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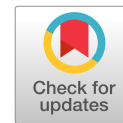
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Administering Change Orders in Highway Projects

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Abstract: Change orders continue to be one of the main challenges faced by the construction industry. Despite many previous research efforts related to managing change orders in the construction industry, there is still a lack of research that investigates the contractual aspects of change orders for transportation projects. This paper tackles this knowledge gap within the context of Ohio Department of Transportation (ODOT) highway projects. To this end, the authors used an integrated research method comprised of (1) selection and analysis of ODOT case studies; (2) identification of the main change orders aspects that lead to conflicts, claims, and/or disputes in the considered case studies; and (3) analysis of the contractual provisions and procedures related to change orders on ODOT projects. The authors consulted throughout all the research steps with ODOT experts for verification and validation. Through the analysis of 10 ODOT case studies, results show that the major contractual challenges related to change orders on ODOT projects are caused by definition terms and their associated processes, approvals according to the contractual provisions, and approvals in light of the applicable laws. Accordingly, this paper identifies (1) a list of opportunities and risks, and (2) a series of checklist questions. These research outcomes shall help project parties in identifying the contract terms that can lead to improper handling of change orders, and thus facilitate better managing of change orders on ODOT projects. Ultimately, this research adds to the body of knowledge by providing contractual guidelines to facilitate a better administration of the contractual procedures of change orders for a timely and cost-effective execution of highway transportation projects. DOI: 10.1061/(ASCE)LA.1943-4170.0000528.

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Introduction

The construction industry is considered a complex sector (Assaad et al. 2020a), with change orders continuing to be one of the main issues it faces. In fact, it is reported that around 40% of all projects in the construction industry experience more than 10% change (Ibbs 2012). In the United States, around USD 60 billion are spent annually on change orders (Akhavian and Behzadan 2012).

Moreover, change orders are considered among the main reasons behind extension of time, which could result in cost overruns as well (El-adaway et al. 2016a). If not properly managed, change orders could lead to detrimental effects on the relationship between the contracting parties and could ultimately result in disputes (Alnuaimi et al. 2010).

According to Arcadis (2019), the following are three main causes for construction disputes: (1) owner/contractor/subcontractor inability to understand and/or comply with contractual obligations; (2) errors and/or omissions in the contract document; and (3) failure to properly administer the contract. These three main causes of construction disputes could lead to change orders and can ultimately be managed by following proper contract administration. This conforms with the views of Colin et al. (1996), Cheung and Yiu (2006), Abotaleb and El-adaway (2017), and Ahmed et al. (2021), who also attribute construction disputes to poor contract administration. According to Arcadis (2019), construction disputes were estimated to possess a value of USD 16.3 million and an average dispute length of 15.2 months in North America. Such sizable delays and monetary amounts could be minimized or avoided through proper contract administration (Kitt 2015).

The global spending on infrastructure projects is anticipated to be more than USD 53 trillion between 2010 and 2030 (US Department of Commerce 2020). The US Census Bureau assessed that spending in public construction in 2021 is estimated to be USD 353 billion, with transportation projects being a major sector of the public infrastructure spending (US Census Bureau 2021). According to the ASCE Infrastructure Report Card (ASCE 2021), America's infrastructure possesses an overall grade of C−, which falls within the mediocre rating interval, and America's roads have an overall grade of D, which falls within the poor rating interval.

To meet US infrastructure needs, the federal government spent approximately USD 29 billion on infrastructure projects and transferred USD 67 billion to states for enhancing their infrastructure (USA Facts 2020). Recently, the US president signed a five-year \$1.2 trillion infrastructure bill into law. This infrastructure bill

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constitutes the largest investment in the US infrastructure in nearly a century (Walpole 2021). In general, DOTs in the United States play an important role in constructing and managing public infrastructure and transportation projects.

However, the infrastructure sector topped the list of construction disputes in 2018 (Arcadis 2019). More specifically, infrastructure projects in the United States face substantial issues related to change orders. For instance, a research report by the Kentucky Transportation Center (KTC 2010) highlighted that change orders are the main reason for schedule and cost overruns within public transportation projects. Taylor et al. (2012) reported that 61% of new US highway construction projects suffered from contract-omission change orders of various sizes. Choi et al. (2015) reported that change orders contributed to schedule and cost changes of up to 243% and 140%, respectively, for US highway improvement projects. To this end, proper management of change orders is vital to avoid cost and schedule overruns, minimize the associated disputes, and facilitate the successful execution of infrastructure and transportation projects.

Highway Infrastructure in Ohio

With an estimated value of transportation infrastructure projects of USD 115 billion, the Ohio Department of Transportation (ODOT) is responsible for maintaining the fourth largest interstate system, second largest inventory of bridges, and sixth highest number of vehicle-miles traveled in the nation (Advisory Committee on Transportation Infrastructure 2019). In Ohio, there are approximately 122,987 mi of public roads, with 17% in poor condition (ASCE 2021). According to the Federal Highway Administration (FHWA), the annual vehicle-miles traveled by the functional system in Ohio are considered among the highest in the Midwest (FHWA 2017). ODOT assigned USD 11.1 billion for rehabilitation and new transportation projects for the period spanning from 2020 to 2023 (Rovan 2019) including 10 projects in 2020 with a cost of around USD 400 million (Carey 2020).

Nevertheless, ODOT is expected to not only run out of money for new projects but also to fall behind on regular maintenance and preservation of existing roads due to adverse fiscal development as well as increased spending (Advisory Committee on Transportation Infrastructure 2019). According to ODOT, a project that would have a cost of about USD 110,000 per lane-mile could easily cost USD 335,000 per lane-mile in 5–6 years (Advisory Committee on Transportation Infrastructure 2019). Under these extremely tough conditions, it is projected that change orders would constitute approximately 5% of the annual overall cost of ODOT projects (ODOT 2020). Furthermore, Carey (2020) highlighted with the current COVID-19 pandemic, ODOT projects may witness delays leading to the occurrence of more change orders in the future. In addition, KTC (2010) highlighted that while ODOT is considered to have very detailed procedures for handling change orders compared to other states, ODOT infrastructure projects are still witnessing issues related to the management of change orders. All aforementioned reasons justify considering ODOT as a case study for investigating change orders and their procedures under their projects.

Research Goal, Objectives, and Questions

The goal of this paper is to provide contractual guidelines to facilitate better contract administration of change orders on highway transportation projects. To this end, the associated objectives of this research are to (1) better understand the change order provisions under the

standard specifications for highway transportation projects managed by ODOT, and (2) provide guidance on the proper change order procedures that would (a) directly benefit contractors working on highway transportation projects funded by ODOT, and (b) indirectly benefit contractors working on projects for other DOTs that share similar characteristics. Ultimately, this study shall help in the proper management and administration of change orders to facilitate successful completion of highway transportation projects.

To this end, in this study, the case is the contractual management and administration of change orders on highway transportation projects. The unit of analysis is the change orders' contractual aspects and procedures of ODOT and its applicable laws. Within the context of ODOT highway transportation projects, the associated research questions include the following:

- What are the contractual issues related to change orders?
- What are the main contractual aspects associated with change orders that lead to conflicts, claims, or disputes?
- How do the contractual documents address the identified change order aspects? And what are the interrelated opportunities and risks for the contracting parties?

Literature Review

This section presents previous research studies on change orders and highlights the knowledge gap.

Previous Research Works Related to Change Orders

Previous research efforts that focused on studying change orders in the construction industry can be categorized into the following three categories: (1) research studying the contractual provisions and main causes of change orders, (2) research investigating the impacts associated with change orders, and (3) research investigating and developing methods and models for handling change orders.

Studies on the Contractual Provisions and Causes of Change Orders

In regard to previous research work that studied the contractual provisions and causes of change orders, Cox et al. (1999) found the main reasons for design change orders include omission in a contract's documents by the designer, differing site conditions, changes by client, and coordination errors in contract documents. Hsieh et al. (2004) found that planning and design are the main source of change orders in metropolitan public projects in Taiwan. Anastasopoulos et al. (2010) discovered that contract duration and contract award amount are the most significant factors affecting change orders frequency. Taylor et al. (2012) revealed proper front-end planning and clearer project scope can significantly minimize change orders on highway projects. It is noticeable that while the aforementioned studies highlighted contract-related causes of change orders, they did not focus on investigating the associated contractual provisions. In that regard, El-adaway et al. (2016b) conducted a comparative analysis between the change order provisions under standard forms of contract, namely, the American Institute of Architects (AIA), ConsensusDocs, the Engineers Joint Contract Documents Committee (EJCDC), the International Federation of Consulting Engineers (FIDIC), the World Bank, the Joint Contracts Tribunal (JCT), and the New Engineering Contract (NEC). It was concluded that NEC, which is used for many construction and engineering projects in the UK and overseas, is considered the most flexible contract for arrival at the associated cost with change orders because it is adjusted after a series of offers and counteroffers between project stakeholders (El-adaway et al. 2016b). In spite of the valuable findings of this study, it did not cover the contractual provisions and procedures

implemented by DOTs for managing change orders on highway transportation projects in the United States.

Studies on the Impacts of Change Orders

In regard to the research work that studied the impacts associated with change orders, Moselhi et al. (2005) developed a neural network model for quantifying the impact of change orders on labor productivity in the construction industry. Serag et al. (2010) created a statistical model, which concluded that timing of the change order is among the most significant variables that affect the impact of change order on cost overrun. Likhitruangsilp et al. (2018) developed a system based on building information modeling (BIM) to study the impacts of change orders, related to physical conditions, schedule, and budget, on construction projects. In addition, Shrestha and Maharjan (2019) studied the impacts of change orders on cost and schedule performance of small low-bid highway projects using a data of 615 small highway design-bid-build projects under Florida DOT. Fathi et al. (2020) studied change orders and schedule performance differences in highway and water and wastewater projects using data from 53 design-build highway projects and 44 design-build water and wastewater projects. Kim et al. (2020) conducted statistical analysis indicating that change orders due to unforeseen existing conditions have substantial cost impacts compared with those caused by other reasons. Generally, all previous research concluded the existence of substantial negative impacts caused by change orders on the project cost and duration. Such impact differs based on project type, project delivery method, level of initial planning and scope clarity, and the methodology followed for handling the change orders. Moreover, it is noticeable that the aforementioned previous research studies focused on applying statistical techniques to investigate the impact of change orders on various project performance metrics; mainly, schedule and cost.

Studies on Methods and Models to Handle Change Orders

In regard to the research work that investigated and developed methods and models for handling change orders, Chen and Hsu (2007) utilized artificial intelligence techniques for solving of disputes and lawsuits caused by change orders in construction projects. Also, Cheng et al. (2015) developed an evolutionary fuzzy-support vector machine inference model (EFSIM) to predict productivity loss resulted from change orders in the construction industry. In addition, Hanna and Iskandar (2017) developed a statistical regression model to predict the cumulative impact of change orders on productivity using data of 68 electrical and mechanical construction projects. Most recently, Noruwa et al. (2020) concluded that utilization of emerging technologies such as virtual reality (VR), drones, and BIM can help in preventing or minimizing the occurrence of change orders. That said, it can be noticed that the aforementioned research studies focused on utilizing statistical and artificial intelligence techniques for proposing methods and models to better manage change orders; however, none focused on investigating change order-related contractual aspects and procedures for further enhanced management of change orders.

Knowledge Gap

In light of the preceding information, despite the aforementioned valuable research efforts related to change orders, the majority of studies focused on utilizing statistical, modeling, and artificial intelligence techniques to study and investigate change orders, their causes, and their associated impacts on the construction industry. In addition, KTC (2010) stated that despite the existence of an extensive amount of research that examined the causes of change orders, the majority of research has focused on industrial and commercial construction projects. Moreover, Hsieh et al. (2004) emphasized

that the undesirable consequences associated with change orders can be minimized or avoided through proper understanding of the contractual mechanism and procedures of handling change orders. Furthermore, Anastasopoulos et al. (2010) highlighted that although previous studies offered valuable insights on the administration of change orders, there still exists a crucial need for further investigation. Recently, Khalafallah and Shalaby (2019) stated that problems caused by change orders in public infrastructure projects create a critical need for practical methods that enable public agencies to analyze and review the characteristics of change orders to minimize their negative impacts. That said, there is a clear need for research studies that focus on the contract administration aspect of change orders within the context of highway transportation projects. This paper fills this knowledge gap and critical research need.

Research Method

Overview

The authors used an integrated research method comprised of multiple steps as depicted in Fig. 1. The authors consulted throughout all the followed steps with a group of experts from the ODOT construction administration department. In general, the construction administration department within ODOT is responsible for providing expertise in construction project monitoring, specifications, and administration, including management and processing of change orders on highway transportation projects. To this end, the consulted group of ODOT experts constituted three individuals: (1) construction administration administrator; (2) controlling board, claims, and dispute resolution coordinator; and (3) change orders and specification coordinator. This group of experts have an average experience of 30 years in construction and contract administration with around 24 years of experience with ODOT operations specifically. Moreover, they are the main individuals responsible for the management of change orders within ODOT projects. That said, the ODOT experts were consulted for verification of the followed research steps (i.e., including selection of ODOT projects, identifying aspects of change orders, and analysis of contractual provisions) and validation of the developed research outcomes (i.e., including charts and tables). To this end, communications with ODOT experts were conducted through online interviews and phone discussions as well as emails.

Research Steps

The following subsections provide all necessary details related to the steps of the research method.

Step 1: Selection and Analysis of ODOT Case Studies

The first step is the selection and analysis of ODOT case studies. This step aims to address the first research question through analyzing ODOT case studies for identification of major issues related to changes orders faced on ODOT projects. For that purpose, the authors followed two procedures for selection of ODOT case studies: (1) keyword search, and (2) consultation with ODOT experts.

In the first procedure, the authors conducted a keyword search for information extraction from the following well-known search engines for law cases: Google, Google Scholar, the Casetext website, and the Westlaw website. The conducted keyword search included the following words: Ohio Department of Transportation, ODOT, change order, variation order, change management, claim, conflict, and dispute. Also, the conducted keyword search was not limited for a specific period in order to include all possible cases considering the extreme limitations regarding the public availability

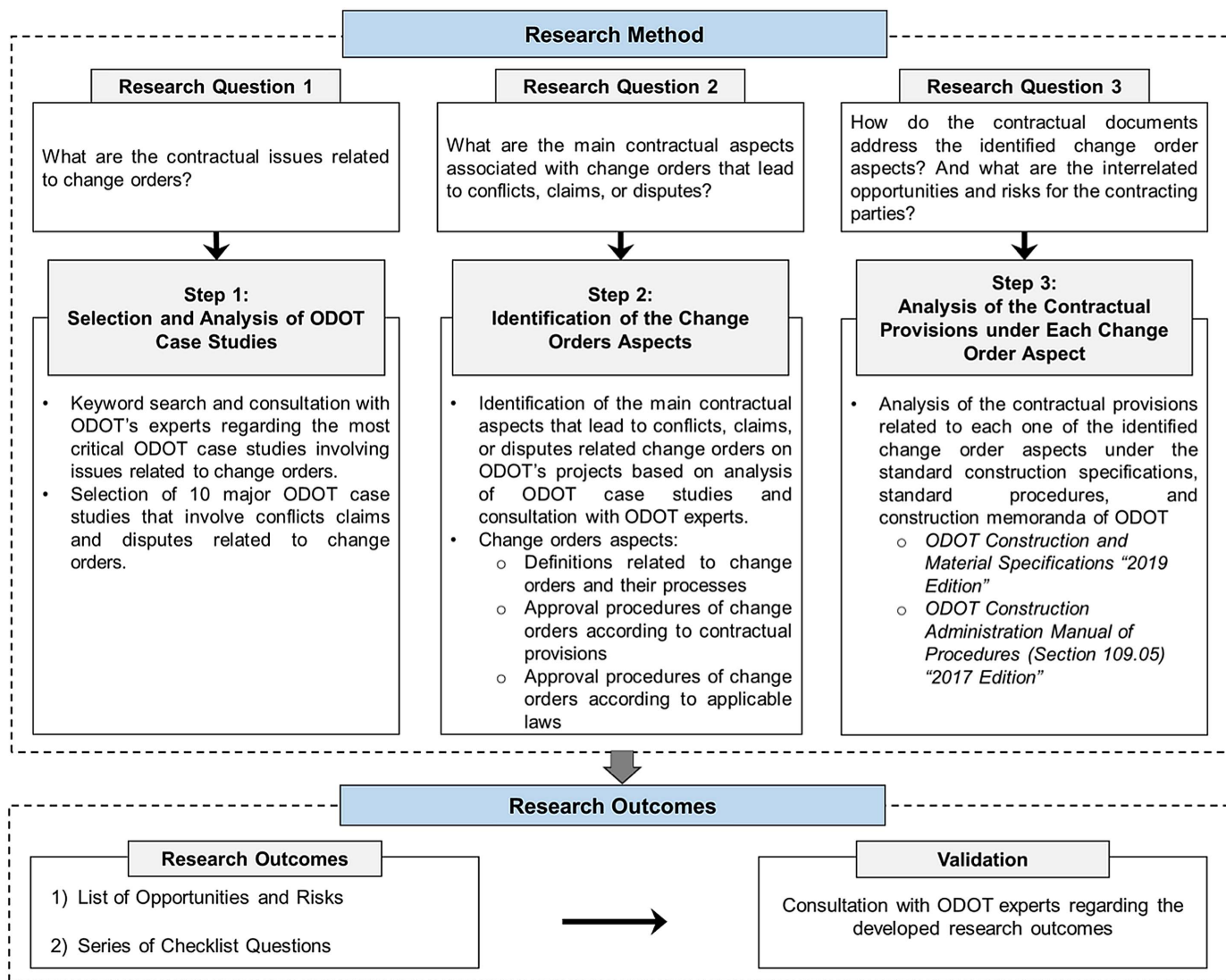


Fig. 1. Research method and outcomes.

of such information. However, this keyword search was conducted in 2020 (the time of conducting this study). The authors also studied and analyzed each law case in order to identify the main cause(s) of conflict, claim, or dispute as related to change orders. The authors targeted law cases that (1) were managed through ODOT, and (2) reflected a point of conflict, claim, and/or dispute as related to change orders' contractual aspects and procedures of ODOT and/or applicable laws.

In the second procedure, the authors consulted with ODOT experts regarding the most critical project cases that involved issues related to change orders. The authors did not provide limits or boundaries to the experts in relation to the period for project cases under consideration. The main reason is to better facilitate acquiring as many of the critical change orders cases within ODOT projects as possible, which in turn should aid in ensuring the comprehensiveness of the study. As such, the ODOT experts provided preliminary information about 10 project cases that are considered in their opinion as being the most critical ODOT project cases involving various issues related to change orders. Further, the authors (1) collected all data related to each ODOT project case from ODOT databases, and (2) studied and analyzed the collected data related to each ODOT project case in order to identify the main cause(s) of conflicts, claims,

or disputes as related to change orders. Similar to the first procedure, the authors considered only project cases that reflected a point of conflict, claim, and/or dispute as related to change orders' contractual aspects and procedures of ODOT and/or applicable laws. Fig. 2 summarizes all the steps followed in the selection and screening of ODOT case studies in this paper.

As such, the authors considered 10 ODOT case studies in this paper: two law cases and eight project cases (one related to contractual provisions and seven related to applicable laws). The authors had no prior knowledge of these ODOT case studies (either law cases or project cases). Further, there was no bias or conflict of interest because (1) the ODOT case studies were collected from two different sources, as highlighted in Fig. 2; (2) the identified aspects were verified for their comprehensiveness and relevance in considering major contractual aspects related to change orders; and (3) the consulted group of ODOT experts had no interest in reaching any specific outcome.

That said, the main aim of the investigated ODOT case studies is to provide insights on the contractual issues related to change orders that may arise between the contractual parties on ODOT highway transportation projects. In addition, 10 case studies are considered a reasonable number compared to previous research

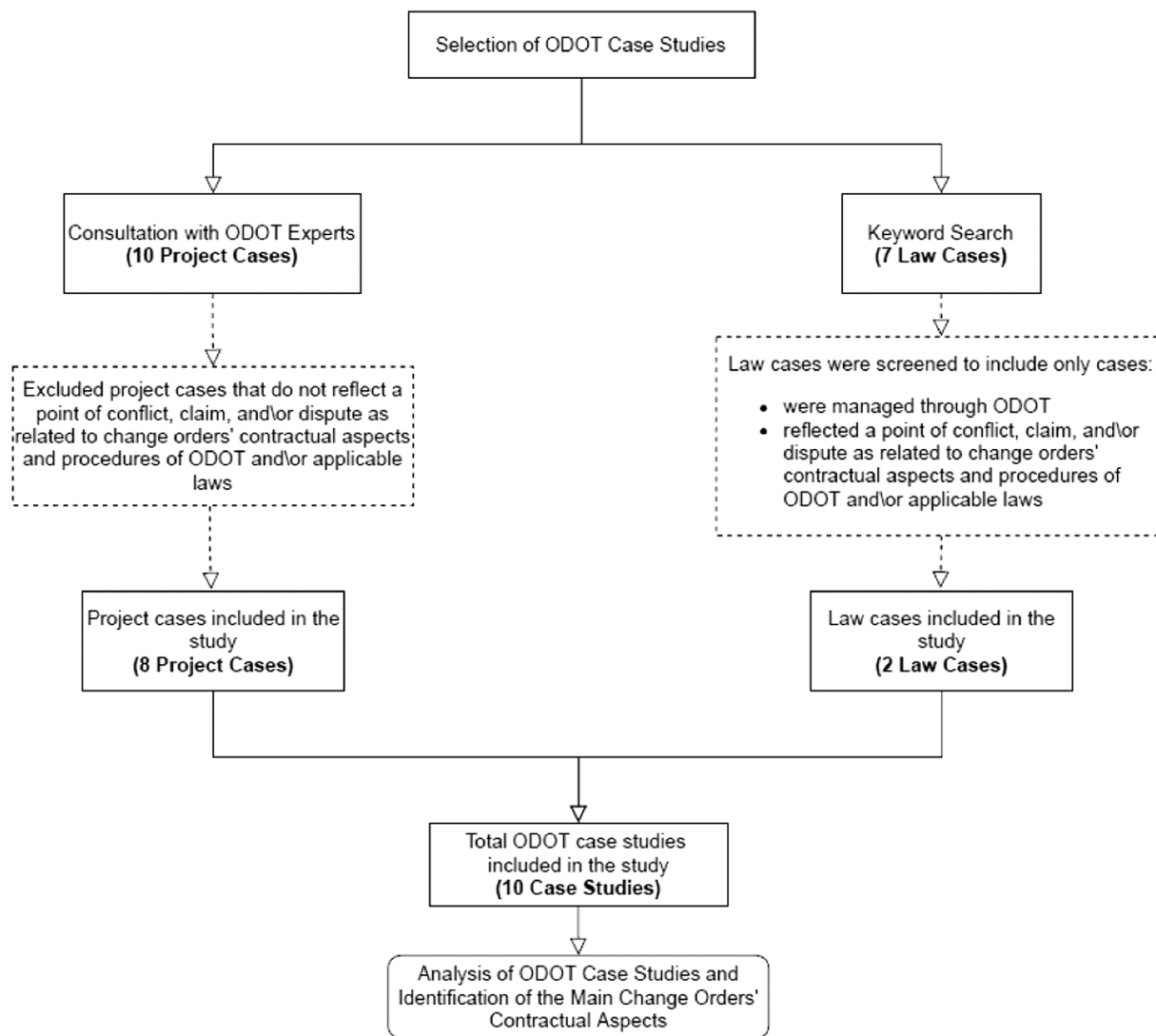


Fig. 2. Steps for selection and screening of ODOT case studies.

efforts that utilized similar research approaches of reviewing case studies for studying contract language of different construction documents. For instance, Maemura et al. (2018) analyzed five case studies in the investigation of the root causes of recurring contractual conflicts in international construction projects; Khalef et al. (2020) considered 16 case studies in analysis of the risk allocation process according to exculpatory clauses under commonly used US standard forms of construction contracts; and Assaad et al. (2020b) analyzed six case studies for studying the commercial and legal considerations of offsite construction projects.

Step 2: Identification of the Change Orders Aspects

The second step is the identification of the main contractual aspects that lead to conflict-, claim-, or dispute-related change orders on ODOT highway transportation projects. This step aims to address the second research question. In other words, upon analysis of the considered 10 ODOT case studies in this study as per Step 1, the authors identified the contractual issues related to changes orders faced on ODOT projects. However, these identified contractual issues are specific to the considered case studies (e.g., misunderstanding of what constitutes extra work in the case of *Tony Zumbo and Son Construction Co. v. Ohio Department of Transportation*,

which will be explained subsequently). Further in this step, the authors generalized these contractual issues and identified the main corresponding change orders' contractual aspects and procedures of ODOT and/or applicable laws before consulting with ODOT experts.

As highlighted in Table 1, the following three major change order aspects were identified to be of relevance of ODOT projects: definition terms and their associated processes, approvals according to the contractual provisions, and approvals in light of the applicable laws. There was similarity between Law Case 2 and Project Case 3, as shown in Table 1. However, the similarity is not on the incidents/disputes that happened within each case, it is on how the incidents/disputes are related to the same main change orders' contractual aspect and procedure of ODOT.

Further, the authors consulted with ODOT experts about the identified aspects who verified their comprehensiveness and relevance of these aspects in the sense that they lead to the major contractual change order-related challenges encountered on ODOT projects. In addition, ODOT experts emphasized that a good understanding of these three aspects is essential to facilitate proper management and administration of change orders within ODOT highway transportation projects. To this end, there was no bias or conflict of interest

Table 1. ODOT case studies and associated change order aspects

No.	ODOT case study	Type of case study	Associated change order aspect
1	<i>Tony Zumbo and Son Construction Co. v. Ohio Department of Transportation</i>	Law case	Definitions related to change orders and their processes
2	<i>Complete General Construction Company v. Ohio Department of Transportation</i>	Law case	Approval procedures according to contractual provisions
3	Contract ID 180538 ^a	Project case	Approval procedures in light of the applicable laws
4	Contract ID 190328 ^a	Project case	
5	Contract ID 140536 ^a	Project case	
6	Contract ID 188012 ^a	Project case	
7	Contract ID 110628 ^a	Project case	
8	Contract ID 100281 ^a	Project case	
9	Contract ID 113003 ^a	Project case	
10	Contract ID 110168 ^a	Project case	

^aPseudonyms used are for confidentiality in relation to the identities of the contractors.

because (1) the ODOT case studies were collected from two different sources, as highlighted in Fig. 2; (2) the identified aspects were verified for their comprehensiveness and relevance in considering major contractual aspects related to change orders; and (3) the consulted group of ODOT experts had no interest in reaching any specific outcome.

Step 3: Analysis of the Contractual Provisions under Each Change Order Aspect

The third step is the analysis of the contractual provisions related to each of the identified change order aspects under the standard construction specifications, standard procedures, and construction memoranda of ODOT. This step aims to address the third research question. In conducting this step, the authors reviewed the document titled *Construction and Material Specifications*, developed by ODOT, which includes general requirements and contractual provisions related to materials and construction of ODOT highway transportation projects (ODOT 2019). The authors focused on all contractual provisions and procedures related to the approval of change orders and their associated compensation considerations. The authors also reviewed the document titled *Construction Administration Manual of Procedures*, Section 109.05, developed by ODOT, which details the procedures by which all change orders must be managed and administered as well as the circumstances under which change orders are permitted on ODOT highway transportation projects according to applicable laws (ODOT 2017).

Research Outcomes

Based on the research method and associated steps, this research provides two main outcomes. First, the authors identified a list of opportunities and risks associated with ODOT procedures for the management of change orders based on case studies and contract analysis. Second, the authors provided, based on case studies and contract analysis, a contractual checklist—in the form of a list of questions—that the contracting parties shall consider in order to avoid any ambiguity and ensure the development of clearly defined contract documents in regard to change orders. That said, these two research outcomes were based on the dual analysis of ODOT case studies as well as ODOT contractual provisions and procedures for the proper management of change orders. To validate the developed research outcomes in this paper, the authors consulted with ODOT experts to ensure that the paper's recommendations and findings are useful, novel, and applicable to actual ODOT highway transportation projects for better management and mitigation of change orders. All details pertaining to the validation of the research outcomes are provided in the "Validation of the Research Outcomes" section.

Results and Analysis

Definitions Related to Change Orders and Their Processes

Motivating Case Study

The case study of *Tony Zumbo and Son Construction Co. (TZSC) v. Ohio Department of Transportation* highlights an issue related to the definitions of change orders and their procedures occurring between the contracting parties in highway transportation projects. ODOT contracted TZSC for grading, draining, widening, and resurfacing of approximately 1.5 mi of Wilson Mills Road in Mayfield in Cuyahoga County. During execution, TZSC encountered unsuitable conditions of the existing pavement, and consequently found that it was functionally adequate to remove the existing road and construct a new one. This is considered a major change to the work of TZSC; hence, a major change order was prepared. TZSC and ODOT did not reach an agreement on the compensation amount that shall be made for this additional work. This agreement was not possible due to the diverging opinions of the contracting parties on the definitions related to change orders and their procedures. However, TZSC proceeded with the work and received payments according to the issued change orders by ODOT, which was less than that claimed by TZSC. As such, the remaining amounts were a matter of dispute between the parties, which was taken to the court. As stated by the Ohio Court of Claims, because the additional work constitutes extra work and the parties failed to reach a mutual agreement on the compensation amount, the additional work should have been entirely issued on a force account basis. Therefore, the project parties were not well informed on the definitions and difference between change orders and extra work as well as on changes issued on a force account basis. More specifically, this misunderstanding of the definitions contributed to disputes between ODOT and TZSC including (1) discrepancy between the contractual parties on what constitutes fair and equitable compensation for such extra work, and (2) nonimplementation of the force account provisions by the contractual parties, although it was stipulated by the ODOT standard document for *Construction and Material Specifications* and its basic definitions related to change orders. As such, this case study highlights the importance of the contractors and ODOT representatives fully understanding and being aware of the definitions related to change orders and their procedures according to ODOT's *Construction and Material Specifications*. That said, the following subsection presents the main definitions related to change orders and their processes for highway transportation projects funded by ODOT.

Table 2. Contract limits

Original contract price	Contract limits
USD 500,000 or lower	USD 25,000
USD 500,001 to USD 2,000,000	5% of total contract price
Over USD 2,000,000	USD 100,000

Source: Data from ODOT (2019).

Provisions of ODOT

Under ODOT (2019), a change order is defined as “a written order issued by the Director to the Contractor, covering changes to the terms and conditions, plans and/or quantities, within or beyond the scope of the contract and establishing the basis of payment and time adjustments for the work affected by the changes.” Furthermore, ODOT (2019) states that the term *significant change* applies when “the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction, or when the product of the quantity in excess of the estimated quantity of a contract item and the unit price exceeds contract limits.” The contract limits are given in Table 2.

Moreover, ODOT (2019) defines extra work as “an item of work not provided in the contract as awarded but found essential to the satisfactory completion of the contract within its intended scope.” Extra work contract is considered to be the contract related to the performance of the extra work, which may be performed as per agreed prices or on a force account basis. That said, the term *force account* refers to the payment method utilized when the contractor and ODOT are not able to agree, similar to the aforementioned case study, on a unit price or lump sum amount, corresponding to extra work, or if either of these methods are impracticable. In addition, in estimating compensation for equipment costs, ODOT refers to FHWA’s Blue Book, which is considered a comprehensive guide for estimation of construction equipment-related ownership and operating costs (Equipment Watch 2020). Moreover, ODOT (2019) introduces the term *quantity underrun* in case of a change order with decrease in quantity of the original contract, and it applies when “the estimated quantity of a contract item exceeds four units, the decrease in quantity of any unit price contract item exceeds 25 percent of the estimated quantity, and the total of all such adjustments for all contract items is more than USD 400.” Furthermore, ODOT (2019) defines *fringe benefits* as the actual costs paid to workers for health and welfare benefits, pension fund benefit, or other benefits, when such benefits are required by prevailing wage laws, collective bargaining agreement, or other applicable employment contracts.

Approval Procedures According to Contractual Provisions

Motivating Case Studies

The case study of *Complete General Construction Company (CGCC) v. Ohio Department of Transportation* provides a good example of claims and disputes occurring between contracting parties in relation to the contractual approval procedure of change orders. This case study was the construction of a highway project that was divided into five portions. ODOT contracted CGCC for the construction of four portions of the project. On one of these four project portions, disputes arose between the parties due to an unsettled claim related to the contractual approval procedures of change orders. More specifically, the claim was to recover idle equipment costs, extended equipment costs, additional bond costs, and unabsorbed overhead costs, as well as interest corresponding to these

costs. ODOT agreed to pay a partial amount for unabsorbed overhead costs, bond costs, and interest through a change order. The remaining amounts were a matter of dispute between CGCC and ODOT. The main concerns of the dispute were related to the contractual approval procedures including (1) the method or formula for calculation of unabsorbed overhead costs, (2) recovery of idle equipment costs, (3) extended equipment costs and associated lost opportunity costs, and (4) interest associated with the additional incurred costs.

Another case study of ODOT happened in 2019 as related to ODOT’s Contract ID 180538, which is a USD 11.02 million highway transportation project in Defiance County, Ohio. The project comprised replacing the Clinton Street bridge over the Maumee River, reconstructing approaches and surrounding streets, constructing a shared use path on the north bank of the Maumee River, constructing aesthetic lookouts over the river, and performing all related work. While executing the project, the contractor ran into unknown building foundations and unknown utilities, which added a significant amount of time and extra work to complete. The cost to complete this work was unknown, and thus the work was performed on a force account basis. After ODOT received all required force account records from the contractor, the cost of this work was estimated to be USD 346,350, approximately, as per the change order report. This change order is considered a significant change order as per ODOT experts with its sole value constituting a significant percentage, around 3.1%, of the original contract amount. As highlighted by ODOT experts, understanding the approval procedure of change orders under a force account basis and full awareness of the required reports and documents to be prepared and submitted is essential for contractors as well as ODOT employees to ensure proper handling of such change orders and issuing the precise amount of compensation. As such, the presented case studies highlight the importance of understanding the approval procedures of change orders as per contractual provisions. The following subsection analyzes the approval procedure of change orders and the associated compensation considerations under ODOT contractual provisions stipulated by its *Construction and Material Specifications*.

Provisions of ODOT

According to ODOT (2019), the department has full authority and right to revise the contract documents, increase or decrease quantities, and alter work to achieve satisfactory completion of the project, at any time, without invalidating the contract or releasing its surety. Such authority is subject to the limitation that such revisions must be directed to the contractor in writing. Therefore, contractors shall not perform any change or extra work until receiving a written direction from the engineer in order to not fall prey to rejection of their claims for reimbursement of any incurred costs or delays. That said, ODOT (2019) refers to the engineer as “the duly authorized agent of the Department acting within the scope of its authority for purposed of engineering and administration of the contract.” Moreover, under ODOT (2019), the contractor is entitled for payment with a change order, if the department revises the contract under one of the following clauses of *Construction and Material Specifications* of ODOT: (1) Revisions to the contract documents that are necessary for project completion, which can be general revisions, due to differing site conditions, suspension or delay of work by the engineer, significant changes in character of the work, eliminated items, extra work, or unilateral authority to pay; (2) co-operation with utilities; (3) inspection of work; (4) haul roads; (5) protection and restoration of property; (6) opening sections of project to traffic; (7) contractor’s responsibility for work; (8) termination of the contract for convenience of the department; (9) directed acceleration; and (10) unrecoverable costs.

According to ODOT (2019), for reimbursement to the contractor for any change or extra work, there are three methods: (1) original contract unit price, (2) negotiated prices (such as agreed unit price or agreed lump sum price), and (3) force account basis. Before introducing the guidelines for those methods, it is imperative to highlight the compensation shall constitute the payment in full for all change or extra work, completed by original contract price, agreed unit price, agreed lump sum price, or under a force account basis, including "Administration, Superintendence, Project and field office overhead, Home office overhead, Use of tools and equipment for which no rental is allowed, Profit, Taxes other than sales tax, and Premiums on insurance . . . excluding pollution and railroad General Liability Insurance" (ODOT 2019). The first payment method, original contract unit price, applies when the change is not considered to be a significant change. Such change is considered a minor change and the department will pay for it as per the original contract unit price. Moreover, in case of quantity underrun, the engineer shall adjust the original contract unit prices after obtaining quantities for the affected contract items at the end of the project by multiplying them by a factor as per the contract documents based on percentage of decrease. Payment for quantity underrun items will be as per the adjusted contract unit prices under the second payment method, negotiated prices, which applies when the change is considered to be a significant change. The engineer and the contractor shall negotiate and agree on lump sum prices, or unit prices. As per ODOT (2019), contractors shall submit their proposed prices and cost analysis for the change or extra work within 5 business days after the request of the department, and the department shall respond to the contractor's submittal within 5 business days, unless both the contractor and department agree on other time limits. Following any of the aforementioned methods, and in case the department and contractor failed to agree on price adjustments, the engineer can direct the contractor to perform the change or extra work under a force account basis.

Under the third payment method, force account basis, which occurs in case of disagreement between the department and contractor on pricing of the change or extra work, the contractor must submit a proposal and estimated costs. Then, in order to obtain full compensation for the performed work, contractor shall prepare a daily force account record of utilized labor, equipment, and materials, and then submit itemized statements to the engineer for review and approval. Failure to do so can make the contractor lose full or part of the compensation for the performed work. Moreover, itemized statements for force account work shall include all details related to the performed work including labor, equipment, and materials, as well as insurance premiums.

Furthermore, the contractor shall be careful to follow the *Construction and Material Specifications* of ODOT (2019) related to payments under a force account basis:

1. Labor and supervisors: The contractor is entitled to be paid the wages and fringe benefits for all labor and supervisors who are engaged in the performed change or extra work. Contractors shall be aware that the department shall pay an additional 38% of the sum of these wages and benefits as a markup. On the other hand, the department shall pay the actual monetary amount, without markup percentage, for the following: Social Security tax, Medicare tax, Ohio workers' compensation premiums, state and federal unemployment insurance, longshore and harborworkers' compensation premiums in case of unloading material or working from a barge or ship, subsistence and travel allowances, and fees paid to labor unions or business associations. Furthermore, contractors shall be careful that as per ODOT (2019), the department will not pay for wages and benefits of personnel of contractors above the classification of supervisor, who only generally supervise the force account work.

2. Materials: The contractor is entitled to be paid the actual cost of materials used in execution of change or extra work that are delivered to the construction site. Furthermore, in case the contractor intended to use materials from their own stocks, for which invoices are missing, then the contractor shall first provide an affidavit to certify that. Contractors shall be careful to not use materials prior to agreement with the engineer on the price. Furthermore, the department shall pay an additional 15% of the aforementioned total incurred costs as a markup. In addition, ODOT (2019) addresses the issue of changes in material specifications that may result in increased or decreased costs to the contractor. In case of increased cost to the contractor, the contractor is entitled to receive a compensation equal to the invoice-supported material cost plus 15% markup for profit and overhead. On the other hand, in case of decreased cost to the contractor and original material has not been ordered, then material cost savings shall be credited to the project by a lump sum adjustment plus 15% markup. In case of decreased cost to the contractor but original material has been ordered, then material cost savings shall be credited to the project by a lump sum adjustment plus 2.5% markup.
3. Equipment: The contractor is entitled for payment for any equipment subject to approval by the engineer and the contractor agreed with the engineer on price by writing. The department will pay for equipment for the lesser of the period approved by the engineer or the period required by the contractor to complete the force account work. Payment will be based on the equipment's operation status and ownership as follows:
 - a. Equipment owned by the contractor: The contractor working with ODOT will be paid on an hourly basis according to following hourly rate: Hourly owned equipment rate = [(regional adjustment factor) \times (age rate adjustment factor) \times (current monthly rate/176)] + HOC, where HOC refers to estimated hourly operating cost as per FHWA's Blue Book. In addition, regional adjustment factor, age rate adjustment factor, and current monthly rate shall also be retrieved from FHWA's Blue Book, if available. In case of owned equipment not listed in the Blue Book, then hourly owned equipment rate shall be calculated utilizing rates of similar equipment or using 6% of the purchase price as the monthly rate and adding hourly operating rate of similar equipment in the Blue Book. Moreover, if equipment is brought for the force account work, exclusively, for less than a month, then the current monthly rate of the Blue Book shall be multiplied by a factor according to Table 3. Moreover, contractors shall be aware that for equipment used intermittently on force account work, the department will pay for it as working equipment, even during its idle time, during the workday, if the following conditions apply: (1) equipment is exclusively for force account work and not used on other work, and (2) its working time during the working day is at least 2 h. On the other hand, for idle time of equipment, or equipment that must remain on change or extra work site but does not qualify for the aforementioned conditions of intermittently used owned equipment, the department shall pay the contractor at following rate: Hourly idle equipment rate = $0.5 \times$ (Hourly owned equipment rate) – HOC. The aforementioned rates

Table 3. Factors for monthly rate calculations

Working hours	Factor
Less than or equal to 8.0	2.00
8.1 to 175.9	$2.048 - (\text{hours}/168)$
176 or greater	1.00

Source: Data from ODOT (2019).

- include the cost of fuel, oil, lubrication, field repairs, tires, expendable parts, supplies, depreciation, storage, and insurance.
- b. Rented equipment: In case of rented equipment solely for the force account work, the contractor will be paid the actual invoiced amount, the corresponding Blue Book hourly operating costs, state and local sales taxes, and an additional 15% of these costs as a markup for overhead and profit. For the time the rented equipment is idle, the contractor will be paid the same as aforementioned excluding the corresponding Blue Book hourly operating costs. On the other hand, in case of rented equipment for original contract work but used for force account work, the contractor will be paid according to the following rate: Hourly rented equipment rate = $(\text{HRI} \times 115\%) + \text{HOC}$, where HRI refers to "hourly rental invoice costs prorated for the actual number of hours that rented equipment is operated solely on force account work. Use a monthly invoice rate divided by 176, a weekly invoice rate divided by 40, or a daily invoice rate divided by 8" (ODOT 2019). Contractors shall be careful to obtain prior approval from the engineer for rates that exceed the corresponding Blue Book rates. Furthermore, the department will not pay for rented small tools or equipment that have a daily rate less than USD 5 or equipment with a value less than USD 400.
 - c. Moving of equipment: The contractor will be paid for the time of moving the equipment to the location of force account work and to return it to its original location. Furthermore, the department shall pay loading and transportations costs in case the equipment is shifted by means other than its own power. The aforementioned applies for equipment used solely for force account work, otherwise the contractor will not be entitled to those payments. In addition, if the equipment is transported by a common carrier, the contractor will be entitled to the invoiced amount paid for the freight plus an additional 15%.
4. Subcontracted work: For any subcontractor's work under force account work, the contractor is entitled to be paid the invoiced cost plus a monetary amount, as administrative costs, of 8% on the first USD 10,000 of work and 5% for work in excess of USD 10,000. Furthermore, contractors shall be aware that a subcontractor's work or trucking services performed by the subcontractor is not entitled for additional markup payment.
 5. Premium for contract bonds: The final bond premium amount for the payment and performance bonds is usually calculated based on the actual final contract value. If the final contract value is different from the original value, then this amount shall be adjusted. Contractors shall be aware that no adjustment will be made to the final bond premium amount if the difference between the actual final and original contract value is less than USD 40,000.

Based on the preceding contractual analysis of change orders' procedures under ODOT, the authors developed comprehensive flowcharts, as shown in Figs. 3–5.

These developed flowcharts could be used by contractors and ODOT to ensure proper and efficient management of change orders in highway transportation projects. The developed flowcharts are interrelated, and thus they should be read as a whole. That said, the generated flowcharts are believed to be of great value to ODOT and their contractors because this state department does not have comprehensive, yet easy to follow, flowcharts that depict the detailed needed steps and procedures to be followed when a change order is to be approved as per ODOT's *Construction and Material Specifications*. However, the generated flowcharts have an advantage over ODOT's *Construction and Material Specifications* in summarizing

the overall procedures in a stepwise way enabling visualizations of the different steps involved in the management of change orders as well as their sequence.

Approval Procedures in Light of the Applicable Laws

Motivating Case Studies

The case study of ODOT Contract ID 100281, which is a USD 63.8 million highway transportation project, comprising improvement works for an interstate route in the city of Toledo in Lucas County was scheduled to be completed in 2012 but it was delayed for around 4 years until 2016. The total net amount of change orders was around USD 5.7 million. This amount constitutes around 9.0% of the original contract amount, which is considered to be a substantial percentage. In addition, another major case study of ODOT Contract ID 110628, which is a USD 81.2 million project, comprising construction of the new Ironton–Russell bridge between Ohio and Kentucky, related infrastructure improvements and demolition of the existing structure. This project was intended to be completed in 2015 but it was delayed until 2017. The total net amount of change orders was around USD 6.2 million, which is also considered a substantial percentage of around 7.6% of the original contract amount.

Table 4 summarizes the aforementioned and other ODOT case studies as highlighted by ODOT experts to be major projects involving change orders' related issues. In fact, major delays for completion of these ODOT projects were attributed, in part, to improper management of change orders and their applicable laws. As far as applicable laws are concerned, ODOT classifies change orders into two main categories: regular work change orders (RWCOs) and extra work change orders (EWCOs). For instance, there were 106 RWCOs and 200 EWCOs in the ODOT case study Contract ID 100281. Thus, this case study reflects the importance of better understanding the approval procedures of change orders according to Ohio's applicable laws. Given that, the authors reviewed and analyzed the change orders' provisions stipulated by Section 109.05 of ODOT's *Construction Administration Manual of Procedures*.

Provisions of ODOT

According to ODOT (2017), the approval of change orders shall conform with the applicable Ohio state laws: the Ohio Revised Codes (126.30, 127.16, 5517.02, 5525.11, 5525.14, and 5525.99), and Code of Federal Regulations (635). As mentioned previously, in dealing with change orders under applicable laws, ODOT classifies change orders into RWCO and EWCO. As per ODOT (2017), a change order is considered an RWCO in the following cases: (1) contract quantity adjustments; (2) adjustments for contract-specified payments or deductions; (3) changes in the contract documents or specifications; (4) changes in materials requirements; (5) revision of an interim or contract completion date; (6) implementation of nonperformances as a result of acceptance of a value engineering change proposal (VECP); and (7) other reasons as authorized by the ODOT Division of Construction Management. On the other hand, a change order is considered an EWCO in the following cases: (1) increase of contract quantities that are beyond contract limits, previously shown in Table 2; (2) costs of project termination for convenience of the department; (3) force account work; (4) implementation of an accepted VECP and payment of the contractor's share of the VECP; (5) payments that differ from fixed amounts established in the proposal by the department, or final payment for an item that differs from the lump sum amount bid by the contractor; (6) payment for allowable delay costs, or payment of interest on delays in processing payments; and (7) compensation to the contractor for damages associated with claims. As mentioned,

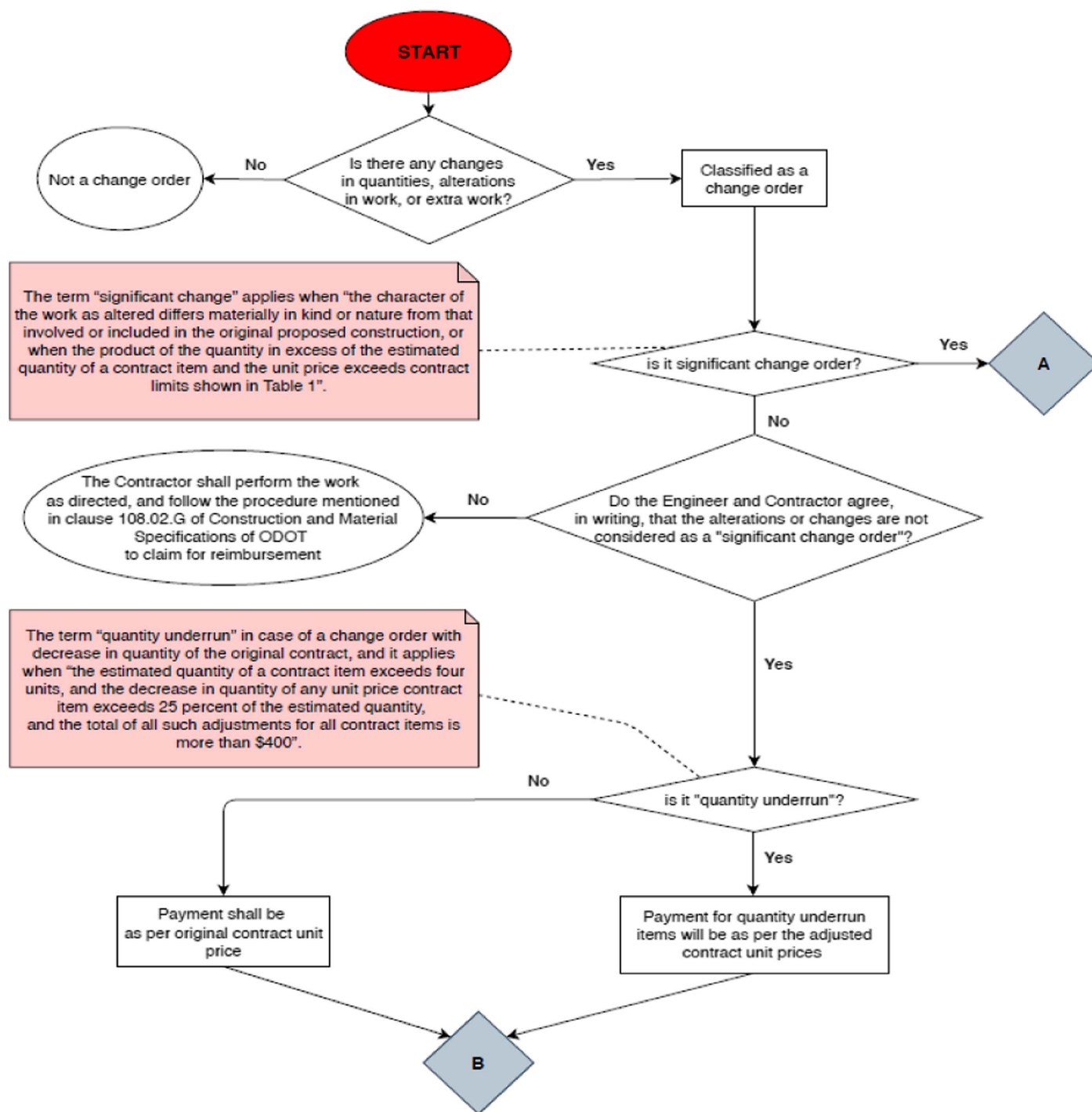


Fig. 3. Change order procedure for insignificant changes under ODOT.

contractors working under ODOT shall be aware to not commence any change or extra work prior to being approved in writing. The written approval shall have the signature of the authorized person or one who has delegated authority. As per ODOT (2017), Table 5 summarizes approval authority based on a project's type of funding and type of change order.

Furthermore, in case of any change order for an item with local funding, the district shall coordinate and notify, in writing, an agent of the local participating agency. Moreover, for state-funded projects, the deputy director of the Division of Construction Management of ODOT may approve any change order, instead of the director, after consultation with the district and director. On the other hand, under

specific conditions, the contractor may be directed to proceed with change or extra work prior to processing of change order by the following individuals: (1) the director, who may grant emergency permission to proceed with added work; and (2) the district construction engineer, being authorized by the director, who may grant permission to proceed with new items of work if the total payment for each item is less than the contract limits. Contractors shall be aware that in both cases, the permission shall be in writing, well defined, and documented. Moreover, the district shall not approve RWCO for the increase of quantity of original bid item to the contract limits, which is combined with an EWCO for added quantity to the same original bid item, until the director grants a declaration of emergency

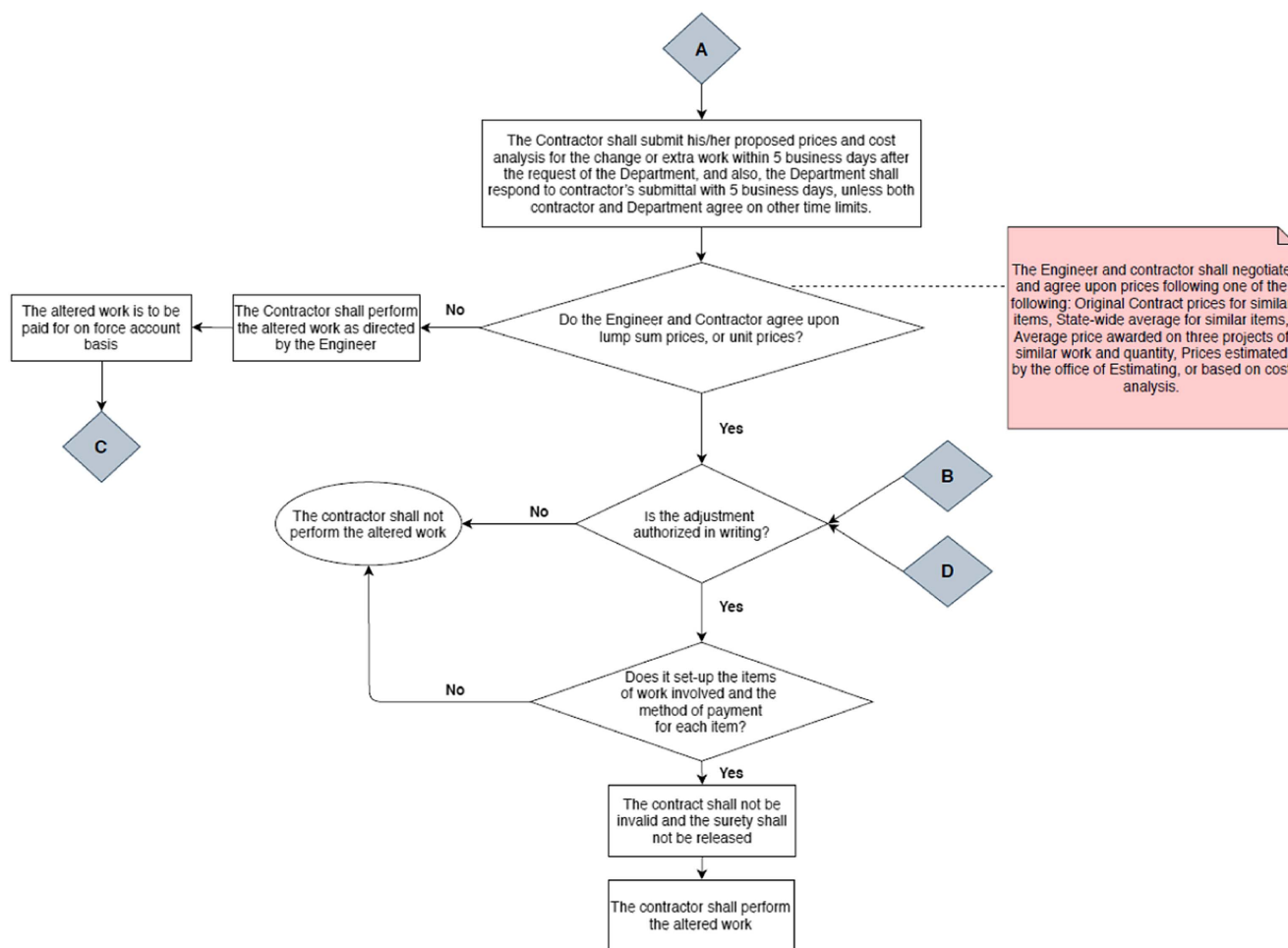


Fig. 4. Change order procedure for significant changes under ODOT.

or other preliminary authorization for the EWCO. Generally, it is responsibility of the district construction office (DCO) to coordinate and obtain all necessary approvals (such as FHWA, director, program managers, controlling board, local participating agency) for any change order prior to execution of the work. Once the change order is prepared, the DCO forwards it to the aforementioned approval-authorized individuals for signatures. Once the change order is signed and approved, it shall be sent to the contractor to proceed with work. Aforementioned was a brief description of the overall approval process of change orders under ODOT.

In more details, as per ODOT (2017), any EWCO with a pay item exceeding the contract limits, regardless of project's type of funding, must be submitted to the controlling board for approval prior to execution of the work. Nevertheless, in some cases, an EWCO with a pay item exceeding the contract limits, regardless of project's type of funding, does not require approval of the controlling board, but must be reported quarterly to the controlling board. Those cases are as follows: (1) change orders for final measurements; (2) added work that is necessitated by federally mandated requirements that were not available at time of original contract award; and (3) added work for which the director granted an emergency permission.

Moreover, as per ODOT (2017) and as shown in Table 5, on all federal oversight projects, formal approval by FHWA is required for all major change orders prior to execution of work. For non-major change orders, formal approval is required but it can be given retroactively, at the discretion of the chief FHWA official assigned to the ODOT district. Moreover, all change orders for amendment of

contract time shall be submitted to FHWA for approval. That said, FHWA considers a change order to be classified as a major change order if it increases the project cost by the lesser of USD 250,000 or by 5% of original contract value, if it alters the planned access controls, highway controls, or work limits or if it results in new environmental impacts. To this end, for full federal oversight projects, the district shall consult with the FHWA transportation engineer assigned to the ODOT district for all major change orders. ODOT approves change orders, including major change orders, on behalf of FHWA for state-administered federally funded projects.

Opportunities and Risks

Based on the conducted analysis, the authors identified a list of opportunities and risks, given in Table 6, in relation to the management of change orders under ODOT projects. This list can act as contractual guidance that helps the contracting parties in identifying the contract terms that may lead to improper handling of change orders on ODOT projects and result in risks and losses.

Checklist

Finally, the authors developed a checklist consisting of 43 questions, as shown in Table 7, in order to shed light on various important contractual aspects related to the provisions and approval procedures of change orders under ODOT. The developed checklist is based on

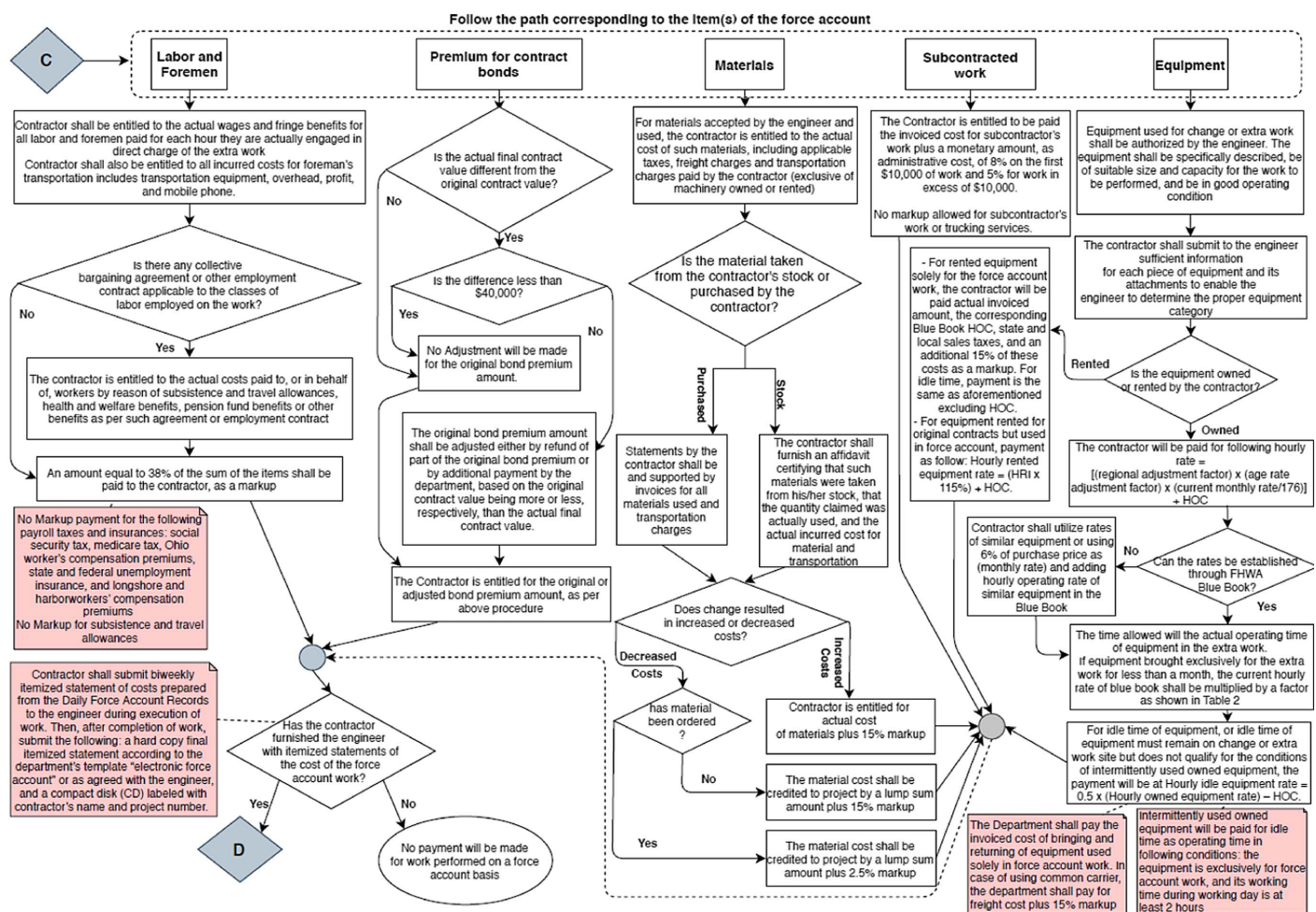


Fig. 5. Change order procedure for changes under force account basis under ODOT.

Table 4. Example of change orders related to approval procedures according to applicable laws within ODOT highway transportation projects

Contract ID	Project description	Original completion date	Postponed completion date	Original contract amount ^a (USD million)	Net amount of change orders and extra work ^a (USD million)	Percentage ^a
190328 ^b	Structural rehabilitation and replacement of some bridges in Stark County, Ohio	August 28, 2023	May 24, 2024	56.2	5.4	9.6%
140536	Improving section Luc-75-6.70 in the city of Toledo, Lucas County, Ohio	May 31, 2017	July 9, 2020	62.6	7.9	12.6%
188012	Improving various sections of State Route 91 in Summit and Cuyahoga Counties	August 31, 2019	November 30, 2019	4.1	0.5	12.2%
110628	Construction of the Ironton-Russell bridge between Ohio and Kentucky	October 30, 2015	October 3, 2017	81.2	6.2	7.6%
100281	Improvement works for an interstate route in the city of Toledo in Lucas County	November 12, 2012	November 3, 2016	63.8	5.7	9.0%
113003	Improvement works of an interstate route in Sandusky County	October 31, 2012	August 21, 2013	12.2	2.7	22.1%
110168	Improvement of state route in Ottawa and Erie Counties	September 30, 2011	June 30, 2013	0.7	0.2	28.6%

^aValues are rounded to the nearest decimal place.

^bCompletion dates may further change for ongoing projects.

Table 5. Approval power and authority

Project's type of funding	Type of change order	Approval-authorized individual(s)	Related statutory source
State-funded projects	<ul style="list-style-type: none"> • All change orders for the extension of an existing contract item of work or for the addition of a new item of work beyond the contract limits, shown in Table 2 • Or additional work that consists of multiple related items, the sum of which exceeds the lesser of USD 100,000 or 25% of original contract value • Or change orders based on an emergency declaration • Or change orders for final measurements^a 	Director	Section: 5525.14, Ohio Revised Code
State-funded projects	<ul style="list-style-type: none"> • Within contract limits and does not fall under director 	District	Section: 5525.14, Ohio Revised Code
Federal oversight projects	<ul style="list-style-type: none"> • Major change orders 	FHWA	Section: 23 C.F.R. 635.120
District-funded projects	<ul style="list-style-type: none"> • All 	District program manager	Section: 127.16 and 5525.14, Ohio Revised Code
Central office-funded projects	<ul style="list-style-type: none"> • All that exceed specified threshold 	Central office program manager	Section: 5525.14, Ohio Revised Code

^aFinal measurements is a legal term used in Ohio Revised Code 5525.14 that means an increase in an original bid item that was required to accomplish the originally planned work within the original work limits but resulted in a payment on the bid item that exceeded the contract limits, shown in Table 2.

dual analysis of ODOT case studies, as well as ODOT contractual provisions and procedures for the management of change orders in identifying the main points that shall be carefully and clearly defined in the contract documents. Answering those questions helps contractors in negotiation and ensuring clearer and more comprehensive contract language in relation to different aspects associated with the management of change orders. In addition, the developed checklist aims to act as a reference for ODOT representatives to help them in updating their standard contracts, as well as drafting new ones, in relation to change orders' provisions and their associated procedures.

Validation of the Research Outcomes

The research outcomes—presented in the developed guiding flowcharts in Figs. 3–5 as well as the research outcomes in Tables 6 and 7—were validated through consultation with experts from the construction administration department of ODOT and who are responsible for the management of change orders within ODOT highway transportation projects. More specifically, the authors shared the developed flowcharts in Figs. 3–5 as well as the research outcomes in Tables 6 and 7 with ODOT experts—via email—to obtain their feedback about the applicability, novelty, and usefulness of the obtained research outcomes for ODOT operations.

In relation to the developed guiding flowcharts shown in Figs. 3–5, ODOT experts highlighted the following:

- The developed flowcharts are accurate and reflective of ODOT change order contractual provisions.
- Compared to an existing ODOT flowchart related to change order procedures that is currently used on ODOT projects, the developed flowcharts in Figs. 3–5 constitute a more detailed representation of the change orders' approval procedures according to ODOT contractual provisions.
- The developed flowcharts are believed to be beneficial to contractors working under ODOT for a better visualization and understanding of the change orders' approval procedures according to ODOT contractual provisions.

Further, in relation to the developed research outcomes in Tables 6 and 7 (i.e., the list of opportunities and risks and series of checklist questions), ODOT experts highlighted the following:

- The developed research outcomes shall be of a great value in assisting new ODOT employees and contractors to fully understand the change order process, especially for changes under force account basis.
- The developed list of opportunities and risks shall aid new ODOT employees and contractors in understanding the risks associated with the change order process, and consequently minimize the occurrence of inefficiencies in handling change orders under ODOT highway transportation projects.
- According to ODOT experts, a contractor that does not fully comprehend the change order process could submit insufficient documentation and waste time and/or resources trying to resubmit all required documentation for a full reimbursement. Similarly, an ODOT employee that does not fully comprehend the change order process could make mistakes while reviewing the change order documentation, resulting in overpayment or underpayment of the extra work. That said, the developed research outcomes shall facilitate proper understanding and handling of change orders under ODOT highway transportation projects.

Therefore, the ODOT experts validated and confirmed the accuracy of the obtained outcomes in this paper and their usefulness in actual practice for existing contractors and ODOT employees as well as for new contractors and ODOT employees.

Research Contributions

The research conducted in this paper offers substantial contributions to the body of knowledge. First, it tackles the research need of investigating the contract administration aspects of change orders and the associated procedures within the context of highway transportation projects. Many studies have highlighted that there is a pressing need for further research on the proper administration of change orders (Anastasopoulos et al. 2010), particularly in

Table 6. Opportunities and risks under ODOT

Aspect	Opportunities	Risks
Definitions related to change orders and their processes	<ul style="list-style-type: none"> • Clear definition of change order and associated terms such as <i>quantity underrun</i> and <i>fringe benefits</i> • Clear definition of what work items are classified as significant changes and associated contract limits • Clear definition of what is considered as an extra work 	N/A
Approval procedures according to contractual provisions	<ul style="list-style-type: none"> • Explicit and clear provision of the roles of the engineer, the contractor, and ODOT in relation to change orders • Specifically states that ODOT reserves the right to make changes at any time during execution of the works • Explicitly states that the contractors shall not perform any change or extra work prior to receiving written direction from the engineer • Clearly provides specific conditions under which contractor may be directed to proceed with change or extra work, prior to processing of change order and specifically states that such direction must be in writing • Detailed description of how the change orders' compensation should be calculated and paid to the contractor under various payment methods such as original contract prices, negotiated prices, or under force account basis 	<ul style="list-style-type: none"> • Probability of delay due to the substantial efforts associated with the approval process according to ODOT requirements • ODOT requires contractor to obtain prior approval from engineer for rented equipment with rates that exceed the corresponding Blue Book rates; thus, contractor need to be aware of that in order to not lose entitlement for payment • There is no procedure for reimbursing the contractor in case some/all change orders' work was performed prior to the engineer's authorization under emergency conditions • Lots of submittals on part of the contractor in case of payment under force account basis such as itemized statements and daily force account records; failure to do so can make the contractor lose full or part of compensation for the performed work • Dependence of the compensation under force account on the nature of the work, which can create much confusion on how it is to be determined. • Ambiguity in relation to which work items will be compensated with additional markup payment; contractors shall be aware that some compensated amount will not include markup, and factor that in their bid • ODOT requires contractor to provide sufficient evidence for incurred costs for bonds, taxes, and insurances associated with change or extra work, which might not be easily accessible • To enable the engineer to determine the proper equipment category, the contractor must submit information of the equipment and its attachments; such information could not be readily available • ODOT is considered released from any obligation for payment for the change or extra work in case the contractor fails to furnish the needed documentation • Ambiguity in relation to the timeline limit for submittal of various documents; contract is not clear whether such limit is strict, and contractor loses right for compensation or not • ODOT will not pay for wages and benefits of personnel of contractors above the classification of supervisor, who only generally supervise the force account work; thus, contractors need to factor that in their bid • Contractors are not entitled to any additional allowance for general superintendence, the use of small tools, or other costs for which no specific allowance is provided; thus, contractors need to factor that in their bid • Contractors shall be aware that labor costs are not included in the formulas used to calculate the compensation related to equipment owned by the contractor; thus, contractors need to factor that in their bid
Approval procedures in light of the applicable laws	<ul style="list-style-type: none"> • Having detailed change orders' procedures within Section 109.05 of the <i>Construction Administration Manual of Procedures</i> to provide the district with a detailed procedure for processing change orders and ensure fair and reasonable pricing of change orders 	<ul style="list-style-type: none"> • Probability of delay due to the substantial efforts associated with the approval process according to applicable laws • Applicable laws' procedures add some complications for contractors working under projects funded by ODOT because they affect the process of work addition to their contracts and the payment provisions for that work • Possibility of discrepancies or contradictions between the contract language and the different applicable laws

transportation systems compared to industrial and commercial projects (KTC 2010). Second, it provides contractual investigation and guidelines for the management of change orders in public highway transportation projects through a case study approach within the context of ODOT. Third, it identifies the main contractual areas related to change orders that could lead to conflicts, claims, and/or disputes between the contracting parties on ODOT highway

transportation projects. This would offer a better understanding of the contractual mechanism and procedures of handling change orders; and thus, helping in minimizing or avoiding the undesirable consequences associated with change orders (Hsieh et al. 2004).

In addition, this research has practical implications to industry practitioners. First, it facilitates theoretical and practical understanding of change orders approval procedures according to the

Table 7. Checklist questions

Aspect	Question
Definitions related to change orders and their processes	<ol style="list-style-type: none"> 1. Does the contract explicitly define change order? If yes, how? 2. Does the contract explicitly define the conditions under which a change order can be considered? If yes, how? 3. Are there any other terms related to change orders, such as quantity underrun? Are they clearly defined and noted in the contract? 4. Are there any classifications for change orders as per nature of work or associated quantity? If yes, are the explicitly noted in the contract?
Approval procedures according to contractual provisions	<ol style="list-style-type: none"> 5. Does the contract differentiate between change in work and extra work? If yes, how? 6. How does the contract specify the department's authority in issuing change orders? 7. Are there any limitations to the department's authority in issuing change orders? If yes, are they explicitly noted? 8. Is a written direction from department or engineer to the contractor considered a mandatory requirement prior to proceeding with change or extra work? If yes, is it explicitly noted in the contract? 9. Are there any exceptions to the mandatory requirement of written direction for a change order, if required? If yes, are they explicitly noted? 10. What are the methods of reimbursement to the contractor for any change or extra work? 11. Does the contract explicitly define when to apply each method of reimbursement to the contractor for change or extra work? 12. Does the contract explicitly address the cost items that shall be included in the reimbursement to the contractor for change or extra work? 13. Is negotiated prices considered one of the reimbursement methods? If yes, does the contract provide any guidelines to contractual parties to estimate those prices? 14. Is there any timeline limit within which the contractor shall submit proposed prices and cost analysis for the change or extra work? If yes, is the contractor obliged to stick to this timeline limit? Is that explicitly addressed in the contract? 15. Is there any timeline limit within which the department shall respond to the contractor's submittal of proposed prices and cost analysis for the change or extra work? If yes, is the department obliged to stick to this timeline limit? Is that explicitly addressed in the contract? 16. In case of failure of the department and contractor to agree on costs or unit prices of a change order, does the contract explicitly define what procedure to follow? 17. Is the reimbursement method force account basis considered in the contract? If yes, refer to questions in the following section. 18. Does the contract clearly define the conditions under which the reimbursement method force account basis can be applied? If yes, how? 19. What must the contractor submit in order to obtain full compensation under force account basis? What items shall be included in each submittal? 20. Is the contractor obliged to prepare a daily force account record? If yes, what items shall be included? 21. Is the contractor obliged to submit itemized statements to the department or engineer for review and approval? If yes, what information shall be included in itemized statements? And how often shall the contractor submit itemized statements? 22. In case of compensation for labor and supervisors' costs, does the contract explicitly mention which incurred costs will be compensated? If yes, how? 23. In case of compensation for labor and supervisors' costs, will the contractor be entitled for additional payment as a markup? If yes, how? 24. In case of compensation for material costs, does the contract explicitly mention which incurred costs will be compensated? If yes, how? 25. In case of compensation for material costs, will the contractor be entitled for additional payment as a markup? If yes, how? 26. Does the contract explicitly address the situation in which the contractor uses material from their own stocks for change or extra work? If yes, how? And what documents shall the contractor submit? 27. Does the contract explicitly address the issue of changes in material specifications that may result in increased or decreased costs to the contractor? If yes, how will compensation be estimated? 28. In case of compensation for equipment costs, does the contract explicitly mention which incurred costs will be compensated? If yes, how? 29. In case of compensation for equipment costs, does the contract explicitly mention which incurred costs will be compensated? If yes, how? 30. What conditions must the contractor fulfill in order to be entitled for reimbursement for incurred equipment costs? 31. Does the contract explicitly address the situation in which equipment owned by the contractor is used for change or extra work? If yes, how will compensation be estimated? 32. Does the contract explicitly address the situation in which rented equipment is used for change or extra work? If yes, how will compensation be estimated? 33. How will compensation be estimated for the idle time of the equipment? 34. Does the contract explicitly address the contractor's entitlement for compensation for incurred costs for moving of equipment? If yes, how? 35. How is the contractor compensated for subcontracted work related to change or extra work? 36. How are the incurred costs, for change or extra works, reflected on determination of the final bond premium amount?

Table 7. (Continued.)

Aspect	Question
Approval procedures in light of the applicable laws	37. What are the applicable laws the approval of change order shall be in conformity with?
	38. Does the contract explicitly mention the entities or individuals with approval authority for various types of change orders? If yes, how?
	39. Can the approval authority be delegated? If yes, does the contract clearly mention the conditions under which such delegation can occur? If yes, how?
	40. Who is responsible to obtain the approval of authorized individuals?
	41. Does the contract explicitly define specific conditions under which the contractor may be directed to proceed with change or extra work? If yes, what are those conditions? And who are the authorized individuals?
	42. Is FHWA approval required for any type of change order? If yes, how is that defined in the contract? And what are types of change orders that require FHWA approval?
	43. Can the department approve change orders on behalf of FHWA? If yes, what are the conditions for that?

contractual provisions and applicable laws of ODOT highway transportation projects. Second, it summarizes the overall approval and compensation procedures of change orders according to ODOT contractual provisions in a visually appealing way through the developed flowcharts shown in Figs. 3–5. Third, it aids contracting parties in identifying contract terms that need to be carefully considered or revised to eliminate any ambiguities and risks and to avoid the rise of unnecessary disputes related to change orders. This could be achieved through the developed list of opportunities and risks and the checklist shown in Tables 6 and 7. Fourth, it improves the cooperation and coordination between the contractual parties in handling change orders, which would result in mutual benefits to all parties and in having a successful execution of projects. As such, this research tackled a critical research need because practical guidelines are needed to enable public agencies to analyze and review the characteristics of change orders to minimize their negative impacts (Khalafallah and Shalaby 2019).

Limitations and Future Work Recommendations

The research presented in this paper has some limitations and areas for potential improvement within future research work.

First, while the outcomes of this research were validated by ODOT experts, this research may benefit from further in-depth testing on actual ODOT projects. Such a process may take a long time (i.e., several years) to render concrete and reliable results. As such, the authors recommend future studies provide in-depth testing of the various considerations provided in this paper on different and actual ODOT projects and report about their pros and cons in future publications.

Second, during the search and review of ODOT case studies, there was an extreme limitation regarding the public availability of such information, especially as related to law cases. This is mainly due to the confidentiality of agreements between contracting parties. As such, construction stakeholders are recommended to provide more data about conflicts, claims, and/or disputes related to change orders on their projects—even in redacted form regarding the identity of the contracting parties—to facilitate further analysis of such an important topic. With the availability of more case studies, future research is recommended to extend this research to cover further identified challenges, if any, in relation to contractual administration of change orders on highway transportation projects.

Third, while this research is applied to ODOT, it can be argued that this limits its broad applicability. To this end, it is worth noting that the analysis and findings included therein should also support other DOTs nationwide that share similar contractual characteristics as ODOT in better managing their projects. In particular, other

DOTs, especially the ones with less detailed change order procedures, can benefit from this research in identifying contract terms that may need to be revised and updated within their standard procedures of change order management. In that regard, the authors recommend that future research consider conducting a comparative analysis between the change order procedures followed by multiple DOTs.

Conclusion

Administering change orders is a challenge facing the construction industry including highway transportation projects. Comprehensive theoretical and practical understanding of change order contractual provisions and associated procedures as well drafted contract documents facilitate efficient handling of change orders toward successful execution of infrastructure projects. Following an integrated research method consisting of dual analysis of case studies and contractual provisions, this paper tackled a critical research need by providing contractual analysis and guidelines for the administration and management of change orders in the context of highway transportation projects. ODOT was considered as a case study for investigation of change orders and associated procedures under their projects. In general, this paper intends to act as a reference for contracting parties in updating their standard contracts, as well as drafting new ones, as related to provisions of change orders and associated procedures in highway transportation projects.

The 10 studied ODOT case studies demonstrated that the major change order aspects of ODOT highway transportation projects are definitions related to change orders and their processes, approval procedures of change orders according to contractual provisions, and approval procedures of change orders according to applicable laws. Definitions related to what constitutes an extra work and the basis of the force account were found to be of great importance based on the studied ODOT case studies and contractual provisions. Further, upon analysis of the contractual provisions under each change order aspect, the authors developed detailed flowcharts that facilitate understanding and visualization of change orders' procedures under ODOT and highlight the roles and responsibilities at each step of the change order process. By utilizing the developed flowcharts, ODOT representatives as well as contractors can ensure that all required steps for managing of various types of change orders and their sequence are understood and followed properly and avoid missing any required step. Moreover, this paper reflected the importance of better understanding the approval procedures of change orders according to Ohio's applicable laws, namely, RWCO and EWCO.

In addition, the authors identified a list opportunities and risks and a series of checklist questions. ODOT representatives as well as

contractors can benefit from the developed list opportunities and risks in identifying the contract terms that constitute a risk and may lead to improper handling of change orders. Furthermore, ODOT representatives as well as contractors can benefit from the developed series of checklist questions in checking their contract documents or drafting clearer and comprehensive ones in relation to managing and handling of change orders under ODOT projects.

The lessons learned in this research include the following: (1) comprehensive and efficient understanding of contractual provisions, especially as related to the identified change orders aspects, as well as full awareness contractors parties of their rights and obligations as per the contract document shall facilitate minimization or avoidance of the rise of unnecessary claims, conflicts, or disputes; (2) recognizing that DOT representatives as well as contractors shall ensure the compliance of their followed procedures for management of change orders with the related applicable laws; and (3) suggestion that contractors shall identify all risks related to management of change orders in their contractual agreements with various DOTs, prior to signing of the contract, to examine if they can comply with it or if adjustments need to be made in order to avoid losing their rights for reimbursement. Ultimately, this research shall better enable contractors to administer the contractual procedures of change orders in a way that hopefully supports timely and cost-effective execution of highway transportation projects.

Data Availability Statement

All data used and/or generated during this study are included in the published article.

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