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CONSTRUCTION INDUSTRY ON THE BRINK: THE COVID-19 IMPACT

Agana Parameswaran[1] and K.A.T.O. Ranadewa[2]

ABSTRACT

The COVID-19 pandemic has affected all industries globally, including the construction industry. As a result, the construction industry is experiencing several challenges in terms of delivering projects on time and on budget. However, a few studies have shown that the COVID-19 pandemic has a positive impact on the construction industry. Hence, analysing the issues caused by COVID-19 is vital to lessen the effects of the pandemic. Therefore, this study aims to investigate the impact of COVID-19 on the construction industry. Accordingly, a detailed literature review was carried out to gain a theoretical understanding of the topic. A quantitative research approach was used to collect data. The questionnaire survey was conducted using snowball sampling with a total of one 108 respondents. Statistical Package for Social Science" (SPSS) was used to analyse the collected data. The findings revealed 86 negative impacts for the construction industry owing to the pandemic, which was classified as resources-related issues, project management issues, quality issues, financial issues, contractual issues, safety issues, technology-related issues, and other issues for the construction industry. An increase in the price of materials and equipment, project cost, exchange rate, and inflation rate were noted as significant negative impacts to the construction industry. The research further identified twelve (12) favourable impacts for the construction industry as a result of the pandemic. Encouraging risk assessment and collaboration and encouraging Personal Protective Equipment (PPE) were highlighted as the significant positive impacts. Therefore, strategies need to be identified to neutralise the negative impacts using the positive impacts caused by the pandemic. This study contributes to the body of knowledge to advance the construction industry towards the next level during the post-COVID-19 scenario, which will be the focus of the next phase of this research.

Keywords: *Construction Industry; COVID-19; Negative Impact; Positive Impact; Sri Lanka.*

1. INTRODUCTION

McKibbin and Fernando (2021) emphasised that COVID-19 was initially discovered in Wuhan, China, in December 2019 and rapidly spread throughout the world, creating a worldwide pandemic. Thereafter, the WHO Director-General proclaimed the current epidemic a public health emergency of global concern on January 30, 2020, and the COVID-19 pandemic was designated a pandemic on March 12, 2020 (WHO, 2020).

Moreover, Gamil and Alhagar (2020) underlined many nations have imposed an overall state lockdown after the WHO declared the COVID-19 outbreak as a pandemic following

[1] Graduate, Department of Building Economics, University of Moratuwa, Sri Lanka, aganaparameswaran@gmail.com
[2] Senior Lecturer, Department of Building Economics, University of Moratuwa, Sri Lanka, tharushar@uom.lk

a dramatic increase in COVID-19 cases. Alsharef et al. (2021) and Hatoum et al. (2021) indicated that the COVID-19 epidemic has sparked a global health catastrophe that has caused significant disruptions and sufferings in countries and all industries including restaurants, retail, and airlines. The further author highlighted that the construction industry has been affected in many ways. The impact of the COVID-19 pandemic in the construction industry has been listed such as delay (time and cost overrun), payment delay, material shortage, and delivery delay, labour shortage, price variation at the market, lack of site management and supervision, insufficient communication between parties, supply chain disruption, less productivity and workflow, impact on revenue and cash flow (Alenezi, 2020a, 2020b, 2020c; Ghandour, 2020; Ogunnusi, et al., 2020). Nevertheless, the COVID-19 pandemic has had a beneficial impact on the construction industry (Ogunnusi, et al., 2020; Alsharef, et al., 2021; Oey and Lim, 2021).

King and Lamontagne (2021) affirmed construction industries are regarded as major economic foundations of the society in which they operate across the world. Salleh et al. (2020) broadened enhancements in the construction industry are critical for a country's economic success. Likewise, both developed and developing countries have recognized and comprehended the importance of the construction industry in a country's socio-economic and long-term growth (Khan, et al., 2020). Similarly, the Sri Lankan construction industry faces several challenges due to COVID-19 (Pathirana, 2020; Vithana, et al., 2020). However, there is a lack of research to examine the COVID-19 impact on the Sri Lankan construction industry. Accordingly, it is vital to define the COVID-19 impacts that have a significant influence on the Sri Lankan construction sector to recognize a solution to the pandemic. There is a need to fulfill this research gap through a proper empirical study to "investigates the impact of COVID-19 to the construction industry". Therefore, this research aims to "investigate the impact of COVID-19 to the construction industry". This paper written about COVID-19 impact to the construction industry, methodology, findings and discussion of findings.

2. LITERATURE REVIEW

2.1 COVID-19 IMPACT ON THE CONSTRUCTION INDUSTRY

The COVID-19 pandemic has impacted nearly every area of human society, both collectively and individually, from professional and personal aspects (Saurin, 2021). Gamil and Alhagar (2020) testified that many countries are experiencing an economic downturn and recession, and all commercial operations have been halted unless they fall into key categories such as essential medical sectors and supplies, as well as a few critical projects that are required to maintain the people's safety and health system. Furthermore, the COVID-19 pandemic had also sparked a healthcare, environmental, social, and economic disaster affecting all demographics and sectors of the economy (Bsisu, 2020; Gautam, 2020; McKibbin and Fernando, 2021). The research examined the economic impact of the pandemic breakout on the economies of 30 nations, concluded that gross domestic product (GDP) is expected to be affected by 3-6%, with some countries losing more than 10% and 15% (Fernandes, 2020). Globally, the COVID-19 epidemic attacked and impacted all construction industries in unprecedented ways (Gamil and Alhagar, 2020; Alsharef, et al., 2021; Bou Hatoum, et al., 2021; Oey and Lim, 2021; Raoufi and Fayek, 2021; Zamani, et al., 2021). Gamil and Alhagar (2020) argued that the situation was made even worse by a scarcity of construction materials, which had a negative

influence on the construction sector. Further, Gamil and Alhagar (2020) asserted many employees in the construction industry have lost their employment, and most small businesses are unable to pay remunerations during lockdowns.

Hence, Ogunnusi et al. (2020) explored well-planned construction projects that have been equally impacted by this epidemic, which was never addressed while tendering for any construction project. All employees in the construction industry have lost their employment, and most small businesses are unable to pay remunerations during lockdowns. Unlike, the Construction sector differs from other sectors in that it generally necessitates the participation of all project participants on-site (Gamil and Alhagar, 2020). Gamil and Alhagar (2020) emphasised during the virus's spread, several nations began taking steps to restrict people's travel, which has affected construction since it necessitates on-site work, and every project parties must be accessible to work, inspect, and supervise all work operations. The COVID-19 impact on the Global and Sri Lankan construction industry is summarised in Table 1.

Table 1: COVID-19 impact on the global and Sri Lankan construction industry

No	Impacts	Reference
	Resources Related Issues	
	Material	
1	Scarcity in material	[4],[5],[7],[8],[9],[10],[11],[13],[14]
2	Supply chain disruptions	[2],[4],[7],[8],[9],[10],[11],[12],[13],[14]
3	Difficulties in finding suitable alternative materials	[10],[11]
4	Delay in delivery	[6],[9],[10],[11]
5	Difficulties in storing material	[12]
	Workforce	
6	Shortage in workforce	[2],[4],[5],[6],[7],[8],[9],[10],[11],[12]
7	Increased in workload	[2]
8	Unstable mental and physical health of workers	[10],[11],[12]
9	Difficulties in transportation	[6]
	Equipment	
10	Delay in delivery	[5]
11	Shortage in construction equipment	[5]
	Project Management Issues	
12	Restriction on operations	[1],[7],[9],[10],[12],[13]
13	Inappropriate site conditions	[5],[9],[10]
14	Difficulties in adapting to the new normal	[12]
15	Lack of experts	[12]
16	Poor decision making	[12]
17	Lack of previous experience on a pandemic	[12]
18	Poor control and monitoring	[2],[11]

No	Impacts	Reference
19	Continuous changes in project scheduling and planning	[5],[7],[10],[11]
20	Lack of communication between parties	[5]
21	Lack of supervision and site management	[2],[5]
22	Disruption to the progress of work and workflow	[2],[4]
23	Lack of safety conditions	[5]
24	Lack of Coordination	[10],[12],[13]
25	Ineffective work on site	[11]
26	Delay on project completion	[1],[2],[4],[5],[7],[8],[9],[10],[11],[12]
27	Slowing and suspension of an ongoing project	[7],[10],[12]
28	Delay to start new projects	[10]
29	Project abandonment/stopped/termination	[4],[6],[12],[13]
30	Reduction of per day working hours	[6]
31	Delay from construction-related activities	[6]
	Quality Issues	
32	Reduction in quality due to continuous changes	[11]
33	Reduction in quality due to material changes	[11]
34	Reduction in quality due to limited time and delay	[11]
35	Reduction in quality due to lack of coordination	[11]
36	Decrease in productivity	[2],[4],[5],[9],[10],[11],[12]
	Financial Issues	
37	Increased in project cost	[4],[7],[8],[9],[10],[11],[13]
38	Increase in exchange rate, and inflation rate	[5],[7],[10],[11],[12],[14]
39	Increase price of materials and equipment	[5],[6],[7]
40	Unstable cash flow and revenue	[2],[4],[10],[11]
41	Lack of funding	[4],[6],[7],[12]
42	Bankruptcy	[13]
43	Reduction in other costs	[9]
44	Employees get payment without work	[13]
	Contractual Issues	
45	Delay in payments	[3],[5],[8],[10]
46	Delay due to approval and revising	[1],[2],[4],[5],[7],[8],[9],[10],[11],[12]
47	Delay from permitting and inspection	[1],[2],[4],[5],[7],[8],[9],[10],[11],[12]
48	Delay in providing instructions	[1],[2],[4],[5],[7],[8],[9],[10],[11],[12]
49	Delay due to main contractor	[1],[2],[4],[5],[7],[8],[9],[10],[11],[12]
50	Delay due to subcontractors	[1],[2],[4],[5],[7],[8],[9],[10],[11],[12]
51	Changed or unclear standard operating procedures	[9],[11]

No	Impacts	Reference
52	Increase in claims, disputes, and litigation	[7], [10],[12]
	Safety-Related Issues	
53	Shortage in personal protective equipment	[10]
54	Quarantining and temporary shutdown	[10]
	Technological Related Issues	
55	Lack of practices in virtual working	[7],[10],[11]
56	Insufficient support to adapt to new technologies	[7],[10],[11]
57	Issues with work from home	[10],[11]
58	Ineffective transition to remote work	[10],[12]
	Other Issues	
59	Challenges to sustainability of future project	[11],[12],[13]
60	Uncertainty of the project	[7],[13]
61	Shrink in market size	[11],[12],[13]
62	Reduction in number of projects	[4],[8], [11],[12],[13]
63	Spend more time to review the project	[11],[12],[13]
64	Anxiety for termination	[11],[12],[13]
65	Lack of improvements to the project	[11],[12],[13]
66	Termination of staff employment	[13],[14]
67	Impact on social sustainability	[7],[14]

[1] (Alenezi, 2020c), [2] (Ghandour, 2020), [3] (Alenezi, 2020b), [4] (Ogunnusi, et al., 2020), [5] (Alenezi, 2020a), [6] (Osuizugbo, 2020), [7] (Gamil and Alhagar, 2020), [8] (Zamani, et al., 2021), [9] (King, et al., 2021), [10] (Alsharef, et al., 2021), [11] (Oey and Lim, 2021), [12] (Kawmudi, et al., 2020), [13] (Vithana, et al., 2020), [14] (Pathirana, 2020)

Table 2 shows that the majority of the problems in the construction sector as a result of the COVID-19 pandemic are linked to financial issues, resource shortages, project delays, decreased productivity, and reduced project numbers. On the other hand, few researches highlighted the positive impact of the COVID-19 pandemic on the construction industry as well (Ogunnusi, et al., 2020; Alsharef, et al., 2021; Oey and Lim, 2021). The positive impact of the COVID-19 pandemic on the construction industry is shown in Table 2.

Table 2: The positive impact of the COVID-19 pandemic on the construction industry

No	Positive Impact	Reference
1	Reduction in other costs	[3]
2	No impact on quality	[3]
3	Increase in demands for local manufacturers and suppliers	[2]
4	Less interest rate for the loan and other favourable loan programme provided by the government	[2]
5	Increase in investment on expand and renovation, buying a new house	[2]
6	Increase in demand on fast rack medical, transportation, residential and Other Projects	[2]
7	Job opportunity for skilled workers	[2]

No	Positive Impact	Reference
8	Improvement on existing systems and internal reviews	[2]
9	Improvement on alternatives for offsite works and virtual	[1]
10	Improvement on workplace design and material planning	[1]
11	Encouraging risk assessment and collaboration	[1]
12	Encouraging on Personal Protective Equipment (PPE)	[1]

[1] (Ogunnusi et al., 2020), [2] (Alsharef et al., 2021), [3] (Oey and Lim, 2021)

Oey and Lim (2021) specify that reduction in cost including salary decreased as the positive impact from the employer perspective. On the other hand, when considering the contractor perspective reduction in other costs has a negative impact (King, et al., 2021). It means project suspension and reduction as well as lack and no production directly influence the contractors as the contractor did not entitle to claim without working. Similarly, in the Sri Lankan context, Vithana, et al. (2020) mentioned that Employees' getting payment without work has a negative impact due to COVID-19 in the construction industry from an Employer perspective. However, this different perspective occurs, varies between countries' legal amendments, and newly amended rules and regulations as well. Based on the study, provided a table to categorize positive and negative COVID-19 impacts in the construction industry. According to the literature study identified 12 positive impacts and 67 negative impacts with COVID-19 in the construction industry. Accordingly, there is a need to validate, if these impacts are relevant to the Sri Lankan context.

3. METHODOLOGY

A systematic literature survey was conducted to analyse the impact of the COVID-19 pandemic on the construction industry in Sri Lanka. The research has been used a quantitative research approach to accomplish the research aim. Since each respondent is asked to reply to the same set of questions, questionnaires are one of the most extensively used data collection techniques in the survey approach, they provide an efficient means of gathering responses from a large sample before conducting quantitative analysis (Saunders, et al., 2009). Furthermore, Kumar (2011) agreed that they are most effective when asked standard questions. Therefore, the questionnaire survey was conducted to validate the literature findings, which was COVID-19's impact on the construction industry, in the Sri Lankan context. Subsequently, a questionnaire survey was undertaken to identify the additional COVID-19 impact on the Sri Lankan construction industry as well. The questionnaire was created based on the findings of the literature. Moreover, the questionnaire was also divided into three segments. In addition, some critical questions were put together in section one to determine the respondent's profile. The second section was dedicated to determining the impact of COVID-19 on the Sri Lankan construction industry. In this part, the sixty-seven factors found in the literature analysis are organized into eight categories. The final segment identified 12 positive effects of the COVID-19 pandemic on the construction industry. In Parts 2 and 3, respondents were asked to rate the criticality, efficacy, and efficiency of the specified impact of the COVID-19 epidemic on the construction using a five-point "Likert scale" where 1 meant "strongly disagree" and 5 meant "strongly agree". Thereafter, the questionnaires were administrated electronically via electronic mail using the Internet (Internet-mediated questionnaires). However, a pilot study should be conducted to pre-test the questionnaire to refine it, that

respondents will have no trouble completing the questions and recording the data (Kothari, 2004).

A pilot survey of chosen industry employees was conducted for assessment. Thereafter, the questionnaire may be revised in light of the pilot study's findings. Snowball sampling is also known as reputational sampling or network chain referral was chosen as it is based on the concept of a rolling snowball, where one or few individuals are first sampled and then the sample rolls out depending on connections to the initial respondents (Khalid, et al., 2012). Therefore, the respondents for the questionnaire survey were chosen using the snowball sample method. As a result, questionnaires were provided to those who worked in the Sri Lankan construction industry and had prior experience. Accordingly, online questionnaire forms were distributed to 211 respondents and 108 responses were returned out of 211. As a result, the questionnaire survey had a response rate of 51.18%. Figure 1 presents the details of the respondents.

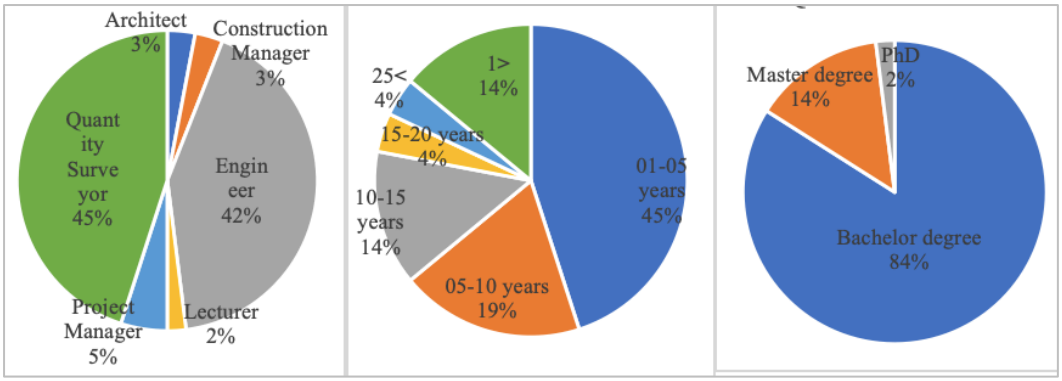

Figure 1: Details of the respondents

According to Figure 1, a large number of respondents fell into two categories: Quantity Surveyors with 45% of respondents and Engineers with 42%. As a result, the results of the questionnaire survey mostly reflect the perspectives of Quantity Surveyors and Engineers. Consequently, the opinions of the remaining types of respondents were also used for analysis, such as Project Managers (5%), Construction Managers (3%), Architects (3%), and Lecturers (2%). Subsequently, Figure 1 depicts respondents' general experiences across five different category ranges. Even though, a high proportion of respondents have experienced between 1 and 5 years with 45% of respondents. Despite this, 41% of responders had more than 5 years of experience. Despite this, 41% of responders had more than 5 years of experience. According to this, the results of the questionnaire survey reflect the opinions of well-experienced respondents, and their perspectives and insights on the proposed questionnaire will be more experienced than those of respondents with less than a year of experience. In addition, when it comes to academic qualifications, Figure 1 shows that 84% of respondents have a bachelor's degree, 14% have a master's degree, and 2% have a Ph.D. As a result, a large proportion of responders fell into one of two categories: Engineers and Quantity Surveyors with more than one year of experience. To enhance the statistical analysis of the Likert scale, the method of RII has been used. Further, the RII approach is commonly used to analyse survey data arising from the use of Likert scales in construction management research questionnaires (Holt, 2013). Throughout this study, RII was employed as a questionnaire survey analysis technique to rank the COVID-19 impacts according to their relative

importance. Meanwhile, the findings of the questionnaire and RII were analysed using the SPSS software.

4. RESEARCH FINDINGS

The purpose of the questionnaire was to apply the findings from the literature to the Sri Lankan context, as well as highlight the significant factor and any other additional factors. the results of the questionnaire were analysed using the SPSS software.

4.1 COVID-19 IMPACT ON THE SRI LANKAN CONSTRUCTION INDUSTRY

The impact of COVID-19 on the Sri Lankan construction industry was identified using a Likert scale questionnaire survey (1 meant "strongly disagree" and 5 meant "strongly agree"), and significant COVID-19 impacts identified through the RII analysis are listed in Table 3. They are all divided into eight categories.

Table 3: COVID-19 impact on the Sri Lankan construction industry

No	Impacts	1	2	3	4	5	RII	Rank
	Resources Related Issues	**Scale Percentage**						
	Material							
1	Scarcity in material	0.9	2.8	4.6	48.1	43.5	0.86	**7**
2	Supply chain disruptions	2.8	0.9	4.6	46.3	45.4	0.86	**8**
3	Difficulties in finding suitable alternative materials	0.0	3.7	16.7	57.4	22.2	0.80	25
4	Delay in delivery	1.9	0.9	6.5	44.4	46.3	0.86	**6**
5	Difficulties in storing material	6.5	27.8	31.5	25.9	8.3	0.60	67
	Workforce							
6	Shortage in workforce	2.8	2.8	11.1	41.7	41.7	0.83	14
7	Increased in workload	2.8	4.6	18.5	48.1	25.9	0.78	32
8	Unstable mental and physical health of workers	2.8	3.7	13.0	43.5	37.0	0.82	18
9	Difficulties in transportation	0.9	4.6	10.2	40.7	43.5	0.84	12
	Equipment							
10	Delay in delivery	0.0	4.6	13.9	52.8	28.7	0.81	21
11	Shortage in construction equipment	2.8	6.5	29.6	42.6	18.5	0.74	46
	Project Management Issues							
12	Restriction on operations	1.9	4.6	13.0	50.0	30.6	0.81	24
13	Inappropriate site conditions	1.9	12.0	25.9	49.1	11.1	0.71	56
14	Difficulties in adapting to the new normal	1.9	3.7	11.1	53.7	29.6	0.81	22
15	Lack of experts	1.9	16.7	40.7	28.7	12.0	0.66	62
16	Poor decision making	5.6	20.4	33.3	32.4	8.3	0.64	66
17	Lack of previous experience on a pandemic	1.9	7.4	12.0	39.8	38.9	0.81	20
18	Poor control and monitoring	3.7	11.1	31.5	40.7	13.0	0.70	58
19	Continuous changes in project scheduling and planning	0.0	5.6	8.3	47.2	38.9	0.84	13
20	Lack of communication between parties	2.8	7.4	29.6	43.5	16.7	0.73	51
21	Lack of supervision and site management	2.8	15.7	23.1	39.8	18.5	0.71	57
22	Disruption to the progress of work and workflow	0.9	2.8	13.0	50.0	33.3	0.82	17
23	Lack of safety conditions	5.6	10.2	17.6	44.4	22.2	0.74	47
24	Lack of Coordination	2.8	12.0	27.8	40.7	16.7	0.71	55
25	Ineffective work on site	0.9	12.0	26.9	40.7	19.4	0.73	49
26	Delay on project completion	1.9	0.9	4.6	40.7	51.9	0.88	**4**
27	Slowing and suspension of an ongoing project	1.9	2.8	6.5	56.5	32.4	0.83	15
28	Delay to start new projects	0.0	3.7	9.3	41.7	45.4	0.86	**10**
29	Project abandonment/stopped/termination	6.5	3.7	25.0	35.2	29.6	0.76	42
30	Reduction of per day working hours	2.8	14.8	22.2	38.0	22.2	0.72	52
31	Delay from construction-related activities	3.7	5.6	17.6	46.3	26.9	0.77	34

No	Impacts	1	2	3	4	5	RII	Rank
	Quality Issues							
32	Reduction in quality due to continuous changes	4.6	22.2	29.6	28.7	14.8	0.65	65
33	Reduction in quality due to material changes	3.7	20.4	25.0	38.9	12.0	0.67	61
34	Reduction in quality due to limited time and delay	2.8	20.4	20.4	41.7	14.8	0.69	59
35	Reduction in quality due to lack of coordination	2.8	19.4	35.2	31.5	11.1	0.66	64
36	Decrease in productivity	0.9	10.2	15.7	39.8	33.3	0.79	29
	Financial Issues							
37	Increased in project cost	0.0	1.9	2.8	42.6	52.8	0.89	**3**
38	Increase in exchange rate, and inflation rate	0.9	0.0	1.9	34.3	63.0	0.92	**2**
39	Increase price of materials and equipment	0.0	2.8	0.0	27.8	69.4	0.93	**1**
40	Unstable cash flow and revenue	0.0	2.8	8.3	45.4	43.5	0.86	**9**
41	Lack of funding	1.9	4.6	14.8	45.4	33.3	0.81	23
42	Bankruptcy	0.9	7.4	34.3	36.1	21.3	0.74	45
43	Reduction in other costs	3.7	20.4	29.6	34.3	12.0	0.66	63
44	Employees get payment without work	10.2	11.1	28.7	32.4	17.6	0.67	60
	Contractual Issues							
45	Delay in payments	2.8	2.8	3.7	50.9	39.8	0.84	11
46	Delay due to approval and revising	0.0	4.6	7.4	58.3	29.6	0.83	16
47	Delay from permitting and inspection	0.0	5.6	16.7	51.9	25.9	0.80	26
48	Delay in providing instructions	1.9	7.4	30.6	42.6	17.6	0.73	48
49	Delay due to main contractor	4.6	3.7	25.9	46.3	19.4	0.74	43
50	Delay due to subcontractors	0.0	2.8	18.5	56.5	22.2	0.80	27
51	Changed or unclear standard operating procedures	0.9	5.6	24.1	52.8	16.7	0.76	41
52	Increase in claims, disputes, and litigation	0.9	2.8	12.0	56.5	27.8	0.81	19
	Safety-Related Issues							
53	Shortage in personal protective equipment	2.8	11.1	25.9	42.6	17.6	0.72	53
54	Quarantining and temporary shutdown	0.9	0.9	4.6	44.4	49.1	0.88	**5**
	Technological Related Issues							
55	Lack of practices in virtual working	1.9	7.4	14.8	58.3	17.6	0.76	38
56	Insufficient support to adapt to new technologies	1.9	5.6	24.1	46.3	22.2	0.76	39
57	Issues with work from home	1.9	7.4	13.0	46.3	31.5	0.80	28
58	Ineffective transition to remote work	0.9	6.5	16.7	50.9	25.0	0.79	30
	Other Issues							
59	Challenges to sustainability of future project	1.9	2.8	20.4	56.5	18.5	0.77	35
60	Uncertainty of the project	1.9	4.6	18.5	52.8	22.2	0.78	33
61	Shrink in market size	0.9	10.2	15.7	49.1	24.1	0.77	36
62	Reduction in number of projects	1.9	5.6	22.2	46.3	24.1	0.77	37
63	Spend more time to review the project	1.9	5.6	22.2	51.9	18.5	0.76	40
64	Anxiety for termination	0.9	12.0	30.6	38.0	18.5	0.72	54
65	Lack of improvements to the project	1.9	12.0	20.4	50.9	14.8	0.73	50
66	Termination of staff employment	5.6	5.6	21.3	46.3	21.3	0.74	44
67	Impact on social sustainability	0.9	3.7	18.5	55.6	21.3	0.79	31

The result shows that overall RII values are more than 0.60, which indicates that most of the respondents considered all these sixty-seven (67) COVID-19 impacts apply to the Sri Lankan construction industry as well. Furthermore, as per RII value which is more than 0.86, shows that the majority of the problems in the Sri Lankan construction sector as a result of the COVID-19 pandemic are linked to financial issues (increase price of materials and equipment, increase in the exchange rate, and inflation rate, increased in project cost, and unstable cash flow and revenue), safety-related issues (quarantining and temporary shutdown), project management issues (delay on project completion, and delay to start new projects), and resources related issues (delay in delivery, scarcity in material, and supply chain disruptions). Furthermore, Figure 2 graphically demonstrates the level

of significance of COVID-19 impact in the Sri Lankan context through findings of the questionnaire survey.

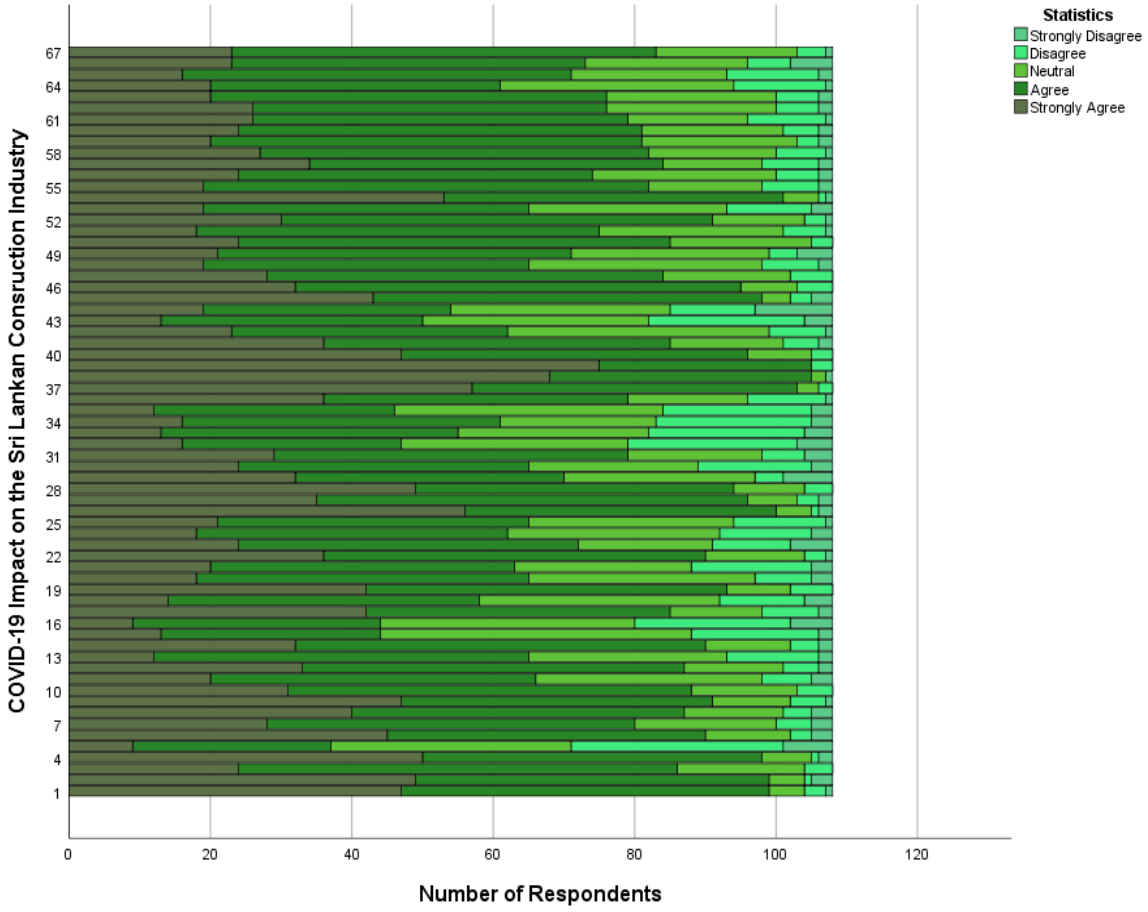

Figure 2: Impact of COVID-19 on Sri Lankan construction industry

Figure 2 shows that all respondents agreed that COVID-19 influences the Sri Lankan construction industry. Consequently, this figure merely shows the extent to which respondents agree or disagree with the COVID-19 impact and how it has affected the Sri Lankan construction sector. Finally, Figure 3 summarises the significant COVID-19 impacts on the Sri Lankan construction industry, industry through a polar chart, arranged from most influencing to least influencing factors.

Figure 3 demonstrates that the construction industry in Sri Lanka was strongly influenced by impacts 39, 38, 37, 26, and 54, while it was least impacted by impacts 5, 16, 32, 43, and 35. Further, few respondents have noted and elaborated on the COVID-19 impacts that have been reported in the literature under contractual-related issues, particularly delayed payments in government projects. Furthermore, the respondents have emphasised lack of communication and coordination (most notable, no direct communication with managements) (Alsharef, et al., 2021), difficulty to adapt to the workers to work with the new government health and safety guidelines (Kawmudi, et al., 2020), difficulties in staff and labour movement off-site (Osuizugbo, 2020), difficulty to work with new government rules and regulations (King, et al., 2021a), lack of plans for pre-and post-disaster events (Oey and Lim, 2021), and less controlling and monitoring of main contractors (as they are a foreign contractor) (Ghandour, 2020)are all project management

related issues. Furthermore, as noted in the literature, equipment operator shortages (Alenezi, 2020a) were mentioned by a few respondents under equipment-related concerns. Similarly, under workforce-related issues, only a limited number of labourers are allowed within sites, inadequate accommodation, work progress is affected abruptly when workers are quarantined, at the initial stage of COVID-19, labours turned to agriculture and left construction work in March 2020, and workers accommodation must be maintained for safety according to COVID 19 regulations (Gamil and Alhagar, 2020; Ogunnusi, et al., 2020) specified by few respondents as mentioned in literature.

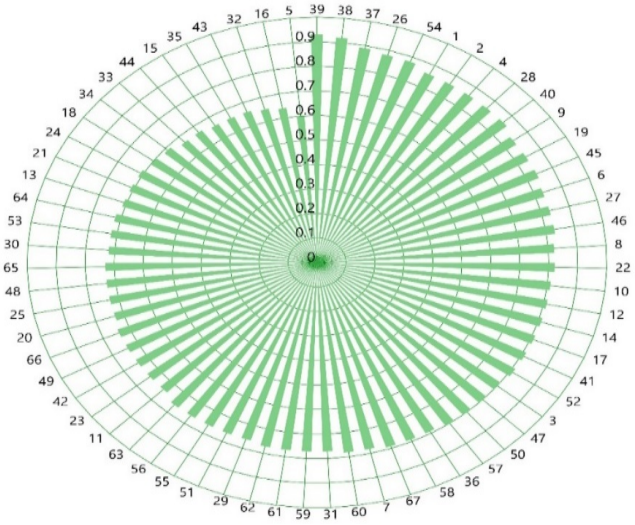

Figure 3: COVID-19 impacts on the Sri Lankan construction industry

Furthermore, under material-related issues, an increase in material prices (Zamani, et al., 2021), as well as the instability of the foreign currency component (Gamil and Alhagar, 2020) in Sri Lanka, had an impact on imported materials such as DI and PE, as well as restrictions on the import and shipment of material from foreign countries, as mentioned in the literature. In addition, due to a lack of funds (Ogunnusi, et al., 2020), government projects have decreased, international and domestic investment in the construction industry has been reduced (Zamani, et al., 2021), and the tourism business (Oey and Lim, 2021) has had a significant impact on the construction industry, as stated by the respondents in the literature. Table 4 lists some further COVID-19 impacts highlighted in the respondent's additional remarks that they have encountered.

Table 4: COVID-19 impacts added by the respondents

No	Impacts
	Resources related issues
	Material
1	Reduction in quality of materials
2	Some materials will ruin after a long period of storage
	Workforce
3	Difficulties in finding relevant Skill labours on a limited salary scale
4	Increased in salary
5	Unable to get Specialist workforce from foreign countries
6	Difficult in coordination with workers

	Equipment
7	Equipment price fluctuation
8	Unable to repair the equipment due to shortage in spare parts
9	Increased in hire vehicle rate due to fuel price increase
10	Equipment corroded due to lockdown
11	Scarcity of equipment
	Quality Issues
12	Reduction in a quality due use of labour of inappropriate skills
13	Often rectifications, and reworks
	Financial Issues
15	Liquidity issues of money
16	Delay in approval of compensation
	Contractual Issues
17	Poor contractual interpretation on pandemic situation
	Safety-Related Issues
18	The difficulty of managing labours as per health standards
19	Avoidance of health and safety standards due to increasing Working space/ accommodating space

Table 4 demonstrates that the study revealed nineteen (19) new COVID-19 impacts in the Sri Lankan construction industry that were not found in the literature review. According to the findings, the COVID-19 pandemic has caused eighty-six (86) negative elements in the construction industry, which are classified under resources-related issues, project management issues, quality issues, financial issues, contractual issues, safety issues, technology-related issues, and other issues.

4.2 POSITIVE IMPACT OF THE COVID-19 PANDEMIC ON THE SRI LANKAN CONSTRUCTION INDUSTRY

In contrast, a few studies in the literature review showed the positive impact of the COVID-19 pandemic on the construction industry (Ogunnusi et al., 2020; Alsharef et al., 2021; Oey and Lim, 2021). 53% of respondents believe the COVID-19 pandemic has had a positive impact on the Sri Lankan building industry. Table 5 shows the significance of the COVID-19 pandemic's positive influence on the Sri Lankan construction industry.

Table 5: The positive impact of the COVID-19 pandemic on the Sri Lankan construction industry

No	Positive Impacts	1	2	3	4	5	RII	Rank
		Scale percentage						
1	Reduction in other costs	15.7	39.8	19.4	20.4	4.6	0.52	12
2	No impact on quality	9.3	38.9	26.9	15.7	9.3	0.55	11
3	Increase in demands for local manufacturers and suppliers	3.7	11.1	25.0	44.4	15.7	0.71	4
4	Less interest rate for the loan and other favourable loan programme provided by the government	3.7	15.7	34.3	37.0	9.3	0.66	7
5	Increase in investment on expand and renovation, buying a new house	5.6	24.1	30.6	31.5	8.3	0.63	9
6	Increase in demand on fast rack medical, transportation, residential and Other Projects	3.7	14.8	25.9	47.2	8.3	0.68	6
7	Job opportunity for skilled workers	9.3	23.4	22.4	34.6	10.3	0.62	10
8	Improvement on existing systems and internal reviews	2.8	20.8	36.8	26.4	13.2	0.64	8

No	Positive Impacts	1	2	3	4	5	RII	Rank
		Scale percentage						
9	Improvement on alternatives for offsite works and virtual	2.8	12.0	27.8	38.9	18.5	0.72	3
10	Improvement on workplace design and material planning	2.8	16.7	22.2	42.6	15.7	0.70	5
11	Encouraging risk assessment and collaboration	1.9	11.1	22.2	48.1	16.7	0.73	2
12	Encouraging on Personal Protective Equipment (PPE)	1.9	6.5	15.7	52.8	23.1	0.78	1

RII values for the 10 COVID-19 positive impacts are greater than 0.60, indicating that the majority of respondents believe these 10 COVID-19 positive impacts apply to the Sri Lankan construction industry. Nevertheless, for the first two positive impacts, which are reduction in other costs, and no impact on quality, RII is less than 0.6. Except for those two positive outcomes, all others were found to be positive COVID-19 impacts on the Sri Lankan construction industry. According to the RII value of 0.78, the positive effects of the COVID-19 pandemic on the Sri Lankan construction industry are linked to encouraging PPE. Finally, Figure 4 depicts the considerable COVID-19 positive impacts in the Sri Lankan construction industry.

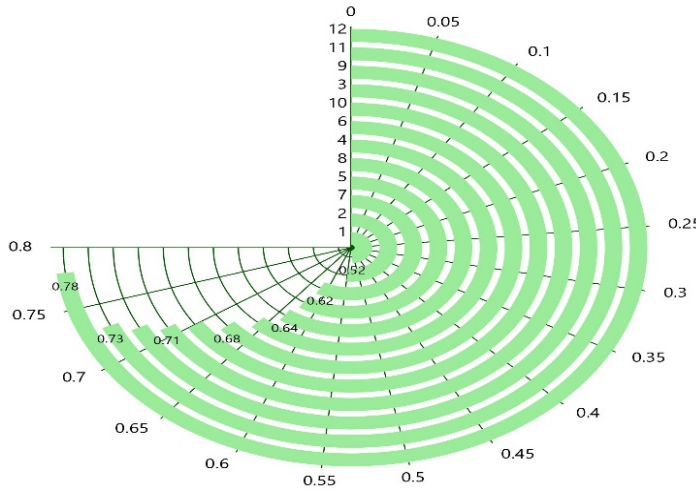

Figure 4: COVID-19 positive impacts in the Sri Lankan construction industry

According to the findings of the literature, Alsharef, et al. (2021), Oey and Lim (2021), and Ogunnusi, et al. (2020) discovered 12 positive impacts on the construction industry. Only a few respondents have mentioned things that have already been mentioned in the literature, such as increased demand for local manufacturers (Alsharef, et al., 2021), and increased usage of or adaption to BIM/Digital Construction (Ogunnusi, et al., 2020; Alsharef, et al., 2021). Consequently, additional COVID-19 positive impacts are emphasised in the respondent's additional notes: the labour force's availability whereas many workers in the tourism industry have lost their jobs and have turned to the construction industry to make ends meet, and work can be monitored more carefully than previously. Finally, the research found 12 positive impacts.

5. DISCUSSION OF FINDINGS

The construction industry was affected by the COVID-19 pandemic (Alsharef, et al., 2021; Raoufi and Fayek, 2021). Furthermore, most of the research has been highlighted while evaluating the influence of the COVID-19 pandemic on the construction sector, such as resource shortages, financial concerns, project delays, lower productivity, and

reduced project numbers (Ghandour, 2020; Ogunnusi, et al., 2020; Oey and Lim, 2021; Zamani, et al., 2021). Based on the literature review 67 COVID-19 impacts have been identified under eight categories including resources-related issues, project management issues, quality issues, financial issues, contractual issues, safety issues, technology-related issues, and other issues, and all of them have been validated using a Likert scale questionnaire survey. In addition, the respondents indicated nineteen additional COVID-19 impacts. Eighty-seven COVID-19 impacts on the Sri Lankan construction sector have been discovered under eight categories. In contrast, a few research in the literature review revealed that the COVID-19 pandemic had a twelve 12 favourable influence on the construction industry (Ogunnusi, et al., 2020; Alsharef, et al., 2021; Oey and Lim, 2021). Based on that, ten 10 positive COVID-19 impacts on the Sri Lankan construction industry have been validated and identified as positive COVID-19 impacts. Further, two more COVID-19 positive impacts were also highlighted by the responders. Twelve COVID-19 positive impacts on the Sri Lankan construction industry have been identified.

6. CONCLUSIONS

The research's objective was met by conducting a systematic literature study and conducting a questionnaire survey of construction industry professionals. By referring to journals and conference proceedings, the impact of COVID-19 on the construction sector was covered in the literature review. As a result, 67 COVID-19 impacts were found, which were divided into eight categories: resources-related issues, project management issues, quality issues, financial issues, contractual issues, safety issues, technology-related issues, and other issues. Furthermore, using a questionnaire survey, these findings from the literature were confirmed in the Sri Lankan context by construction industry professionals. Further, a total of 19 new COVID-19 impacts were gathered from construction industry professionals. On the other hand, ten positive COVID-19 impacts found in the literature were confirmed in the Sri Lankan context. In addition, data analysis revealed two more positive impacts. COVID-19's impacts on the Sri Lankan construction industry have been recognized as a result. This study highlights that COVID-19 is catastrophe as well as a blessing in disguise to the Sri Lankan construction industry. For example, this pandemic has developed a platform for the construction industry to enter the digital environment. As a result of this pandemic, the construction industry has been promoted to the next level. However, while the COVID-19 pandemic has had various detrimental effects on the construction industry, it has allowed the sector to improve and advance to the next level by providing a solution to the situation. The outcomes of this research will be valuable to Sri Lankan construction organizations in developing a strategy based on these impacts. Further, the findings will assist construction organizations in better understanding the impacts that the construction sector experiences to develop solutions and, as a result, to enhance the evolutionary process to mitigate the impacts in Sri Lanka. Finally, the findings results will open the way for the next stage of the study that focus on investigating a solution to the COVID-19 impact using innovative technology such as Building Information Modelling and lean construction, which will be the focus of the next phase of the research.

7. REFERENCES

Alenezi, T.A.N., 2020a. COVID-19 Causes of delays on construction projects in Kuwait. *International Journal of Engineering Research and General Science*, 8(4), pp. 35-39.

Alenezi, T.A.N., 2020b. Minimising the delay factors on construction projects: A local case study in Kuwait City during COVID-19. *International Journal of Engineering Research and General Science*, 8(5), pp. 5-8.

Alenezi, T.A.N., 2020c. The impact of COVID-19 on construction projects in Kuwait. *International Journal of Engineering Research and General Science*, 8(4), pp. 6-9.

Alsharef, A., Banerjee, S., Uddin, S.J., Albert, A., and Jaselskis, E., 2021. Early impacts of the COVID-19 pandemic on the United States Construction industry. *International Journal of Environmental Research and Public Health*, 18(4), pp. 1-21.

Bou Hatoum, M., Faisal, A., Nassereddine, H., and Sarvari, H., 2021. Analysis of COVID-19 concerns raised by the construction workforce and development of mitigation practices. *Frontiers in Built Environment*, 7(May), pp. 1-15.

Bsisu, K.A., 2020. The impact of COVID-19 pandemic on Jordanian civil engineers and construction industry. *International Journal of Engineering Research and Technology*, 13(5), pp. 828-830.

Fernandes, N., 2020. Economic effects of coronavirus outbreak (COVID-19) on the world economy. *SSRN Electronic Journal*, pp. 1-29.

Gamil, Y. and Alhagar, A., 2020. The impact of pandemic crisis on the survival of construction industry: A case of COVID-19, *Mediterranean Journal of Social Sciences*, 11(4), pp. 122-128.

Gautam, S., 2020. The influence of COVID-19 on air quality in India: A boon or inutile. *Bulletin of Environmental Contamination and Toxicology*, 104, pp. 724-726.

Ghandour, A., 2020. The impact of COVID-19 on project delivery: A perspective from the construction sector in the United Arab Emirates. *Humanities & Social Sciences Reviews*, 8(5), pp. 169-177.

Holt, G.D., 2013. Asking questions, analysing answers: Relative importance revisited. *Construction Innovation*, 14(1), pp. 2-16.

Kawmudi, W.N., Jayasooriya, S., Rupasinghe, A., and Ariyarathna, K.C., 2020. Identification of the challenges imposed by COVID-19 pandemic on Sri Lankan Construction projects. In *13th International Research Conference of General Sir John Kotelawala Defence University*, Colombo, Sri Lanka. pp. 35-44.

Khalid, K., Hilman, H. and Kumar, D., 2012. Get along with quantitative research process. *International Journal of Research in Management*, 2(2), pp. 15-29.

Khan, R.A., Liew, M.S. and Ghazali, Z. Bin., 2020. Malaysian construction sector and Malaysia vision 2020: Developed nation status. *Procedia - Social and Behavioral Sciences*, 109, pp. 507-513.

King, S.S., Rahman, R.A., Fauzi, M.A., and Haron, A.T., 2021. Mechanisms for addressing the impact of COVID-19 on infrastructure projects. In *IOP Conference Series: Earth and Environmental Science,* IOP Publishing. 682(1), p. 012047.

King, T.L. and Lamontagne, A.D., 2021. COVID-19 and suicide risk in the construction sector: Preparing for a perfect storm. *Scandinavian Journal of Public Health*, 49(7), pp. 774-778.

Kothari, C., 2004. *Research Methodology: Methods and Techniques*. New Delhi, India: New Age International.

Kumar, R., 2011. *Research Methodology: A Step-by-Step Guide for Beginners*. 3rd ed. Sage Publications Ltd. Available from: www.ijsom.com.

McKibbin, W. and Fernando, R., 2021. The global macroeconomic impacts of COVID-19: Seven scenarios. *Asian Economic Papers 2021*, 20(2), pp. 1-30.

Oey, E. and Lim, J., 2021. Challenges and action plans in construction sector owing to COVID-19 pandemic - A case in Indonesia real estates. *International Journal of Lean Six Sigma*. 12(4), pp. 835-858.

Ogunnusi, M., Hamma-Adama, M., Salman, H., and Kouider, T. 2020. COVID-19 pandemic: The Effects and prospects in the construction industry. *International Journal of Real Estate Studies*, 14(2), pp. 120-123.

Osuizugbo, I.C., 2020. Disruptions and responses within Nigeria construction industry amid COVID-19 threat. *Covenant Journal of Research in the Built Environment*, 8(2), pp. 37-48.

Pathirana, L.P.D.S., 2020. Effect of COVID-19 and strategic response: A review on Sri Lankan construction industry. *SSRG International Journal of Economics and Management Studies*, 7(June), pp. 73-77.

Raoufi, M. and Fayek, A.R., 2021. Identifying actions to control and mitigate the effects of the COVID-19 pandemic on construction organizations: Preliminary findings. *Public Works Management and Policy*, 26(1), pp. 47-55.

Salleh, F., Palaniappan, S., Theng, I.L.P., Helmi, H.N.M., Abd Hamid, A. and Kassim, N.M., 2020. A review on risk management implementation in the construction industry. *Journal of Critical Reviews*, 7(11), pp. 562-567.

Saunders, M., Lewis, P. and Thornhill, A., 2009. *Research Methods for Business Students*. 5th ed. England: Pearson Education Limited.

Saurin, T.A., 2021. A complexity thinking account of the COVID-19 pandemic: Implications for systems-oriented safety management. *Safety Science,* 134, p. 105087.

Vithana, N.D.I., Bandara, K. and Jayasooriya, S.D., 2020. Impact of COVID-19 pandemic to construction industry in Sri Lanka. In *the 13th International Research Conference General Sir John Kotelawala Defence University*, Colombo, Sri Lanka. pp. 161-166.

WHO, 2020. Preparedness, prevention and control of COVID-19 in prisons and other places of detention, Interim guidance, World Health Organization, Available at: www.euro.who.int.

Zamani, S.H., Rahman, R.A., Fauzi, M.A. and Yusof, L.M., 2021. Effect of COVID-19 on building construction projects: Impact and response mechanisms. In *4th National Conference on Wind & Earthquake Engineering*. In IOP Conference Series: Earth and Environmental Science, 682(1), p. 012049. IOP Publishing.