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Challenges and Strategies Incorporated with Transportation Construction Inspection

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ABSTRACT

The number of transportation construction projects has increased in the U.S. over the past several decades, and inspection challenges have increased proportionally or at an even higher rate. Therefore, it is important to identify these challenges and to offer appropriate inspection strategies to avoid project failures. In this study, the challenges of transportation construction inspections were identified, and strategies for tackling these challenges were proposed. Several national U.S. inspection documents, peer-reviewed papers, and other types of publications were thoroughly reviewed, and the potential inspection challenges of transportation projects were identified. Then, the management strategies that lead to effective inspection processes and successful projects were identified. The results of this study demonstrated that the current practices for the inspection of transportation construction projects need to be thoroughly reviewed and improved upon. The list of potential inspection challenges and management strategies determined by this research can assist project managers and inspectors allocate resources to transportation construction activities more efficiently and achieve higher productivity rates.

INTRODUCTION

Inspection planning is a vital part of the construction management system; however, the current practice is based on the engineers' and project manager's judgment. Interest is growing in how to achieve a systematic and organized inspection procedure during construction projects.

During the last decade, the U.S. Department of Transportation (DOT) increased its budget drastically, which enabled them to invest more money in construction projects (Mostafavi et al., 2013). DOTs have faced significant challenges in inspection, specifically in the construction sector, where the challenges relative to testing and inspection increase due to the increasing number of projects. The need to determine and implement what actions are needed to reduce such challenges and complete projects within the scope and schedule agreed upon (Chelsea et al., 2009), has stimulated project managers' interest in finding solutions to reduce the challenges.

Several researches have focused on inspection challenges. DOTs are exploring more effective methods in order to manage the testing and measurement of workloads (Chelsea et al., 2009). Sommer et al. (1993) reviewed the requirements for bridge inspections and through an optimization procedure proposed probability-based inspection strategies for bridges. Jagars-Cohen et al. (2009) suggested development of a checklist to prioritize various activities relative to construction and inspection elements, which would lead to appropriate resource allocation for the inspection in construction of the critical infrastructures.

The inspection in construction projects needs prioritization in order to minimize the risks due to reduced inspections and insufficient resources (Mostafavi et al., 2013). Some of the strategies that deal with inspection challenges include increasing inspection responsibilities of contractors,

inspections outsourcing to contractors, creating training programs (Kermanshachi and Safapour, 2020), and specifications modifications in order to lessen the time-intensive measurements. Summarizing the best practices of the state DOTs that have already implemented successful programs to reduce the challenges of inspection and that could potentially assist other DOTs to address specific inspection challenges is required. In addition, implementing new technologies and productive project management are two of the best-known practices for managing inspection challenges (Valdes and Perdomo, 2013).

Based on the literature, there is a lack of mobile applications specifically designed for usage by DOTs (Taylor et al., 2013), as well as limited studies on implementation of new technologies in large-scale construction projects. Some of such technologies include mobile devices and cloud-based data management applications. Several studies indicated that modern technologies can help improve the productivity in construction projects by replacing the paper-based method for inspection data collecting (Bowden et al., 2005; Asbahan and DiGirolamo, 2012). However, implementing these tools and new technologies always include challenges in construction projects (Erdogan et al., 2008; Dossick and Sakagami, 2008). In addition, adopting these technologies has led to a high rate of failures in organizations (Kotter, 1995; Burnes and Jackson, 2011). Yamaura et al. (2019) studied the process of organizational change in the Washington State DOT (WSDOT) through a research program in which they implemented an inspection application based on a cloud-based mobile system to 18 engineering offices. A combination of electronic and manual methods for collecting inspection data in DOT projects are implemented (Shah et al., 2017). The electronic methods normally would be used for the purpose of storing and managing data; however, personnel working in the field generally collect information using traditional paper-based method (Shah et al., 2017; Taylor et al., 2013). According to the increasing complexity of infrastructure projects (Warne, 2003; Mostafavi et al., 2013), DOTs are looking for appropriate methods in order to achieve more efficient operations, including for inspection of the projects.

Even though many DOTs have implemented different strategies to mitigate inspection challenges, many of them remain unsolved. In addition, these challenges and controlling strategies have been untold, and have not been documented properly This paper presents a list of the important inspection challenges that were identified, and proposes strategies to address them. A comprehensive literature review was conducted, and the current state of DOT inspection challenges and management strategies were identified. The results of this paper will help project managers identify, prevent, and manage the potential inspection challenges of construction projects, and will be a valuable resource of common potential construction inspection challenges.

RESEARCH METHODOLOGY

The approach of this research was to produce a detailed and systematic recording of inspection challenges and suggested solutions. This research included six main steps. In the first step, a thorough literature review was conducted on inspections and their relevant challenges (preliminary search). The search was conducted through databases including Science Direct, EBSCO Host, Scopus, etc. The search was comprehensively conducted to collect as many publications as possible related to construction inspection and the corresponding management strategies. In step two, secondary search, the duplicates were removed from the initially created database. Third, the peer-reviewed publications were included and the rest were removed from the database. In step four, the publications that were not related to the subject were removed by reviewing the title and abstract of the papers from one hand and searching the gathered

publications by a different set of keywords. In step five, the final database was studied in detail and the list of potential challenges in inspection of construction procedure was identified. In step six, management strategies were collected from the literature. Figure 1 shows the schematic methodology implemented in this study.

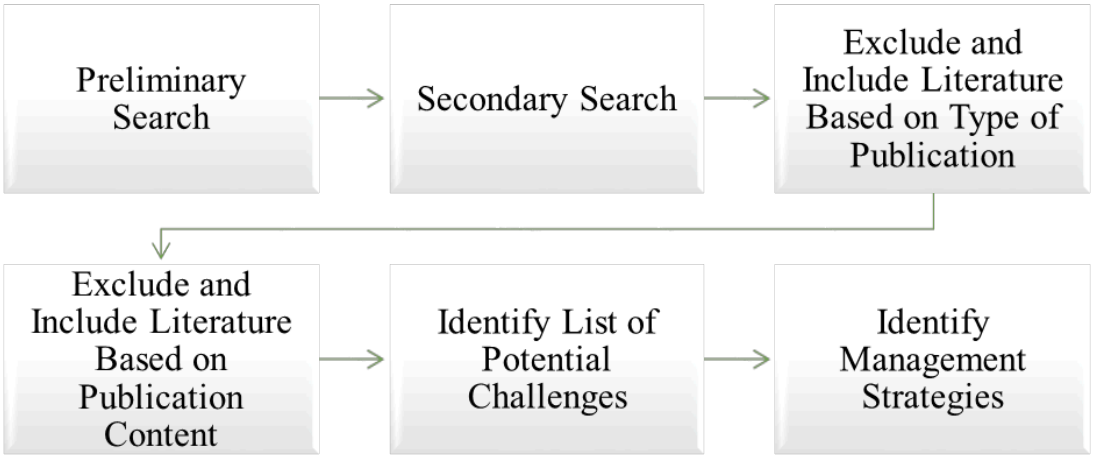

Figure 1. Research methodology

IDENTIFICATION OF POTENTIAL INSPECTION CHALLENGES

Fourteen potential inspection challenges were recognized via the review of the literature. Table 1 shows the list of collected challenges. These challenges are discussed in the following.

Table 1. List of Collected Potential Inspection Challenges

#	Potential Challenge
1	Lack of enough number of specialized inspectors
2	Lack of documenting the inspection process
3	Lessons learned are not collected from the experienced inspectors
4	Lack of appropriate training programs, specifically for the new inspectors
5	Outsourcing the inspection leads to doubling the work
6	Lack of appropriate quality assurance procedure
7	Lack of new technologies including the applications and software
8	Difficulties in acceptance of new technologies by the inspectors
9	Change orders cause delays in the process
10	Change order approval process is so time-consuming
11	Each office follows its own rules for change order management
12	Providing utility power to the project location would be a big challenge
13	Lack of safety control check-list
14	Using papers for ticketing and communications makes the process time-consuming and inefficient

Lack of an adequate number of specialized inspectors

A limited number of field skilled workers causes major challenges in construction projects including cost overruns and schedule delays (Habibi and Kermanshachi, 2018). The limitation related to available resources for inspection can be described by considering that (1) the

inspectors who are experienced are retired, (2) the experienced inspectors move to private sector, and (3) lack of enough trainings for green inspectors (Martin 2001). One of the challenges most of the literature mentioned was an insufficient number of inspectors to dedicate to the projects (Park and Kim, 2013). This is due to two main reasons. First, the DOT's policy is to outsource the projects and inspections so that they need to hire a smaller number of experts (Yusuf and O'Connell, 2014).

Lack of documenting the inspection process and lessons learned

Documentation was mentioned as an appropriate means of avoiding conflicts and messing up the process of any project (Kermanshachi et al., 2016; Safapour et al. 2019), including inspections (Le et al., 2014). Thus, having the managers and the other staff document every single communication, report, etc. would be of great help to the inspection to progress, in a positive and less challenging manner (Phares et al., 2004).

The lessons learned from previous works are not gathered (Banlasan, 2015). The conducted reviews showed that useful information, based on inspectors' experience, needs to be systematically collected and organized for later use and further analysis (Smallwood et al., 2016).

Lack of appropriate training programs, specifically for new inspectors

Even though many of the inspectors take training courses, the reviews showed that more courses and workshops should be required for all of the staff – both new and experienced (Le et al., 2014). It was reported that many of the training programs are held in locations far from their offices, making it difficult for inspectors to attend the classes.

Outsourcing the inspection leads to doubling the work

Challenges have been created by outsourcing inspection in important projects were performed by state DOT forces previously. The main challenge of outsourcing might be due to the weakness of the contractor selected for the assigned work, which, at minimum, leads to delays and possibly even doubling the project time and increasing the project's budget.

Lack of appropriate quality assurance procedures

Based on our findings from the literature, there is not a predefined step-by-step procedure for project quality assurance when the project is completed. Although quality control has a major impact on schedule performance of construction projects (Kermanshachi et al., 2017), this process is performed based on the inspector's and PM's experience, which might cause conflicts and further issues. Since safety control is one of the most important responsibilities of the inspectors, it is important to have a checklist, so that no items is overlooked.

Lack of new Technologies and their corresponding issues

New technologies and software for inspection purposes are not implemented or even partially used in some cases (Guo et al., 2012; Park and Kim, 2013). Even though there may be some opposition to this change, the long-term benefits of implementing such features would increase the productivity and reliability of the inspection (Guo et al., 2012). Training programs will help the staff to get familiar with these technologies quickly, and project control would be both easier

and more accurate when using e-construction (Nourbakhsh et al., 2012). As mentioned, it is difficult for inspectors, especially the highly experienced ones, to accept new technologies (Matthews et al., 2015). While releasing payments, challenges arise between the DOTs and contractors due to missing tickets. Using traditional ticketing for material delivery and paper reporting leads to such conflicts (Nipa et al., 2019). In addition, other new technologies such as automated pavement condition assessment technology reduce inspectors' daily activities and increase the reliability of the achieved results (Aslan et al., 2019).

Change orders and their corresponding issues

According to the literature, many of the inspectors experience delays due to change orders in their projects (Assaf and Al-Hejji, 2006). The essence of the change orders leads to delays (Yazdani et al., 2012; Safapour et al., 2018; Kermanshachi and Rouhanizadeh, 2019), so this problem must be considered when scheduling. In addition, change orders were recognized as one of the most important challenges. According to the literature, the process for change order approvals is time-consuming and leads to excessive delays in the project's completion (Kermanshachi et al., 2018). Furthermore, change order management is not based on predefined guidelines or rules; thus, development of a standard that considers all of the experiences from previous projects would be helpful.

Providing utility power to the project location would be a big challenge

One common challenge mentioned in the literature was providing utility power to project sites (Ko and Li, 2014). Sometimes, this takes more than the normal amount of time and energy and causes delay of the entire progress of the project and inspections.

IDENTIFICATION OF MANAGEMENT STRATEGIES

Management strategies were collected from the literature to lessen the inspection challenges. The list of these strategies is shown in Table 2. In the following, some of these strategies are discussed.

It is widely suggested to conduct inspections in construction projects at a consistent time interval to facilitate project planning (Shah et al., 2017). The inspection intervals should be selected accurately to minimize the costs due to inspection, failure, and repair (Ko and Li, 2014). This would lead to decrease in the costs in structures with large number of similar components. In addition, generating a standard procedure according to the experience of DOTs experts from different levels could be a good solution to achieve a united and reliable method for project approval. Another important strategy would be conducting online classes that might be a useful solution for difficulties attending training courses or workshops (Kermanshachi et al., 2018).

Collecting and sharing the lessons learned through a pre-defined procedure and shared at least through the staff of each office to enhance their productivity and avoid repetition (Jagars-Cohen et al., 2009). For example, apart from the solutions to lessen the negative effects of change orders, the idea of collecting lessons learned from change order experiences could be so useful for later projects (Nourbakhsh et al., 2012). One solution to reduce the change order approval time is to make use of automation to collect the required approvals as fast as possible (Assaf and Al-Hejji, 2006). For this purpose, required appliances such as scanner, printer, etc. should be provided as well. The list of collected management strategies is presented in Table 2.

Table 2. List of Recommended Strategies

#	STRATEGY
1	Implement electronic documentation and moving toward e-construction.
2	Collected and share the lessons learned
3	Have alternative online and/or video-based courses.
4	Employ tested contractors should be selected for the projects.
5	Generate a standard procedure based on the experience of DOTs experts.
6	Hold training programs.
7	Use automation to collect the required approvals as fast as possible.
8	Establish good coordination with utility responsible in any location.
9	Develop one comprehensive safety control check-list.
10	Implement E-ticketing.
11	Outsource the entire project to one testing technician.
12	Completely outsource low-risk projects.
13	Develop a thorough concrete quality control program.
14	Decrease the number of measuring items for pay.
15	Decrease the specification items.
16	Outsource the inspection to a contractor.
17	Evaluate the basic knowledge and construction specifications of the contractors.

Another recommended strategy would be developing a thorough concrete quality control program and have contractors to perform the majority of the tests to save DOTs inspectors' time (Mostafavi et al., 2013). Also, since there is not a checklist for safety control purpose, collecting all the experiences in this area and developing one comprehensive safety control check-list is highly recommended. In addition, outsourcing low-risk projects, such as curb and landscaping (Warne, 2003; Gross and Jovanis, 2008), so that DOTs inspectors can focus on high-risk projects. Outsourcing the project to one technician is also suggested. This technician will be asked to manage and conduct all required on-site tests to avoid multiple technicians doing the tests, which leads to reducing the efficiency of the operations (Arnold et al., 2013).

A good coordination and agreement with utility responsible in any location could reduce delays and other corresponding losses due to utility providing challenge. Tested contractors should be selected for the projects (Gross and Jovanis, 2008). On the other hand, practical guidelines for the contractors can be developed to follow during the project in order to avoid any deviation from the project scope and goal (Anderson et al., 2016). Electronic documentation and moving toward e-construction and making use of its various features, such as e-ticketing, could be a complementary action to this requirement (Fuller et al., 2019). E-ticketing, as an important feature of e-construction is suggested to avoid challenge due to traditional ticketing and increase the productivity (Nipa et al., 2019). Holding training programs helps the staff to get familiar with new technologies quickly (Valdes and Perdomo, 2013). In addition, it was recommended to decrease measuring pay items to decrease the time spent by inspectors on measuring for the payment.

CONCLUSION

In this study, a thorough literature review was conducted on construction inspection

challenges and the corresponding management strategies. The results revealed to 14 major challenges that can affect the inspection and consequently the progress of a project. One of the most important of these challenges was change orders and their corresponding effects on the time and costs of a project. The lack of checklists for safety control, and project approval procedures are other important inspection challenges that were noted in the literature. To control such challenges, 17 strategies were collected through the reviews. Of those strategies, implementing e-construction, project and inspection outsourcing, holding training programs, and collecting the lessons learned from previous experiences were found to be the most important. The results of this study can help project managers and inspectors organize inspections more insightfully, and prioritize their resources and inspection staff in a rational and productive manner.

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