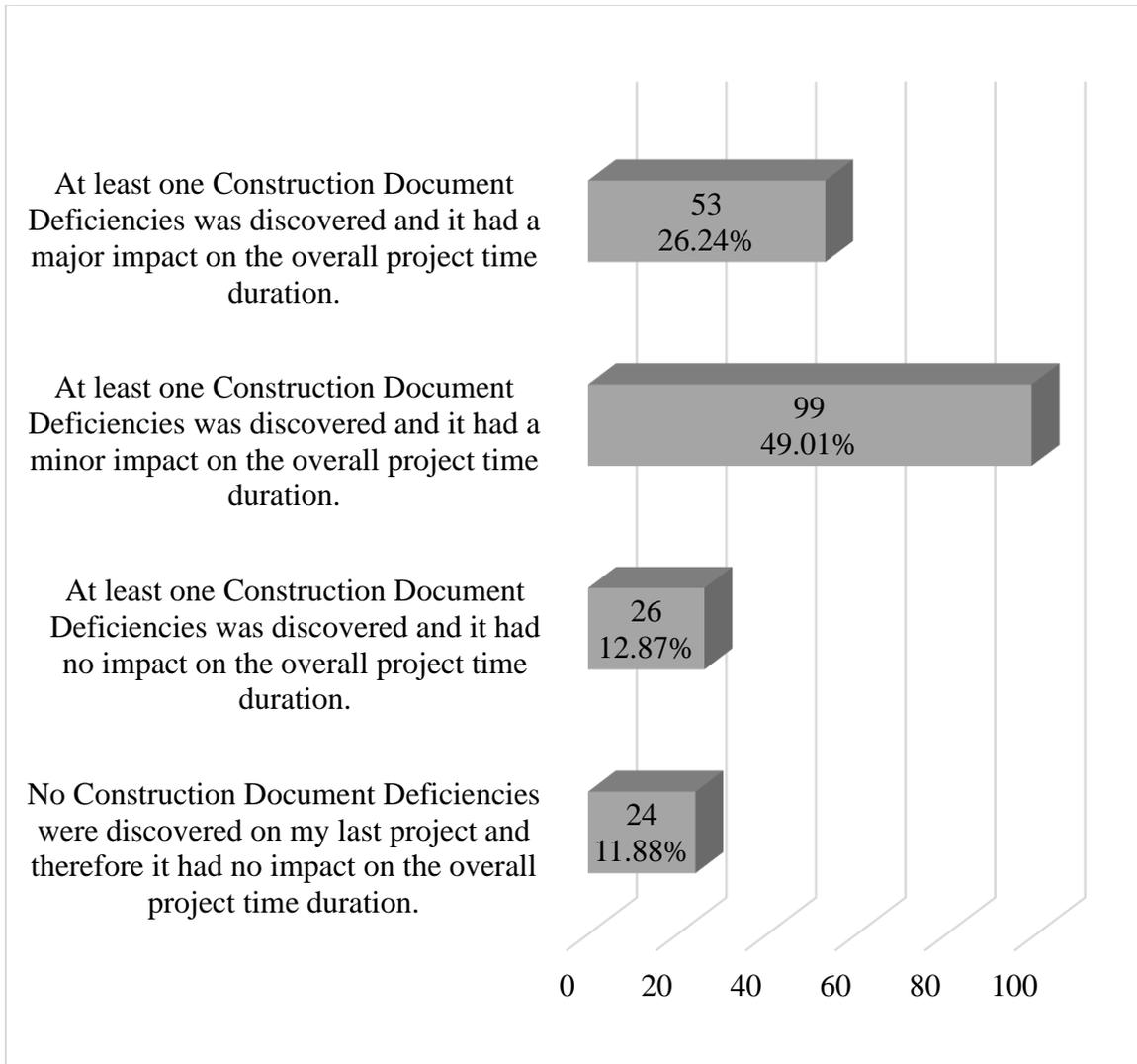


Figure 5.16. Impact of document deficiencies on overall project duration.

5.9 DISCUSSING DOCUMENT DEFICIENCIES PRIOR TO THE CONSTRUCTION PHASE

After identifying the impacts of document deficiencies on project cost and duration, the respondents were asked whether project cost and time savings would be possible if contractors and project owners identified and discussed document deficiencies prior to the construction phase.

5.9.1 Potential Cost Savings

First, respondents were asked whether they agreed that cost savings were possible if contractors and project owners identified and discussed document deficiencies prior to the construction phase. Respondents chose from the following:

- Strongly agree: A project cost savings would be realized.
- Agree: A project cost savings would be realized.
- Somewhat agree: A project cost savings would be realized.
- Neither agree nor disagree: No effect on the project cost.
- Somewhat disagree: A project cost savings would not be realized.
- Disagree: A project cost savings would not be realized.
- Strongly disagree: A project cost savings would not be realized.

The results, depicted in Figure 5.17, indicate that 75.74% ($n = 153$) of respondents strongly agreed, agreed, or somewhat agreed that identifying and discussing document deficiencies before the construction phase could effectuate project cost savings. Only 10.89% ($n = 22$) of respondents strongly disagreed, disagreed, or somewhat disagreed. The findings suggest that both project owners and contractors want to see improvements regarding document deficiencies in low-bid heavy/civil construction projects.

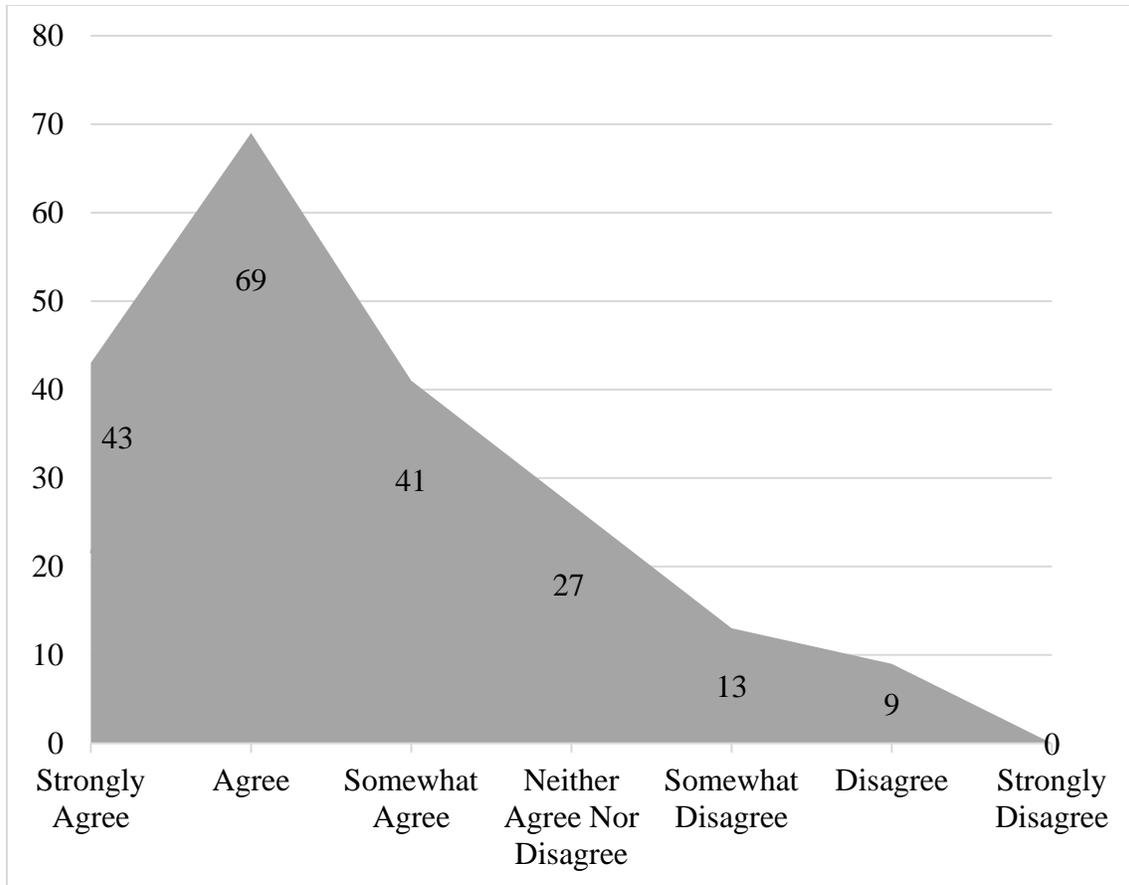


Figure 5.17. Belief that project cost savings are possible if construction document deficiencies are identified and discussed prior to the construction phase.

5.9.2 Potential Time Savings

Respondents were then asked whether they agreed that identifying and discussing document deficiencies prior to the construction phase would result in potential project time savings. Respondents chose from the following options:

- Strongly agree: A project time savings would be realized.
- Agree: A project time savings would be realized.
- Somewhat agree: A project time savings would be realized.

- Neither agree nor disagree: No effect on the project time.
- Somewhat disagree: A project time savings would not be realized.
- Disagree: A project time savings would not be realized.
- Strongly disagree: A project time savings would not be realized.

The data, displayed in Figure 5.18, indicate that 78.22% ($n = 158$) of respondents strongly agreed, agreed, or somewhat agreed that identifying and discussing document deficiencies prior to the construction phase would result in potential project time savings. Only 9.90% ($n = 20$) strongly disagreed, disagreed, or somewhat disagreed. Similar to the cost saving findings above, the data indicates that the majority of project owners and contractors want document deficiencies on low-bid heavy/civil construction projects to be handled more responsibly in an effort to save project time.

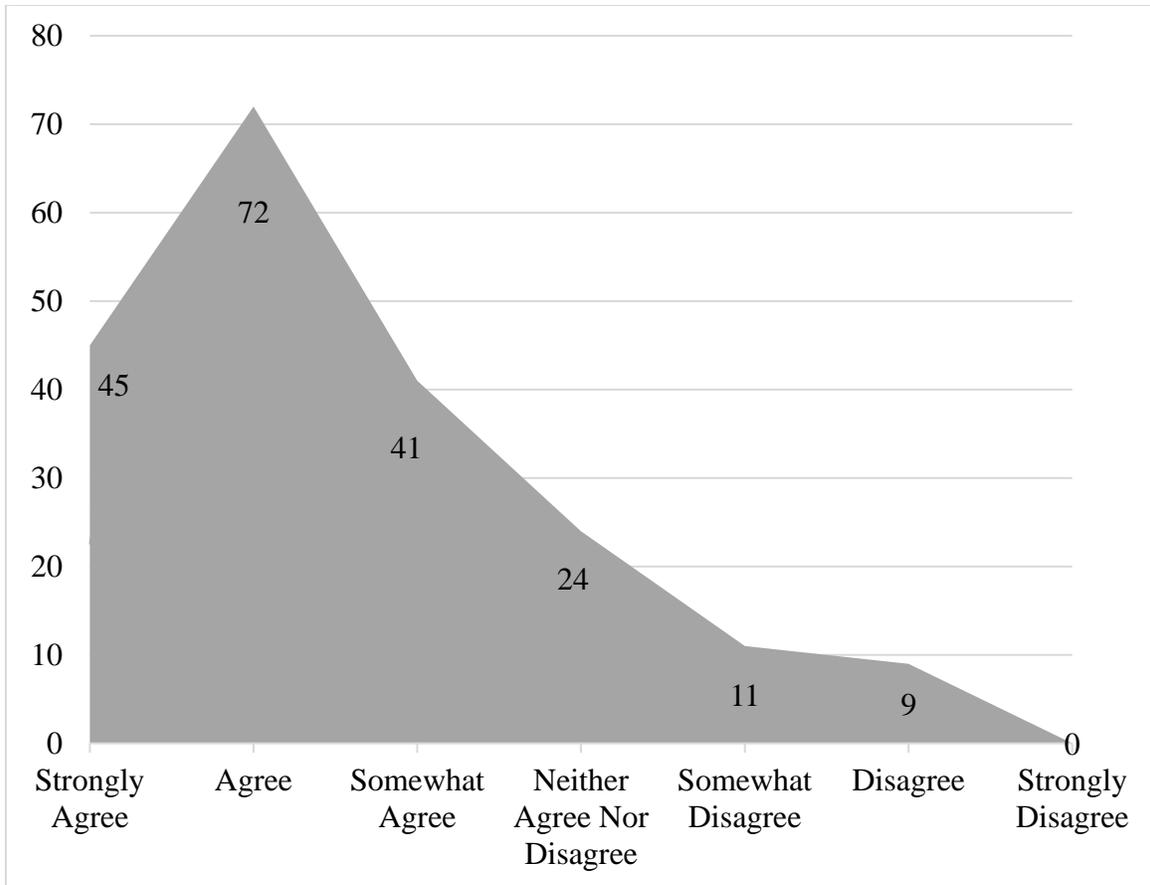


Figure 5.18. Belief that project time savings are possible if construction document deficiencies are identified and discussed prior to the construction phase.

5.10 NEED FOR IMPROVEMENT

The study results indicate that contractors and public project owners believe document deficiencies on heavy/civil construction projects can be addressed more effectively, which could lead to project cost and time savings. The next chapter contains a strategy for identifying and reporting construction document deficiencies.

CHAPTER 6

PROPOSAL

6.1 CONTRACTOR DOCUMENT REVIEW ASSESSMENT (CDRA)

Nearly 90% of respondents reported that their most recent heavy/civil project included at least one construction document deficiency. Further, over 80% of respondents stated that a potential project cost or time savings would result if document deficiencies were reported and discussed before the construction phase started. These findings overwhelmingly indicate that the handling of construction document deficiencies need to be addressed in order to improve the low-bid selection methodology. However in doing so, it critical that improvements do not compromise the principles that price-based procurement is founded on.

The study data show that contractors discover document deficiencies during the bidding phase almost 40% of the time. During this phase, the contractor's estimator (or estimating team) prepares a project estimate based on carefully reviewing the information contained in all bid-package documents; projecting how the work will be performed; and evaluating which resources are required, such as labor, equipment, and materials, to complete each of the specified construction activities for the project. During this process, the estimator begins to fully comprehend the project documents and thus may discover document deficiencies.

The study findings indicate the bidding phase is the most advantageous time to identify document deficiencies. For this reason, the researcher has created the Contractor Document Review Assessment (CDRA) to assist contractors in discovering document

deficiencies during the bidding phase. The CDRA is designed to help contractors identify the following types of document deficiencies:

- Design drawings containing plan errors, inaccuracies, and omissions
- Quantity discrepancies (a substantially higher or lower number than specified in the plan)
- Constructability concerns arising because the plan drawings conflict with the actual field conditions
- Construction material issues in which the specified materials are not applicable or readily available
- Pay items that have been omitted or incorrectly specified in the contract
- Project specification provisions that are inaccurately specified or not relevant to the project

6.2 UTILIZATION OF THE CDRA

The CDRA process can be applied to publicly funded heavy/civil projects. As outlined in Figure 6.1, the public entity includes the CDRA in the bid packages for contractor estimators, who complete the CDRA after developing a project estimate and then submit the CDRA with all other bid submission documents. The project owner reviews the completed CDRA's to obtain multiple contractor perspectives regarding the completeness and accuracy of the construction documents. Through reviewing the CDRA's, the project owner is better able to recognize and resolve document deficiencies during the bidding phase. It is important to emphasize that the CDRA process is intended to be an element that enhances price-based procurement; the CDRA process is not a means of selecting a contractor.

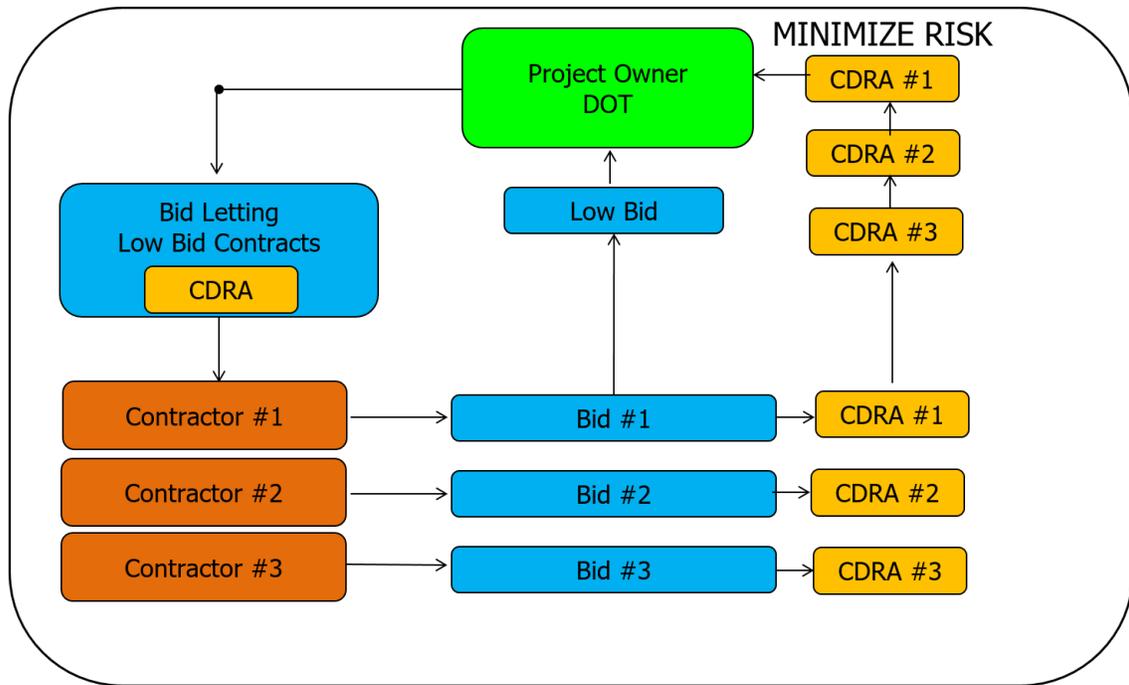


Figure 6.1. Overview of the CDRA process.

6.3 RATINGS IN THE CDRA

As part of the CDRA process, the contractor’s estimator will evaluate the overall completeness and thoroughness of the project documents in terms of each CDRA category. The estimator will select one of the following ratings:

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

The rating of “meets expectations” is appropriate if the estimator believes that the documents do not contain any errors regarding a specific CDRA category. The “improvement needed” rating is appropriate if the estimator identified document errors

that the estimator believes will have a minor impact on the project. The “unsatisfactory” rating is suitable if the estimator discovers document errors that will have a major impact on the project.

6.4 CDRA TEMPLATE

PURPOSE

The objective of the Contractor Document Review Assessment (CDRA) is to identify document deficiencies contained within the project documents. A construction document deficiency is any error or omission in the construction drawings, documents, or specifications.

INSTRUCTIONS

As a potential contractor for this project, you are required to use this form to rate project documents in terms of issues related to design drawings, quantities, constructability, materials, contract pay items, project specifications, and any other categories you deem appropriate. On the following pages, please assign each of the categories one of the following ratings:

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

If you assign a category of “improvement needed” or “unsatisfactory” rating, please briefly explain the document deficiencies related to the category.

Project Contract: _____

Contractor: _____

1. Design Drawings

Design drawings are free of plan errors, inaccuracies, and omissions.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

2. Quantities

The quantities specified in the construction plan documents are not substantially higher or lower than the quantities I calculated in my takeoffs.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

Project Contract: _____

Contractor: _____

3. Constructability

The construction plan drawings and documents do not conflict with actual field conditions.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

4. Materials

The specified construction materials are applicable and available for use for this project.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

Project Contract: _____

Contractor: _____

5. Contract Pay Items

No pay items have been omitted or wrongly specified in the contract.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

6. Project Specification Provisions

Project specification provisions are accurately specified and relevant to the project.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

Project Contract: _____

Contractor: _____

7. Other

Please identify any document deficiencies not addressed on the previous pages.

Explanation: _____

6.5 POTENTIAL BENEFITS OF THE CDRA

Certain contractors selected through the priced-based approach in design-bid-build projects typically do not report document deficiencies until after signing the contract. Document deficiencies can lead to increased costs for the project owner and can provide contractors with justification to extend the project duration. Implementing the CDRA can mitigate these circumstances because the project owner will become aware of and can resolve many project risks before awarding a contract. The following are specific benefits of the CDRA:

- It enables project owners and contractors to mitigate risk during the bidding phase, which project owners in the study indicated was the most financially advantageous time to identify document deficiencies.

- It can reduce overall project time and costs.
- It provides project owners with multiple contractors' feedback regarding the design and constructability of the project.
- It allows contractors to use their expertise and demonstrate to the project owner their understanding of the construction documents.
- The CDRA requires minimal time to complete. Contractors are already reviewing project documents to generate project estimates; with the CDRA, they simply add the step of documenting and reporting their assessments.

6.6 PANEL OF INDUSTRY EXPERTS CONTRIBUTION TO THE CDRA

The researcher drafted the CDRA based on the data collected in this study, guidance from the dissertation committee, and his own heavy/civil construction experience. To obtain industry input about the CDRA, feedback was obtained from an industry expert panel consisting of eight heavy/civil construction professionals. The panel members were selected because they participated in the study survey and they agreed to further contribute to the study.

The researcher informed the panel that the goal was to present the CDRA in a format that contractors and project owners could effectively use to mitigate risk in low-bid heavy/civil projects. Consequently, it was important that both project owners and contractors would feel comfortable with the document's language, structure, and use. The researcher and panel members met multiple times to discuss the survey data. In response to these meetings, feedback was gathered from contractors and owner representatives in the heavy/civil industry.

The panel members proposed several alterations to improve the CDRA document. One of the most significant modifications involved renaming the assessment. The original name was Expert Review Assessment. One panel member stated that the document name needed to specify who the document was for and the exact purpose of the document. The researcher brainstormed document titles, and the panel mutually agreed that the name Contractor Document Review Assessment best identified who the document is for and what the document's purpose is.

One issue that was not resolved during discussion with the panel regards whether contractors should identify themselves on the CDRA or whether the feedback should be anonymous. The panel members presented different perspectives on the topic, and the researcher recognizes that both options have advantages and disadvantages. Therefore, project owners who implement the CDRA are encouraged to decide, based on their specific objectives, whether to require contractors to identify themselves in the document.

CHAPTER 7

CONCLUSIONS

7.1 RESEARCH SUMMARY

This study examined 202 contractors and project owners in the heavy/civil construction sector. These professionals had a wide range of experience in the heavy/civil construction sector and represented a variety of construction positions. The study participants responded to survey questions regarding construction document deficiencies and their impacts on heavy/civil construction projects.

The heavy/civil construction professionals identified the most common construction document deficiencies to be (a) design drawings containing plan errors, inaccuracies, and omissions; (b) constructability concerns arising because the plan drawings conflict with the actual field conditions; (c) project specification provisions that are inaccurately specified or not relevant to the project; and (d) quantity discrepancies (a substantially higher or lower number than specified in the plan). These four categories composed of 89.10% of all construction document deficiencies in the respondents' heavy/civil construction projects.

Contractor respondents reported that 38.10% of the time they discovered document deficiencies during the bidding phase. The contractors reported they always share document deficiencies with project owners during the bidding phase 28.57% of the time. In contrast, project owners stated that they learned of document deficiencies during the bidding phase only 18.18% of the time; 61.82% of the time they learned about the document deficiencies during the construction phase. Therefore, it is not surprising that

76.36% of the project owner respondents reported resolving the document deficiencies during the construction phase of heavy/civil projects.

Additional data indicate that the contractors' and project owners' interests were sometimes in opposition. Almost half (45.58%) of the contractor respondents stated that the most financially profitable time to report document deficiencies to the project owner was after the low-bid contract was executed. In contrast, 96.36% of project owner respondents stated that learning of document deficiencies during the bidding phase resulted in the greatest project value.

Both contractors and project owners recognized the effect of document deficiencies on project cost and duration. For example, 81.68% of respondents reported that in their most recent projects, document deficiencies had a major or minor impact on project cost. Further, in 75.25% of the respondents' most recent projects, document deficiencies had a major or minor impact on project duration.

Due to the frequent occurrence of document deficiencies and their negative effects, the CDRA was developed to help identify document deficiencies in heavy/civil construction projects. The focus of the CDRA is on the following categories of document deficiencies: design drawings, quantity discrepancies, constructability conflicts, material issues, contract pay item discrepancies, and project specification conflicts.

7.2 FUTURE RESEARCH

The results of this study could be augmented by collecting data from additional contractors and public project owners to include more than the 202 participants in this study. Further, the implementation of the Contractor Document Review Assessment on

multiple publicly funded heavy/civil construction project could be examined to determine the actual project cost and time savings realized.

7.3 CONCLUSIONS

This study's results confirm that construction document deficiencies affect the outcomes on heavy/civil low-bid construction projects. Contractors may not report construction document deficiencies until after signing the project contract because these deficiencies can result in higher profits for the contractors. As illustrated in Figure 7.1 and Figure 7.2, contractor respondents stated they discovered document deficiencies during the bidding phase 38.10% of the time, whereas owner respondents reported learning of document deficiencies during the bidding phase only 18.18% of the time—a variance of 19.92%. Similarly, contractor respondents reported identifying document deficiencies 39.45% of the time during the construction phase, while project owner respondents stated they learned of document deficiencies 61.82% of the time during the construction phase—a variance of 22.37%.

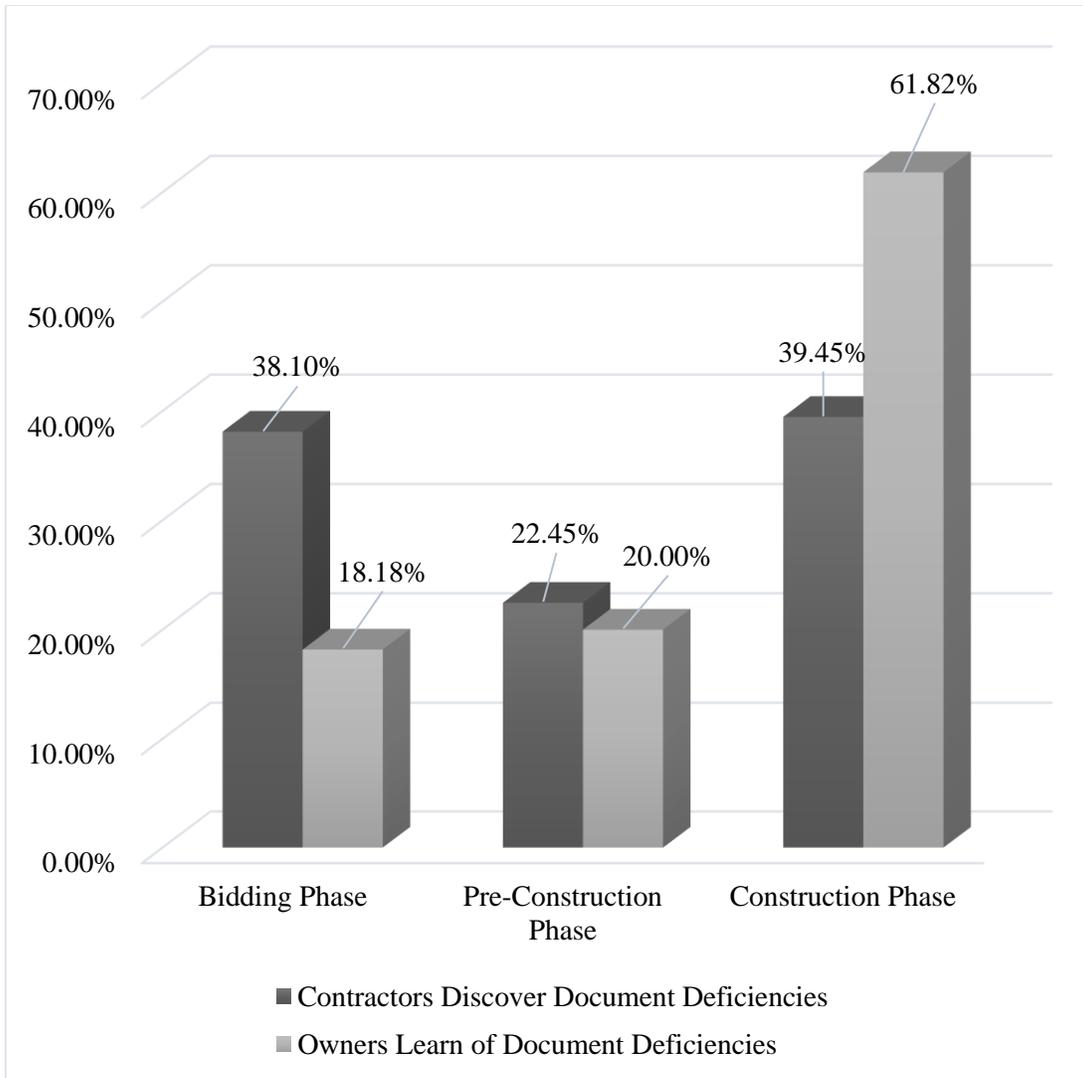


Figure 7.1. Phase during which contractors discover document deficiencies compared to when owners learn of document deficiencies.

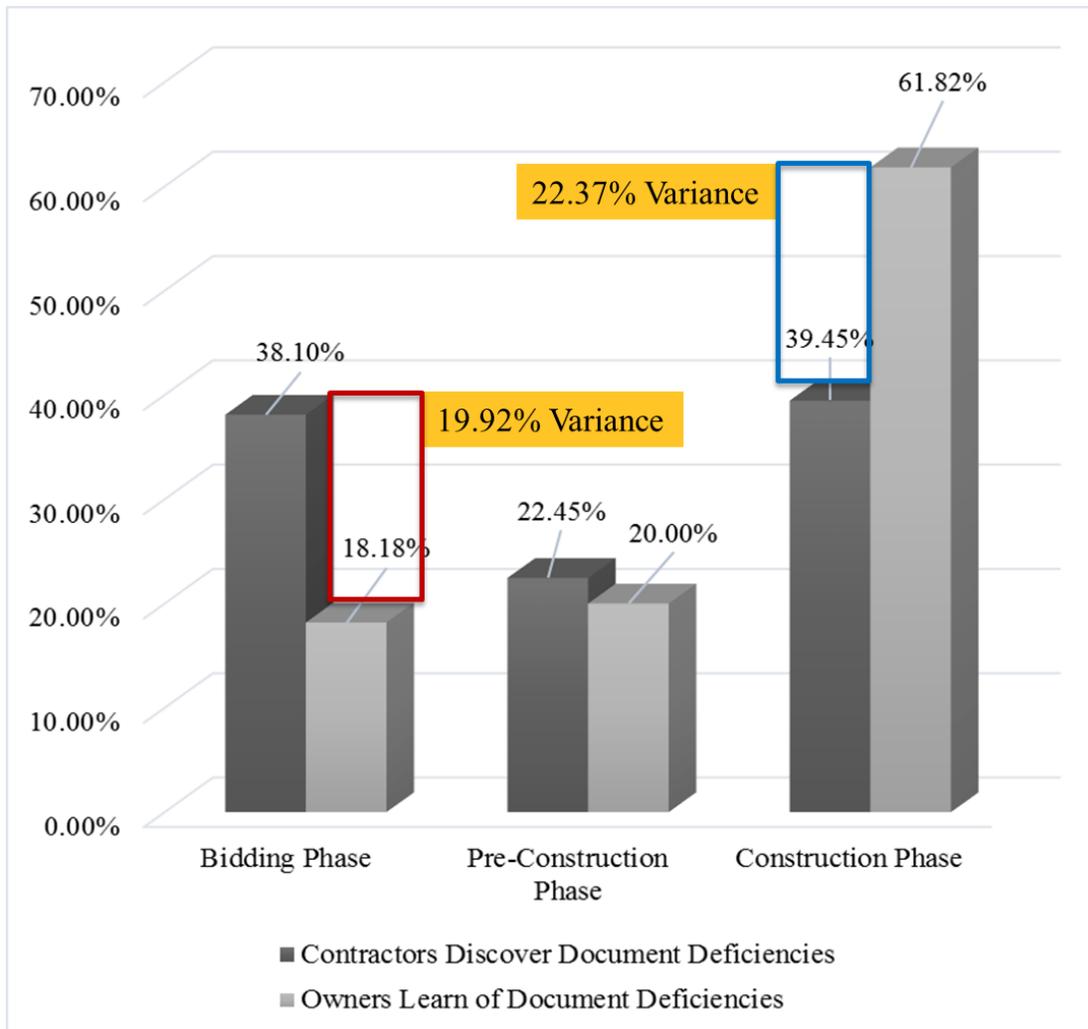


Figure 7.2. Variance of when contractors discover document deficiencies compared to when owners learn of document deficiencies.

The research study confirms that contractors are withholding 52.28% of document deficiencies discovered during the bidding phase. As detailed in Figure 7.3, contractors will eventually go on to report these deficiencies to the public project owner during a later phase in the project. The research data indicates that a time delay does exist between when a contractor discovers document deficiencies, compared to when a contractor

reports the construction document deficiencies to the public project owner. Contractors will strategically wait to share over 50% of construction document deficiencies discovered during the bidding phase, until after the project contract has been executed.

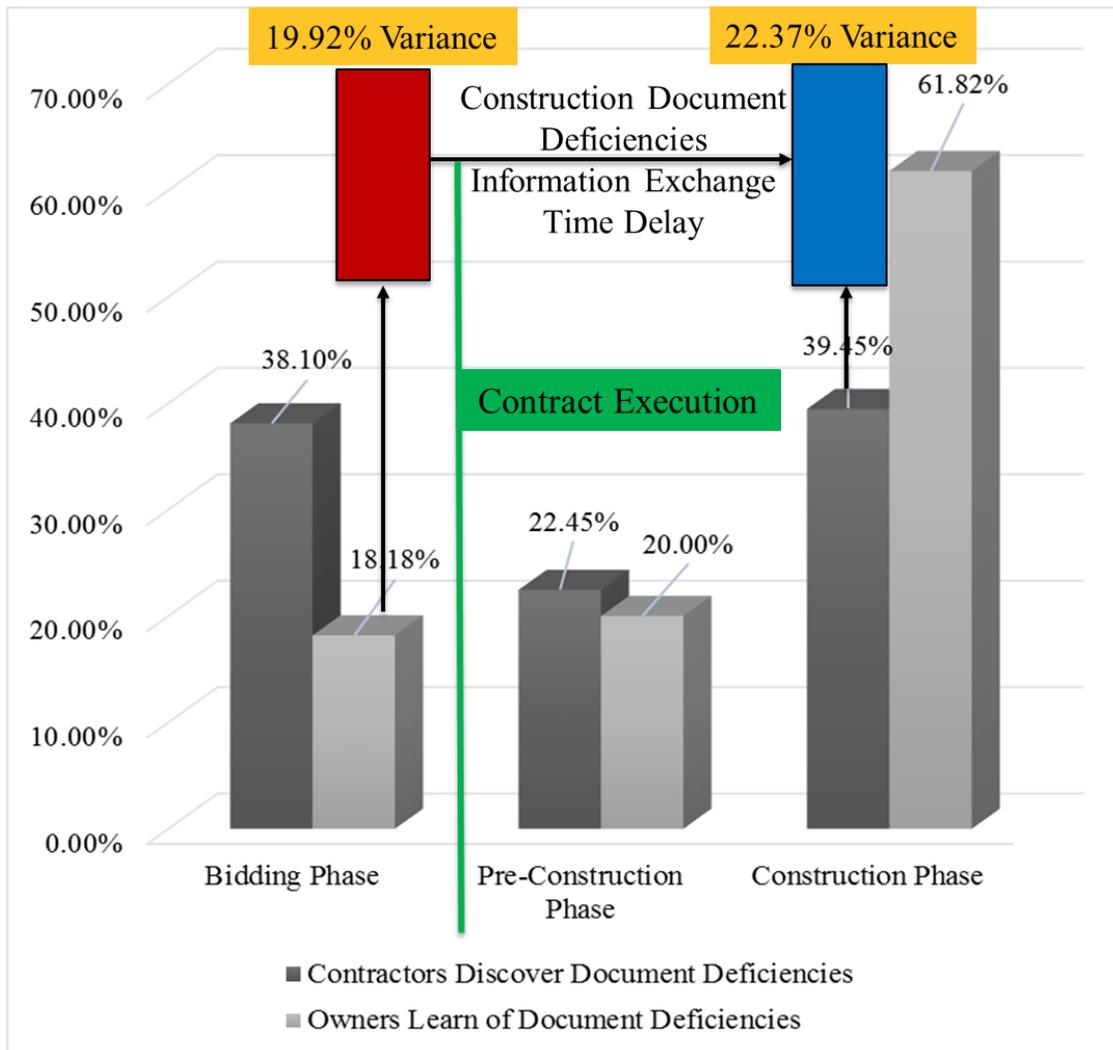


Figure 7.3. Information exchange time delay of when contractors discover document deficiencies compared to when owners learn of document deficiencies.

In conclusion, the research data indicates that contractors will withhold a significant amount of construction document deficiencies from the public project owner until after the project contract has been executed. For this reason, the researcher has developed the Contractor Document Review Assessment to encourage the exchange of information prior to the project contract being executed.

The Contractor Document Review Assessment acts as a proactive risk mitigation device for both the public project owner and the contractor. It offers the project owner with actual contractor feedback as to the state of their project's construction documents. The Contractor Document Review Assessment will create an open dialogue to address potential project concerns well before the start of construction activities. Ultimately, this can lead to reducing project costs and limiting the potential for project schedule delays. The utilization of the Contractor Document Review Assessment can offer a significant improvement to the price-based procurement model on heavy/civil low bid infrastructure projects.

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APPENDIX A
HEAVY/CIVIL CONTRACTOR SURVEY

HEAVY/CIVIL CONTRACTOR SURVEY

Overview:

The survey should take approximately 15 minutes to complete.

Please answer all questions based on your professional construction experience.

The study will examine construction document plan deficiencies on heavy/civil design-bid-build construction projects, where the contractor was selected based on a low bid procurement model. The purpose of this research is to improve the heavy/civil competitive price construction sector.

If you have any questions, please contact: Anthony.Pesek@asu.edu

Section #1: Heavy/Civil Construction

“Heavy/Civil Construction” is a category of construction that is comprised of projects related to site development and infrastructure type work. This includes construction projects such as earthwork, roads, highways, bridges, aviation, railway, and utilities.

1. Select your current role on heavy/civil low bid projects. (select one)
 - General Contractor
 - Subcontractor
 - Project Owner
 - Consultant to the Project Owner

2. How many years of experience in the heavy/civil construction sector do you have? (select one)
 - Less than 4 years
 - 5 to 9 years
 - 10 to 14 years
 - 15 to 19 years

- 20 to 24 years
- 25 years or More

3. In which areas of heavy/civil construction do you have experience in? (select all that apply)

- Earthwork
- Mining
- Roads & Highways
- Bridges
- Aviation
- Railway
- Marine
- Water
- Sewer
- Energy
- Communications
- Other_____

4. What is your position at your current organization? (select one)

- Project Manager
- Site Superintendent
- Field Operations
- Estimator

- Designer/Engineer
- Quality Control
- Owner/Developer
- Division Manager
- President/Senior Executive
- Other_____

5. In which region of the United States did your low bid heavy/civil construction experiences occur in? (select all that apply)

- West
- Southwest
- Midwest
- Southeast
- Northeast

Section #2: Construction Document Plan Deficiencies

A “Construction Document Deficiency” is any error or omission within the construction drawings, documents, or specifications. This includes design plan inaccuracies, constructability issues, plan quantity discrepancies, project specification conflicts, or material applicability issues. A construction document deficiency may or may not result in an increase of time and/or cost to the original contract amount. The construction document deficiencies are commonly discovered in the phases detailed below.

Bidding Phase: The low bid contract has NOT been executed and the construction activities have NOT started.

Pre-Construction Phase: The low bid contract has been executed and the construction activities have NOT started.

Construction Phase: The low bid contract has been executed and construction activities have started.

6. Based on your professional experience, please indicate the three most common Construction Document Deficiencies on heavy/civil low bid projects. (select three)
- Design drawings containing plan errors, inaccuracies, and omissions.
 - Quantity discrepancies with a substantial increase or decrease in the plan quantities.
 - Constructability concerns where the plan drawings conflict with the actual field conditions.
 - Construction material issues where the specified materials are not applicable or available for use.
 - Pay items that have been omitted or wrongly specified in the contract
 - Project specification provisions that are inaccurately specified or not relevant to the project.
 - Other _____
7. On low bid heavy/civil construction projects, when do you **discover** Construction Document Deficiencies? Please allocate the frequency utilizing a percentage for each construction phase. The sum of all answer choices needs to equal 100%.

Bidding Phase _____%

Pre-Construction _____%

Construction _____%

8. How often do you **share** the Construction Document Deficiencies with the owner during the **Construction Phase**? (select one)

- Always
- Almost Every Time
- Occasionally
- Rarely
- Never

9. How often do you **share** the Construction Document Deficiencies with the owner during the **Pre-Construction Phase**? (select one)

- Always
- Almost Every Time
- Occasionally
- Rarely
- Never

10. How often do you **share** the Construction Document Deficiencies with the owner during the **Bidding Phase**? (select one)

- Always
- Almost Every Time

- Occasionally
- Rarely
- Never

11. In terms of maximizing profit, when is the most **beneficial** time for your organization to **share** the Construction Document Deficiencies with the project owner? (select one)

- Before the low bid contract is executed.
- After the low bid contract is executed.
- The timing has no impact on profit.

12. Based on your experience, please estimate how often Construction Document Deficiencies result in an **increase** in the overall **contract price**? i.e. project change orders, a newly created authorized unit price, or time & material billings. (select one)

- 0%
- 1%-9%
- 10%-19%
- 20% to 29%
- 30% to 39%
- 40% to 49%
- 50% to 59%
- 60% to 69%
- 70% to 79%

- 80% to 89%
- Greater than 90%

13. Based on your experience, please estimate how often Construction Document Deficiencies result in an **increase** in the overall **project time** duration? (select one)

- 0%
- 1%-9%
- 10%-19%
- 20% to 29%
- 30% to 39%
- 40% to 49%
- 50% to 59%
- 60% to 69%
- 70% to 79%
- 80% to 89%
- Greater than 90%

14. Considering only your most recently completed low bid project, please select the statement that best describes Construction Document Deficiencies impact to the project **cost**. (select one)

- No Construction Document Deficiencies were discovered on my last project and it had no impact on the project cost.

- At least one Construction Document Deficiencies was discovered and it had **no** impact on project cost
- At least one Construction Document Deficiencies was discovered and it had an **impact** of \$1,000 to \$10,000 on the project cost.
- At least one Construction Document Deficiencies was discovered and it had a **major impact** of greater than \$10,000 on the project cost.

15. Considering only your most recently completed low bid project, please select the statement that best describes Construction Document Deficiencies impact to the project **time**. (select one)

- No Construction Document Deficiencies were discovered on my last project and it had no impact on the overall project time duration.
- At least one Construction Document Deficiencies was discovered and it had **no** impact on the overall project time duration.
- At least one Construction Document Deficiencies was discovered and it had an **impact** of 1 to 10 days on the overall project time duration.
- At least one Construction Document Deficiencies was discovered and it had a **major impact** of greater than 10 days on the overall project time duration.

16. Please indicate the extent to which you agree or disagree with the following statement. If Construction Document Deficiencies were shared and discussed between the project owner and the selected contractor prior to construction starting this would result in a potential project **cost** savings. (select one)

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

17. Please indicate the extent to which you agree or disagree with the following statement. If Construction Document Deficiencies were shared and discussed between the project owner and the selected contractor prior to construction starting this would result in a potential project **time** savings. (select one)

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

APPENDIX B

HEAVY/CIVIL PUBLIC PROJECT OWNER SURVEY

HEAVY/CIVIL PUBLIC PROJECT OWNER SURVEY

Overview:

The survey should take approximately 15 minutes to complete.

Please answer all questions based on your professional construction experience.

The study will examine construction document plan deficiencies on heavy/civil design-bid-build construction projects, where the contractor was selected based on a low bid procurement model. The purpose of this research is to improve the heavy/civil competitive price construction sector.

If you have any questions, please contact: Anthony.Pesek@asu.edu

Section #1: Heavy/Civil Construction

“Heavy/Civil Construction” is a category of construction that is comprised of projects related to site development and infrastructure type work. This includes construction projects such as earthwork, roads, highways, bridges, aviation, railway, and utilities.

1. Select your current role on heavy/civil low bid projects. (select one)
 - General Contractor
 - Subcontractor
 - Project Owner
 - Consultant to the Project Owner

2. How many years of experience in the heavy/civil construction sector do you have? (select one)
 - Less than 4 years
 - 5 to 9 years
 - 10 to 14 years
 - 15 to 19 years
 - 20 to 24 years

25 years or More

3. In which areas of heavy/civil construction do you have experience in? (select all that apply)

Earthwork

Mining

Roads & Highways

Bridges

Aviation

Railway

Marine

Water

Sewer

Energy

Communications

Other _____

4. What is your position at your current organization? (select one)

Project Manager

Site Superintendent

Field Operations

Estimator

Designer/Engineer

Quality Control

- Owner/Developer
- Division Manager
- President/Senior Executive
- Other_____

5. In which region of the United States did your low bid heavy/civil construction experiences occur in? (select all that apply)

- West
- Southwest
- Midwest
- Southeast
- Northeast

Section #2: Construction Document Plan Deficiencies

A “Construction Document Deficiency” is any error or omission within the construction drawings, documents, or specifications. This includes design plan inaccuracies, constructability issues, plan quantity discrepancies, project specification conflicts, or material applicability issues. A construction document deficiency may or may not result in an increase of time and/or cost to the original contract amount. The construction document deficiencies are commonly discovered in the phases detailed below.

Bidding Phase: The low bid contract has NOT been executed and the construction activities have NOT started.

Pre-Construction Phase: The low bid contract has been executed and the construction activities have NOT started.

Construction Phase: The low bid contract has been executed and construction activities have started.

6. Based on your professional experience, please indicate the three most common Construction Document Deficiencies on heavy/civil low bid projects. (select three)

- Design drawings containing plan errors, inaccuracies, and omissions.
- Quantity discrepancies with a substantial increase or decrease in the plan quantities.
- Constructability concerns where the plan drawings conflict with the actual field conditions.
- Construction material issues where the specified materials are not applicable or available for use.
- Pay items that have been omitted or wrongly specified in the contract
- Project specification provisions that are inaccurately specified or not relevant to the project.
- Other _____

7. On low bid heavy/civil construction projects, when do you **learn** of Construction Document Deficiencies? Please allocate the frequency utilizing a percentage for each construction phase. The sum of all answer choices needs to equal 100%.

Bidding Phase _____%

Pre-Construction _____%

Construction _____%

8. How often is **resolution** achieved for the Construction Document Deficiencies during the **Construction Phase**? (select one)

- Always
- Almost Every Time
- Occasionally
- Rarely
- Never

9. How often is **resolution** achieved for the Construction Document Deficiencies during the **Pre-Construction Phase**? (select one)

- Always
- Almost Every Time
- Occasionally
- Rarely
- Never

10. How often is **resolution** achieved for the Construction Document Deficiencies during the **Bidding Phase**? (select one)

- Always
- Almost Every Time
- Occasionally
- Rarely
- Never

11. In terms of maximizing project value, when is the most **beneficial** time for your organization to **learn** of the Construction Document Deficiencies? (select one)

- Before the low bid contract is executed with the project owner.
- After the low bid contract is executed with the project owner.
- The timing has no impact on project value.

12. Based on your experience, please estimate how often Construction Document Deficiencies result in an **increase** in the overall **contract price**? i.e. project change orders, a newly created authorized unit price, or time & material billings. (select one)

- 0%
- 1%-9%
- 10%-19%
- 20% to 29%
- 30% to 39%
- 40% to 49%
- 50% to 59%
- 60% to 69%
- 70% to 79%
- 80% to 89%
- Greater than 90%

13. Based on your experience, please estimate how often Construction Document Deficiencies result in an **increase** in the overall **project time** duration? (select one)

- 0%
- 1%-9%
- 10%-19%
- 20% to 29%
- 30% to 39%
- 40% to 49%
- 50% to 59%
- 60% to 69%
- 70% to 79%
- 80% to 89%
- Greater than 90%

14. Considering only your most recently completed low bid project, please select the statement that best describes Construction Document Deficiencies impact to the project **cost**. (select one)

- No Construction Document Deficiencies were discovered on my last project and it had no impact on the project cost.
- At least one Construction Document Deficiencies was discovered and it had **no** impact on project cost

- At least one Construction Document Deficiencies was discovered and it had an **impact** of \$1,000 to \$10,000 on the project cost.
- At least one Construction Document Deficiencies was discovered and it had a **major impact** of greater than \$10,000 on the project cost.

15. Considering only your most recently completed low bid project, please select the statement that best describes Construction Document Deficiencies impact to the project **time**. (select one)

- No Construction Document Deficiencies were discovered on my last project and it had no impact on the overall project time duration.
- At least one Construction Document Deficiencies was discovered and it had **no impact** on the overall project time duration.
- At least one Construction Document Deficiencies was discovered and it had an **impact** of 1 to 10 days on the overall project time duration.
- At least one Construction Document Deficiencies was discovered and it had a **major impact** of greater than 10 days on the overall project time duration.

16. Please indicate the extent to which you agree or disagree with the following statement. If Construction Document Deficiencies were shared and discussed between the project owner and the selected contractor prior to construction starting this would result in a potential project **cost** savings. (select one)

- Strongly agree
- Agree

- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

17. Please indicate the extent to which you agree or disagree with the following statement. If Construction Document Deficiencies were shared and discussed between the project owner and the selected contractor prior to construction starting this would result in a potential project **time** savings. (select one)

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

APPENDIX C
CONTRACTOR DOCUMENT REVIEW ASSESSMENT

PURPOSE

The objective of the Contractor Document Review Assessment (CDRA) is to identify document deficiencies contained within the project documents. A construction document deficiency is any error or omission in the construction drawings, documents, or specifications.

INSTRUCTIONS

As a potential contractor for this project, you are required to use this form to rate project documents in terms of issues related to design drawings, quantities, constructability, materials, contract pay items, project specifications, and any other categories you deem appropriate. On the following pages, please assign each of the categories one of the following ratings:

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

If you assign a category of “improvement needed” or “unsatisfactory” rating, please briefly explain the document deficiencies related to the category.

Project Contract: _____

Contractor: _____

1. Design Drawings

Design drawings are free of plan errors, inaccuracies, and omissions.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

2. Quantities

The quantities specified in the construction plan documents are not substantially higher or lower than the quantities I calculated in my takeoffs.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

Project Contract: _____

Contractor: _____

3. Constructability

The construction plan drawings and documents do not conflict with actual field conditions.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

4. Materials

The specified construction materials are applicable and available for use for this project.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

Project Contract: _____

Contractor: _____

5. Contract Pay Items

No pay items have been omitted or wrongly specified in the contract.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

6. Project Specification Provisions

Project specification provisions are accurately specified and relevant to the project.

- Meets expectations—no construction document deficiencies
- Improvement needed—minor inaccuracies
- Unsatisfactory—major inaccuracies

Explanation: _____

Project Contract: _____

Contractor: _____

7. Other

Please identify any document deficiencies not addressed on the previous pages.

Explanation: _____
