

DELAYS AND DISRUPTIONS IN THE CONSTRUCTION INDUSTRY DURING THE GLOBAL PANDEMIC

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ABSTRACT

COVID-19 pandemic has become a global catastrophe today dragging many nations towards severe economic distress. The Sri Lankan economy has no exception. Not surprisingly, the sluggish economic conditions in the country have adversely affected the construction industry in Sri Lanka. The pandemic has resulted in almost every construction project getting delayed or disrupted. This research aims to determine the factors that caused delays and disruptions in large scale construction projects in Sri Lanka due to pandemic. The overall impact of the global pandemic on construction projects in both local and international platforms were identified through a comprehensive literature review. Additionally, the impact on the local domain in terms of delay and disruption was assessed based on exploratory interviews and survey questionnaire disseminated among industry experts. Final conclusions were drawn by conducting 9 case studies and analysing responses to survey questionnaire provided by 30 industry practitioners. This study assisted in finding measures and mechanisms currently in use to mitigate the impact of delay and disruption of the construction phase of construction projects. The findings also paved the way to recognize innovative mitigation strategies to control the adverse impact on on-going construction projects. Analysis of the responses concluded that, delay in project kick-off, delays in material delivery, shortage of material, project suspension, reduction in the workforce productivity, health and safety concerns, regular price escalations as the key elements attributed to impact the project progress. The study has identified the present mitigating controls over delays or disruption are barely sufficient to address the concern and thus emphasised the need to resort to more effective techniques to remedy the issue.

Keywords: Construction; COVID-19; Delay; Disruption.

1. INTRODUCTION

The COVID-19 pandemic has been the world's most serious health emergency in the recent past. The influence of COVID-19 on the society is evident due to worldwide lockdowns, labour mobility restrictions, travel bans and airline suspensions (Shafi, et al., 2020). Moreover, the world has had a negative impact on the manufacturing industry, affecting both market distribution and supply chain (Tambrallimath, et al., 2021). The travel restrictions and curfews imposed regularly, caused major delays and disruptions in construction projects. During the crisis, construction, planning and scheduling were considerably impacted. The findings indicated that the project delays were serious, and

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the main reason being 95% of staff was unable to work at any moment due to the government's response to the epidemic (Alenezi, 2020). In fact, many construction firms found it difficult to retain their existing workforce due to cashflow constraints. Partly the job losses were due to work interruptions caused by work-related limitations enforced to stop the spread of the virus, a scarcity of personal protective equipment (PPE) since it was prioritised for healthcare personnel, and general market anxiety (Alsharef, et al., 2021).

More importantly the research gap should be identified in order to contribute towards research objectives. The delays and disruptions in construction projects have not only been avoidable but also created an unfavourable impact on the industry at large. Therefore, it is essential to identify and implement methods to avoid or minimise construction project delays. However, before implementing counter solutions, one should identify which factors affect the delays in the construction stage of a construction project, which is currently lacking in terms of research. Identifying these factors and prioritising them with regard to the impact on the project efficiency is crucial when implementing solutions to the said delays and disruptions.

The aim of this study was to identify factors that cause delays and disruptions of large-scale construction projects in Sri Lanka at its construction stage, due to the COVID-19 pandemic. In order to facilitate systematic achievement of the aim, few research objectives were developed such as to identify the impact of COVID-19 pandemic on the construction industry globally and locally, to investigate the impact of the pandemic to a construction project in terms of delays and disruptions during the construction phase of a project, identify and evaluate the significance of those factors, to explore the existing methods which are used to mitigate those delays and disruptions during the construction phase of a construction project and to recommend strategies which could be used by the industry to minimise delays and disruptions due to pandemic.

2. LITERATURE REVIEW

In a pandemic scenario, concepts of delay and disruption are most relevant to the construction industry. Disruption is a term which is directly combined with the loss of efficiency in construction projects (Haidar, 2011). In addition, the concept of 'Force Majeure' has been a point of controversy, as it permits the contracting party to avoid fulfilling its obligations due to events beyond their control (Hansen, 2020). Kikwasi (2013) has specified ten (10) critical causes of delay and disruption in construction projects. They are building permits approval, change orders, changes in drawings, incomplete paperwork, inspections, changes in specifications, decisions made during the development stage, shop drawings and approval. Further, the researcher has ranked the effects of delays and disruptions on the construction stage of a project in relation to their significance. Time overrun was the number 1 ranked effect in terms of significance followed by cost overrun, idling resources, disputes, poor quality of work due to hurry, delaying in getting profit by clients, bankruptcy, create stress on contractors, and total abandonment, were ranked in order of highest to least significance, whereas acceleration losses being the least significant factor as per the research findings.

It is evident that the global economy has been negatively impacted in almost every sector due to the pandemic. Sri Lanka has had no exception to this global phenomenon. The construction industry in Sri Lanka is among the critically affected industries among many.

According to the Department of Census and Statistics Sri Lanka, Gross Domestic Product (GDP) from the construction industry decreased from LKR 154.3 billion in the 1st quarter of 2021 to LKR 137.3 billion in the 2nd quarter of 2021. However, it has increased from LKR 142.8 billion in the 3rd quarter of 2021 to LKR 170.3 billion in the 4th quarter of 2021.

The study was mainly focused on the current situation in the construction industry in Sri Lanka and it was limited to high rise commercial buildings which have a project value of more than LKR 50 million. The intention was to cover a fair representation of the building construction projects which are at construction stage at present. Most of the existing building projects are of commercial type of developments in the western province in Sri Lanka. Research was carried out studying nine (9) construction projects in detail as case studies and only focused on the construction phase of each project.

3. METHODOLOGY

This study was carried out following a mixed method approach involving both qualitative and quantitative approaches in varied degrees. Qualitative research possesses specific benefits compared to quantitative approach. According to Kumar (2011) the primary goal of qualitative research is to understand, explain, discover and clarify circumstances, perceptions and experiences of a group of people. On the other hand, empirical assertions are expressed numerically in quantitative research. These empirical evaluations are described as a method of determining the degree to which a program or policy empirically meets or fails to meet a set of standards or norms (Sukamolson, 2007). Through further evaluation, a mixed method approach was used in this research study.

A researcher uses sampling as a technique to systematically pick a sample of representative items or individuals from a predefined population to serve as subjects for observation or experimentation based on the study objectives (Sharma, 2017). As the sampling method for this research, purposive sampling was used. Purposive sampling is a simple and straightforward, yet effective sampling method. It improves the rigour of the study and the reliability of the data and outcomes by better matching the sample to the research's goals and objectives (Campbell, et al., 2020). Under purposive sampling there are various study designs such as case studies, oral history, focus groups, participants' observation, holistic research and community discussion forums. Out of these study designs, case studies were used for this research. Case studies are very useful when exploring a scenario where knowledge is limited or to have a holistic understanding of the situation (Kumar, 2011). Therefore, nine (9) case studies were carried out with the engagement of a specific focus group which consists of construction industry professionals. Conclusions of the research are based on these nine case studies.

Purposive sampling was used as the sampling method, with the aim of focusing only on professionals from the construction industry in Sri Lanka. In order to generate quantitative results, a questionnaire survey was shared among professionals in the construction industry. The questionnaire survey consisted of 16 questions which included multiple choice questions, Likert scale questions and open-ended questions. The sample size of the survey was 30 respondents. The questionnaire survey was followed by nine (9) case studies using open-ended expert interviews which generated qualitative data. Finally, the qualitative data which was gathered through case studies, were analysed

through a thematic data analysis while quantitative data which was gathered through the questionnaire survey was analysed through a descriptive statistical analysis.

Questionnaire survey and case studies were employed as the data collection methods. However, due to the sudden outbreak of the 3rd wave of COVID-19, interviews have to be conducted over the phone or online video calling methods. It solely depended on the interviewee's preference and convenience. According to (Blumberg, et al., 2008), because of the privacy and cost-effectiveness it provides to the interviewee, data gathering via email has become indispensable. Therefore, questionnaires were emailed to respective professionals in advance, which was then followed up with a telephone interview.

The scale of the impact was evaluated with respect to the local construction market. The adverse impact in terms of delays and disruptions of a construction project were also identified and analysed. There were several delay and disruption factors that emerged as a result of the pandemic such as travel restrictions, partial or complete closure of sites, stringent health regulations and spread of virus among construction workers. The data collected through questionnaire surveys and case studies provided a large amount of specific data which revealed the possible factors that have caused delay and disruption on a construction phase of a project. The quantitative analysis of the study paved the way to discover twelve (12) factors that have made a significant impact on projects. Moreover, these 12 factors were ranked based on their severity. The study confirmed that all of these factors have a negative impact of moderate to major scale. Finally, existing methods, which are implemented in construction projects at present, are ascertained through a thematic analysis of nine (9) case studies. A thematic analysis was used to analyze data which was collected through interview and questionnaire survey. In addition, Clarke and Braun (2014) states that many research questions can be addressed with Thematic Analysis, ranging from inquiries about people's practices and beliefs in specific circumstances. The collected data from case studies were divided into six themes. They are the adverse impact from COVID-19, impact on the continuation of site works, impact on the workforce, impact on suppliers and imported goods, health and safety measures and delay and disruption mitigation techniques.

The descriptive statistical analysis and Significance Index (SI) were used to analyze quantitative data. There are two major outputs of statistical analysis, which are the Standard Deviation (SD) and mean.

4. RESULTS

4.1 QUANTITATIVE FINDINGS

The objective of the study is to offer a holistic understanding of the impact due to the COVID-19 pandemic on the construction industry in relation to delay and disruption. The first and foremost concern was to confirm whether all construction projects were severely affected due to the pandemic. It was evident that only 63% of the projects were severely affected while 30% were affected moderately and 7% were less affected. Most of the participants have experienced labour shortage as a common issue. The main reason for this burning issue is prophylactic absenteeism among workers. Moreover, labourers show reluctance to work in distant areas to their hometowns due to sudden lockdowns and travel restrictions. It reflected the government-imposed travel restrictions as yet another cause for the negative impact. It is understandable that all the factors that caused adverse consequences are interconnected. Another factor given by respondents is the rapid price

escalations and material scarcity. Due to the unexpected increase in operational costs many material prices have also increased in tandem. Consequently, contractors were unable to source basic materials such as sand, cement and bricks during the early months of the pandemic. In addition, finishing materials are in high demand due to import restrictions. Higher concern in health and safety protocols have also resulted in delaying of projects. As an example, contractors are unable to occupy the total number of workers due to health issues. At the same time complying with safety conditions at site level has slowed down work proceedings significantly. In contrast, as a result of all these factors almost every construction project got delayed or overran the budgeted cost limits. Further, investors are reluctant to invest in the industry, making a big blow to the country's economy.

More than 93% of the respondents agreed that their construction projects are significantly delayed and disrupted due to regular shutdowns of the country. Participants were asked to give a number on a scale of 1-5 (1 being the most) about how much of an adverse impact caused due to the pandemic on their current construction project in terms of delay and disruption. Figure 1 displays the summarized results of it.

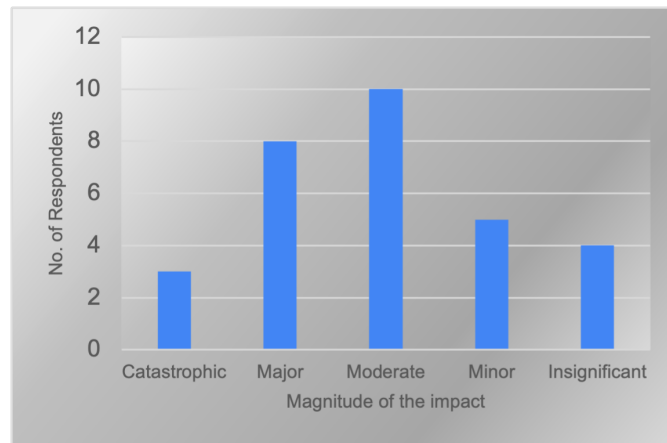


Figure 1: Scale of adverse impact due to COVID-19

Even though the general public interprets the impact of the pandemic on the construction industry as a severe one, the above bar chart mirrors the true magnitude of the impact which is at moderate level. In terms of factors impacting the project progress, after conducting a thorough literature survey, 12 major factors were identified which could have a severe impact on the project in terms of delay and disruption during the pandemic period. All the participants were asked to rank these factors on a Likert scale from 1 to 5 (1 being insignificant and 5 being catastrophic, Refer Table 1), based on the magnitude of the impact. Furthermore, collected data was analysed and ranked by the Weighted mean method using Eq. 01. Findings are presented in Table 2.

$$\text{Weighted mean} = \frac{\sum_{i=1}^n \omega_i \cdot x_i}{\sum_{i=1}^n \omega_i} \quad (\text{Eq. 01})$$

Where,

ω = Frequency of responses

x = Rating of each factor

Table 1: Likert scale weightings

Scale	Description
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Catastrophic

Table 2: Rankings of delay and disruption factors

Factor	Weighted mean	Rank
Safety concerns regarding virus spread in the construction site	3.900	1
Material delivery delays and shortage of material	3.670	2
Suspension or slowing of the project	3.670	2
Disparities across government parties and governing bodies whether construction operations are essential or non-essential	3.567	4
Workforce related challenges	3.533	5
Delay in the start date of the project	3.533	5
Delays in inspections and securing permits	3.500	7
Price escalations, additional costs, loss of revenue, and payment delays	3.500	7
Lack of motivation in the workforce	3.500	7
Reduction in efficiency and productivity rates	3.467	10
Transition to work from home for non-site personnel	3.300	11
Increase in Disputes and Claims	3.200	12

Table 2 reveals the factors that have the most to least impact on a construction project in terms of delay and disruption during the pandemic. Those factors are ranked and shown in a tabular format based on their weighted mean. Considering the data received from the respondents it is noticeable that all the factors have a weighted mean ranging in between 3 and 4. Therefore, the impact of these 12 factors can be interpreted as either a major or a moderate impact according to the Likert scale weightings. According to the respondents, out of 30 participants 20 of them have taken extra measures to mitigate the impacts of the pandemic on their project. Furthermore, they have implemented following specific strategies to control the negative impact (Refer Table 3).

Table 3: Current strategies implemented at site level to mitigate delay & disruption

Strategy	Activities
Adhere to new health & safety practices	Maintain daily record book which includes body temperatures, any diseases, telephone numbers and body oxygen level of workers when entering into the site, keep 1m distance, wear masks, random body temperature check during the day. Provide masks, sanitizers, safety equipment, hand washing areas & steam machines, promote personal disinfectant practices.

Strategy	Activities
	<p>Use signs of safety practices and symptoms inside the site and training for employees on the spread of the disease.</p> <p>Using Environmental Protection Agency-approved cleaning chemicals from List N or that have label claims against the corona virus for cleaning frequently touched surfaces like tools, handles, and machines.</p> <p>Restrict entry for all visitors during the pandemic.</p> <p>Instructions are given that if workers feel sick, that they must stay home.</p> <p>Antigen and Polymerase Chain Reaction (PCR) tests are done when workers show symptoms.</p> <p>Prohibit site gathering and close contacts.</p>
<p>Implementation of Bio Bubble concept</p>	<p>Isolating the work staff and labours including supplying food and accommodations for them.</p> <p>Prohibit workers from going outside the site premises.</p> <p>One team is allocated to bring necessary items for workers from outside.</p>
<p>Other strategies in terms of construction work proceedings</p>	<p>Work from home method for non-site based personnel and minimizing site staff and follow roster basis.</p> <p>Parallel tasks were omitted in the same area for two gangs of workers to minimize labour congestion.</p> <p>Working and negotiating potential changes for time, schedule, project completion and management.</p> <p>Understanding supply agreement and purchase orders to determine impacts of delays, delivery obligations, payment and financing issues, and other liability risks.</p> <p>Encourage vaccination.</p> <p>Prioritize most important materials to purchase.</p> <p>Prioritize critical tasks.</p> <p>Minimize physical meetings and transfer to an online platform and plan to work shift or roster basis.</p> <p>Instruct staff and workers to avoid public transport. Provide transportation facilities.</p> <p>Using this extended time period to finalize designs which will ultimately reduce variations and disputes due to design changes in projects which are at design stage.</p>

4.2 QUALITATIVE FINDINGS

4.2.1 Sample information

Respondents were asked to provide a brief outline of their current project. All the nine (9) projects were clustered together based on their characteristics and given in Table 4.

4.2.2 Study Findings

The thematic analysis approach paved the way to summarise and categorise data and present them in a comprehensive manner. The purpose of a thematic analysis is to find relevant or intriguing themes or patterns in data and utilize them to address the research or make a point about a problem. (Maguire and Delahunt, 2017). It is a standard method generally utilized to analyse qualitative data of an unknown phenomenon (Amoah, et al., 2021). Therefore, thematic analysis can be regarded as the most suitable method to

analyse qualitative data related to this study. The data collected from interviews were reviewed and divided into five themes. As the 3rd step of the analysis, five themes were defined and collected data were divided among these five themes. These categorised data is used to interpret the final outcome of the research.

Table 4: Details of case studies

Project	Type of project	Estimated duration before COVID-19 (months)	Total value (LKR)	Government /Private	No of days delayed	Delay as a Percentage of the total duration (approx.)
P1	Office building	12	192Mn	Government	40	11%
P2	Office building	22	1.7Bn	Private	100	15%
P3	Apartment	9	283Mn	Government	21	8%
P4	Housing	22	1.2Bn	Private	140	21%
P5	Housing	30	2Bn	Private	21	2%
P6	Apartment	36	6.35Bn	Private	200	19%
P7	Water resource development project	72	3.8Bn	Government	90	4%
P8	Mixed development	12	425Mn	Government	90	25%
P9	Mixed development	44	15Bn	Private	250	19%

Note: “Mn” refers to Millions and “Bn” refers to Billions

Theme 01 - Impact on the continuation of site works

All the projects are currently continuing their site works despite the pandemic situation. However, projects P4, P5 have reported that it took less than one month to fully restore operations after 1st and 2nd waves of COVID-19 in Sri Lanka. It has taken more than one month to completely restore operations in other projects. Conversely, respondents had no idea on the question on how long it would take their site to fully restore operations after the current wave. Every construction activity of projects P1, P3, P4 and P6 are delayed or disrupted as a result of the pandemic. However, in other projects, only specific activities were delayed. For example, structural works of P2 were affected due to the fact of having only one skilled carpenter at a particular time for the whole site. Furthermore, there were no skilled bar benders for certain periods of time. In P5, mobilization, foundation and excavation work has been delayed. The delay of the foundation and excavation stage which is in the critical path has made a major impact on the progress of the project. In addition, there were delays caused due to delays in client supply materials. Another concern for P5 was that the advance payment has also been delayed. The respondent from the P5 stated that if the advance payment was paid on time, they could have purchased materials before any price escalation. Similarly, mobilization of P7 is also affected by the pandemic. According to the case study of P8, all work activities are connected with each other. Therefore, even a slight delay in one activity has caused a

more or less of a delay in another activity. For instance, delivery of plywood was delayed in P8 and it has delayed the reinforcement process. In the same way, supply of imported glass façade materials was delayed in P9 which has affected the pace of the project.

Theme 02 - Impact on the workforce

At the time of this study, there are 50 or less workers in P1 and P2 projects, while P2 and P8 projects accommodate 51-100 workers. All the other projects have more than 100 workers currently working in the sites. According to the study, during the 3rd wave, projects P1, P4 and P2 have faced a reduction in workforce of 11-20, 21-50 and more than 50 respectively. Despite the travel restrictions and rising number of positive cases throughout the island, projects P3, P5, P6, P8 and P9 have managed to retain their existing workforce. A quite controversial data was collected from P5 and P7 where they explained a 20% increase in productivity during the 3rd wave. In P5, workers have done more overtime work during this period compared to the time period before the pandemic. Mainly financial difficulties and job insecurity have driven workers' mindset to work more during these trying times. P7, which is a public sector project, has also reported a 20% increase in productivity. As an example, previously it has taken at least a week to get approval for certain items whereas now it takes only a couple of days for approval. Therefore, this is a significant benefit in the planning stage for P7. In general, all other projects have reported a decrease in productivity levels. Inability for people to move freely, health restriction, higher distress on exposure to the virus and lack of motivation are some of the reasons for the lack of productivity. On the other hand, it is impractical to exhaust the available workers beyond their capacity. There were specific measures which also affected productivity such as, in P6, only 4 people were allowed to travel in the lift which has a capacity of 8. In overall following were the percentages of productivity decrease in each project.

30% - P3

40% - P4, P9

50% - P1, P6

60% - P2, P8

Theme 03 - Impact on suppliers and imported goods

All the projects have faced challenges in bringing materials to the site due to travel restrictions. For example, supply of lift has been delayed in P1 delaying the installation process. In P2 few of their materials are imported from India, where there are issues in the movement of goods from factories to ports, increase in transportation costs, closure of infrastructure to transport goods and lack of manpower. Furthermore, due to restrictions imposed on imported materials, there was an artificial scarcity created in the market and there were price increases of materials to cater to the increasing demand. Therefore, respondents stated that there was an immense loss to the contractor since there was a lower material price at the tender stage, but when they require to purchase those items, prices have increased drastically. Further, both clients and contractors were unable to open up Purchase Orders (POs) and Letter of Credits (LCs) due to the closure of relevant departments/banks. The main reason for the import restriction by the government is to preserve foreign reserves. Moreover, the government has been prescribed to take at least a 90-day credit period from the foreign suppliers, which enables US dollars to leave the country after 3 months. Even though some suppliers have agreed to this condition,

some of them have not. Therefore, in case of P9 they have acquired the service of an intermediary financial provider from Dubai. Using sales through their facility, P9 was able to open LCs to the suppliers where the credit is given to the Dubai based financial organisation. The financial company has charged a margin from them for providing the service. Although it was an extra cost, there had been no other option for P9 to get the imported goods.

Theme 04 - Health and safety measures

In general, all the projects have implemented various health and safety measures required by the government health guidelines. Body temperature checking at the gate, providing hand sanitization facilities, and making it compulsory to wear masks all the time were common safety measures applied in every project under study. At the initial phase of the pandemic, staff members were cooperative with respect to wearing the masks, but some workers did not adhere since they are uneducated and unaware about the severity of this situation. Most workers were reluctant to wear the mask, reasoning that it is difficult to wear it during construction activities since they have to breathe heavily. In some of the projects, to make people wear the mask, continuous supervision was done by a safety officer. As a controlling measure, project P9 has introduced a fine for the people who do not wear the mask. If they still found it difficult to make them wear the mask, they have released them from the site. In P1, P3, P5 and P6 to make people wear the masks, continuous supervision was done by a safety officer. However, in P7 and P8 supervisors were not in a position to implement strict health regulations since they are government-based institutes. In case of positive cases or if workers show symptoms, they were accommodated in separate labour billets and quarantine inside the site. Furthermore, some contractors have asked workers to get a Rapid Antigen Test (RAT) as it is cheaper than a PCR. In some projects they have done PCR testing within the site incurring an extra cost by the contractor. In terms of making awareness about the pandemic, projects P1, P3, P4, P5, P6, and P7 have displayed signs related to health measures and symptoms. In P2 and P3 training was conducted on special health regulations in a pandemic situation for workers. In projects P4, P5, P6 and P8, they conduct daily meetings to announce and remind about health measures whereas in P1 it is done in 3-4 days. In project P7, they have not been reminded about health measures on a daily basis, because they believe that all the people are now well aware about all safety measures and guidelines. Furthermore, many contractors mentioned that they have encouraged vaccination, but they were unable to make it compulsory as the government has not made it compulsory. Contractors have found that previously mentioned health and safety measures were not 100% effective hence, they have come up with more practical and effective methods, which are mentioned in theme 6 below.

Theme 05 - Delay and disruption mitigation techniques

After the pandemic started, many organisations from different industries focused on teleworking policies and developed the concept of work from home. Unfortunately, construction workers or professionals do not have that luxury of work from home since it is a site based physical delivery. However, in some projects Quantity Surveyors were allowed to work from home for a short period of time, but then again when it comes to activities such as taking measurements, they must be physically present in the site. Nevertheless, some portion of communication activities were shifted to online platforms. As an example, monthly progress meetings are held in virtual platforms such as Zoom

and increased the use of emails, WhatsApp etc. In terms of project management, professionals have regularly monitored the master programme of the project, pre plan activities and ask for Extension of Time (EOT) justifying the delays. The delay and disruption mitigation techniques followed by each project are summarised in Table 5.

Table 5: Delay and disruption mitigation techniques

Project	Delay and disruption mitigation techniques
P1	Increase the number of times that we communicate with clients and consultants. Discuss about the progress of the site regularly. Limit the travels of labourers. Facilities are provided for workers to cook their own meals inside the site
P2	Implemented a formwork system to minimize the use of skilled carpenters. Managed to train the workforce to be able to carry out multiple tasks therefore, if anyone of their team is down, they can handle other team’s work. Break workers into isolated gangs, therefore the exposure is minimized.
P3	Increase number of skilled labours. Limit the travels of labourers.
P4	Increase labour rates. Increase number of skilled labours. More Overtime work – provided workers with an additional meal.
P5	Provide transport facilities and issue curfew passes to workers and staff members. Special focus on reducing labour idling. - As an example, workers tend to take more time to get back to work after their lunch. Therefore, they tried to reduce that kind of idling time Rented out 2 houses outside the site in order to fulfil the additional space requirement. Encourage both labourers and staff to steam and use Ayurveda medicines, provide herbal drinks to staff members instead of tea.
P6	Increase the number of suppliers per material. Divided the work into mini contracts and increased the amount of work per gang. Procure material in advance.
P7	Limit the travels of labourers. Increased the use of emails to get approvals.
P8	Provide transport facilities and issue curfew passes to workers and staff members. Increase labour rates.
P9	Pre ordered meals and delivered to the site at their cost, canteen is also available in the site. Did not hold meetings to make sure that workers do not gather in one place. Set up speakers in their own accommodation and the canteen to share COVID-19 related guidelines and instructions.

In summary all projects reported that these techniques are 90% successful compared to earlier methods.

5. CONCLUSIONS

The COVID-19 pandemic has been the most serious economic catastrophe in the world recently. It has negatively impacted almost every industry pushing national economies to

deeper troubles. The construction industry is no exception, in fact it has been identified as one of the highly disrupted industries as it involves many physical activities. Therefore, the study was begun with the aim of exploring the consequences of the COVID-19 pandemic on the industry and to identify factors that cause delays and disruptions in the construction projects due to this. Accordingly, four main objectives were set up upfront to identify the impact on the construction industry, to investigate the impact in terms of delays and disruptions, identify and evaluate factors that have the most to least impact and finally identify existing methods to mitigate delays and disruptions due to these factors.

The scale of the impact was evaluated with respect to the local construction market. The adverse impact in terms of delay and disruptions of a construction project were also identified and analysed. There were several delay and disruption factors that emerged as a result of the pandemic such as travel restrictions, partial or complete closure of sites, stringent health regulations and spread of virus among construction workers. Finally existing methods which are implemented in construction projects at present, are ascertained through a thematic analysis of nine (9) case studies. The collected data from case studies were divided into five themes. They are the adverse impact from COVID-19, impact on the continuation of site works, impact on the workforce, impact on suppliers and imported goods, health and safety measures and delay and disruption mitigation techniques. Methods of controlling delay were common in most of the construction projects and only few of them have looked forward to implementing innovative and suitable techniques to mitigate delays.

Recommendations could be made on the need of a contingency plan in a pandemic situation can be very useful and beneficial to contractors. Moreover, steps such as creating a bio bubble inside the site, regular health and safety monitoring, providing sanitation facilities, division of work into small contracts and allocating separate labour gangs to them, limit movement of workers by providing all the basic amenities, procure material as early as possible and shifting into online platforms for meetings can be further recommended as effective delay and disruption mitigation techniques.

There were few limitations to the study despite making significant contributions for researchers, industry practitioners and decision makers. Although the study reveals important findings related to the impact of the pandemic on the construction industry, this might not be an exhaustive list of factors. There could be certain factors overlooked. On the other hand, there are frequent updates on the health and safety guidelines, which will have an impact on the performance of the industry. Further, the study was limited only for the large-scale construction projects where they were defined as projects which have a value of more than LKR 50 million. Also, the study was limited on projects in Sri Lanka and the impact on the construction phase of the project.

The results of the study could be very useful for industry practitioners. In addition, delay and disruption mitigation methods presented in the study could be directly implemented in construction projects since they were acquired from existing projects which have effectively managed the adverse impact. The study has assisted in filling the knowledge gap of discovering the impact of the pandemic in terms of delay and disruption in construction projects. In fact, the study has opened the door for researchers to explore innovative delay and disruption mitigation techniques, and to uplift the standards of the construction industry in the future.

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