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# Trends in Quality Management Approaches to Design–Build Transportation Projects

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# Trends in Quality Management Approaches to Design–Build Transportation Projects

## **Abstract**

Beyond time and cost savings realized through alternative project delivery methods, the salient question has been whether project quality is degraded by either the speed of design and construction or the owner's loss of direct control. Decisions made in the early phases of a project create impacts that may not be evident until many years after the project commences operation. Research conducted 10 years ago showed that owners assumed the design–build team's qualifications automatically translated into design and construction quality. This study determined whether owners had changed their approach to quality management in design–build projects. Content analysis of 58 bid documents for design–build projects (\$13 billion aggregate contract value) issued between 1999 and 2013 by state departments of transportation (DOTs) revealed a noticeable shift in DOTs' dependence on qualifications. Most DOTs are now evaluating competing design–build teams' design and construction quality plans before the award. This finding indicates an increased focus on design quality requirements during the preaward stage and suggests that DOTs are recognizing the importance of design quality in the project's overall quality standard.

## **Disciplines**

Construction Engineering and Management | Transportation Engineering

## **Comments**

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## **QUALITY MANAGEMENT APPROACH TRENDS IN STATE DESIGN-BUILD TRANSPORTATION PROJECTS**

**Ghada M. Gad, Ph.D., Simon A. Adamtey, and Douglas D. Gransberg, Ph.D.**

### **Abstract**

During the 1990's, the transportation industry began experimenting with various forms of alternative project delivery methods. Beyond the documented time and cost savings realized, the salient question has been to determine if the quality is degraded by either the speed at which design and construction has to be completed or by the agency's loss of direct control over the design and construction process. Decisions made in the concept and feasibility phases of a project's life create impacts that may not be evident until many years after the completed project has been in operation. Based on a research conducted ten years ago, it was seen that owners assumed that the professional qualifications of the design-builder will automatically translate into design and construction quality. The aim of this paper is to determine if owners have changed the way they utilize approach quality management in their design-build (DB) projects. The paper reports the result of a content analysis of the Request for Proposals/Request for Qualifications (RFPs/RFQs) of 58 state departments of transportation (DOT) DB projects. The projects were advertised in two times frames; 29 RFPs/RFQs from year 1999 to 2004 and the other 29 from year 2008 to 2013 with an aggregate contract value of over \$13billion. Through the content analysis and the statistical analysis of the output, trends d directly relating to design and construction quality were identified. The study revealed that there has been a noticeable shift from dependence on qualifications over the past 10 years ago, to allowing design-builders the maximum amount of latitude to establish the quality of the project through its design details. The majority of state DOTs are now evaluating competing DB team design and construction quality plans before awarding the project. This indicates an increased in focus on design quality requirements at the pre-award stage and suggests that state DOTs are recognizing the importance of design quality as a means of setting the standard for the overall project quality.

### **Introduction**

Design-build (DB) is a project delivery method where a single entity executes both engineering and construction services. The design-builder may be a single integrated firm, a consortium, joint venture, or other organization. Thus, the fundamental element of DB delivery is that one entity assumes the primary responsibility for project design and construction, which is different from the traditional design-bid-build (DBB) approach where an owner contracts with different firms to perform design and construction services (Gransberg and Barton 2007) According to the Design-Build Institute of America (DBIA), the single contract between the owner and the DB team transforms the adversarial relationship between designers and contractors in DBB into a partnership r that fosters innovation, collaboration, and teamwork (Corey 2013). Dealing with a single entity decreases owners' administrative burden and allows them to focus on the project rather than managing separate contracts. This approach also reduces owner's risk and results in fewer litigation claims for all parties involved (Corey, 2013).

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DB project delivery's advantages led the private sector to increasingly use DB primarily on vertical buildings and has continued to rapidly expand into the 21st century. Interest in DB project delivery also started increasing gradually within the public sector where it was not only used in vertical projects but also in horizontal transportation projects (Transportation Design-Build Users Group, 2009). In 1990, the Federal Highway Administration (FHWA) established the Special Experimental Project Number 14 (SEP-14) – Innovative Contracting, to enable state transportation agencies to experiment with a variety of alternative project contracting methods (one of which was DB) that provided the potential to expedite highway projects in a more cost-effective manner, without jeopardizing product quality or contractor profitability. Between 1990 and 2002, about 300 projects representing \$14 billion were proposed for DB contracting under SEP-14 by transportation agencies in 32 states, the District of Columbia, and the Virgin Islands (FHWA, 2006). DB is now widely used in the transportation industry. Since the introduction of DB in the transportation industry, 47 state DOTs and Puerto Rico utilize this delivery method to execute projects (HNTB, 2013).

A study conducted by FHWA revealed that the majority of SEP-14 DB projects cost over \$100 million and included new construction, road widening, road rehabilitation or reconstruction, bridge and tunnel projects (FHWA, 2006). The Alaska DOT cited the opportunity for greater innovation and efficiencies between the designer and the builder compared to the DBB method as the reason for using DB project delivery method on its projects. It also indicated that it realized significant savings in project delivery time that could be realized by using DB.

Given documented DB time and cost savings, skeptics maintain that the salient question is whether the quality of the construction product is compromised by either the speed at which the DB project is delivered or by an agency loss of control over design details and the construction process (Gransberg & Molenaar, 2008). There are a number of variations on the DB procurement process but all involve three major components.

1. The DOT develops a Request for Qualifications/Request for Proposal (RFQ/RFP) that describes project's scope of work and its essential requirements.
2. The DOT then evaluates competing design-builders' proposals.
3. The DOT awards the contract based on the proposals' evaluation.

The RFP serves as the medium through which the DOT articulates its needs to the design-builder and expects the proposal to meet those requirements to be responsive. It is therefore critical to both the DOT and the design-builder that requirements for both design and construction quality be clearly communicated in the RFP, allowing the resultant proposals to be responsive to the DOT's needs as the cost, technical, and time constraints of the project permit (Gransberg & Windel, 2008).

Quality, time, and cost are the three elements that form the triangle of objectives of every project delivery method (Gransberg et al. 2013). In DB project delivery method, the owner requires the design-builder to produce quality of design and project to meet specific cost and schedule. The variable objective here is quality. It is therefore important to understand how DOTs are managing quality using DB project delivery method. As a continuation of previous study on owner's DB design and construction quality management approaches conducted by Gransberg and Molenaar (2004), this paper discusses the results of a study that investigated

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current trends of quality management approaches being utilized by DOTs to determine if DOTs have changed the way they articulate their approach to quality management of their DB projects.

### **Quality Management Approaches in Design-Build Projects**

With schedule and cost fixed, quality becomes the variable that DB firms must manage to achieve the necessary balance with the DB contract's budget and delivery period. The American Society of Quality defines quality as "the characteristics of a product or service that bears on its ability to satisfy stated or implied needs" (ASQ, 2008). The DB contract requires the design-builder to satisfy such 'needs'. To do so, the owner must first clearly express the 'need' for design and construction quality in a way the design-builder will understand. A FHWA (2006) study looked at over 300 DOT DB projects built under SEP-14 and found that DB project delivery results in an equal or higher level of quality than the traditional DBB method. However, the owner loses the checks and balances found in DBB when the designer-of-record who was the owner's construction quality advocate becomes a member of the DB contract team. (Lee & Arditi, 2006). The structural change in the contracting relationships implies an increased need to evaluate the DB team's proposed quality management process for guaranteeing design quality before the DB contract is awarded. Thus, owners may consider including performance requirements for design quality management process in their DB solicitation. Including giving some weight to the evaluation of the process in the project's best-value award formula.. This cues design-builders to prepare design quality management plans detailing their proposed process for each specific project which can be evaluated as a part of the selection process (Gransberg & Windel, Communicating Design Quality Requirements for Public Sector Design/Build Projects, 2008)

Essentially, the designer and the builder are contractually linked in the DB team as a single entity. The builder is, therefore, able to participate in the design process thereby enhancing the ability to compress project delivery period and also to produce a more constructable final design. In theory, constructability is virtually ensured by merely selecting DB as the project delivery method (Gransberg & Windel, 2008). However, constructability does not ensure that the quality requirements of the project will be met. The owner must make a conscious effort to establish the quality requirements during the design process.

In transportation, quality control (QC) and quality assurance (QA) are common measures in most design and construction activities. QC activities help the project team determine if quality standards are being met, while QA includes all planned and systematic actions necessary to provide confidence that a product will perform satisfactorily in service. According to a report by FHWA (2012), the transportation industry has moved away from the term QC/QA and now uses QA as a more global concept. A construction QA program consists of the following core elements: contractor QC, agency acceptance, independent assurance, dispute resolution, personnel qualification and laboratory accreditation/qualification. These core elements of QA apply regardless of the project delivery method (FHWA, 2012). However, every DB project is unique in quality requirements and there is the need to tailor the quality requirements to the specific needs of the project.

Studies done on how owners are approaching quality management in DB projects revealed that owners are addressing quality issues of DB projects with a DBB mentality (Gransberg & Molenaar, 2008). Existing quality management philosophies in DB contracts were

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originally developed for traditional DBB project delivery. Many owners, architects/engineers, and construction contractors still have not made the shift from a DBB culture to a DB contracting culture (Scott, Molenaar, & Gransberg, 2006). In 2004, Gransberg and Molenaar (2004) explored the quality management approaches used in DB proposals by conducting content analysis of 78 RFPs for public DB projects advertised between 1997 and 2002. The aim was to analyze how owners communicate their quality requirements and to provide guidance to help design-builders better base their proposals on the actual quality expectations as reflected in DB RFPs. The study concluded that owners were missing an opportunity to ensure the quality of a DB project by not asking for QM plans before they award the DB contract. The study also revealed that only in highway projects was there an apparent published concern for design quality and design QM (Gransberg & Molenaar, 2004). Almost 10 years after that study was published, this paper will explore current quality management approach trends of in DB projects and determine if DOTs have altered their quality management approaches.

### **Research Methodology**

The research involved content analysis of 58 DOT DB solicitation documents (RFPs/RFQs). The documents were collected from 22 different states. They were divided into two groups based on time periods so as to compare and identify the trends of how DOTs are approaching both design and construction quality in their solicitation documents. The first group consisted of 29 RFPs/RFQs from year 1999 to 2004 with an aggregate contract value of more than 4 billion dollars. Majority of these RFPs were advertised between year 2000 and 2004. The second group consisted of 29 RFPs from 2009 to 2013 with an aggregate contract value of more than 9.5 billion dollars. Majority of these RFPs were advertised in years 2011 and 2012. Content analysis of the documents was then conducted to identify the issues that directly relate to both design and construction quality that will be evaluated by the owner.

### **Content Analysis**

Content analysis is broadly defined as “any technique for making inferences by systematically and objectively identifying special characteristics of messages” (Hosti, 1968). It is used to develop “valid inferences from a message, written or visual, using a set of procedures” (Weber, 1985). The criteria of selection used in any given content analysis must be sufficiently exhaustive to account for each variation of message content and must be rigidly and consistently applied so that other researchers or readers looking at the same messages would obtain the same or comparable results. This may be considered a kind of reliability of the measures and a validation of eventual findings (Selltiz, Deutsch, & Cook, 1967).

Content analysis involves the interaction of two main processes; specification of the content characteristics (basic content elements) being examined and application of explicit rules for identifying and recording these characteristics. The categories into which the content items are coded vary according to the nature of the research and the particularities of the data (Holsti, 1969). One advantage of content analysis is that it provides a means by which to study processes that occur over long periods of time or that may reflect trends in a society (Babbie, 1998). Content analysis of RFP/RFQ documents was used in this study as it was well-suited in providing a means to capture the trends of quality management approaches adopted in bid documents over time.

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Content analysis of the RFPs was done by “first developing a set of standard categories into which words that appear in the DB procurement or policy document can be placed, then the method utilizes the frequency of their appearance as a means to infer the content of the document (Neuendorf, 2002). The standard categories are the quality plan requirements and quality management approaches. Spreadsheet matrices were developed to record and identify quality criteria requirements in both the design and construction phase. The categorization developed by Gransberg and Molenaar (2004) for quality management approaches and quality plans’ requirements was utilized to articulate the owner’s quality requirements. Table 1 below summarizes the quality management approaches and quality plan requirements.

**Table 1: Categorization of Quality Management Approaches & Quality Plan Requirements (adopted from Gransberg and Molenaar2004)**

<b>Quality Management Approaches</b>	<b>Quality Plan Requirements</b>
Quality by specification	Design quality in evaluation plan
Quality by evaluated program	Construction quality in evaluation plan
Quality by specified program	Quality plan in evaluation plan
Quality by qualifications	Quality qualifications in evaluation plan
Quality by performance criteria	Design quality plan required
Quality by warranty	Construction quality plan required

These quality management approaches are explained as follows:

- *Quality by qualifications*: The RFP requires past performance and/or personnel qualifications that indicate the owner is concerned about the qualifications of the DB team. It is vague or silent on specific requirements for a DB QM program.
- *Quality by evaluated program*: The RFP requires the design-builder to submit a proposed QM program of its own design in the proposal, and the owner competitively evaluates it.
- *Quality by specified program*: The RFP requires the design-builder to submit a proposed QM program that complies with an owner-specified program in the proposal, and the owner verifies this compliance.
- *Quality by performance criteria*: The RFP requires the design-builder to submit a proposed technical solution that is responsive to owner-furnished technical performance criteria, and the owner competitively evaluates it.
- *Quality by specification*: The RFP requires the design-builder to submit proposed technical solutions that were responsive to the owner’s prescriptive technical specifications, and the owner verifies this compliance during the design submittal process.
- *Quality by warranty*: The RFP requires some type of performance warranty or maintenance bond

The final step was to synthesize the results and draw conclusions from the analyses.

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### Results and Analysis

Both descriptive and inferential statistics were used to analyze the data. The descriptive statistics included counting and finding the sum of quality plan requirements and quality management approaches in the RFPs, and bar graphs to compare the trend in the quality management approaches in the two year groups. The inferential statistics involved hypothesis testing using Pearson Chi-Square Test to determine if there has been a statistically significant change in trend in the quality management approaches adopted by owners.

#### Group 1 (1999-2004)

Types of construction projects in this group included new construction and resurfacing of highway/interstate, rails, road improvements, tunnels, and other horizontal construction such as fiber optic network and pavement improvements. Some road improvement projects included the installation of traffic lights and renovation of existing toll facilities. The largest project in terms of cost was a freeway road and building in Utah (\$1.5 billion). Table 2 presents the data summary of group 1.

**Table 2: Summary of Group 1 (year 1999 through 2004)**

Project type	No. of RFPs	Owners (DOTs)
Highway	20	Florida, Minnesota, North Carolina, Utah, Washington
Rail	3	Colorado, Nevada
Tunnel	1	Utah
Other horizontal	5	Florida, Indiana, Utah, Virginia, New York
<b>Total</b>	<b>29</b>	<b>10 DOTs</b>

#### Group 2 (2009-2013)

Types of construction projects in this group ranged from road/highway and bridge construction to railway construction. There were projects that involved widening of road and corridor improvements, and some rock fall mitigation. Other horizontal construction included parking facilities and pavement improvements. The largest project in terms of cost was Caltrans high speed rail project advertised by the California DOT. Table 3 presents the data summary of group 2.

**Table 3: Summary of Group 2 (year 2009 through 2013)**

Project type	No. of RFPs	Owners (DOTs)
Highways	11	California, Florida, Minnesota, North Carolina, Idaho, Kansas, Ohio, Kentucky, Virginia
Bridge	13	Delaware, Ohio, Maine, Vermont, Mississippi, Tennessee, Minnesota, Missouri, Washington
Rail	2	California, Florida
Other horizontal	3	Delaware, Montana
<b>Total</b>	<b>29</b>	<b>17 State DOTs</b>

The results of the content analysis groups are shown in Table 4, which includes the owners' RFP requirements for quality and the requirements for post-award review and approval

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of quality-related plans. It is seen in Group 1 that the majority of the RFPs (18 out of 29) evaluated the quality-related qualifications of the design-builder before awarding the contract. The importance of this qualification to owners was evident in the heavy score (around 20%) that was normally assigned to it in the evaluation criteria. However, 11 of the proposals did not request quality-related qualifications, and 19 did not evaluate the quality plans of the design-builder before award of the contract. Even if owners rely on post-award quality plans from the design-builder, this could generate many issues in situations where the submitted quality plans do not meet the expressed quality requirements in the RFP. It is clear from Table 4 that the requirement and evaluation of a design quality plan was not one of the important factors considered by owners, as only seven RFPs evaluated design quality management. However, several studies have proven that design quality affects the overall quality performance of the project (Fynes & De Burca, 2005).

Group 2, on the other hand, found that 21 of 29 projects requested a design quality plan before award. Also, 22 of 29 also requested a construction quality plan. Post-award, design quality plans was required in six projects while construction quality plans were asked for in 14 projects (Table 4).

**Table 4: Quality Evaluation Requirements by Groups**

<b>Quality Evaluation Requirement</b>	<b>Group 1: 1999-2004</b>	<b>Group 2: 2009-2013</b>
Design quality in evaluation plan	7	21
Construction quality in evaluation plan	8	22
Quality plan in evaluation plan	10	10
Quality qualifications in evaluation plan	18	13
Design quality plan required	9	6
Construction quality plan required	12	14

Table 5 presents the owners' approaches used to articulate quality in the RFPs. In Group 1 the majority of the RFPs (16 out of 29) used the "quality by qualification" approach. These DOTs depend on previous or past performance and the personnel qualifications of the DB team to bring "quality" to the project. The second most popular approach is "quality by specified program" where owners provide their own programs in the RFP and require the design-builder to submit a quality plan that complies with the owner-specified program. It is worth stating that all the RFPs reviewed had one or more quality approaches.

**Table 5: Quality Management Approaches by Groups**

<b>Quality Management Approach</b>	<b>Group 1: 1999-2004</b>	<b>Group 2: 2009-2013</b>
Quality by specification	2	2
Quality by evaluated program	7	21
Quality by specified program	10	12
Quality by qualifications	16	13
Quality by performance criteria	3	7

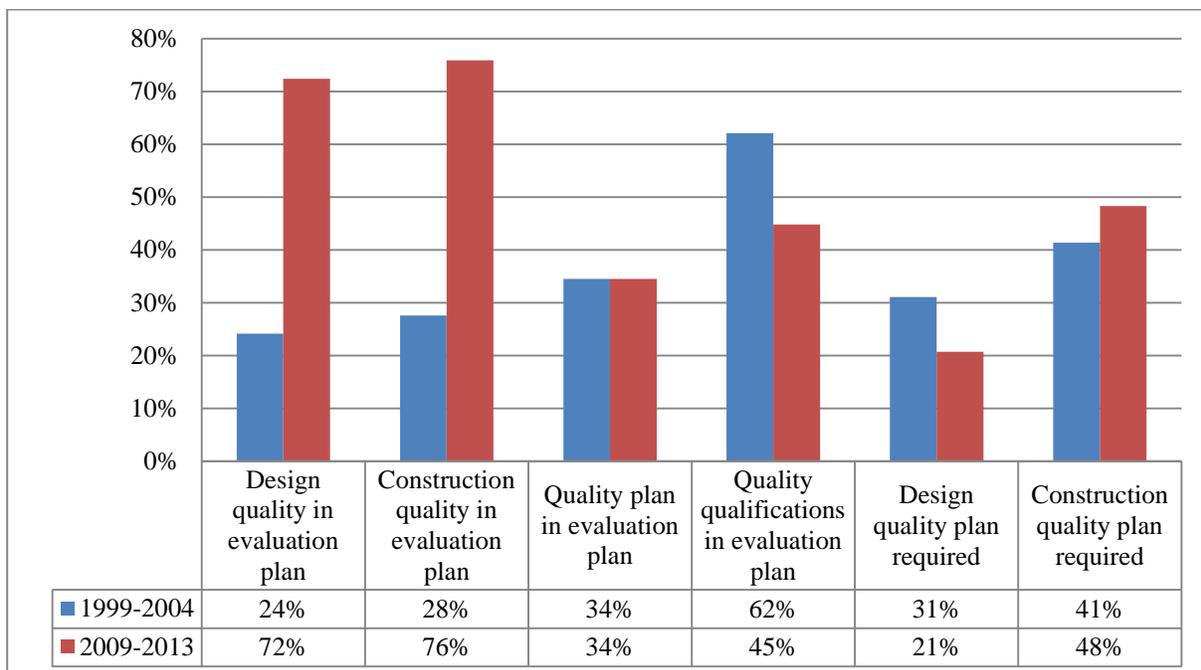
Quality by warranty	5	5
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For Group 2, the majority of the RFPs (21 out of 29) used “quality by evaluated program” approach. In these RFPs, the owner is giving the design-builder the opportunity to submit a quality management of its own design in the proposal. The design-builder then establishes the project’s quality through the details of the design. The second most popular approach is “quality by qualifications”. Past experience relating to quality and qualifications of the DB team are still considered valuable by owners. Quality by specified program is the third most common approach used by owners) followed by quality by performance criteria the least commonly used approach is the quality by specification .

### Comparison of Trends

Figures 1 and 2 show the comparison of trends of quality evaluation requirements and quality management approaches respectively. For quality evaluation requirements, the comparison shows that:

- Design quality in the evaluation plan has nearly tripled from 2004 to 2013;
- Construction quality in evaluation plan has also increased threefold from 2004 to 2013; and
- Quality plan in evaluation, quality qualifications in evaluation, design quality plan required, and construction quality plan required showed a slight difference.
- 

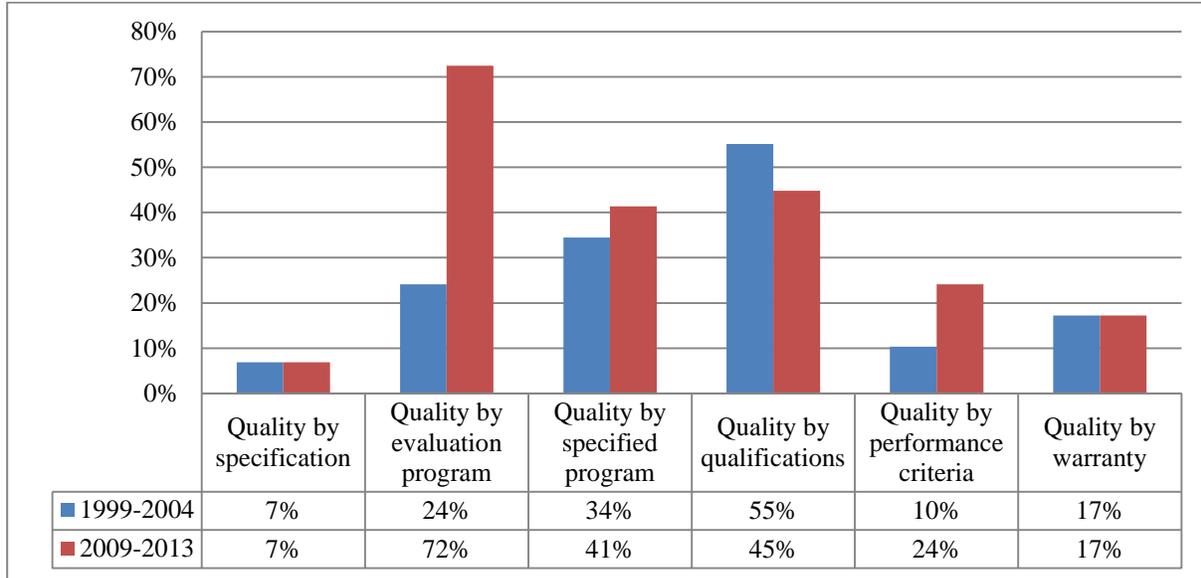


**Figure 1: Comparison of trends of quality evaluation requirements**

As for quality management approaches, the comparison reveals that:

- Quality by evaluated program increased nearly tripled from 2004 to 2013;

- There is a slight increase in quality by specified program and quality by performance criteria; and a slight decrease in quality by qualification.



**Figure 2: Comparison of trends of quality management approaches**

A statistical analysis was conducted using Pearson Chi-Square Test to identify and confirm trends found in the data. The Pearson Chi-Square Test is a statistical method that can be used both as test of goodness-of fit and as a test of independence (McDonald, 2009). As a test of independence, it is used to determine whether two categorical variables are associated with each other (Runyon, Coleman, & Pittenger, 2002). Thus, the Pearson Chi-Square Test of independence was used to determine if there has been a significant change in quality evaluation requirement trends and quality management approaches from 2004 to 2013.

The hypothesis tested was:

$H_o$ : There is no difference in quality evaluation requirements and management approaches between Group 1 (1999-2004) and Group 2 (2009-2013).

$H_a$ : There is a difference in quality evaluation requirements and management approaches between Group1 (1999-2004) and Group 2 (2009-2013).

As can be seen from Table 6 below, there are only two statistically significant quality evaluation requirements.

- Design quality in evaluation plan ( $\chi^2 = 13.53, p=0.00$ ). Since  $p < 0.05$ , the null hypothesis is rejected. There is, therefore, a statistically significant difference in design quality in evaluation plan between Group 1 (1999-2004) and Group 2 (2009-2013).
- Construction quality in evaluation plan ( $\chi^2 = 13.53, p = 0.00$ ). Since  $p < 0.05$ , the null hypothesis is rejected. There is, therefore, a statistically significant difference in

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construction quality in evaluation plan between Group 1 (1999-2004) and Group 2 (2009-2013).

**Table 6: Summary of Chi-Square Test**

<b>Quality Evaluation Requirements</b>	<b>Chi-Squared (<math>\chi^2</math>)</b>	<b>Significance (<math>p</math>)</b>
Design quality in evaluation plan	13.53	0.00
Construction quality in evaluation plan	13.53	0.00
Quality plan in evaluation plan	0.00	1.00
Quality qualifications in evaluation plan	1.73	0.18
Design quality plan required	0.80	0.36
Construction quality plan required	0.27	0.59
<b>Quality Management Approaches</b>		
Quality by specification	0.00	1.00
Quality by evaluation program	13.53	0.00
Quality by specified program	0.29	0.58
Quality by qualifications	0.62	0.43
Quality by performance criteria	1.93	0.16
Quality by warranty	0.00	1.00

Only one quality management approach is statistically significant as shown in Table 6:

- Quality by evaluated program ( $\chi^2 = 13.53$ ,  $p = 0.00$ ). Since  $p < 0.05$ , the null hypothesis is rejected. There is, therefore, a statistically significant difference in quality by evaluated program between Group 1 (1999-2004) and Group 2 (2009-2013).

## Conclusions

The paper discusses the investigation of current trends in quality management approaches in DOT DB projects. via the content analysis of 58 solicitation documents from DOT DB projects issued between 1999 and 2013. The documents were divided into two groups based on the time frame the project was advertised. The comparison of the two sets of documents yields several conclusions.

The primary finding was that DOTs have shifted their emphasis from the evaluation of qualifications to the evaluation of quality management plans in DB project. The largest change was seen in the requirement for the submission and evaluation of design quality management plans, which infers that The increase in focus on that DOTs have become more cognizant of the importance of design quality of the contractual mechanism to set overall project quality standards. Additionally, the study finds that DOTs are relying more on quality by evaluated program as their primary approach to DB quality management. This trend infers that as DOTs gained DB experience over the past decade, they became comfortable giving design-builders the more latitude to establish project quality through the details of the design. The comfort level is the result of including a rigorous evaluation of competing design-builders' quality management plans. Roughly 50% of the RFPs analyzed in this paper required submission of both quality

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management plan and quality management. qualifications for evaluation before award. It is worth stating that even at the early stages of inception of DB in the transportation industry, state DOTs employed multiple quality management approaches in their RFPs. With DB project delivery, the owner has options to achieve quality that are different from those available in traditional DBB project delivery method. Thus, it appears that DOTs are availing themselves of the opportunities available to manage quality in the DB project delivery.

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