EPiC Series in Built Environment

Volume 4, 2023, Pages 541–549

Proceedings of 59th Annual Associated Schools of Construction International Conference

Materials Delay Impact due to COVID-19 on Construction Projects

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The COVID-19 pandemic has affected all businesses across the globe, particularly, the material supply disruption delaying many construction projects. This material supply disruption presents unprecedented challenges to construction companies in terms of coping with the new circumstances. The purpose of this study is to analyze the materials delivery impact due to the COVID-19 pandemic on construction projects schedule. This study was completed through a quantitative methodology using as a collection instrument an online questionnaire targeting construction company executive members across the United States. The questions and analysis presented in this paper focus on Master Format divisions 40 to 48 of the Construction Specifications Institute corresponding to the projects' process equipment activities. The result shows that the pandemic increased project duration and disrupted the supply chain of the project activities. The findings can provide a better understanding and solution to reduce the impact of supply chain disruptions caused by future pandemics (or wars as the one currently in Ukraine) on the construction industry.

Key Words: COVID-19 Impact, Material Delivery Delay, Construction Cost

Introduction

As of October 2022, according to the CDC's COVID Data Tracker, in the United States (U.S.) alone there have been over 97 million total cases of COVID-19 and over one million deaths attributed to COVID-19 (CDC 2022a). COVID-19 mortality risk has been linked to factors that include older age, male sex, history of diabetes, lymphopenia, and increased procalcitonin (Yu, C., et al., 2020). Unfortunately, Brown et al. (2020) found that nearly 60% of the construction workforce has at least one risk factor (such as: older age, racial and/or ethnic minorities, and smoking and e-cigarette use) that makes them vulnerable to severe illness from COVID-19.

Given the significant impact of COVID-19 in the U.S. and across the globe the ability of factories to produce construction materials and distribute them has suffered a bottleneck. Consequently, the construction industry has been highly impacted by the pandemic due to COVID-19 (Araya, F. 2021). The COVID-19 pandemic has impacted construction projects in many ways (Kisi, K. & Sulbaran, T., 2022). COVID-19 impacted performance, suspension of projects, workforce shortage, and time and

cost overruns (Gamil & Alhagar 2020; Shen et al., 2020). Moreover, Bailey et al. (2020) added that construction and engineering projects around the world are being impacted by the COVID-19 pandemic in numerous ways, and many projects had stopped.

It is beneficial for construction professionals to understand how the COVID-19 pandemic has impacted their daily lives and affected their construction schedule so that they are better prepared for future projects during a similar pandemic (or wars as the one currently in Ukraine) that disrupt the production and distribution of construction materials. This study discusses how the COVID-19 pandemic has impacted material supply disruption in the construction industry and how it has affected the construction projects' duration. The study focuses on project delays due to material supply disruption in the Construction Specification Institute (CSI) Master Format process and equipment divisions.

Literature Review

Overview *COVID-19*

The coronavirus disease 2019 also known as COVID-19 is a respiratory illness caused by the virus named severe acute respiratory syndrome coronavirus 2 (i.e., SARS-CoV-2) (CDC 2021; WHO 2021). The Centers for Disease Control and Prevention (CDC) states that the coronavirus is confirmed as being transmitted from human to human and results in symptoms including fever, dry cough, fatigue, and shortness of breath (CDC 2021). Many countries have been experiencing economic slowdowns, financial and labor burdens associated with project delays, cost escalations, lack of supplies, and worker safety and health problems (Al Amri and Marey-Perez, 2020; Denny-Smith et al., 2021; Esa et al., 2020; Kaushal & Najafi, 2021).

COVID-19 transmission is primarily airborne as droplets from person to person such as coughing (Fenelly 2020; CDC 2020). Since the virus can remain in the air and transmit through self-inoculation such as nose and mouth, or by hand contact, the strategy for prevention has been to limit person-to-person contact, either through social distancing or completed reduction in social contact such as lockdowns or shut down of workplaces and public events. The initial guideline from CDC was to wear a mask, maintain at least a 6-foot social distance, cleaning of contact surfaces, and handwash (CDC 2019). Over time the CDC guideline has changed and as Oct 2022 CDC indicates that vaccination is the safest way to help build protection. CDC suggests getting all recommended vaccine doses and boosters as soon as possible to maximize protection and as Oct 2022 72.4% of people five years or older are fully vaccinated in the U.S. (CDC 2022b).

Challenges and Mitigation of Construction Supply Chain Disruption

The construction of projects is considered by many a service industry. However, The U.S. Bureau of Labor Statistics classifies it as a good-producing sector, not a service sector (Valle, G. 2022). As a good-producing sector, COVID-19 had a significant impact on its construction supply change. The COVID-19 pandemic caused supply and demand disruptions with resonating effects (McMaster, M. et al. 2020). Research results unveil that manufacturing firms have faced limited production and delays in procuring goods and services, while distribution centers have been challenged with inventory shortages. Furthermore, supplying firms have encountered increased lead times amid the COVID-19 outbreak (Butt, A. 2022). Studies reveal that the supply chain for construction projects has been significantly affected by COVID-19 (Susanti, R. et al., 2021).

COVID-19 allowed researchers to study supply chain disruptions to gain an understanding of possible approaches to reduce the impact of future pandemics (or wars like the one currently in Ukraine) on the good-producing sector such as the construction industry. The results of some research indicate that strategies such as: "manufacturing flexibility", "diversifying the source of supply", and "developing backup suppliers" will have significant positive consequences for managing the impacts in the supply chain of future pandemics (Taqi, H. et al., 2020). Additionally, including flexibility in the management of the supply chain will mitigate the risk of both future epidemics and demand variability (McMaster, M. et al., 2020). It is evident that the mitigation actions proposed such as redundancy and flexibility are good strategies to mitigate supply chain disruptions (due to future events), but there is also a stronger pressure for digitalization and supply-based localization (Pujawan,I. N. & Bah, A. U., 2022). The finds of research of previous papers as well as the ones presented in this paper are important as they help managers recover from supply chain disruptions by identifying and classifying the impacts and strategies required to manage the major supply chain disturbances (Taqi, H. et al., 2020).

COVID-19 Pandemic Impact on Construction Projects

Construction management is a difficult decision-making process including constant time and cost constraints (Okonkwo, C., et al, 2022). Construction was significantly impacted by the COVID-19 pandemic. In the early stage of the COVID-19 pandemic in 2020, a significant number of construction workers reportedly tested positive for COVID-19 (Alsharef et al., 2021; Allan-Blitz et al., 2020). Pasco et al. (2020) emphasized that the risk of COVID-19 infections among construction workers was about five times more likely to be hospitalized because of COVID-19 than workers in other industries. Although an important component of a COVID-19 protection plan is to educate workers with information on the most current science and protective practices to reduce disease spread (Choi & Staley 2021), research shows that levels of workplace safety literacy and risk perception in the construction industry are influenced by factors such as safety training, hazard recognition, risk-taking behaviors, attitudes, and the dynamic nature of the profession (Namian et al., 2016; Gunduz & Ahsan, 2018; Pandit et al., 2019; Loosemore & Malouf, 2019; Uddin et al., 2020). Studies have highlighted varieties of issues in construction such as aging workers and the entrance of "Gen Z" into the workplace, technological modernization, improving efficiency, and the use of sustainability and renewable products (Ayodele et al., 2020; Brown, 2019; Choi et al., 2018; Heigl, 2018; Rodriguez, 2019; Zidan et al., 2013). The COVID-19 crisis led to a reduction in site productivity, increased compliance costs, delayed projects, and increased construction workers' exposure to risk and infections(Olanrewaju, A.L., et al, 2021). A study found the most prominent impacts of COVID-19 were the suspension of projects, labor impact, job loss, time overrun, cost overrun, and financial implications (Gamil, Y., & Alhagar, A., 2020).

Methodology

A quantitative methodology was implemented because the purpose of this study was to generate knowledge and create an understating of a specific subject(Allen, M., 2017). More specifically, this study aimed to understand the impact of the COVID-19 pandemic on construction project delays in the activities in the CSI Master Format divisions 40 to 48 (projects' process equipment activities). In fact, quantitative methodology as the one used for this study has been used in several scientific inquiry studies relying on survey data (Allen, M., 2017).

Data Collection

The data for this study was collected using an online questionnaire. The online questionnaire was used because it is effective, convenient, fast return rate, and reduced expenses (Handscomb, L., et al, 2016). The online survey consisted of questions that focused on project delays due to material supply disruption in process and equipment divisions (Divisions 40 to divisions 48) of the CSI's Master Format. The questionnaire surveys were distributed and completed online since this technique would be the most beneficial and appropriate route to acquire a fast response during this COVID-19 pandemic. The questionnaire was developed in Qualtrics following the Human Subject Research protocol approved by two universities in Texas. The data collection focused on information related to the COVID-19 pandemic delay in the projects, the duration of the active projects during the pandemic, and the reasons behind the delay.

The questionnaire was distributed during the Fall 2020 and Spring 2021 to fifty construction company executive members. Among them, the data valid for this study were collected from twenty-eight executive members in the United States. The data collected respondents were professionals who are mostly experts in commercial construction projects in addition to other construction sectors.

Questionnaire Survey

The questionnaire consisted of three major sections: demographic information, material delay information, and project delay impact information. The survey focused on construction delays due to material disruptions among eight process equipment divisions of the CSI Master Format. The eight process equipment divisions are Division 40- Process Interconnections, Division 42- Process heating, cooling, and drying equipment, Division43- Process gas and liquid handling, purification, and storage equipment, Division 44- Pollution and waste control equipment, Division 45- Industry-specific manufacturing equipment, Division 46-Water, and wastewater equipment, as well as Division 48-Electrical power generation.

Results

The survey was filled out by 20 General Contractors, 5 Sub-Contractor, and 3 consulting firms. There was a good distribution of respondents with ages between 25 years old and more than 50 years old. Thirty-five and seven-tenths of a percent (35.7%) of the respondent were between 25 and 39 years old with the majority of the respondents between 40 years old and more than 50 years old as shown in Table 1.

Table 1

Survey Demography

Age	Frequency	Percent	Accumulated Percentage
25-29 years old	1	3.6	3.6
30-34 years old	5	17.9	21.5
35-39 years old	4	14.3	35.7
40-44 years old	5	17.9	53.6
45-49 years old	4	14.3	67.9

50 years old or more	5	17.9	85.7
No Response	4	14.3	100.0
Total	28	100.0	100.0

Thirty-nine and three-tenths of a percent (39.3%) of the respondents had fifteen (15) years of work experience or less with the majority of the respondents (60.7%) having fifteen (15) years or more of work experience as shown in Table 2. The fifteen years or more of work experience is important for this study as it indicates that the responses came from highly knowledgeable and informed construction professionals as supported by studies that indicated that work experience is the greatest predictor of competitive intelligence (Pellissier, R., & Nenzhelele, T., 2013). Competitive intelligence refers to the ability of an individual to gather, analyze, and use information collected for businesses' competitive advantages (Bloomenthal, A., 2021).

Table 2
Work Experience in Construction

Age	Frequency	Percent	Accumulated Percentage
1 to 5 years	1	3.6	3.6
5 to 10 years	7	25.0	28.6
10 to 15 years	3	10.7	39.3
15 to 20 years	2	7.1	46.4
more than 20 years	11	39.3	85.7
No Response	4	14.3	100.0
Total	28	100.0	100.0

Based on the online survey question “How many calendar days (on average) did the COVID-19 pandemic delay your active projects?” the result shows that the projects were delayed from less than 5 days to more than 56 days as shown in Figure. 1. Among those projects delayed, thirty-one percent (31%) of the projects were delayed between 6 to 15 days, twenty-seven percent(27%) of the projects were delayed less than 5 days, and nineteen percent (19%) of the projects were delayed 26 to 35 days. This result is consistent with other references that indicate that in 2020 the average construction job delay was 17.47 days (Robinson, S., 2022). This study also expands the current knowledge by presenting the variability and distribution of the number of days delayed due to COVID-19. This could be attributed to the fact that during the COVID-19 pandemic, there were travel restrictions including the closure of the facilities that distribute metals and products that are related to long lead time. Manufacturing companies say they received supplier deliveries more slowly in the month of May than in April (Wood, 2021).

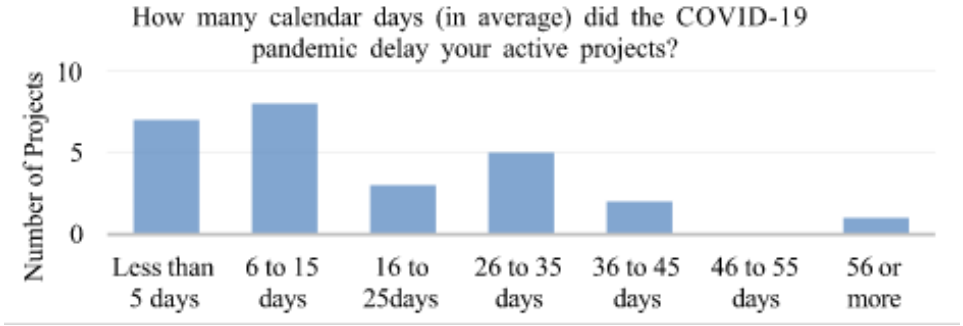

Figure 1. Active project delayed due to the COVID-19 pandemic

Analysis And Discussion

Material Delays by CSI Divisions

The materials delay for the CSI Master Format process equipment divisions (Divisions 40, 41, 42, 43, 44, 45, 46, 48) is shown in Figure 2. The materials delay in the process equipment subgroups varied significantly ranging from 0 to 50 days. For example, the median delay for materials associated with Division 40 - Process Interconnections and Division 43 – Process Gas and Liquid Handling, Purification and Storage Equipment was between 6 and 15 days (blue bar in Figure 2); while the median delay for materials associated with Division 48 — Electrical Power Generation was between 21 to 31 days as shown in Figure 2. Furthermore, the variability of the delays was significantly different among the different divisions. For example, the number of delay days in the 25% percentile (shortest delay) of Division 40 was between 0 and 5 days (green line in Figure 2), while for Division 48 was between 4 and 13 days. On the opposite side of the spectrum, the number of delay days in the 75% percentile (longest delay) of Division 40 was between 11 and 21 days (red line in Figure 2), while for Division 48 was between 41 and 50 days. This significant delay variability (among the different divisions) found in this study, could be attributed to the different supply chain used in the manufacture of the different construction components. Reports show that fabricated metal products, transportation equipment, and chemical products had the slowest deliveries (Wood, 2021) which supports the results of this study. Furthermore, this information is very important for decision-makers to identify the divisions that required the earliest intervention in future supply disruptive events.

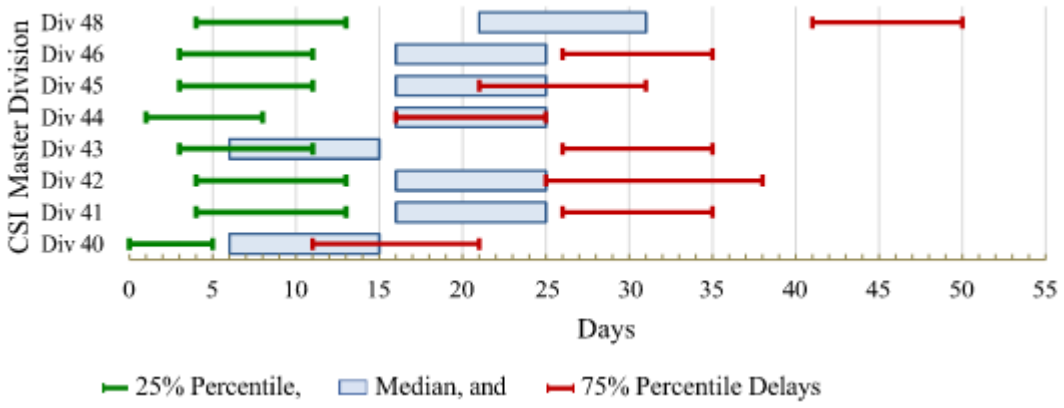

Figure 2. Processing Equipment Division

Conclusions

This study collected and analyzed the survey response from 28 construction companies (20 General Contractors, 5 Sub-Contractor, and 3 consulting firms) regarding how materials disruption in supply caused delays in projects and impacted their cost in the United States. The findings show that COVID-19 impacted the most of the materials supply chain related to CSI Division 48 – Electrical power generation followed by Division 41 – material processing and handling equipment, Division 42 – process heating, cooling, and drying equipment, and other divisions such as Division 44, 45, and 46. These delays could be attributed (as Research indicates) to the order backlogs that expanded for

11 straight months after the COVID-19 shut down in March 2020. Additionally, supplies shortage, and logistic issues had a greater impact on the project schedule during this pandemic.

The results of this study are consistent with the estimated construction job delay of 17.57 and expand it by presenting the variability and distribution of the number of days delayed due to COVID-19. It also shows the significant delay variability (among the different divisions) which is important information for construction decision-makers to make informed decisions regarding the part of the jobs (based on CSI Divisions) that will require the earliest intervention in future possible supply disruptive events. In short, the analysis and findings of this study help decision-makers to better understand the impact of COVID-19 to better find solutions to supply chain disruptions in the construction industry caused by possible future pandemics (or wars as the one currently in Ukraine). In the future, it would be interesting to study the changes that construction companies have made following the research findings of this and other papers.

Acknowledgment

The authors acknowledge the assistance of the executive members of the construction companies who participated in the survey and express gratitude for providing valuable input to this research.

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