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Assessing the Post-Disaster Effects of COVID-19 Pandemic Towards Malaysian Construction Industry

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Abstract: Amidst the global upheaval caused by the Coronavirus 2019 (COVID-19) pandemic, substantial disruptions reverberated across nations, including Malaysia, prompting extensive lockdown measures. In response to the virus's transmission, the Malaysian government enforced the Movement Control Order (MCO) starting on the 18th March 2020. This directive wielded a profound influence, notably impacting diverse sectors within Malaysia, including the construction industry. This study aimed to assess the effects of the COVID-19 pandemic as a post-disaster scenario, with the construction sector as the focal point. The study is executed within the framework of two primary parameters: the occurrence and the significance of the ramifications from the pandemic. A quantitative research methodology was employed, wherein a questionnaire survey was distributed to active industry participants in the construction industry in East and West Malaysia. In total, 197 responses were collected and analysed using the relative importance index technique. Across nine construction domains, 49 effects were investigated. Findings show that the scarcity of materials and workforce, followed by the shortage of labour force especially foreign labour, construction delays stemming from restrictive mandates, revisions in scheduling and work scope and an escalation in material costs are among the top five rankings of the post COVID-19 effects on the construction industry. The outcomes of this research have substantially contributed to the comprehension of the effects induced by the COVID-19 pandemic on the construction industry. The main aim is to amass data that can be leveraged by policy makers to bolster post-disaster management strategies within Malaysia, thereby facilitating the transfer of knowledge for future post disaster management endeavours. Additionally, the study has shed light on the disparities delineated along the regional demarcation of East and West Malaysia.

Keywords: Malaysian construction industry, COVID-19 pandemic, Disaster management, Post-disaster effects, Post-disaster recovery

INTRODUCTION

Disasters, as defined by the UNDDR (United Nations for Disaster Risk Reduction, 2021), are serious disruptions of a community or society at any scale, caused by hazardous events interacting with conditions of exposure, vulnerability and capacity. These events lead to human, material, economic and environmental losses and impacts. Disasters can be categorised into man-made and natural disasters (Severin and Jacobson, 2020). The Coronavirus 2019 (COVID-19) pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus, represents a biological threat. Despite the virus's natural origin, the disaster brought on by the pandemic can be considered a socially mediated event due to global

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vulnerabilities, including the response capacity of health systems, overcrowding and social work practices (ECLAC-UNDDR, 2021; Kelman, 2020). Malaysia's encounter with COVID-19 started on 25th January 2020 (Ministry of Health Malaysia, 2022), with the government implementing various stages of Movement Control Orders (MCO) to curb the spread of the disease (Hamzah, Yu and See, 2021).

The COVID-19 pandemic as a global public health emergency, has significantly impacted various economic sectors around the world, including the construction industry (Hamzah, Yu and See, 2021). Characterised as a slow-onset, extensive crisis by Silva (2020), it has caused economic and societal disruption with its countermeasures, notably the lockdowns (Kelman, 2020). Similar to developing nations around the region, Malaysia experienced a sharp economic contraction in 2020 due to lockdown measures and disruptions in global trade. Industries such as tourism, retail, hospitality, construction and manufacturing were particularly hard-hit, leading to job losses and business closures. Government stimulus packages and monetary policies were implemented to mitigate the economic fallout, but economic recovery has been uneven. The pandemic accelerated trends like digitalisation, e-commerce and remote work, which have had lasting effects on the labour market and business operations. Additionally, Malaysia's heavy reliance on exports and its integration into global supply chains made it susceptible to disruptions in international trade flows. Despite concerted efforts to manage the crisis, the full extent of the long-term economic consequences of the pandemic remains uncertain.

As one of the major contributors to the nation's economy, typically contributing 4% to 5% of the country's gross domestic product (GDP) (Alaloul et al., 2021), the impact of the pandemic on the construction industry is not only significant but multifaceted. It affects many areas such as project time, cost, technical aspects, quality and safety, supply chain and resources, and governance, management and contractual matters. The preceding discussion provides a general overview of the implications of the COVID-19 pandemic on the construction sector. However, it underscores the need for a comprehensive understanding of these implications on the construction industry, with the aim of fortifying the sector resilience in the aftermath of a disaster. This necessitates not only the formulation of recovery strategies but also the establishment of robust mitigation plans, applicable not only to pandemics but also broader disaster scenarios.

The aim of this study is to undertake an in-depth assessment of the effects of the COVID-19 pandemic on the construction industry, specifically in Malaysia, as lessons learned for post-disaster recovery plan. The study focused on the following objectives:

1. To extract the events that have affected the different domains of the construction sector.
2. To rank these events in terms of the occurrence and significance.

The novelty of this research lies in the fact that Malaysia has historically been a country with relatively few disasters, which contributes to the lack of emphasis on disaster management and post-disaster recovery as a whole. The COVID-19 pandemic, being a rare form of disaster, caught many policymakers unprepared. This study emphasises the urgent need for all nations, including Malaysia, to recognise the significance of post-disaster recovery and management. It underscores the crucial role of retaining COVID-19 data, which is vital not only for the construction

industry but also for the broader economy of the country. The study highlights its capacity to provide a crucial understanding of the sector's vulnerabilities and potential opportunities for resilience and growth. More importantly, it aims to furnish valuable insights and data that are crucial for the formulation of effective strategies for the construction industry in mitigating and recovering from future calamities, whether of pandemic or broader disaster origin.

LITERATURE REVIEW

The COVID-19 pandemic exemplifies how disasters are a combination of hazards and vulnerabilities, reinforcing the need to examine both natural and social factors in disaster management. The following section will delve deeper into the effects of the COVID-19 pandemic on a specific sector, the construction industry.

Impacts of COVID-19 on the Construction Industry

The advent of the COVID-19 pandemic has profoundly influenced the construction industry, instigating sweeping changes and posing unprecedented challenges (Abdillah, Janipha and Judi, 2022; Arifin, Azmi and Sheffie, 2022). One of the most significant impacts was the requirement to enforce social distancing measures on construction sites, a particularly challenging prospect given the labour-intensive nature of the industry (Abdillah, Janipha and Judi, 2022). These measures reduced the workforce and, while successfully controlling virus spread on construction sites, also resulted in substantial project delays (Arifin, Azmi and Sheffie, 2022). Government-imposed restriction orders, particularly the MCO, resulted in the halting or slowdown of projects, disrupting project planning and scheduling (Esa, Ibrahim and Kamal, 2020; Gara et al., 2022). This not only caused delays but also constrained the operational capacity of construction sites (Vasudevan and Yuen, 2022).

Furthermore, reductions in workforce capacity due to COVID-19 fears, combined with restriction orders, led to a substantial decrease in labour force participation and productivity on construction sites (Abdullah et al., 2021; Vasudevan and Yuen, 2022; Alawag et al., 2021). Additionally, material shortages and delivery delays, aggravated by disruptions in international trade, further contributed to project delays (Arifin, Azmi and Sheffie, 2022; Abdullah et al., 2021; Tan and Abdul-Samad, 2022). Consequently, contractors had to seek extensions of time (EOT), introducing complexities in contractual obligations (Arifin, Azmi and Sheffie, 2022). These disruptions necessitated revisions in project schedules and work breakdown structures, resulting in extended project completion timelines (Badroldin et al., 2016; Tan and Abdul-Samad, 2022). The implementation of new health and safety compliance measures due to the pandemic, coupled with testing and inspection processes, proved time-consuming and further hindered project progress (Jagun et al., 2022; Vasudevan and Yuen, 2022). Overall, these challenges underscore the profound impact of the pandemic on construction timelines and schedules in construction projects in Malaysia.

The COVID-19 pandemic has also induced a range of unforeseen cost overruns and financial challenges in the Malaysian construction industry. Safety measures and altered project designs led to unexpected expenses, including those related to social distancing, sanitisation and personal protective equipment,

causing financial losses (Gara et al., 2022; Esa, Ibrahim and Kamal, 2020). Work interruptions and a decrease in project value resulted in substantial cash flow issues, leading to layoffs and furloughs for contractors and subcontractors (Tan and Abdul-Samad, 2022; Alawag et al., 2021). Supply chain disruptions and resource shortages led to increased construction costs, with rising prices of materials and transportation contributing to budget overruns (Arifin, Azmi and Sheffie, 2022; Tan and Abdul-Samad, 2022).

Contractors also faced additional costs for regulatory compliance, including purchasing COVID-19 protective equipment, hygiene kits and conducting testing and training (Abdullah et al., 2021; Esa, Ibrahim and Kamal, 2020). Moreover, the pandemic exacerbated project completion challenges, with contractors grappling with ongoing operational expenses even during work suspensions and facing delays due to reduced productivity (Jagun et al., 2022). These financial pressures highlight the need for support measures such as financial aid and liquidity provision to help businesses endure and maintain their workforce, ultimately alleviating the pandemic's impacts on productivity (Radzi, Rahman and Almutairi, 2022).

The strict enforcement of the MCO, which excluded construction from essential services, severely limited the number of workers allowed on construction sites, leading to a marked reduction in both the volume and quality of construction work (Vasudevan and Yuen, 2022). This restriction on workforce capacity also had a direct impact on labour performance, further decreasing overall productivity and efficiency (Tan and Abdul-Samad, 2022). Remote monitoring of construction projects became challenging during the pandemic, potentially affecting the quality of work due to the absence of on-site supervision and limitations in virtual oversight. Consequently, the pandemic has exposed deficiencies in the industry's conventional practices, resulting in an increased prevalence of poor-quality buildings (Alawag et al., 2021). Factors such as reduced labour force, decreased efficiency and challenges in remote monitoring have collectively contributed to the decline in the quality of completed projects. Additionally, concerns regarding worker safety and engagement have emerged as prominent issues, further influencing the overall quality of work (Tan and Abdul-Samad, 2022). Consequently, contractors have faced heightened difficulty in meeting client expectations, exacerbating the quality-related challenges posed by the pandemic.

Construction materials and finishes faced delays at supplier warehouses and ports, causing disruptions in supply timelines (Vasudevan and Yuen, 2022). This was further exacerbated by Malaysia's MCO, which affected the availability of crucial resources like suppliers, materials, machinery and skilled personnel (Ibrahim, Esa and Kamal, 2022). Manufacturing shutdowns and restrictions on supplier movements also contributed to delayed material supply (Esa, Ibrahim and Kamal, 2020). Supply chain inefficiencies were compounded by lockdowns, mobility restrictions and worker shortages, leading to project delays (Jagun et al., 2022). Additionally, disruption in logistics and deliveries led to a surge in material and logistics costs, particularly for raw materials like steel, due to supply disruptions from China (Vasudevan and Yuen, 2022; Arifin, Azmi and Sheffie, 2022). The pandemic also caused shortages in both materials and workforce, with reduced material production and job losses due to plant closures during the MCO (Gara et al., 2022; Vasudevan and Yuen, 2022; Alawag et al.,2021). Lockdown measures prompted the need for resource reorganisation, including alterations in material delivery and receiving processes, showcasing the industry's adaptability in response to the pandemic (Tan and Abdul-Samad, 2022). To mitigate these impacts, Radzi, Rahman

and Almutairi (2022) advocated for restructuring and diversifying the supply chain, underscoring the importance of strategic adaptations for normal operations during a pandemic.

The industry also grappled with a substantial manpower shortage, experiencing a reported 50% reduction in workforce capacity, with sites permitted to operate with only 30% of their usual workforce (Vasudevan and Yuen, 2022; Gara et al., 2022). The scarcity of foreign labour, as many workers returned to their home countries, exacerbated this issue (Abdillah, Janipha and Judi, 2022). Safety concerns heightened with the need for protective measures like face masks and social distancing, impacting labour productivity and adding an extra layer of risk and anxiety for workers (Abdillah, Janipha and Judi, 2022; Alawag et al., 2021). This resulted in a limitation of resources on construction sites, affecting both manpower and materials (Esa, Ibrahim and Kamal, 2020; Tan and Abdul-Samad, 2022). To address these challenges, re-examining and reorganising resources, including labour, products, materials, machinery and equipment, became crucial (Tan and Abdul-Samad, 2022). Additionally, having consistent and reliable sources for the latest policies and procedures was emphasised to prevent confusion in construction project operations (Radzi, Rahman and Almutairi, 2022).

The operational capacity of construction sites in Malaysia was profoundly impacted by government measures and regulations during the COVID-19 pandemic. Registration processes for operations became time-consuming due to limited government staff available for inspections, leading to delays in project progress (Vasudevan and Yuen, 2022). The MCO brought about a halt in most construction activities, disrupting schedules significantly (Tan and Abdul-Samad, 2022; Jagun et al., 2022). Workforce limitations and mandatory safety measures also led to shortages and changes in workspaces on construction sites, particularly affecting SMEs (Gara et al., 2022; Vasudevan and Yuen, 2022; Abdillah, Janipha and Judi, 2022). Compliance with Ministry of Health mandates and government checks on construction sites had a profound impact on operational aspects (Alawag et al., 2021; Esa, Ibrahim and Kamal, 2020). Collaboration with stakeholders, particularly the Ministry of International Trade and Industry (MITI), played a crucial role in mitigating adverse impacts, with all types of construction work permitted upon strict adherence to standard operating procedures (SOPs) (Radzi, Rahman and Almutairi, 2022; Ibrahim, Esa and Kamal, 2022).

The COVID-19 pandemic necessitated a rapid shift towards remote working in the construction industry, driven by government restrictions like the MCO (Arifin, Azmi and Sheffie, 2022). This transition involved the virtualisation of various activities including meetings, design work, estimating and costing. While this introduced technical challenges, it also paved the way for innovative construction methods and project management approaches (Tan and Abdul-Samad, 2022). The increased reliance on communication technologies emerged as an adaptive response to the new working conditions, although the adoption of advanced collaborative platforms and building information modelling (BIM) faced ongoing technical hurdles (Esa, Ibrahim and Kamal, 2020 as cited in Tan and Abdul-Samad, 2022). This shift towards more technology-driven processes also facilitated the emergence of new construction methods, albeit with some associated cost overruns (Arifin, Azmi and Sheffie, 2022). Nevertheless, it provided an opportunity for companies to explore innovative solutions and integrate technologies like Artificial Intelligence (AI) into their operations, potentially revolutionising future construction projects (Arifin, Azmi and Sheffie, 2022). The increased use of AI in the industry signifies a

promising direction for future operations, enhancing teamwork, efficiency and project completion timelines (Abdullah et al., 2021).

The COVID-19 pandemic has brought about several significant impacts on contractual factors within the construction industry. Firstly, it has led to a surge in legal disputes, stemming from project overruns due to disruptions in the original project schedule caused by the unpredictable MCO and restrictions imposed during the pandemic. This surge has resulted in increased conflicts, claims and litigation (Gara et al., 2022; Alawag et al., 2021). Additionally, there has been a notable rise in claims such as force majeure and extension of time (EOT) claims. Contractors have sought to invoke Force Majeure, arguing that the pandemic was an unforeseeable circumstance that hindered their ability to fulfil contractual obligations, while also requesting EOT for adjustments to project timelines due to pandemic-induced disruptions (Arifin, Azmi and Sheffie, 2022). This situation has introduced added complexity and disputes regarding the enforcement of contractual obligations.

Furthermore, payment delays have become prevalent, as contractors have struggled to claim payment from clients due to work halts and delays in inspection and approval (Radzi, Rahman and Almutairi, 2022; Gara et al., 2022). This has further strained the financial stability of contracting firms. Contractors also faced challenges in meeting their contract obligations, including delays in completion caused by late client payments or work stoppages due to the pandemic (Abdillah, Janipha and Judi, 2022). Additionally, costs related to site contamination and quarantining workers have also added to their obligations. Finally, there has been an interruption of contractual terms, with contractors bearing the costs of site contamination and worker quarantines in accordance with the PWD Form of Contract (Abdillah, Janipha and Judi, 2022). However, if the contract does not address this issue, contractors may not be obligated to conduct such tests, potentially leading to further legal complexities (Abdillah, Janipha and Judi, 2022; Alawag et al., 2021).

The COVID-19 pandemic mandated the strict implementation of SOPs on Malaysian construction sites to ensure safety and curb the virus's spread (Ibrahim, Esa and Kamal, 2022). These measures, directed by MITI (Ministry of Domestic Trade, 2017) reshaped risk and safety management protocols on construction sites (Tan and Abdul-Samad, 2022). Construction companies responded by incorporating additional sanitisation measures, including providing personal protective equipment, disinfecting tools and equipment and improving site facilities' sanitation (Abdullah et al., 2021). However, this introduced added costs for companies, involving investments in COVID-19 screening tests and personal protective equipment for workers (Arifin, Azmi and Sheffie, 2022). The pandemic underscored the heightened risks faced by the construction industry's workforce, necessitating an increased focus on their safety and well-being (Abdullah et al., 2021; Tan and Abdul-Samad, 2022). Construction companies responded by adopting measures like health screening, thermal scanning and COVID-19 testing as part of their preventive strategies (Esa, Ibrahim and Kamal, 2020; Abdullah et al., 2021). The implementation of new SOPs, including restrictions on workforce size, induced significant disruptions to work processes, prompting changes in workforce management and necessitating training for workers on new hazards and controls (Radzi, Rahman and Almutairi, 2022; Jagun et al., 2022).

RESEARCH METHODOLOGY

The extensive literature review indicates that the repercussions of the COVID-19 pandemic are far-reaching and often interconnected, with various events exhibiting interdependency with one another. The study has systematically categorised the identified effects with respective to the construction domains from the literature review, outlined as follows:

A : Time domain,
B : Cost domain,
C : Supply chain domain,
D : Resources domain,
E : Government and regulatory domain,
F : Contract domain,
G : Technological domain,
H : Quality domain and
I : Safety domain.

The study involved an extensive survey targeting key industry stakeholders such as government officials, clients, consultants and designers actively engaged in construction activities during the pandemic in both the West and East of Malaysia. A comprehensive set of 600 questionnaires was distributed through platforms like email, as well as social media channels including WhatsApp. Among the distributed questionnaires, 197 were returned with completed responses, resulting in a response rate of 32.83%. According to Gamil, Al-Sarafi and Najeh (2022), a response rate of 14.1% is considered acceptable in the construction industry. Hence, the response rate obtained in this study, which is 32.83%, is deemed satisfactory. Questionnaires were divided into three sections as follows:

1. Section A: Demographics of the respondents,
2. Section B: Occurrence of the effect event and
3. Section C: Significance of the effect event in relation to the domain of construction projects.

The questionnaire has a five-point Likert scale as its methodology. The respondents are asked to indicate how strongly they agree with occurrence and the significances of the effect. Scales of 1 to 5 are designed for this study, one for the frequency of occurrence of the effects and another for the significance of the effects of COVID-19 pandemic on construction projects. Table 1 presents the five-point Likert scale designed to analyse the effect of COVID-19 within each construction domain based on occurrence and significance.

Table 1. Likert scale for occurrence and significance

Occurrence	**Significance**
1 = No Occurrence	1 = Not Significant
2 = Low Occurrence	2 = Slightly Significant
3 = Moderate Occurrence	3 = Moderately Significant
4 = High Occurrence	4 = Highly Significant
5 = Definitely Occur	5 = Strongly Significant

Data collected are analysed using the relative importance index (RII) based on the five-point Likert scale on the occurrence and significance of the effects, respectively. The RII method was chosen for its simplicity and high accuracy that allows for an effective classification and ranking of the pandemic's impacts. Mohammad Badroldin et al. (2016) explained that relative index is based on a formula stated in Equation 1:

$$RII = \frac{\sum W}{A * N} \quad \text{Eq. 1}$$

where, W is the weight given to each factor by the respondents (scale 1 to 5), A is the highest weight (scale 5) and N is the total number of respondents. The classification of RII in this study is described in Table 2:

Table 2. Classification of RII

RII	Description
0.00 ≤ RII < 0.20	"No Occurrence" or "Almost No Significance"
0.20 ≤ RII < 0.40	"Low Occurrence" or "Low Significance"
0.40 ≤ RII < 0.60	"Moderate Occurrence" or "Moderate Significance"
0.60 ≤ RII < 0.80	"High Occurrence" or "High Significance"
0.80 ≤ RII < 1.00	"Definitely Occur" or "Very Strong Significance"

RESULTS AND DISCUSSION

This section presents the findings based on the data gathered regarding the occurrence and importance of the effects within specific domains on the construction industry attributable to the COVID-19 pandemic (as shown in Table 3). Discussion put forward further explained the findings from the study.

Table 3. Respondents' demographic

Respondent's Background		%
Organisation	Client (government agency)	16.75
	Client (private)	7.61
	Consultant	36.55
	Contractor	33.50
	Academician	2.54
	Supplier	3.05
Involved project locations	Perlis	0.72
	Kedah	3.24
	Pulau Pinang	11.51
	Perak	2.88

(*Continued on next page*)

Table 3. *Continued*

Respondent's Background		**%**
	Selangor	8.63
	Negeri Sembilan	3.96
	Melaka	1.80
	Johor	3.96
	Pahang	2.16
	Terengganu	2.16
	Kelantan	1.08
	Sarawak	41.73
	Sabah	–
	Labuan	–
	Putrajaya	1.80
	Kuala Lumpur	10.07
Industry experience	Less than five years	40.61
	5 years to 10 years	22.84
	11 years to 20 years	18.27
	More than 20 years	18.27
Highest contract amount involved (MYR)	Less than 5 million	24.37
	5 million to 10 million	12.18
	10 million to 50 million	13.71
	50 million to 100 million	8.12
	100 million to 500 million	24.37
	More than 500 million	17.26
Work specialisation	Building construction (residential)	29.10
	Building construction (commercial)	22.29
	Industrial construction	13.93
	Infrastructure construction	34.67

Background of Respondents

There are respondents from all over Malaysia except for Labuan with 59.63% of respondents having more than five years' experience in the industry. All respondents are construction industry participants with highest respondents from consultant (36.55%) followed by contractors (33.5%) and client from government agencies (16.75%). Table 3 presents the demographic and background of the 197 respondents who responded to the survey based on respondents' organisation, state they are from, number of years of experience, value of projects involved and types of projects involved.

Ranking of the Effects' Occurrence and Significance

This section presents the data collect and analysed with RII method where effects within each construction domain of A to I. Table 4 shows the results of the occurrence of the project in the respondent projects and the significance of the same effect with respect to the category itself.

Table 4. Occurrence and significance of COVID-10 pandemic effects according to construction domains

No.	#	Occurrence (O) and Significance (S) of COVID-19 Pandemic-Related Effects	RII (O)	Rank (O)	RII (S)	Rank (S)
Time Domain						
1	A1	Delays due to restriction orders	0.7848	7	0.8569	3
2	A2	Delays due to workforce	0.7898	5	0.8558	4
3	A3	Delays due to material shortages and delivery delays	0.7675	15	0.8437	6
4	A4	Claim of EOT	0.7777	9	0.8294	10
5	A5	Rescheduling and work breakdown revisions	0.7949	2	0.8203	14
6	A6	Delay due to new compliances	0.7269	25	0.7848	31
Cost Domain						
7	B1	Increased overhead costs	0.7513	19	0.8152	16
8	B2	Increased cash flow issues	0.7594	17	0.7949	26
9	B3	Increased cost due to supply chain disruptions	0.7736	12	0.8142	19
10	B4	Increased cost due to resources shortages	0.7736	12	0.8274	11
11	B5	Increased cost due to regulatory compliance	0.7147	32	0.7817	32
12	B6	Increase contractor expenses	0.7777	9	0.8305	9
Supply Domain						
13	C1	Logistics and delivery disruptions	0.7381	22	0.8162	15
14	C2	Increased price of materials	0.7909	4	0.8508	5
15	C3	Increased cost of logistics	0.7503	20	0.8264	12
16	C4	Material and workforce shortages	0.7959	1	0.8619	1
17	C5	Altered work procedure due to supply chain disruption	0.7310	23	0.7929	27
Resources Domain						
18	D1	Disruption of material supply	0.7523	18	0.8213	13
19	D2	Manpower shortage	0.7929	3	0.8589	2
20	D3	Worker's absence due health and safety concerns	0.7249	26	0.8041	25
21	D4	Limited availability of resources on site	0.7178	31	0.8051	24
22	D5	Adjustments in workforce management	0.7188	29	0.7919	28
Government and Regulatory Domain						
23	E1	Disruption by limited authority manpower (approval of permits, inspections)	0.7310	23	0.8132	20
24	E2	Project suspensions and lockdowns	0.7188	29	0.8386	8
25	E3	Disruption by new regulatory compliance	0.7208	27	0.8081	21

(*Continued on next page*)

Table 4. *Continued*

No.	#	Occurrence (O) and Significance (S) of COVID-19 Pandemic-Related Effects	RII (O)	Rank (O)	RII (S)	Rank (S)
26	E4	Foreign labour shortage due to cross border limitation	0.7685	14	0.8396	7
27	E5	Support and initiatives by government	0.6589	41	0.7249	43
Contractual Domain						
28	F1	Increase in legal disputes (claim, conflicts, litigation and complaints)	0.6497	44	0.7472	40
29	F2	Increase in payment delays	0.7036	33	0.7766	33
30	F3	Unable to fulfil contractual terms	0.6995	34	0.7635	37
31	F4	Contractual terms interruption	0.6944	36	0.7695	34
32	F5	Increase in claims such as force majeure and EOT	0.7442	21	0.8152	16
Technical Domain						
33	G1	Adoption of communication technologies	0.6234	47	0.7299	42
34	G2	Disruption of traditional construction processes	0.6609	40	0.7462	41
35	G3	Modification of design and working methods	0.6234	47	0.7066	46
36	G4	Increased remote working	0.6944	36	0.7695	34
37	G5	Disruption caused by adaptation towards the new normal	0.6893	38	0.7635	37
Quality Domain						
38	H1	Inspection delays	0.6853	39	0.7574	39
39	H2	Mismatch between client expectations and final deliverable	0.6508	43	0.7147	45
40	H3	Disruption in quality checks due to remote monitoring	0.6528	42	0.7218	44
41	H4	Decreased work quality	0.6132	49	0.6975	48
42	H5	Decreased productivity and efficiency	0.6985	35	0.7868	30
43	H6	Disruptions in lab testing for quality	0.6325	46	0.6904	49
Safety Domain						
44	I1	Increased in SOP guidelines	0.7838	8	0.8081	21
45	I2	Provisional of additional COVID-19 health and safety requirements	0.7878	6	0.8081	21
46	I3	Additional health monitoring and prevention measures	0.7766	11	0.8152	16
47	I4	Additional sanitising measures	0.7675	15	0.7878	29
48	I5	Disruption due to social distancing measure	0.7198	28	0.7685	36
49	I6	Worker's refusal to work due to COVID-19 concerns	0.6345	45	0.7056	47

DISCUSSION

The comprehensive analysis of 49 effects related to nine domains of the construction projects show an RII exceeding 0.6 in occurrence and more than half of these effects has RII exceeding 0.8 in terms of significance. These findings underscore the effects' high occurrence and very strong significance based on the classification as shown in Table 2 to the Malaysian construction industry post COVID-19 disaster. However, with a total of 49 number of effects from COVID-19 pandemic, across nine areas in the construction sector to consider and with most of them having high occurrence and significance, it is important to adopt a strategic approach to achieve a critical reflection of the findings (Kelley et al., 2003). It is crucial that the targeted analysis can provide stakeholders with actionable insights and recommendations to navigate the challenges posed by the COVID-19 pandemic effectively. By concentrating on a selected number of effects, there is more focused and depth when delving into their root causes, consequences and potential mitigation strategies.

Ranking of the Effects based on Occurrence with Respect to the Domains

The top five post COVID-19 effects identified are "Material and workforce shortages" (RII = 0.7959), "Rescheduling and work breakdown revisions" (RII = 0.7949), "Manpower shortages" (RII = 0.7929), "Increased price of materials" (RII = 0.7909) and "Delays due to workforce constraints" (RII = 0.7898) emerge as consistent and prominent themes across projects. The high RIIs indicate their widespread occurrence underscores their high frequencies of occurrences across construction projects in both the West and East Malaysia, reinforcing the need for meticulous examination and strategic responses.

The pandemic has certainly disrupted global supply chains of goods and materials. Factories closing due to COVID-19 outbreaks, coupled with transportation delays and stricter border controls, have created critical shortages in construction materials. Simultaneously, workforce availability has dwindled due to health concerns, quarantine requirements and travel restrictions. The combination of these factors has led to prolonged project timelines, increased costs and greater uncertainty in project planning. The volatile environment induced by the pandemic has forced many projects to undergo frequent rescheduling and revisions to the work breakdown structure. These changes can strain project management resources, as teams are continually needing to adjust plans and communicate changes. Furthermore, the constant changes can impact worker morale and productivity, leading to further delays and cost overruns. Results corresponds with not only projects in Malaysia but also other developing country in accordance with Arı et al. (2022) and Chigara and Moyo (2023).

The findings also show that the ramifications of the COVID-19 pandemic on the construction industry are deeply interconnected, with various disruptions exacerbating one another and amplifying the challenges faced by stakeholders. Understanding these interconnected effects is crucial for effective post-disaster management strategies in the construction industry. Proactive measures to diversify supply chains, establish backup labour pools and implement flexible project management frameworks can help buffer against sudden disruptions (Kassem et al., 2023). Additionally, incorporating contingency plans and scenario analyses into project planning processes can better prepare organisations to navigate uncertainties and adapt to evolving challenges.

Furthermore, post-disaster management strategies should prioritise collaboration and communication among stakeholders to facilitate swift decision-making and resource allocation (Adepu, Kermanshachi and Pamidimukkala, 2024). By fostering partnerships between industry players, government agencies and community organisations, the construction sector can leverage collective expertise and resources to address systemic vulnerabilities and enhance overall resilience.

Ranking of the Effects based on Significance with Respect to the Domains

In terms of top five most significant effects, material and workforce shortages again rank the top with the RII of 0.8619. This is followed by manpower shortages (RII = 0.8589), delays due to restriction orders (RII = 0.8569), delays due to workforce (RII = 0.855) and increased in the price of material (RII = 0.8508) as the top five impacts with the highest significance. It is noteworthy all these effects have RII value higher than 0.8 which indicates that they had strongly impacted the construction projects.

The most pronounced impact with very serious consequences has been the acute shortage of material caused by disruption in global supply chain and local suppliers hindered by low productivity. Shortages of manpower are induced by illness, quarantine mandates and travel limitations. Both these shortages have significantly impeded productivity, resulting in widespread project delays, heightened labour costs and potential compromises in overall project quality. These effects not only impacted projects but also has long-term ramifications like a weakened industry and intensified competition for available labour, thereby amplifying labour costs.

Time, costs and quality of projects have been severely affected by the effects of COVID-19. Government-imposed restrictions aimed at mitigating the spread of COVID-19 have wielded a profound influence on project schedules. Entire construction endeavours have been forced to grind to a halt, with uncertain timelines for resumption. These delays not only lead to cost overruns but can also culminate in contractual disputes and, in severe cases, total project abandonment. Simultaneously, the dual challenge of workforce shortages and the imperative to uphold social distancing measures at worksites has resulted in significant project delays. This not only exerts pressure on the existing workforce but also carries the potential to render projects financially untenable and tarnish the reputation of involved parties, impacting future endeavours. Additionally, the surge in material costs due to disrupted supply chains has substantially impacted project budgets, potentially necessitating budget adjustments, or, in extreme cases, a complete cessation of projects. For projects bound by fixed contracts, this predicament can translate into substantial financial losses for contractors. These findings correspond with Ong, Tan and Lim (2024) and Ayat, Malikah and Kang (2021).

Recognising the vulnerability of supply chains to disruptions, the construction industry stakeholders must look to diversifying their sourcing strategies. This could involve establishing alternative suppliers for critical materials or adopting a regionalised approach to reduce dependence on global supply networks (Adhikari and Poudyal, 2021). In addition, leveraging technology such as BIM, drones and remote monitoring systems can streamline project workflows and minimise the need for physical presence on-site. Automation and digital tools can also improve productivity and efficiency while adhering to social distancing guidelines (Yong, Aziz and Mohd-Rahim, 2022). Furthermore, all projects should now implement

thorough risk assessments and developing comprehensive contingency plans can prepare organisations to anticipate and mitigate potential disruptions.

CONCLUSIONS

The study undertook an extensive examination of the effects of the COVID-19 pandemic on the construction industry. A meticulously designed questionnaire survey was administered to 197 respondents representing a brand range of stakeholders from government agencies, consultants, contractors and engineers actively engaged in the construction sector across Malaysia. Through this investigation, the study showed that the most prevalent and consequential effects on the Malaysian construction industry, ranking them using the RII. The top ten impacts in terms of occurrence encompassed material and workforce shortages, rescheduling, work breakdown revisions, manpower scarcity, escalated material costs, delays attributed to workforce limitations, imposition of additional COVID-19 health and safety requisites, setbacks due to restriction orders, heightened adherence to SOPs and claims for EOT. In parallel, the effects of greatest significance comprised material and workforce scarcities, labour shortages, setbacks due to restriction orders, delays stemming from workforce limitations, augmented material costs, hindrances due to material shortages and delivery delays, shortages in foreign labour due to cross-border limitations, project suspensions and lockdowns, amplified contractor expenses and claims for EOT.

Significance of Study

The findings unequivocally demonstrate that in the event of a catastrophic event, such as the COVID-19 pandemic, the availability of essential resources, including materials and labour workforce, bears the highest likelihood of occurrence and significance in terms of effect. As such, any effective post-disaster recovery plan in the future must prioritise the reactivation of supply chains for these essential resources. This necessitates comprehensive and well-considered planning, emphasising risk management and the inclusion of robust remedial clauses in engineering contracts and procurement strategies to facilitate the swift resumption of on-site activities following a disaster.

The assimilation of insights from this COVID-19 effect study is critical as repositories of knowledge and lessons learned, that can serve as a foundation for future post-disaster recovery planning within the construction industry. By understanding and addressing the challenges highlighted in in this study, stakeholders can transform adversity into opportunities for growth and resilience. This not only shapes the future of the construction industry in Malaysia but also provides valuable guidance for similar challenges faced.

Research Limitations

While the study offers significant contributions, it is important to acknowledge its limitations. The reliance on survey data may introduce biases and the scope of our investigation may not encompass all potential impacts or variations across different regions or sectors within the construction industry. Future research could explore

these aspects in greater detail, employing a combination of methodologies to enhance the robustness of the findings. It is hoped the study as such done for Malaysia can shed light on how challenges can be transformed into opportunities for growth and resilience, thus shaping the future of the construction industry in the region.

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