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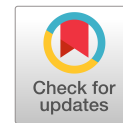
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Management of Change Orders in Infrastructure Transportation Projects

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Abstract: The Illinois Department of Transportation (IDOT) will handle many upcoming projects due to the recent statewide infrastructure strategic plan and the fast-track efforts affecting many infrastructure projects amid COVID-19. Nevertheless, many change orders are anticipated to occur on IDOT's projects. Thus, this paper examines the proper contractual management of changes within IDOT infrastructure transportation projects by following a research method based on the integration between a desktop analysis and a focus group analysis. The desktop analysis involved collecting information and data from existing resources, case studies, and documents related to change orders. The focus group analysis involved consulting with change order experts to verify that the outcome of each research step is useful and to validate the final outcomes of the paper. Based on 50 documented major change orders in IDOT projects and three litigated cases, two findings are provided. First, the top causes for key change orders within IDOT projects include contract administration, allowable contingencies, quantity omission or error, differing site conditions, and design changes. Second, the most critical change order related challenges within IDOT's infrastructure projects include approval procedures, compensation considerations, and applicable laws. This paper offers flowcharts, synopsis of opportunities and risks, and a checklist to help the contracting parties better administer change orders. Ultimately, the contributions of this paper to the practice include: (1) minimizing the number and amount of change orders, (2) helping the contracting parties better understand how their individual responsibilities contribute to the proper processing and management of changes and variations, (3) offering contractors the ability to visualize the different steps involved in the approval of change orders, (4) assisting the project stakeholders in identifying change order-related areas for improvement, and (5) allowing project owners to better mitigate, manage, and administer the contractual aspects of change orders. DOI: 10.1061/(ASCE)SC.1943-5576.0000640. © 2021 American Society of Civil Engineers.

Introduction

The construction industry includes public and private projects with approximately 40% of all construction projects being subject to more than 10% change (Ibbs 2012). Change orders are inevitable on construction projects due to the unique characteristics of the construction industry being a complicated, dynamic, and an uncertain business (Serag et al. 2010). According to latest statistics reported by the US Census Bureau (2021), the value of construction

put in place is \$1,524,183 million and because there is agreement that contract modifications of 5% to 10% are generally expected in most construction projects (Woo and O'Connor 2021; Serag and Oloufa 2007), it is estimated that \$76 billion–\$152 billion are spent on change orders in the United States. Therefore, change orders are one of the main challenges experienced in the construction sector and are difficult to predict (Stare 2010).

Public infrastructure and transportation projects in the United States are constructed, funded, and managed by departments of transportation (DOTs), the county, or local agencies. Change orders persist to be a great challenge faced by DOTs on US infrastructure projects. In relation to that, Taylor et al. (2012) highlighted that about 61% of the new highway construction projects in the United States are subject to contract-omission changes. Also, Choi et al. (2016) provided that changes and variations in US highway improvement projects lead to schedule and cost changes of up to 243% and 140%, respectively. Therefore, infrastructure projects in the United States face considerable issues attributed to change orders.

Illinois possesses one of the biggest infrastructure networks in the United States with 145,936 miles of roadway, and it is the third in the nation for total interstate miles (ASCE 2018). According to the Federal Highway Administration (FHWA 2017), Illinois possesses the highest annual vehicle-miles traveled by functional system in the Midwest. In fact, the Illinois Department of Transportation (IDOT) manages, each year, hundreds of infrastructure projects that aim to improve travel times, decrease congestion, enhance safety, create jobs, and strengthen area economies by supplying new or improved travel options (IDOT 2020c). Despite its extensive network, Illinois roadways were ranked third worst nationally for travel delay, excess fuel consumed, truck congestion

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cost, and total congestion cost (ASCE 2018). In fact, a total cost of \$4.8 billion per year is incurred from driving on Illinois' roads that are in need of repair (ASCE 2018). Illinois' road system has a grade of *D* meaning that it is in poor to fair condition and mostly below standard (ASCE 2018).

In June 2019, the Governor and General Assembly approved and signed the state's first major infrastructure plan (Illinois Comptroller's Office 2020) of \$45 billion to fund future projects across the state (Berlin et al. 2019). More recently, in May 12, 2020, Illinois decided to accelerate work on planned infrastructure projects due to the COVID-19 which has led to a decrease in vehicle travel and lower transportation revenue sources (Lamb 2020). This program aims to help municipalities and other public agencies that are strapped for cash due to the pandemic (Roeder 2020). More specifically, Illinois is expediting \$25 million of existing rebuild funding in the form of fast-track public infrastructure grants to local infrastructure projects (WIFR 2020).

Change orders are considered one of the main challenges faced by infrastructure projects in Illinois (CST 2020). In fact, a total of \$8.8 million as change orders was experienced during a short period of two years (2017–2019) on a single megainfrastructure project (the Jane Byrne Interchange project or the Circle Interchange) which is currently under construction, and is expected to have a total value of changes of approximately 25% of the original contract value (CST 2020).

Research Trigger

The case study of the Jane Byrne Interchange project, formerly known as the *Circle Interchange*, is a major freeway interchange in the proximity of downtown Chicago, Illinois. This interchange is the connection between the Dan Ryan, Kennedy, and Eisenhower Expressways (Interstate 90/Interstate 94 [I-90/I-94] and I-290), and Ida B. Wells Drive. The Jane Byrne Interchange is notorious for its traffic jams and was rated as the country's third-worst spot for highway congestion, with approximately 300,000 to more than 400,000

vehicles traveling through the interchange per day (Sofge 2008; IDOT 2020d).

The Jane Byrne Interchange is critical to the nation's transportation system because it serves as a vital hub for local, regional, and national freight traffic (IDOT 2020d). Nevertheless, the vehicles on this interchange are forced to reduce speed while navigating a network of tightly curved ramps, leading to approximately 25 million combined hours in delay each year (FHWA 2020). In a study of freight congestion for truck speed and travel time, the Department of Transportation ranked the I-290 section of the interchange to possess the worst congestion in the United States with an average truck speed as low as 29.41 mph (FHWA 2019).

To address these critical issues, IDOT took a unique approach to reconstruct this vital interchange by starting the reconstruction of this megaproject in late 2013, and the works are expected to be completed in 2022 (Jane Byrne Interchange Project 2019). Due to its huge scale and substantial complexity, the project was broken into 35 separate contracts or project components with three major stages for the reconstruction works (IDOT 2020b). The project total estimated cost is \$796.5 million as stated in the 2019 financial plan annual update (FPAU), which is about \$83.5 million more than the 2018 FPAU (Osman 2019). Most of the project's contracts were subject to additions and deletions (i.e., changes and variations) to their scope of work. More specifically, the change orders accounted for approximately \$6.1 million during the 1-year period 2018–2019 and for about \$2.7 million during the 1-year period 2017–2018. Also, it is expected that change orders will hike the price to nearly \$1 billion (CST 2020), which is about 25% more than the original contract value. Therefore, change orders are one of the major contributors to the substantial increase in this project's cost and its associated drawbacks. Table 1 shows a summary for the characteristics of the Jane Byrne Interchange case study reconstruction project.

Although this interchange is not complete yet at the time of this research paper, it is obvious that change orders are one of the main issues faced on this infrastructure project. This is reflected by the

Table 1. Summary of the characteristics of the Jane Byrne Interchange case study

Aspect	Attribute or value
Project name	Jane Byrne Interchange project, formerly known as the <i>Circle Interchange</i>
Location	Chicago, Illinois
Average daily traffic	300,000 to more than 400,000 vehicles
Freight transportation	The Chicago Metropolitan Agency for Planning (CMAP) estimates that 36% of freight truck traffic in the Chicago region passes through this interchange
Project goal	To bring upgraded roadway design and system operations while also placing a priority on how to best serve the community
Project objectives	Reconnecting neighborhoods and enhancing pedestrian, bike and transit modes for the surrounding areas
Benefits	Improve mobility and traffic operations, reduce congestion, improve safety, and enhance the interchange aesthetics
Reconstruction phases	Three: Stage 1—Cross Street Bridges; Stage 2—I-290/Ida B. Wells Drive; Stage 3—I-90/94
Schedule	17 contracts have been completed, eight contracts are under construction, and 10 contracts are anticipated to be complete by the end of 2022
Most updated estimated cost	\$796.5 million in 2019
Change order cost in 2018–2019	\$6.1 million
Change order cost in 2017–2018	\$2.7 million

Source: Data from IDOT (2020b).

\$8.8 million that were incurred due to changes during a short period of 2 years (from 2017–2019) (Jane Byrne Interchange Project 2018). It was agreed that, given the project's ambitious scope, the IDOT should have done better advance work to create a realistic budget and timetable (CST 2020) to avoid unnecessary change orders, changes in the scope of work, and contract amendments.

Because public money and property are implicated in Illinois' public construction projects, there are several statutory requirements that must be considered before a change order is sought or processed (Florey 2018). In fact, change orders have many negative impacts including claims and disputes, time delays, cost overruns, overhead expense increase, loss of productivity, and turnover of project team members, among others (Khanzadi et al. 2018; Shalaby et al. 2018). Thus, given the huge volume of current and upcoming expenditure on infrastructure and transportation projects in Illinois (as detailed previously) and the huge costs resulting from change orders that are still being incurred on current IDOT projects, there is a need for a proper management of work changes and variations on IDOT projects. To this end, IDOT has started to adjust its calendar for projects added as part of the infrastructure plan and the fast-track grants (Berlin et al. 2019). All the aforementioned information properly substantiates the authors' choice for studying the procedures for change orders under IDOT infrastructure projects. As such, this paper examines the change order procedures within infrastructure projects of the IDOT.

Background Information

This section provides a literature review of the existing research efforts on change orders.

Contractual Aspects of Change Orders and their Causes

Many research efforts have been conducted to study the contractual provisions and causes of change orders. In relation to that, El-adaway et al. (2016) used a comparative contractual analysis approach to analyze the change order provisions under the most widely used standard construction contracts, and they found and identified the similarities and differences among the changes/ variations mechanism of the studied contracts. Choi et al. (2016) investigated the marginal change-order impacts of accelerated contract provisions, and they found that these provisions led to more schedule-change and cost-change orders compared with conventionally contracted projects. Verweij et al. (2015) collected data from 45 Dutch transportation infrastructure projects to determine the reasons for contract changes, and they found that policymakers and planners should pay more attention to flexible contracting and contract management of smaller projects. Shrestha and Shrestha (2019) used statistical analysis and a Delphi approach to study the causes and preventive measures for change orders on road maintenance contracts, and they found that the main causes of changes orders were incorrect work scope, errors in the estimate, changes in the original plan, and changes in specifications for materials, and failure to verify the work site conditions before signing a contract.

Impacts of Change Orders

Many research efforts have been conducted to study the impacts of change orders. In relation to that, Moselhi et al. (2005) used a literature review analysis and neural networks to investigate the impact of change orders on construction productivity, and they found that the following factors influence the impact of change orders on

labor productivity: intensity, timing in relation to project duration, work type, type of impact, project phase, and onsite management. In addition, Shrestha and Zeleke (2018) used a questionnaire and nonparametric statistical analysis to study the effect of change orders on cost and schedule overruns of school building renovation projects, and they found that, on average, the change orders increased the project cost by 3.56% and that three-fourths of the project cost growth was due to change orders. Assaad and El-adaway (2020) used social network analysis and found that construction companies could be subject to negative cash flows during the project duration because of changes in the scope and high payment retainages. More recently, Kim et al. (2020) used statistical analysis on a change order dataset from building renovation projects to examine the cost impacts of change orders due to unforeseen existing conditions, and they found that change orders due to unforeseen existing conditions have significant impacts compared with change orders caused by other reasons. Assaad et al. (2020) used a risk modeling approach and found that both controllable and uncontrollable changes affect the cost and schedule performance of projects in the construction industry.

Knowledge Gap

Summary of the existing research work is shown in Table 2.

To the best knowledge of the authors, there is very limited research efforts that addressed change orders in public infrastructure projects from a contractual point of view. The reasons why previous findings did not provide sufficient information and analysis regarding change orders in public infrastructure projects *from a contractual point of view* could be attributed to: (1) the difficulties inherent in reviewing and analyzing the contract language and the interdependencies between different clauses and stipulations related to change orders, (2) the complex nature of public infrastructure projects that are usually large in scope, contract amount, and the number of involved project stakeholders and that are also subject to many uncertainties and risks, (3) the potential differences in the change order provisions between different DOTs and other entities that are responsible for managing, constructing, and funding public infrastructure projects; which make it hard on the researchers to provide unified or standard guidelines, (4) the challenges related to the availability of information or data, especially as related to law cases and/or case studies, and (5) the confidentiality of agreements between the contracting parties in some instances.

In fact, the research need of studying change orders in public infrastructure projects was also stressed by Khalafallah and Shalaby (2019) who stated that change order-related problems in public infrastructure projects create a need for practical methods to analyze change orders and minimize their negative impacts. Moreover, KTC (2010) highlighted the same research need by underlining that the majority of existing research focused on industrial and commercial projects; thus, showing the need to expand the research on change orders to study other project types such as public facilities. Accordingly, there is a critical need to provide practical guidelines for project parties working on public infrastructure projects, and IDOT can be a good example for all the reasons highlighted in the "Introduction" and "Research Trigger" sections. Therefore, this paper addresses this knowledge gap.

Research Method

This section provides all details related to the research method implemented in this paper.

Table 2. Summary of existing literature

Reference	Research objective	Research method(s)	Main findings
El-adaway et al. (2016)	Analyze the change order provisions under the most widely used standard construction contracts	Comparative contractual analysis approach.	Identification of the similarities and differences among the changes/variations mechanism of the studied contracts.
Choi et al. (2016)	Investigate the marginal change-order impacts of accelerated contract provisions	Two-stage research methodology: first stage is investigating the marginal change-order impacts of accelerated contract provisions and the second change is numerical modeling and validation of the change orders impact on projects' time-cost performance.	Accelerated contract provisions led to more schedule-change and cost-change orders compared with conventionally contracted projects.
Verweij et al. (2015)	Determine the reasons for contract changes in implementing Dutch transportation infrastructure projects	Statistical analysis (descriptive statistics and nonparametric tests).	Policymakers and planners should pay more attention to flexible contracting and contract management of smaller projects.
Shrestha and Shrestha (2019)	Study the causes and preventive measures for change orders on road maintenance contracts	Statistical analysis (correlation analysis and a Delphi approach).	The main causes of changes orders were due to incorrect work scope, errors in the estimate, changes in the original plan, and changes in specifications for materials, and failure to verify the work site conditions before signing a contract.
Moselhi et al. (2005)	Investigate the impact of change orders on construction productivity	Literature review analysis and neural networks.	The following factors influence the impact of change orders on labor productivity: intensity, timing in relation to project duration, work type, type of impact, project phase, and onsite management.
Shrestha and Zeleke (2018)	Study the effect of change orders on cost and schedule overruns of school building renovation projects	Questionnaire and nonparametric statistical analysis.	Change orders increase the project cost by 3.56% and three-fourths of the project cost growth is generally due to change orders.
Assaad and El-adaway (2020)	Study causes of business failure in construction projects	Social network analysis.	Construction companies could be subject to negative cash flows during the project duration because of changes in the scope and high payment retainages.
Kim et al. (2020)	Examine the cost impacts of change orders due to unforeseen existing conditions	Statistical analysis (t-test and ANOVA).	Change orders due to unforeseen existing conditions have significant impacts compared with change orders caused by other reasons.
Assaad et al. (2020)	Investigate project performance in the construction industry	Risk and mathematical modeling approach.	Controllable and uncontrollable changes affect the cost and schedule performance of projects in the construction industry.

Background on the Research Method

The authors used an integrated research method comprised of four steps: (1) determining the relevant IDOT change order documents, (2) identifying the main causes of key change orders within IDOT projects, (3) discerning the main change order challenges within IDOT projects through case study analysis and interpretation of IDOT standard documents, and (4) developing change order guidelines for IDOT projects. In relation to that, the research method is an integration between a desktop analysis and a focus group analysis. The desktop analysis involved collecting information and data from existing resources, case studies, and documents related to change orders. The focus group analysis involved consulting with change order experts to verify that the outcome of each research step is useful (and thus will help achieve practical and actionable outcomes) and to validate the associated final outcomes of the paper. Fig. 1 shows a brief visual summary of the implemented

steps of the research method. Further details on each one of these steps are shown in the following subsections.

Step 1: Determine the Relevant IDOT Change Order Documents

The first step was consultation with a focus group of IDOT experts to determine the relevant change order documents that are currently being used on IDOT projects. This was performed to ensure that all needed IDOT documents related to change orders are reviewed and analyzed in this study. In relation to that, IDOT experts provided that the following three documents include relevant information for the management of change orders:

- *Standard Specifications for Road and Bridge Construction (IDOT 2016)*. This document is promulgated by IDOT and outlines the general requirements and concerns that are applicable to all road and bridge construction improvements. It also

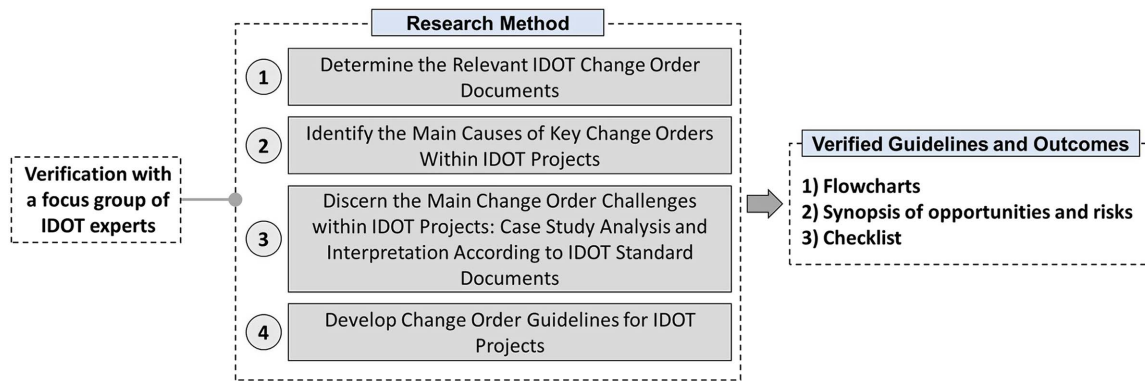


Fig. 1. Research method and outcomes.

provides the provisions related to materials, equipment, and construction requirements for individual items of work on IDOT projects. Because the focus of this research is change orders, only the document's stipulations related to change orders were considered in this paper

- *Construction Memorandum No. 4: Contract Changes (IDOT 2020a)*. This document is exclusively related to contract changes and change orders that are applicable to IDOT projects. This memorandum details the procedures by which all contract changes must be managed and administered, and the circumstances under which change orders will be permitted on IDOT projects. In addition, the procedures stipulated by the memorandum apply to all contracts and projects that are let by IDOT. The analysis of these procedures is very important because it ensures full compliance with the letter and spirit of all applicable laws that affect change orders on IDOT projects.
- *Illinois Construction Manual (IDOT 2020e)*. This document ensures uniform construction inspection practices during the administration of IDOT construction contracts. This manual has been structured based on, and is a companion document to, the IDOT Standard Specifications for Road and Bridge Construction.

Step 2: Identify the Main Causes of Key Change Orders within IDOT Projects

The second step was the determination of the main causes of key change orders within IDOT infrastructure projects. To ensure the reliability of the collected data, the authors consulted with a focus group of IDOT experts to provide information about key projects that experienced the most significant change orders. In relation to that, IDOT experts helped the authors retrieve the relevant change order data. The provided information was related to the contract number and the authorization number for the change order amounts on IDOT's projects. To this end, the authors retrieved the highest 50 change order amounts on IDOT projects to understand the main causes of key change orders out of a total of 99 key change orders with a value greater than \$1 million at the time of conducting this research. It is worth mentioning that the main causes of change orders were provided as part of the data retrieved from IDOT projects rather than determined subjectively by the authors. According to Eqs. (1) and (2) (where Eq. (2) represents the finite population correction factor), a sample size of $n = 49$ is considered representative for a confidence interval of 95% (thus, z is taken as 1.96) (Karakhan and Gambatese 2017), a sample error e of 10% (Pradhananga et al. 2021), and for a value of N being the total number of 99 key change orders. Thus, the retrieved sample of 50 key change orders is considered to be a good representation of the

amounts of the key change orders [because it is higher than the minimum required sample of 49 calculated using Eqs. (1) and (2)]

$$n_0 = \frac{z^2 p(1-p)}{e^2} \quad (1)$$

$$n = \frac{n_0 N}{n_0 + N - 1} \quad (2)$$

Step 3: Discern the Main Change Order Challenges within IDOT Projects: Case Study Analysis and Interpretation According to IDOT Standard Documents

The third step was the analysis of IDOT case study projects to identify the main change order related challenges that led to conflicts, claims, and/or disputes. To ensure the reliability of the collected information on the case study projects, the authors consulted with a focus group of IDOT experts to ensure that the paper tackles the most important change order related challenges that contribute to inefficiencies within IDOT projects. The aim of these case studies is to provide a practical perspective on the change order related challenges on IDOT's projects.

The following three change order related challenges were identified: approval procedures, compensation considerations, and applicable law. The third step also included interpreting the three identified change order related challenges according to IDOT standard documents mentioned in Step 1. Details follow hereunder:

- First, the approval procedures were studied and analyzed as related to: understanding what is considered as a change order, extra work, significant change, major item, and the IDOT's and contractor's roles and responsibilities in relation to the steps needed to properly approve, issue, and manage change orders.
- Second, the compensation considerations were studied and analyzed in relation to: work items appearing in the contract, major items, work items not appearing in the contract (labor; bond, insurance, tax; materials; equipment; subcontract work), cancelled or altered portions of the contract items, and item(s) appearing in the contract but with materially increased or decreased cost(s).
- Third, the applicable laws were studied and analyzed in relation to: the relevant state laws that govern change orders on IDOT projects, the different types of change orders, the state and IDOT policies, the needed approvals and signatures according to the legal procedures, and the required coordination. Thus, these applicable laws provide the procedures by which contract changes will be administered and the circumstances under which such changes will be permitted.

Table 3. Highest 50 change order amounts on IDOT projects

Contract number	Contract amount (rounded to nearest dollar)	Location	Status date	Authorization number	Authorized change order amount (rounded to nearest dollar)	Main cause of change order
62F52	\$26,979,205.00	District 01: Schaumburg, Illinois	11/22/2019	1	\$26,979,205.0	Allowable contingencies
62A12	\$25,770,705.00	District 01: Schaumburg, Illinois	11/15/2017	2	\$25,770,705.0	Allowable contingencies
62A12	\$25,770,705.00	District 01: Schaumburg, Illinois	12/6/2016	1	\$25,770,705.0	Allowable contingencies
60C31	\$13,697,899.30	District 01: Schaumburg, Illinois	4/4/2011	07	\$13,697,899.31	Highway plan quantity omission or error
60W62	\$12,158,939.00	District 01: Schaumburg, Illinois	10/14/2014	1	\$12,158,939.0	Allowable contingencies
60R23	\$11,389,867.00	District 01: Schaumburg, Illinois	8/30/2012	2	\$11,389,867.0	Allowable contingencies
60G47	\$10,483,571.00	District 01: Schaumburg, Illinois	8/9/2010	3	\$10,483,571.0	Allowable contingencies
60X61	\$20,490,228.60	District 01: Schaumburg, Illinois	3/28/2016	11	\$9,889,136.68	Design change
60477	\$45,475,053.10	District 01: Schaumburg, Illinois	4/16/2018	239	\$5,835,350.0	Contract administration
62894	\$5,337,970.30	District 01: Schaumburg, Illinois	7/24/2008	02	\$5,337,970.33	Allowable contingencies
76323	\$21,919,006.60	District 08: Collinsville, Illinois	8/9/2012	23	\$4,997,819.0	Allowable contingencies
60X61	\$20,490,228.60	District 01: Schaumburg, Illinois	4/18/2016	22	\$3,573,277.0	Highway design engineering error
60L71	\$57,095,577.90	District 01: Schaumburg, Illinois	11/21/2017	36	\$3,525,000.0	Utility- caused change/addition
60R62	\$7,650,284.50	District 01: Schaumburg, Illinois	11/21/2013	12	\$3,199,955.85	Allowable contingencies
60F05	\$29,686,265.20	District 01: Schaumburg, Illinois	2/21/2014	10	\$3,157,182.0	Allowable contingencies
66607	\$20,875,237.90	District 03: Ottawa, Illinois	10/27/2009	10d	\$3,012,348.65	Differing site condition
60D61	\$33,012,012.80	District 01: Schaumburg, Illinois	5/9/2013	122	\$3,000,000.0	Contract administration
76E13	\$67,339,438.90	District 08: Collinsville, Illinois	4/13/2020	010B	\$2,999,998.0	Highway plan quantity omission or error
60W26	\$42,559,659.50	District 01: Schaumburg, Illinois	4/26/2018	93	\$2,868,180.3	Contract administration
60W01	\$18,488,185.20	District 01: Schaumburg, Illinois	11/21/2014	30A	\$2,780,170.0	Contract administration
60W29	\$23,622,192.50	District 01: Schaumburg, Illinois	10/26/2018	52	\$2,500,000.0	Contract administration
64821	\$18,995,417.70	District 02: Dixon, Illinois	7/19/2013	2	\$2,500,000.0	Highway plan quantity omission or error
76011	\$11,697,210.08	District 08: Collinsville, Illinois	4/22/2008	44	\$2,500,000.0	Contract administration
63598	\$12,261,094.80	District 01: Schaumburg, Illinois	9/12/2014	9A	\$2,468,035.0	Highway plan quantity omission or error
60L71	\$57,095,577.90	District 01: Schaumburg, Illinois	8/1/2017	29	\$2,334,447.08	Contract administration
62108	\$43,852,281.30	District 01: Schaumburg, Illinois	10/22/2007	25C	\$2,300,000.0	Specification performance adjustment
60G37	\$37,495,559.30	District 01: Schaumburg, Illinois	9/7/2017	158	\$2,223,730.37	Contract administration
60L71	\$57,095,577.90	District 01: Schaumburg, Illinois	7/24/2018	44	\$2,137,254.74	Utility caused change/addition
66586	\$33,938,592.10	District 03: Ottawa, Illinois	11/19/2007	31	\$2,074,258.0	Balance final field measurements
60M62	\$32,920,024.40	District 01: Schaumburg, Illinois	2/21/2014	8	\$2,067,780.0	Allowable contingencies
61F33	\$16,525,113.70	District 01: Schaumburg, Illinois	3/19/2020	21	\$2,039,161.0	Local agency project
64821	\$18,995,417.70	District 02: Dixon, Illinois	10/16/2018	66	\$2,001,136.13	Contract administration
60D61	\$33,012,012.80	District 01: Schaumburg, Illinois	8/1/2012	87	\$2,000,000.0	Contract administration
64F82	\$10,966,143.70	District 02: Dixon, Illinois	5/18/2010	1A	\$2,000,000.0	Differing site condition
62893	\$1,999,112.90	District 01: Schaumburg, Illinois	7/24/2008	02	\$1,999,112.96	Allowable contingencies
60D61	\$33,012,012.80	District 01: Schaumburg, Illinois	8/15/2012	53B	\$1,960,000.0	Specification performance adjustment
74255	\$12,528,799.00	District 07: Effingham, Illinois	6/7/2016	9C	\$1,896,939.52	Differing site condition
60W28	\$55,827,813.60	District 01: Schaumburg, Illinois	8/5/2016	70	\$1,886,200.0	Differing site condition
60R30	\$34,618,122.20	District 01: Schaumburg, Illinois	5/9/2014	21	\$1,860,300.0	Highway design engineering error
62478	\$30,486,603.50	District 01: Schaumburg, Illinois	7/5/2011	12	\$1,855,000.0	Design change
60953	\$22,967,943.40	District 01: Schaumburg, Illinois	3/27/2018	75	\$1,806,971.4	Contract administration
60L72	\$47,244,971.20	District 01: Schaumburg, Illinois	6/14/2018	90	\$1,786,000.0	Utility caused change/addition
60X61	\$20,490,228.60	District 01: Schaumburg, Illinois	8/29/2016	38	\$1,713,405.93	Differing site condition
62H67	\$12,612,286.00	District 01: Schaumburg, Illinois	5/6/2020	2	\$1,700,000.0	Contract administration
60G37	\$37,495,559.30	District 01: Schaumburg, Illinois	4/24/2015	102	\$1,690,000.0	Highway plan quantity omission or error
76N66	\$12,656,313.60	District 08: Collinsville, Illinois	6/25/2020	001	\$1,662,433.1	Highway plan quantity omission or error
60999	\$37,657,777.70	District 01: Schaumburg, Illinois	5/29/2012	38	\$1,629,677.72	Design change
60Y39	\$39,458,694.00	District 01: Schaumburg, Illinois	11/12/2020	047	\$1,575,500.0	Contract administration
62478	\$30,486,603.50	District 01: Schaumburg, Illinois	10/12/2011	12A	\$1,574,197.04	Design change
68620	\$86,596,214.30	District 04: Peoria, Illinois	10/13/2017	133	\$1,561,268.34	Contract administration

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Step 4: Develop Change Order Guidelines for IDOT Projects

The last step was developing change order guidelines to ensure better management and administration of the associated processes. In relation to that, three main outcomes were attained. First, the paper provides a total of three comprehensive flowcharts for change order approval procedures (shown in Fig. 3 later in the paper) and for change order compensation considerations (shown in Figs. 4 and 5 later in the paper). Second, the paper furnishes a contractual synopsis of the opportunities and risks associated with IDOT's change order procedures. Third, the paper offers a contractual checklist comprised of a list of questions that the contracting parties shall consider when handling change orders.

It is noted that the flowcharts were developed by following the subsequent steps: (1) examining the stipulations of the *Standard Specifications for Road and Bridge Construction* document for IDOT projects, (2) identifying and discerning the change orders related clauses, (3) analyzing and scrutinizing the identified change order provisions, (4) describing the flow of information and displaying the tasks associated with the change order process, (5) showing the decisions that need to be made along the chain and the essential relationships and dependencies between the different steps of the change order process, (6) visualize all the change order related procedures that need to be followed and implemented by the contracting parties, and (7) validating the main research output (i.e., Figs. 3–5 and Tables 6 and 7) by sharing them with a focus group of IDOT change order experts to make sure that they are comprehensive, complete, representative, correct, and precise.

Results and Analysis

This section presents the obtained results and the associated analysis in relation to: (1) the main causes of key change orders on IDOT projects, (2) identification of the main change order related challenges based on case studies, and (3) the approval procedures, compensation considerations, and applicable laws for change orders within IDOT projects.

Main Causes of Key Change Orders on IDOT Projects

As detailed in the "Research Method" section, the authors consulted with a focus group of IDOT experts who helped in retrieving the IDOT's change order information for key projects that experienced the highest amounts of changes. To this end, the retrieved data are shown in Table 3.

Table 3 shows that change orders on IDOT projects could reach very high amounts in the orders of \$20M, which reflects the criticality of change orders experienced on IDOT infrastructure projects. Fig. 2 shows the causes of the change orders present in Table 3. It is noted that Fig. 2 was developed by the authors and is not simply taken from existing IDOT manuals.

As shown in Fig. 2, the top five causes of key change orders within IDOT projects include: contract administration, allowable contingencies, highway plan quantity omission or error, differing site condition, and design change. The significance or meaning of each one of these main causes of change orders is explained therein. First, the *contract administration* category includes any costs added to the contract as a direct result of a contract claim settlement. Second, the *allowable contingencies* category includes *built-in* changes that are required by the specifications or state-wide changes in department policy based on the type of work involved in the contract or conditions found at the job site. In general, changes in this category are work efforts called for in the contract

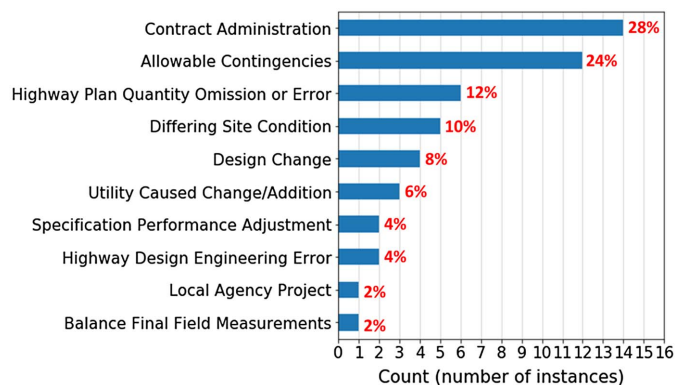


Fig. 2. Main causes of key change orders on IDOT projects.

but specified to be paid for as extra work, or they are planned contingencies, that is, work efforts that depend on the actual field conditions which could not be known at the time of design. Third, the *highway plan quantity omission or error* category includes changes in plan quantity due to significant discrepancy between plan quantity and the as-built quantity with no change in the intended scope of work shown on the plans, and changes for a pay item that was not included in the plans, but for which the work was called for in the plans with the intention of paying for such work as a separate pay item. Design errors in this category are not a change to the intended design but include costs that, had the error not been made, would have been included in the awarded contract amount. Fourth, the *differing site condition* category includes compensation to the contractor for additional costs incurred when subsurface or latent physical conditions are encountered in the project. Finally, the *design change* category includes all changes in the specifications or design that are not specified in another category without regard as to why they were initiated or who initiated them.

Analysis of Case Studies and Identification of the Main Change Order Related Challenges

After understanding the main causes of key change orders on IDOT projects, the authors analyzed individual case studies of IDOT projects to identify the main change order related challenges. As detailed in the "Research Method" section, this was performed through consultation with a focus group of IDOT experts to ensure that the analysis tackles the most important and comprehensive change order related challenges on IDOT projects.

Stone versus City of Arcola Case Study

In the case study of Stone versus City of Arcola [536 N.E.2d 1329, 181 Ill. App. 3d 513, 130 Ill. Dec. 118 (App. Ct. 1989)] which is a \$1.273 million project, change orders were one of the main reasons behind conflicts, claims, and disputes between the parties. Claims and disputes arose between the project parties concerning the approval procedures of change orders. In determining the decision on this case, reference to the provisions present in IDOT's *Standard Specifications for Road and Bridge Construction* was made. In fact, five written change orders were issued in this project and resulted in an increase in the contract price and in an extension of time to complete the work. In relation to the approval procedures in this case study, three of these change orders were made during the time the defendant (City of Arcola) was retaining liquidated damages for plaintiff's (Stone) delay in completing the contract. Also, one of the change orders resulted from a request by the plaintiff and two change orders were requested by the defendant. One of the change

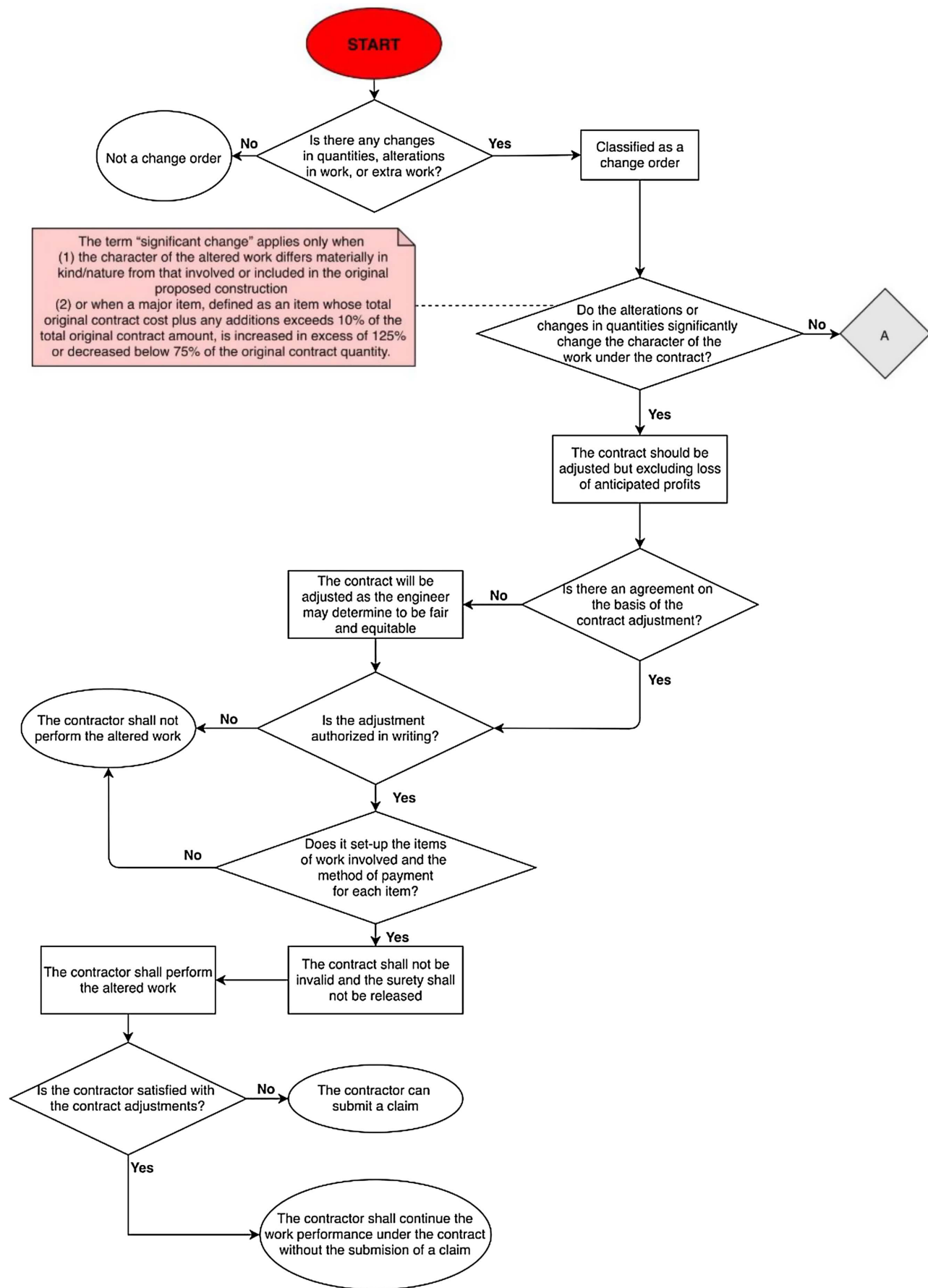


Fig. 3. Approval procedure for alterations in the work's character (Note: Node A leads to Fig. 4: compensation considerations).

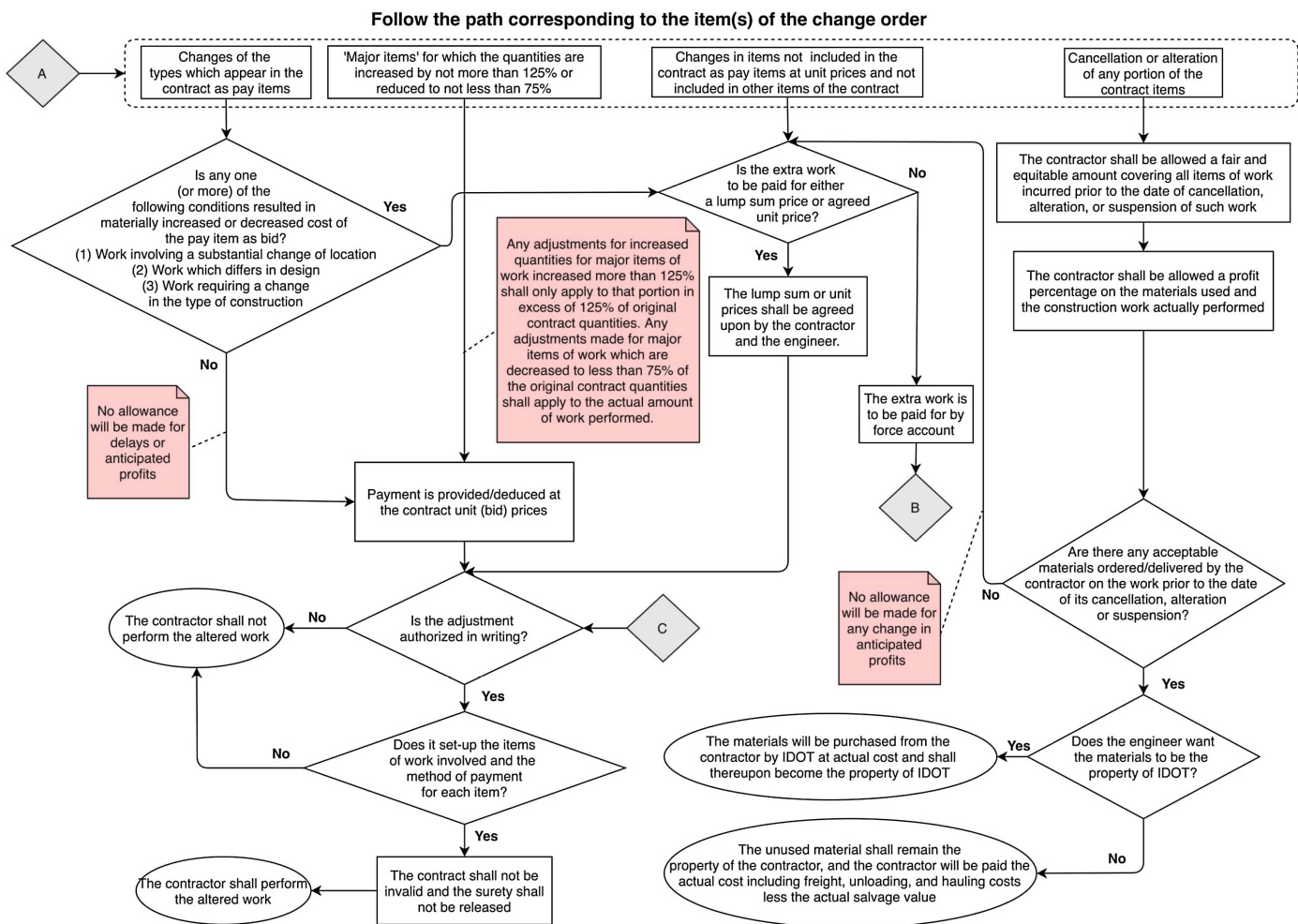


Fig. 4. Change order compensation considerations for changes with no alterations in the character of the work. A starts from Fig. 3, Node B leads to Fig. 5, and Node C starts from Fig. 5.

orders requested by the defendant was for the construction of a metal storage building, which is performed by a subcontractor selected by the defendant and which was merely tied to the plaintiff's contract. As such, this case study reflects that the approval procedures of change orders could lead to claims and disputes.

Jane Byrne Interchange Case Study

In the case study of the Jane Byrne Interchange Project (2019), one of the most notable conflicts on this project arose between the parties due to change order compensation considerations related to labor, material, equipment, work items present in the contract, major items, work items not present in the contract, and work deletions. A total of \$2.5 million was incurred in change orders on the Peoria St. Bridge section of this case study for a compensation related to the contractor's furnish of labor, material, and equipment needed to complete this section of the Jane Byrne interchange in a good and workmanlike manner as stipulated by the contract documents provided by IDOT. That said, this case study stresses that guidelines on the proper management of the compensation considerations for change orders for IDOT projects are needed.

Fruin-Colnon versus Highway & Transp. Commission Case Study

In the case study of Fruin-Colnon versus Highway & Transp. Com'n [736 S.W.2d 41 (Mo. 1987)], conflicts and disputes were present between the parties concerning change orders and the

applicable laws on an agreement to design and construct a bridge project spanning the Mississippi River south of St. Louis. According to the agreement, bids were invited from contractors through bid advertisements reflecting the required design of the structure and anticipated construction conditions. In relation to that, Fruin-Colnon Corporation and Granite Construction Company (Appellants) submitted a bid as joint venturers and were awarded the contract by the IDOT to build the substructure. It was agreed that the substructure shall be constructed in accordance with the bid invitation plans and the *Standard Specifications for Road and Bridge Construction* promulgated by the IDOT. Appellants were faced with many change order issues related to inaccurate representations in the project's documents and to the determination of the applicable laws that shall govern these change orders. More specifically, the plans indicated the Illinois riverbank commenced 360 feet west of its actual location; appellants had to extend their work trestle at added cost to accommodate the underestimate. Moreover, the project's plans reflected that only one navigation channel is present along the river at the proposed site. However, there were two such channels. In addition, river-traffic collided with one of appellants' partially completed *cofferdams* necessitating its reconstruction and installation of a protective nose cone to prevent future damage. The plans also were incorrect in representing certain *Illinois riverbank piers* needed no protection from *scour*; two of appellants' work trestles were destroyed due to a lack of protection against this phenomenon. Nevertheless, the contract provided that

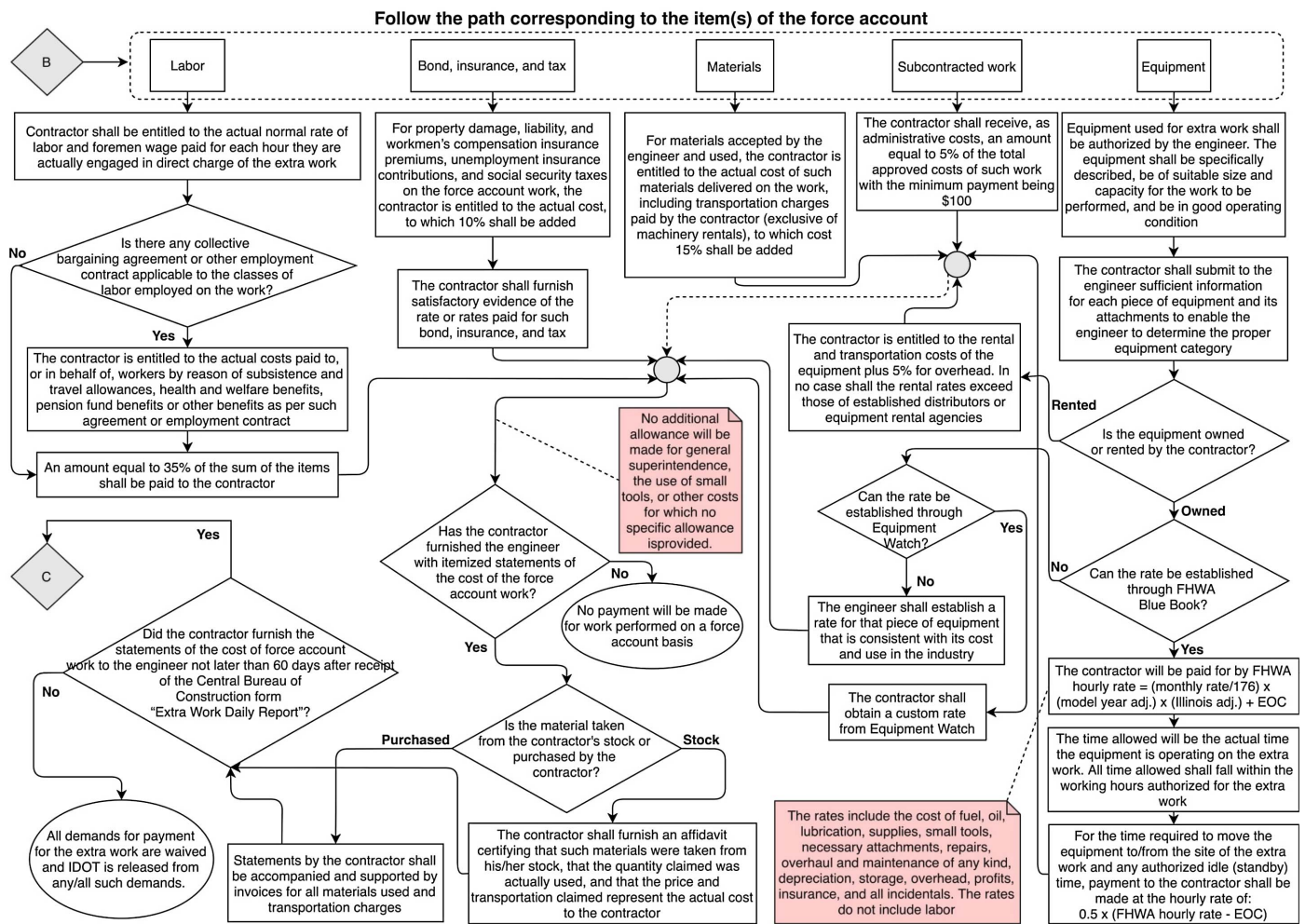


Fig. 5. Change order compensation considerations for changes on force account basis. Node B starts from Fig. 4 and Node C leads to Fig. 4.

disputes, including those related to change orders, shall be submitted to the Illinois Court of Claims, and therefore Illinois had a contractual expectation that its own law be applied. In fact, the contract explicitly stated that the enforcement of Illinois' applicable laws offers "certainty, predictability and uniformity of result." In relation to the conflicts and disputes between the project parties, the final decision on this case study was that "appellants entered into a contract in Illinois which is valid under the law of that state and are thereby bound by its provisions." Therefore, this case study reflects the importance of understanding the applicable laws that govern change orders on IDOT-awarded projects.

Analysis of the Change Order Related Challenges

The analyzed law case studies in the previous section reflect the importance of understanding and studying the IDOT's change order provisions as related to three main challenges: approval procedures, compensation considerations, and applicable laws that govern change orders on IDOT-awarded projects. Hence, this section analyzes these three identified change order related challenges (i.e., approval procedure, compensation considerations, and applicable laws).

It is noteworthy that the identified aspects (based on the analysis of the three case studies) are not causes of change orders but rather they are change order related challenges faced on IDOT projects. For instance, the first aspect which is *Approval Procedures* is not a

direct cause of change orders but rather it is a challenge that contracting parties face in managing and administering change orders on their projects. The same applies to the other aspects of *Compensation Considerations and Applicable Laws*.

Furthermore, it is noted that this section includes information that is the result of the authors' research efforts rather than taken as-it-is from existing resources. Similarly, Figs. 3–5 were developed by the authors and are not simply taken from existing IDOT manuals, and the information present in this section is needed to understand how the flowcharts were developed and how they should be used by the contracting parties.

Approval Procedures

IDOT (2016) specifies that the word *engineer* refers to the *chief engineer* or the *director of highways of the IDOT* or 'any authorized representative limited by the particular duties entrusted to such entity when Illinois is the awarding authority.' According to IDOT (2016), through the standard specifications used as a contractual document with the contractors and at any time during the work, the department reserves its right to: (1) make changes in the quantities, (2) make alterations in work, and (3) perform extra work to ensure the satisfactory completion of the project. However, these changes should be made in writing. Moreover, the contractors should be aware that these changes, alterations, and extra work shall not invalidate the contract with the IDOT nor shall release the surety, and that the work shall be performed as altered. In case the

changes in the quantities or alteration have a significant impact on the character of the work, the contract should be adjusted (excluding loss of anticipated profits) (IDOT 2016). In case there is a disagreement between the contractor and the owner in relation to the contract's adjustment, then the adjustments will be performed based on what the engineer determines to be fair and equitable. On the other hand, IDOT (2016) adds that in case the changes in the quantities or alterations in the work do not have a significant change on the work's character, the altered work(s) shall be paid for as stipulated by the contract between the contractor and IDOT. Furthermore, contractors working under IDOT projects should be aware that all change orders need to be authorized in writing by the engineer before starting the altered work. To avoid any unnecessary risks and dire consequences (such as the engineer's rejection of the contractor's claims), contractors should not perform any alterations, cancellations, extensions, and deductions to the work unless the engineer authorizes them to perform such changes (IDOT 2016).

Compensation Considerations

According to IDOT (2016), in case of an increase or decrease in the quantities of work, payments due to the contractors are calculated as follows:

1. **Items appearing in the contract:** if the increases in the work include items that appear in the contract as *pay items* accompanied by unit rate(s), then the contractor will be paid at the stipulated unit rate(s) in the contract. Similarly, for decreases in such work items, the contract amount will be reduced according to the unit bid prices.
2. **Major items:** for major items with quantities reduced to not less than 75% or increased by not more than 125% of their originally stipulated quantities, the contract amount will be changed as specified in the point above (i.e., items appearing in the contract). However, IDOT (2016) specifies that: "any adjustments for increased quantities for major items of work increased more than 125% shall only apply to that portion in excess of 125% of original contract quantities. Any adjustments made for major items of work which are decreased to less than 75% of the original contract quantities shall apply to the actual amount of work performed."
3. **Items nonappearing in the contract:** the contractor shall not start any work without the engineer's authorization. Two payment methods are possible: (1) lump sum price or agreed unit price, and (2) force account basis. Under the first payment method, the lump sum price or the unit prices shall be agreed upon by the contractor and the engineer. However, under the second payment method, the monetary amount is dependent on the nature of the work to be completed as detailed below:
 - a. **Labor:** the contractor shall be paid the actual normal rate of the wage paid (and every hour) for all labor and foremen actually engaged or in direct charge of the specific operations related to the extra work. The contractor shall receive the actual costs paid to workers as related to subsistence and travel allowances, health and welfare benefits, pension fund benefits or other benefits, in case these amounts are needed by a collective bargaining agreement or other applicable employment contract. Additionally, the contractor is entitled to a monetary amount of 35% of the sum of the previous items.
 - b. **Bond, insurance, and tax:** the contractor is entitled to receive the actual cost incurred for property damage, liability, and workmen's compensation insurance premiums, unemployment insurance contributions, and social security taxes on the force account work. In addition, the contractor shall receive a monetary amount of 10% of the sum of the previous items. Nevertheless, the contractor is required to provide

acceptable evidence of the rate(s) paid for such bond, tax, and insurance.

- c. **Accepted and used materials:** the contractor is entitled to be paid the actual cost of the accepted and used material that is delivered to the construction site. This cost includes the incurred transportation charges (exclusive of machinery rentals) plus 15%.
- d. **Equipment:** Any equipment shall be: (1) authorized by the engineer, (2) specifically described by the contractor, (3) of suitable size and capacity for the work performance, (4) in good operation condition, and (5) with a price agreed on in writing. For equipment, the contractor will be paid as follows:
 - (1) **Equipment owned by the contractor:** the contractor working with IDOT will be paid on an hourly basis using applicable FHWA hourly rate according to Eq. (3)

$$FHWA \text{ hourly rate} = \left(\frac{\text{monthly rate}}{176} \right) \times (\text{model year adj.}) \times (\text{Illinois adj.}) + EOC \quad (3)$$

where the EOC is the estimated operating costs per hour and is retrieved from FHWA's Blue Book (Equipment Watch Rental Rate Blue Book), and 176 is the number of hours per month.

FHWA's Blue Book is a comprehensive guide to the recovery of construction equipment-related ownership and operating costs. These costs are derived from rates formulae and factors developed from field research and from analytic methods used in the industry (Equipment Watch 2020). Equipment Watch is the most trusted by the equipment finance industry because it helps in decisions concerning the purchase, valuation, operation, and disposal of equipment (Equipment Finance Advisor 2020). For the equipment operating time, it is calculated as the actual time the equipment is used for the extra work. Nevertheless, the operating time should fall within the working hours authorized for the extra work. On the other hand, for the time taken to move the equipment to and from the site of the extra work and any authorized idle (standby) time, the contractor will be paid for at the rate specified in Eq. (4)

$$\text{Compensation} = 0.5 \times (\text{FHWA hourly rate} - \text{EOC}) \quad (4)$$

where the EOC is the estimated operating costs per hour and is retrieved from FHWA's Blue Book. Also, the FHWA hourly rate is obtained using Eq. (3).

It is noteworthy that contractors shall be aware that the rates calculated using the previous formulae include the cost of fuel, oil, lubrication, supplies, small tools, necessary attachments, repairs, overhaul and maintenance of any kind, depreciation, storage, overhead, profits, insurance, and all incidentals. Nevertheless, labor costs are not included in these formulae.

- (2) **Rented equipment:** the contractor will be paid for the rental and transportation costs of the equipment, in addition to 5% for overhead. However, the contractor shall be careful that in no case the rental rates shall exceed those of established distributors or equipment rental agencies.
- e. **Miscellaneous:** the contractor will not be entitled to any additional allowance for general superintendence, the use of

small tools, or other costs for which no specific allowance is provided.

f. **Subcontracted work:** the contractor is entitled to receive, as administrative costs, a monetary sum of 5% of the total approved costs of the extra work to be performed by the approved subcontractor with the minimum payment being \$100.

(1) **Cancelled or altered portions of the contract items:** if the cancellation or alternation results in the elimination or noncompletion of any partially performed work, the contractor will be entitled to a fair and equitable amount that covers all work items incurred before such cancellation, alteration, or work suspension. In addition, the contractor will be entitled to a profit percentage on the used materials and the completed work according to the rate specified previously in the case of items nonappearing in the contract (with no allowance to anticipated profits).

(2) **Item(s) appearing in the contract but with materially increased or decreased cost(s):** this applies for the extra work that includes pay item with: (1) stipulated unit price in the contract but materially increases or decreases the cost of the pay item as bid, and (2) which is not included in the prices bid for other items in the contract as a result of one or more of the following reasons: (a) substantial change of location, (b) difference in design, and (c) change in the type of construction. In such cases, the contractor will be paid in the same way as provided above in the case of items nonappearing in the contract.

It is concluded from the above-mentioned discussion and analysis that the compensation considerations for infrastructure projects constitute a detailed and potentially complicated process for the management of change orders. That said, the authors summarized and depicted the entire compensation considerations in Figs. 4 and 5.

Applicable Laws

IDOT (2020a) specifies that the approval of change orders shall be in conformity with the applicable state laws: the Illinois Procurement Code (30 ILCS 500), the State Finance Act (30 ILCS 105/9.02), and the Criminal Code (720 ILCS 5/33E). These applicable laws have created a complex web for contractors working under projects funded by the IDOT as they affect the process of work addition to their contracts and the payment provisions for that work (IDOT 2020a). In fact, mandatory law provisions take precedence over the parties' contractual stipulations (Assaad and Abdul-Malak 2020).

Change orders in IDOT projects could be classified into two main types or categories: minor changes and major changes. It is worth mentioning that IDOT (2020a) is the base of the differentiation/classification of change orders into main major and minor changes. Table 4 shows the differences between major and minor changes.

All contractors working under IDOT projects should be aware of the department's policy that all major changes in the plans or the contractor provisions require the approval of the Central Bureau of Construction before the commitment of any such change orders. In addition, for contractors that work on Projects of Division Interest *PoDI* (also known as full oversight *PoDI*) and/or Projects of Corporate Interest *PoCI* (also known as nonexempt *PoCI*), the FHWA approval is required for all major changes. As such, contractors shall take such policies into account when bidding for infrastructure projects funded by the IDOT. Also, by agreement, the FHWA should review all authorizations of contract changes on selected contracts identified as *PoDI* and *PoCI* and other contracts that might be required by the Oversight Agreement. The FHWA's prior approval is required for major changes. The FHWA's prior approval is not required for minor changes. It is recognized that some additions exceeding \$250,000 may, by their nature, not require prior approval. The coordination with FHWA is the

Table 4. Major changes versus minor changes

Type of change	Conditions
Major change	<p>A contract change is considered as a major change if one of the following cases occurs:</p> <ol style="list-style-type: none"> 1. The change results in a revision of the alignment or typical section of the mainline infrastructure highway asset (such as roadway, ramps, frontage road, or crossing areas), 2. The change results in a revision of the access control to the infrastructure highway asset; being either permanent or temporary, 3. An acceleration of the work that involved payment for premium time or loss of productivity, or any other forms of acceleration greater than \$20,000 per contract, 4. The change results in a revision of the staging of construction where examples include change in the traffic control plans, reduction in the number of lanes open to traffic, impacted traffic flow or patterns, 5. The change results in revisions of the project's limits or that adds omitted work, 6. The change impacts a protected environmental resource or an environmental commitment where a follow-up coordination is needed, 7. The change results in extra work to be performed at the stipulated contract unit prices, agreed-upon unit price, or force account methods with a total cost equal to or higher than \$250,000, 8. The contract claims are filed in accordance with Article 109.09 of IDOT constructional manual (IDOT 2020e), 9. The change results in modifications in the method of measurement or basis of payment for an item of work, and 10. The change is considered as a small purchase procured in accordance with Section 6.100(b) of the IDOT's Procurement Rules.
Minor change	<p>A contract change is considered as a minor change if one of the following cases occurs:</p> <ol style="list-style-type: none"> 1. An adjustment in the unit price with a total less than \$250,000 where such adjustment shall be specifically required by the standard specification or as a special provision (one such example is a price adjustment for traffic control purposes), 2. Any extra work that does not exceed a total cost of \$250,000 and that is to be performed at the stipulated contract unit price, agreed-upon unit price, force account, or any combination thereof given that it does not classify as a major change, 3. A change in the contract that results in quantity adjustments in the contract to match the as-build quantities, and 4. An acceleration of the work that costs less than or equal to \$20,000 per contract.

Source: Data from IDOT (2020a).

Table 5. IDOT—Levels of delegated authority for minor changes

Delegated authority	Total amount of the change order
Resident engineer or technician	\$0–\$20,000
Supervising field engineer	\$20,000–\$40,000
Construction engineer	\$40,000–\$100,000
Implementation engineer	\$100,000–\$150,000
Regional engineer	\$150,000–\$250,000

Source: Data from IDOT (2020a).

responsibility of the District that shall keep FHWA's transportation engineers aware of pending major changes during project visits or through e-mails or calls.

Before starting any extra work, it should be approved in writing and a copy provided to the contractor who will perform the work. The written approval shall have the signature of the person who approved the change order, and who shall have either direct or delegated authority to approach the extra work. Table 5 shows the different levels of delegated for the approval of minor change orders.

As part of Illinois Finance Code and departmental order requirements, when a single or cumulative change has a net amount

of \$250,000 or greater in a fiscal year, the following signatures should be secured before any funds may be obligated for such a change: Secretary, Chief Fiscal Officer, Chief Counsel, and the Chief Procurement Officer for the Department's construction and construction related procurements (IDOT 2020e).

Opportunities and Risks

Based on the previous analyses, the authors developed a contractual synopsis of opportunities and risks for contractors working on IDOT projects as shown in Table 6. It is noted that the synopsis of opportunities and risks was developed by following the subsequent steps: (1) reviewing the content of the *Standard Specifications for Road and Bridge Construction* and the *Construction Memorandum No. 4: Contract Changes* documents for IDOT projects, (2) scrutinizing the change orders related provisions and clauses, (3) identifying the contract language that may trigger problems related to change orders, (4) determining the stipulations that could benefit the change order procedures, (5) creating a record of the identified risks and opportunities, and (6) validating the final developed synopsis of opportunities and risks by sharing it with the focus group

Table 6. Opportunities and risks under IDOT

Opportunities	Risks
<ul style="list-style-type: none"> • Unambiguity in relation to what work items are classified as <i>significant changes</i> • Clear explanation of what is considered as an <i>extra work</i> • Express provision of the roles of the engineer, the contractor, and the IDOT in relation to change orders • Unambiguity in relation to what constitutes a <i>major item</i> • Specifically states that the IDOT reserves its right to make changes at any time during the execution of the works • Explicitly states that the engineer is the project party responsible to make a determination in case of disagreement between the contractor and the IDOT • Clearly provides that all change orders shall be authorized by writing by the engineer before starting the altered works; thus, reducing the likelihood of claims related to verbal change orders • Detailed description of how the change orders' monetary compensation should be calculated and paid to the contractor • Explicit differentiation between minor changes and major changes • Clear definition for change orders • Expressly states that IDOT shall be determined to protect the public interest, the expeditious prosecution of the work, and the compliance with Illinois and Federal law 	<ul style="list-style-type: none"> • Lengthy approval process according to applicable laws and department's requirements. • Applicable laws' procedures create a complex web for contractors working under projects funded by the IDOT as they affect the process of work addition to their contracts and the payment provisions for that work. • Contractors are not entitled to any allowance for delays or anticipated profits for items appearing in the contract, which might open up room for claims between contractors and the IDOT. • Uses different calculation methods for increases and decreases in the quantities of major items. • There is no procedure for the collection of money by the contractor in case some/all change order work was performed prior to the engineer's authorization under emergency conditions. • Dependence of the monetary amount under force account on the nature of the work, which can create much confusion on how the compensation is determined. • Requires the contractor to provide acceptable evidence on the rate(s) paid for bonds, taxes, and insurances which might not be easily accessible. • Contractors shall be aware that labor costs are not included in the formulae used to calculate the compensation related to equipment owned by the contractor; thus, contractors need to factor that in their bid. • To enable the engineer to determine the proper equipment category, the contractor is shouldered to submit sufficient information for each piece of the equipment and its attachments; such information could not be readily available. • The 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. • The IDOT is considered released from any and all demands for payment for the extra work in case the contractor fails to furnish the needed documentation within the specified period. • Possibility of discrepancies between the contract language and the different applicable laws under which the contract is being construed. • Presence of a policy stating that all major changes in the plans require the approval of the Central Bureau of Construction before the commitment of any such change orders. As such, contractors shall take such policies into account when bidding for infrastructure projects funded by the IDOT. • FHWA approval is required for all major changes on projects of division interest (also known as full oversight PoCI) and/or projects of corporate interest (also known as nonexempt PoCI). This could hinder or delay the change order process. • The requirement of five signatures before any funds may be obligated for such a single or cumulative change order with net amount of \$250,000 or greater in a fiscal year. These signatures include those of the Secretary, the Director of Highways Project Implementation, the Director of Finance & Administration, the Chief Counsel, and the Chief Procurement Officer for the IDOT's construction and construction related procurements. • The contractor shall be careful that in no case the rental rates of equipment shall exceed those of established distributors or equipment rental agencies; thus, contractors need to factor that in their bid.

of IDOT change order experts to ensure its comprehensiveness and preciseness.

It is noteworthy that there is no relation between the opportunities and risks in Table 6.

Checklist

Finally, the authors developed a checklist consisting of 30 questions, as shown in Table 7, to better address the three change orders

related challenges under IDOT. It is noted that the developed checklist presented in Table 7 is best applied during the precontract award phase (i.e., the planning and/or negotiation phase). Answering those questions in the contract between IDOT and its contractors shall help the project parties be better enabled and aligned to seek a clearer and more comprehensive contract language in relation to change orders. It is noted that the checklist was developed by following the subsequent steps: (1) examining the stipulations of the *Standard Specifications for Road and Bridge Construction* and the

Table 7. Checklist questions

Challenge	Question
Approval procedures	<ul style="list-style-type: none"> • Does the agreement expressly provide a definition for a change order? • Does the agreement expressly state the conditions for which a change order can be issued? if yes, how? • Does the contract differentiate between work changes and extra work? If yes, how? • Does the contract include any other terms related to change orders, such as significant change or major item? If yes, are these terms explicitly defined in the contract? • Does the contract call for any classifications of change orders such as minor and major changes? If yes, are these classifications clearly defined in the contract? • Does the contract expressly state the department's authority responsible for the issuance of change orders? • Shall there be any limitations to the department's authority responsible for the issuance of change orders? If yes, are such limitations described in the contract? • Is a written direction deemed to be a condition precedent to proceed with the change order? If yes, is it expressly stated in the contract? • Does the contract stipulate the reimbursement methods for change orders? • Does the contract expressly state the conditions for which each reimbursement method shall be exercised?
Compensation considerations	<ul style="list-style-type: none"> • Does the contract expressly state the cost items of change orders that can be reimbursed to the contractor? • Is there any time limit(s) during which the contractor must submit his/her price or cost breakdown related to any change order? If yes, is that expressly stipulated by the agreement? • Is there any time limit(s) during which the department must respond to the contractor's change order submittal? If yes, is that expressly stipulated by the agreement? • In case of disagreement between the contractor and the department on the costs or unit prices of any change order, does the contract expressly provide the procedure to be followed? • Does the contract explicitly state the conditions for which change orders will be processed on a force account basis? If yes, how? • What documents shall the contractor submit to have the needed compensation on force account basis? What items must be provided in each submittal? • Shall itemized statements be submitted by the contractor to the department's or the engineer's review and written approval? If yes, what elements need to be present in such itemized statements? • If compensation for labor and foremen costs is needed for a change order, does the contract expressly state the compensable costs? If yes, how? Also, is the contractor entitled for any markup on such costs? If yes, how? • If compensation for material costs is needed for a change order, does the contract expressly state the compensable costs? If yes, how? Also, is the contractor entitled to any markup on such costs? If yes, how? • Does the contract expressly stipulation for the case where the contractor uses material from his/her own stock to perform the needed change order? If yes, how? Also, what documents are needed to be submitted by the contractor in such case? • In case the change order includes equipment compensation costs, does the contract expressly state the compensable costs? If yes, how? • Does the contract expressly stipulate for the situation where equipment owned by the contractor is utilized to perform the needed change order? If yes, how does the contract estimate the required compensation? • Does the contract expressly stipulate for the situation where rented equipment is utilized to perform the needed change orders? If yes, how does the contract estimate the required compensation? • Does the contract explicitly address how the contractor must be compensated for the idle time of the equipment used to perform the needed change order? If yes, how? • Does the contract explicitly address how the contractor must be compensated for any subcontracted work related to the change order? If yes, how?
Applicable laws	<ul style="list-style-type: none"> • What are the applicable laws that govern the procedures of change orders? • Does the agreement expressly state the authorities that possess approval power for the different kinds of change orders? If yes, how? • Can the approval power be delegated to another authority? If yes, does the agreement explicitly state the conditions for which such delegation is possible? If yes, how? • Does the agreement expressly state the specific conditions for which the contractor can be directed to proceed with the variations, changes, or extra work? If yes, who is authorized to provide such directive? • Is FHWA's approval required for any kind of change orders? If yes, what kinds of change orders need such approval? Does the contract expressly state how FHWA's approval shall be secured?

Construction Memorandum No. 4: Contract Changes documents for IDOT projects, (2) identifying a list of items required, points to think about, and things needed to be present or implemented for a proper management and administration of change orders, (3) transforming the identified list into a question format that includes the informational material required to remind the project parties of the necessary elements that need to be present in the contract between them and to ensure that the important aspects are covered, (4) categorizing the identified list of questions into the determined three change order related challenges: approval procedures, compensation considerations, and applicable law, and (5) validating the final developed checklist by sharing it with the focus group of IDOT change order experts to ensure its completeness and correctness.

Validation of Research Outcomes: Experts Demographics and Provided Feedback

The authors contacted and shared the outcomes of this paper with a focus group of IDOT experts to review the adequacy, suitability, and value of the research outcomes to the proper management of change orders on IDOT infrastructure projects. This group of experts has an average experience of more than 20 years in construction and contract administration with more than 10 years of experience with IDOT operations in specific. Moreover, the authors ensured the expertise of the experts by targeting professionals that hold high positions or job titles within IDOT and that are the main individuals who are responsible for the management of change orders within IDOT projects. More specifically, these experts are staff members from the Office of Highways Project Implementation at IDOT and the Office of Chief Counsel at IDOT. The experts within the Office of Highways Project Implementation are responsible for: monitoring district programs to ensure statewide uniformity of policy interpretation and compliance and to certify program coordination with federal, state, and local agencies; making sure that programs and activities support efficient program implementation across the districts; and, ensuring that highway improvement projects are constructed and operated in a cost effective and timely manner and that funds to local agencies are properly administered. Further, the experts within the Office of Chief Counsel at IDOT are responsible for the provision of legal counsel to IDOT, for the prosecution of all departmental litigation, and for the administration of different claims including change orders. The experts within the Office of Chief Counsel helped in the selection of the major IDOT cases presented in this paper, which involved issues related to change orders.

The obtained feedback comments from the validation stage included the following: (1) confirming that the paper's flowcharts, contractual synopsis of risks and opportunities, and checklist (i.e., Figs. 3–5 and Tables 6 and 7) are accurate and would be useful and facilitating tools for IDOT's staff and for contractors working on IDOT infrastructure projects, and (2) substantiating that the outcomes and guidelines could act as a quick reference—especially for new IDOT contractors—in better understanding of the change order process, its associated procedures, and areas of potential concerns.

The IDOT experts also recommended the following modifications and revisions: (1) examining and coding the main causes of key change orders according to IDOT's standard categories present in the *Construction Memorandum No. 4: Contract Changes* document (IDOT 2020a) to minimize and avoid any subjectivity (which was performed in this paper as shown in Fig. 2 and Table 3), and (2) adding the *Illinois Construction Manual* (IDOT 2020e) as one of the relevant IDOT change order documents that the contracting

parties need to consider when managing and administering change orders on their projects. The experts also clearly mentioned that contractors—who are working on IDOT infrastructure projects—should have proper knowledge of the change order provisions as stipulated by IDOT standard documents.

Discussion

This paper enhanced the knowledge and understanding of the main causes of change orders, the associated approval procedures, the compensation considerations, and the applicable laws. As for the practical implications of this paper, this study provided project stakeholders with guidelines for contractual management of change orders within IDOT infrastructure project that should: (1) enable the project parties to be better aligned to seek a more clear and comprehensive contract language in relation to change orders, (2) serve as a quick reference for practitioners in terms of the proper actions that need to be implemented or followed with respect to change orders, (3) provide the contracting parties with an in-depth understanding of the general provisions associated with the management of change orders, (4) help in minimizing conflicts, claims, and disputes in relation to change orders on infrastructure projects, (5) foster proper administration of the change order provisions in accordance with accepted legal principles, and (6) ensure compliance with the letter and spirit of all applicable laws. Ultimately, this paper adds to the body of knowledge through providing a better discernment of change orders and their procedures in public infrastructure transportation projects.

Limitations and Future Work

One of the limitations of this paper is its emphasis on infrastructure transportation projects in specific rather than other types of projects such as residential, commercial, and industrial, among others. Another limitation is the paper's focus on examining the procedures for change orders in IDOT projects. Further, during the authors' search and review of IDOT case studies, there was a limitation regarding the public availability of information, especially as related to law cases. 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—to facilitate further analysis of such an important topic. With the availability of more case studies, future research is recommended to extend the findings of this study to cover further identified challenges (if any) in relation to contractual administration of change orders on infrastructure transportation projects.

Whereas the research conducted in this paper is applied to IDOT infrastructure transportation projects, the analysis and findings included in the paper should also support other public entities nationwide (that may be following similar guidelines) in better managing change orders within their infrastructure projects. More specifically, other DOTs (especially the ones with less detailed change order procedures) can benefit from this research by identifying contract terms that may need to be revised and updated within their standard management procedures of change orders. Furthermore, the research method implemented in this paper could be followed and utilized to study the aspects of change orders for infrastructure transportation projects in different international countries because the analysis technique is scalable and malleable enough to be used on any similarly available information, data, and case studies. Thus, the authors recommend that future research consider conducting a comparative analysis between the change order

procedures followed by multiple DOTs and different international countries.

Conclusion

Change orders persist to be a great challenge faced by US infrastructure projects. In relation to that, there is a need for proper management of changes and variations within IDOT projects due to the huge volume of current and upcoming expenditure on infrastructure and transportation projects in Illinois and the huge costs resulting from change orders therein. Thus, using 50 documented major change orders within IDOT projects and three litigated case studies, this paper provided change order guidelines that were all verified by IDOT experts. The developed flowcharts in this paper are considered to be of great value to IDOT because it does not have the approval procedures in a flowchart-based representation that shows the needed process necessary to be followed when a change order is to be submitted, approved, and managed. In addition, the provided contractual synopsis of the key risks and opportunities aims to act as a quick reference for the contracting parties in terms of what needs to be carefully considered in relation to change orders under IDOT. Finally, the developed checklist acts as a reference to the contracting parties to help them have an in-depth understanding of the general provisions associated with the management of change orders on infrastructure projects. Ultimately, the implications of the paper's findings and the associated benefits of adopting or using the proposed change order guidelines include: (1) minimizing the number and amount of change orders on infrastructure transportation projects, (2) helping the contracting parties to better understand how their individual responsibilities contribute to the proper processing and management of changes and variations on their projects, (3) avoiding problems and challenges caused by change orders, (4) offering contractors the ability to visualize the different steps involved in the approval of change orders on infrastructure projects, (5) keeping project costs within budget and schedule, (6) supporting the project parties in organizing their change order processes and making the associated information visible to everyone, (7) assisting the project stakeholders in identifying change order-related areas for improvement, and (8) allowing project owners to better mitigate, manage, and administer the contractual aspects of change orders.

Data Availability Statement

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

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