Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

The Technology Adaptation Measures to Reduce Impacts of Covid-19 Pandemic on the Construction Industry

Iffah Sahira Bakeri[1], Siti Rashidah Hanum Abd Wahab[1,*], Adi Irfan Che Ani[2]

[1] College of Built Environment, Universiti Teknologi MARA, 40450 Shah Alam, Selangor,Malaysia
[2] Department of Architecture, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia 43600 UKM Bangi, Selangor, Malaysia

ARTICLE INFO

Article history:
Received 5 January 2023
Received in revised form 20 May 2023
Accepted 25 May 2023
Available online 13 June 2023

Keywords:
Construction industry; Covid-19; impacts; technology adaptation

ABSTRACT

The construction industry is one of the major growth engines of world economics. The recent occurrence of the Covid-19 pandemic has caused great threats to the construction industry. To prevent further damage occurring to the industry, identifying the consequences is necessary. This is to avert the worst level of economic deterioration in decades in the construction industry. However, the adverse effect of the Covid-19 pandemic on the construction industry is still unclear and defined. Hence, this study was conducted to evaluate the impacts of the Covid-19 pandemic on the construction industry with the main objectives of to analyze the current state of the construction industry, then to investigate the impacts of the Covid-19 pandemic on the construction industry and lastly to develop technology adaptation measures to reduce the negative impact towards the construction industry. The study was conducted through the method of quantitative study with the use of a closed-ended online questionnaire survey as the research instrument. The data of the survey was collected from 64 construction personnel all over Sarawak and was analyzed using the Statistical Package for the Social Science (SPSS) software which enables the data collected to be summarized in the nominal and interval scale. The findings of this study show that the outbreak of Covid-19 has caused drastic changes in the construction industry which has led to a few impacts such as delays in construction works, shortage of workers, financial problems, supply chain management issues as well as safety and health conditions. However, through the identification of appropriate technology adaptation measures such as technology development and application as well as e-monitoring site logistics and control, the impacts may be reduced and the adverse effect that is to suffer by the construction industry may be lessened.

1. Introduction

The construction industry is an essential tributary of the global economy that contributes to the overall productivity of the economy. According to Husien *et al.,* [1], the construction industry plays a prominent role in a country's economic growth and development as such an industry is said to have

* *Corresponding author.*
E-mail address: rashidahhanum@uitm.edu.my

https://doi.org/10.37934/araset.31.1.3452

a diverse and complex nature of work, as the construction industry has a lot of extensions and relationships with other industries.

However, recently the global construction industry was disrupted by a newly found disease known as the Coronavirus or Covid-19 disease causing difficulties and safety risks to the industry development [2]. Such disease was declared a global pandemic by the World Health Organizational (WHO) which has undoubtedly changed the construction industry's economy as it contributes to a wide-ranging effect on the industry [3]. Therefore, it is important to distinguish any adverse effects the pandemic could cause to reduce the further downturn of the industry's economic growth. As stated by Global Data in the year 2020, the global construction industry growth in the early phase of the pandemic has already fluctuated from 3.5% to 0.5% and will continue to lessen if the problem is left unidentified and unsolved. Additionally, a safety measure known as the Movement Control Order (MCO) was implemented by the government of every country to control the transmission of the disease and one of the MCO restrictions is Working-from-Home (WFH) [4, 5]. However, according to [6], the WFH concept of work pattern is unhelpful and less beneficial to the construction industry as most works and projects need physical involvement and to be conducted on-site. The reduction of mobility by the authorities has caused many businesses in the construction industry to be shut down, facing a crisis in the matter of the project's essential supplies, project delays, and even problems that lead to job loss [7, 8]. This happens as the transition of working methods had not been easy for the industry, forcing the industry to develop a new reality touch in almost every aspect of the construction process [9]. To add up, the labour-intensive and dynamic nature of the construction industry is also a down factor for the industry's economy as according to the Occupational Safety and Health Administration (OSHA), the industry is said to be one of the most hazardous industries in the World as it involves unsafe work practices and risky work condition of which are factors that can worsen the situation that is already faced by the construction industry due to the pandemic [10]. According to Adhikari and Lochana [11], the construction industry had suffered from great burden and disruption from the Covid-19 pandemic outbreak as most activities were stopped. To prevent further damage occurring to the industry, identifying the consequences is necessary. This is so to avert the worst level of economic deterioration in decades in the construction industry [1]. However, the adverse effect of the Covid-19 pandemic on the construction industry is still unclear and defined. Therefore, this research study is done to identify the various nature of the pandemic impact on the construction industry and to acquire measures that are needed to overcome the impact faced. The following objectives were pursued to achieve the aim of the study

i. To analyze the current state of the construction industry.
ii. To investigate the impacts of the Covid-19 pandemic on the construction industry.
iii. To develop technology adaptation measures to reduce the pandemic's negative impact.

2. Literature Review

2.1 The Covid-19 Outbreak

During the past years, a new high-risk disease was discovered among humankind that had caused great threats to the lives of people and its surrounding. According to [12], the spread of Covid-19 disease or which may also be known as coronavirus disease occurs due to the existence of a virus that is recognized as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Such a virus was formerly reported to be firstly found in Wuhan, China however, it then has subsequently spread to multiple regions around the world [13]. As reported by the World Health Organization 2020, the virus has spread to over 200 nations from the very first case that was identified on 31 December 2019

[12]. Consequently, the Covid-19 disease had contributed to a detrimental effect on global healthcare systems which is relatively conducive to the ripple effect it has on the aspect of human everyday life [14, 15]. This is because such viruses are easily transmitted from human to human [12]. As stated by [14], the coronavirus disease can easily be transmitted and infect people who are nearby based on the research done such viruses are known to be spread through droplets discharged from coughs and exhale of breath for example. Not only that but the virus may also be transmitted through direct physical contact with an infected individual with an incubation period of two (2) to fourteen (14) days along with the basic reproduction number of 2.24 to 3.58 [14].

As of November 2021, World Health Organization mentioned that there were over 260 million confirmed cases and over 5.1 million deaths reported globally, thus resulting in the disease being reported as the fifth documented pandemic since the 1918 flu pandemic [13]. Not only that, but the widespread health crisis had also resulted in a nationwide economic downturn [14, 12]. This is so as the disease outbreak had caused the entire world to a standstill which contributes to a great adverse impact on the operational state of businesses and organizations [16]. Significantly, such a halt occurs due to the implementation of the Movement Control Order (MCO) by the government as an approach to curbing ramifications towards a nation's health and development [5, 35].

However, such measures implemented by the responsible authorities regarding the transmission of the Covid-19 disease are still lacking certainty and have a great amount of underestimation [11]. It is so as the enforcement of the safety measures towards such transmission such as social distancing, quarantines as well as movement restrictions has led to various disruptions and variability to the situation of a nation [17,18]. According to [11], the pandemic outbreak consists of developing risks that are known to be inconsistent in the state hence of which contributing to various amounts of new unrecognized impact. Such unidentified and unknown impacts developed due to the outbreak give rise to greater and higher risk. This can be proved based on the findings obtained by [19] stating that the Covid-19 outbreak has contributed to major negative consequences worldwide as such study done shows a shrink of 4.4% of the global economy in the year 2020 of which happens to be one of the worst crises to happen in the worldwide economy since the event of Great Depression in the 1930s. Therefore, continuous development of an uncertain set of risks may contribute to further arise in negative impacts [20].

2.2 Current Scenario of the Construction Industry

The construction industry is known as the key to the nation's economic drive. However, the existence of the infectious covid-19 disease has caused many severe consequences to most industries thus of which including the construction industry [21]. According to [22], the construction industry was discovered as one of the most affected industries across all nations due to Covid-19 as such industry suffers and experienced the highest rate of infection during the early stage of the disease outbreak. This is due to the construction industry comprising of a wide range and equally diverse projects and products [23]. In addition, the Covid-19 disease pandemic has also significantly affected the operation and development of the construction industry due to the implementation of restrictions such as the Movement Control Order (MCO) and the measures of Working-From-Home (WFH) by the government that is to halt most physical activities [4,5]. Such measures established and imposed by the government were an act of safety upon humankind which is to prevent one from being exposed to such high-risk danger or even having the slightest chance of being infected by the Covid-19 disease [3].

Moreover, it is also due to such industry of construction being characterized as non-essential businesses of which it does not involves matters relevant to medical sectors and supplying necessary living and health supplies [20]. Instead, such industry is known to be operative in an affair that is related to the nation's development and growth such as through the manufacturing and trading of any construction event [21]. Therefore, the reason for the recognition of the construction industry as risky and hazardous as such environment of the industry involves numerous threats and uncertainty [11]. Furthermore, according to [11], the dramatic spread of Covid-19 disease had also caused most construction industry response plan to fail as the established plan lacked consequential measures and the risk predicted was quite underestimated by most professional authorities such as the government and project manager of a project for example. Such inadequacy leads to a far-reaching extent of ramifications for the underlying projects in the construction industry as well as the industry nature of business [9].

This of which causes conflicts and disputes to occur between any relevant parties in the construction industry [11]. Such conflict develops a few concerns which include the uncertain state of safety and health in such industry, decreased amount of workers availability, disrupted supply chain of material and equipment, worsened work practices and conditions, and many more [10]. For instance, it was discovered that about 17,000 firms in the construction industry have suffered adverse effects despite their role and primary drivers in such industry [3].

2.3 Impacts of Covid-19 on the Construction Industry

The construction industry is known to have been reeling to survive and sustain in the event of the Covid-19 pandemic outbreak. It is so as the construction industry is known to be exceptional from any other industry to exist as it requires fully physical involvement to ensure the entire operation of a task is functioning completely and optimally [6]. Additionally, it is also due to most work or tasks that are relevant to the industry need to be done on-site for it to be fitting and precise according to the standards and requirements that are desired. Therefore, the restriction imposed by the responsible authorities as a measure to curb the spread of the Covid-19 disease had contributed to inadequate and decline of the whole operation in the construction industry [2] as well as contributing to extreme disorientation of the situation of the industry, may it be in the category of operational, management as well as financial [23].

According to [15], the action of restriction and suspension executed by the government is the reason for the obstruction and reduction of mobility to the industry's activities operation and development to significantly minimal that which led to various complications. Not only that but the absence and lacked effective risk management on the subject regarding the capability and measure of a party to handle a crisis that may jeopardize the situation of an industry like the Covid-19 pandemic outbreak in the construction industry is also found to be the reason of adverse effect to take place [11]. Such implications that occurred in the construction industry prompt issues and impacts related to operational, financial as well as institutional to arise [11]. Therefore, pinpointing concerns that are done in past studies by multiple researchers is said to be an aid in identifying the impacts the industry is experiencing [10].

Table 1
Past studies of construction industry issues

Country	Insights and concerns of the construction industry
Kuwait	The delays in construction project are considered as critical problems amongst construction players. During pandemic, the government enforce the construction site closed and cannot be operated lead to construction delays [13].
India	Pandemic has caused many negative impacts towards construction industry such as project delivery, supply of equipment and material, changes in price of commodity, disruptions of cash flow etc [16] Lockdown of movement and enforcement of social distancing led to the construction delay's activities [16]
Nigeria	Lockdown led to cause transportation problem for delivering materials and labour to site. The working hours need to be reduced. Therefore, more projects were abandoned [24] The impact of construction industry during pandemic are cost overruns, lack of funding, shortage of labour, fluctuation of price and client late to release payment for work done [24]
Malaysia	Government enforces standard of procedure at construction site to prevent the spread of covid-19 such as social distancing, reduce working hours, reduce numbers of workers at certain time and limit the resources available led to the project's delay [25] The effect from pandemic, the mega projects face with lack of overhead costs due to the shortage of material and labour, delayed payments, etc. [3] The other effect from pandemic are the foreign workers are not allowed to enter Malaysian country which led to the shortage of labour at construction project, material was delayed because of permit to enter cross-country and the suppliers running of short supplies [5]

According to the findings of the study done by [16], it stated that the Covid-19 pandemic outbreak has rendered most construction projects worldwide slowing their process and development which has led to events of disruptions and delays. This is because such occurrence of a pandemic has obstructed workers to do their responsibilities which is to be on-site performing their respective task of general construction works, the work of inspections as well as work monitoring by urging such workers to work remotely at home [6]. Such action of working remotely in a sudden situation has led to a poor transfer of design information among [26] as well as enabling information to be obtained and understood precisely [13] causing the productivity in the construction industry to decrease by 50% on an average basis and causes such industry projects and work to sustain delays [2, 27]. In addition, the effectuation of the Movement Control Order (MCO) and the need of compliance to the Standard Operating Procedure (SOP) imposed by the government were also found to one of the consequences that led to delays in work as it causes such work of construction projects to suffer the change of project timeline [5, 17, 18].

Meanwhile, based on the findings of research by the [28], it was reported that about 81% of workers around the world have been affected by the event of Covid-19 outbreak and such numbers obtained include the workers in the construction industry. Construction workers are found to be the most impacted in the crisis of Covid-19 as it was accounted that such workers have recorded the highest number of positive as well as hospitalized cases throughout the early phase of the outbreak due to the condition and nature of work in such industry [12]. Such circumstances have led to an insufficient and shortage number of workers in the industry [11]. According to [5], the issue also takes place due to the factor that most foreign individual involved in such relevant industry was layoff and deported back to their respective countries as it was one of the measures imposed by the government in curbing the spread of the infectious virus. This contributed to the scarcity of workers that are experienced and skillful as most construction professionals believe that such migrant workers are more proficient and competent in the work of construction [21]. It was also discovered that the issue also occurs due to the local worker's action of refusing to attend or be involved in any work activities may it be physically or virtually as such workers suffer depletion of mental health such

as anxiety, depression as well as difficulty in concentrating that of which was prompt by the pressure imposed by the sudden occurrence Covid-19 outbreak [14, 2].

Furthermore, according to the study conducted by [12], it is discovered that the restrictive measures imposed by the authorities have resulted in a few unexpected consequences for the financial state of the construction industry as such industry was required to bear the extra expenses of managing safety on pandemic related as well as additional expenditure on handling matters regarding contractual implications involving liquidated damages and any relevant liabilities. Not only that, but the increase of outlay on labour and materials during the period of the Covid-19 pandemic outbreak also contributed to the intensifying of the budgeted project cost in the construction industry [5]. Hence, it is found that about 60% of companies and relevant parties in the construction industry decided to defer and cancel investments and projects as a measure of overcoming such issues [2]. Not only that, based on the findings of [16], the industry also suffered several serious financial burdens due to over 70% of the companies, projects, and personnel of the construction industry was discovered to be unbenefited from the government initiatives of such as waivers and subsidies, leading to problems of having to endure most of the construction cost emerge due to the pandemic on its own without the support of any relief packages. In addition, the inability to collect payments such as tax during the restriction period had also led the construction industry to incur huge profit losses and affected a nation's GDP condition [29, 36].

Moreover, the event of Covid-19 pandemic outbreak has also led to great disruption in the supply chain management of the construction industry as most commercial activities around the world were halted and reduced during the period of such events [1]. This is so as according to the study conducted by [12], the disruption of the supply chain occurs due to most raw materials involved in the construction industry are difficult to be obtained as such materials are mainly imported from other countries such as China, Europe, Indonesia and that such supplier and manufacturer of the raw materials are non-operative during the period of lockdown as a consequence of the parties deemed as non-essential. Meanwhile, according to [2], the undermining of supply chain management also takes place due to the issue of delivery delay in the industry that is caused by the hesitation of delivery drivers in traveling or moving around during the term of lockdown as such action may lead to intensifying chances of contracting the covid-19 virus, need of enduring quarantines order as well as the possibility of getting fined on regards to violation of authorities' regulations. In addition, the issue also occurs due to the complications on the matter of fluctuation in the price of supplies and equipment in the construction industry during the period of a pandemic [5, 27].

The construction industry is known for its significant risky nature of work as most facilities and space in such industry is utilized and shared by a lot of individuals and having incompetent and ineffective safety measure that was peremptory implemented by construction players throughout the early period of the outbreak has significantly impacted the safety and health conditions of the industry [12]. According to [22], it is because the coordination in the construction industry is still in need of constant instructions and control upon its workers regarding matters such as hygiene and social distancing as there is still a lack of substantial orders and regulation imposed by the responsible authorities of the industry. It is also caused by the poor and insufficient amount of training as well as education on regard to safety and health standards on workers and space of work by the safety officer or even the OSHA authorities [10]. Additionally, improper sanitization of the workplace, material, equipment, and every other thing that is available on the site of the construction industry [11], as well as the lack of safety essentials such as Personal Protective Equipment (PPE) suits and the accessibility upon free covid test center too, influenced the safety and health conditions [5].

2.4 Technology Adaptation Measures and Development

Construction industries are notably involved with multiple hazards and risks and maintaining the safety of the conventional aspects of the industry is crucial hence of which is then found the need of instituting proper measures and development towards such matters [22]. However, the technology adaptation measures that are to develop are required to be far-sighted with the ability to cover every eventuality that occurs in the key areas of the construction industry such as the occasion of a pandemic outbreak [11]. It is so as the measure functions are to include the coping of high risk and hazardous situations such as the Covid-19 outbreak on multiple scales, frequency, and intensity as well as to obtain the necessary and sufficient information on regards to the event involved during such period [5]. Hence, According to [16], a distinctive change of management is required to be done by every responsible authority such as the government as well as professional construction players to foster an effective action precisely as well as to implement a suitable course of preparing and securing the challenges to exist by evaluating through the specific approach of constructing and recovery plan [30].

In addition, such a response strategy also acts to provide a better response mechanism to any fitting individual or association on the matter of monitoring and acknowledging the imperative situations faced during such a period of crisis [13]. This is so as the incident of Covid-19 outbreak has contributed to constantly changing and inconsistent orders and regulations [11] and there were multiple complaints and circumstances received and documented by the OSHA authorities during the pandemic [10]. Thus, as stated by [22], the plan and measures on the matter of safety donate in providing a flexible technique that would endure the subsequent affairs prompted by the event of the pandemic as well as overcoming the complication of administering the effectiveness of the available vaccines [2]. Therefore, to ensure that every construction activity can be carried out a mitigation plan and measure regarding the guidelines and regulation of the respective industry needed to be addressed and constructed precisely, especially on the matter of the unknown such as the Covid-19 pandemic incident [30]. According to [5], every industry or business is required to construct a Standard Operating Procedure (SOP) consecutively for running any physical activities on-site to reduce close contact as it functions as a standard of prevention against the spread of the virus as well as a guideline for a successful operation. Thus, to achieve such a course of action, there are a few factors to be considered strictly which are the operation procedure of an industry, protective action to be provided as well as the condition of the workspace involved [1]. Not only that but the factors mentioned are also obliged to conform with the government and medical authorities' orders [17] as to ensure the operation involved are in smooth movement and that the welfare of any relevant parties is well taken care of [13]. Based upon the findings of [3], the SOP imposed are to constitute the industry operation or activities to be divided into a category depending on the elements such as nature of work and the professionality of workers as well as necessitating regular disinfection of working areas and any nearby public spaces. Additionally, individuals are also obliged to wear protective gear such as gloves, face shields, and non-medical facial masks for example upon exposing themselves to a shared environment as a measure of minimizing the contraction of such Covid-19 virus through airborne [2].

The occurrence of an outbreak pandemic has led to the need for the construction industry and its relevant parties to implement advanced measures and development towards the technique of overcoming the necessary issue, analyzing performance as well as maintaining the welfare of each element involved in such industry [31]. There were few Information and Communication (ICT) technologies related to safety and health were found to be developed and utilized by developing countries during the period of the pandemic outbreak in the view of that such innovation is said to

be vital and urgently essential in handling the indefinite issue of Covid-19 as well as allowing the operations of safety measures to be set off flawlessly and effectively as such enhancement acts in resilient with the sudden impact of an incident [32]. According to a study conducted by [3], there was three ingenious tracing application technology invented and launched in the time of such Covid-19 crisis namely MySejahtera, MyTrace, and GerakMalaysia that of which operates to track the transmission of the Covid-19 virus through self-physical evaluation. Not only that, but advanced technology such as drones, robotics, and remote sensing devices was also used as such automation helps in overseeing the possible risk and issues to develop in the event of a crisis [33].

In addition, a stern control of physical activity in the construction industry throughout a pandemic outbreak is also crucial as it aids in maintaining a sustainable environment for the industry as well as preventing the transmission of the Covid-19 virus [1]. According to [2], an extreme action of supervising and cleaning the welfare facilities such as the toilets and cafeteria that are available on-site is a part of elements to be well-controlled during such event of a pandemic as such facilities are known to be the secondary center of virus channeling due to its easy access by other individuals or public users. Meanwhile, according to [10], administering a rigid limitation towards the access points of a workplace such as regulating of site register and temperature checks upon entrance as well as imposing poster and infographics signage display on regards to the matter of safety and health information and guidance acts in educating an individual to be vigilant and cautious in the event of a crisis. This is so as such measure aid to reduce the likelihood of congested escapades and unnecessary socialization among individuals at the such worksite of the. Furthermore, the enhancement of engineering control such as the ventilation and air purification of every setting in the construction industry [12] and the development of a distinctive system regarding handling and delivery of materials and equipment acts to avoid greater complications that are subsided by the event of Covid-19 outbreak [29] and complement the current state of a pandemic crisis [31].

3. Research Methodology

An Explanatory Research method was selected in this study as such method acts in connecting various ideas and developing cause-and-effect relationships that highlight the factors of the certain newly developed event as well as pinpointing the action of solving such issues enabling the discovery of information and deeper understanding on the matters that are yet to be studied or attentively explained in a proper manner in the past or even at the current period. Meanwhile, regarding the approach method, the Deductive Approach was adopted as such approach method enables the information to be collected through the means of quantitative. Thus, it acts in promoting a greater understanding of the relevant topic involved through numerical data.

Furthermore, the data collection methods that were imparted in this study were questionnaires and literature review which act as the primary data and secondary data respectively. The literature review is a comprehensive and formal method of data collection process that consists of notably systematic measures of gathering and synthesizing information on previously existing research. This method is exerted as the secondary data of the apropos research as it acts in providing better insight and creating a firm foundation for the subject studied through the survey of journals, books, and articles. Meanwhile, a questionnaire survey, a statistical technique, is prompt as the primary data of the research conducted due to such data transpired as a piece of first-hand information that exemplifies a direct source of knowledge upon research context studied. Thus, a four-section close-ended questionnaire survey with different choices of answers selection as such of Dichotomous and Likert-type scale is implied and distributed to a few selected construction projects around the state of Sarawak and is to be filled by the personnel of project teams involved.

As stated by Deputy Works Minister Datuk Eddin Syazlee Shith in [33], only 5 out of 19 projects implemented by the Works Ministry in Sarawak are still active due to the Covid-19 outbreak. This shows how severely the construction industry in the state of Sarawak is affected by the pandemic. Therefore, the state of Sarawak was chosen as the target audience for the research, and meanwhile, the number of personnel of project team respondents involved was determined using the method of stratified sampling. 15 construction projects all over Sarawak were selected to participate in the study conducted with each of the selected projects having 5 personnel acts as the respondent, which led to a total of 75 respondents implied as the population. Meanwhile, by referring to Krejcie and Morgan's sample size table, the population of 75 respondents contributes to the means of 63 respondents as the acceptable sample size for the research conducted.

The means of data analysis through evaluating and converting the data findings from the questionnaire into favorable and useful information were then carried out using the Statistical Package for the Social Science (SPSS) software which operates through the transfer of data from Microsoft Excel as data obtained from such Microsoft Excel are collected from the questionnaire done. Such a method of data analysis enables the data to be summarized in the nominal and interval scale such as frequency, percentage, mean and standard deviation.

4. Data Analysis and Discussion

4.1 Respondents Demographic

The data for this study was collected using an online questionnaire survey which was administered to 75 respondents of construction personnel. However, out of the 75 distributed, there were only 64 complete responses that were received and were used for the data analysis of the study being conducted. This exemplifies the response rate of 85% from the targeted populations. Thus, this section presents the demographic information of respondents that were involved in the study.

The table below shows the statistical data collected on the respondent's role in the construction industry. It is shown that the Site Supervisor has significantly stated the highest number of responses amongst the role that exists in the construction industry with a frequency of 19 out of 64 and a percentage of 29.7%. The contractors are 17 in number, making up 26.6% of the respondent’s total. The project Manager then recorded the third highest with a frequency of 12 and a percentage of 18.8%. It is then followed by the roles of Developer, Engineer, Architect, and Quantity Surveyor with the frequency of 1, 3, 4, and 8 respectively and the percentage of 1.6%, 4.7%, 6.3%, and 12.5% respectively. Table 2 also shows the grade of respondents involved. grade G7 has indicated the highest number of responses with a frequency of 21 out of 64 and a percentage of 32.8%. G5 and G4 then fall on the second and third highest with the number of respondents 13 and 17 and the percentage of 20.3 and 26.6 respectively. It is then followed by the ones that recorded with less than 10 of which are G2, G3, and G6 with each having a response of 1, 7, and 5, making up 1.6%, 10.9%, and 7.8% respectively. Regarding years of experience, 17.2% of the respondents (11 in number) possess 1 to 3 years of experience. Meanwhile, 16 out of 64 (25%) of the respondents had 4 to 6 years of experience. As for 7 to 9 years of experience, there were 28 in number making up 43.8% of respondents involved. Followed by 14.1% (9 in number) of respondents who recorded 10 and more years of experience. Table 2 also included the data on respondents’ type of project involvement. Infrastructure projects were founded to record the highest with a frequency of 25 and a percentage of 39.1%. Meanwhile, Residential and Commercial projects recorded 21 and 17 in number, making up 32.8% and 26.6% of the total respondents respectively. The least was Industrial with only 1.6% (1 in number) of respondents. Lastly, that is included in the table above is the company's operation duration in Sarawak. 16 to 20 years as well as more than 20 years has significantly stated the highest

number of responses amongst the respondents with the frequency of 116 and 17 and the percentage of 25% and 26.6% respectively. This is then followed by 11 to 15 years of operation duration with 14 in number making up 21.9% of the respondent's total. Finally, the duration operation of is 0 to 5 years and 6 to 10 years with the frequency 9 and 8 and the percentage of 14.1% and 12.5% respectively.

Table 2
Respondent's demographic results

Role	Frequency	Percentage (%)
Architect	4	6.3
Contractor	17	26.6
Developer	1	1.6
Engineer	3	4.7
Project manager	12	18.8
Quantity Surveyor	8	12.5
Site Supervisor	19	29.7
Grade	Frequency	Percentage (%)
G2	1	1.6
G3	7	10.9
G4	17	26.6
G5	13	20.3
G6	5	7.8
G7	21	32.8
Years of Experience	Frequency	Percentage (%)
1-3 years	11	17.2
4-6 years	16	25
7-9 years	28	43.8
More than 10 years	9	14.1
Type of Project involvement	Frequency	Percentage (%)
Commercial	17	26.6
Industrial	1	1.6
Infrastructure	25	39.1
Residential	21	32.8
Company’s duration operation	Frequency	Percentage (%)
0-5 years	9	14.1
6-10 years	8	12.5
11-15 years	14	21.9
16-20 years	16	25
More than 20 years	17	26.6

4.2 Analysis of the Respondent's Perceptions of the Current State of the Construction Industry

The adoption of descriptive analysis using Statistical Package Social Science (SPSS) software was employed in this part of the study as it acts in enabling the data of the respondents' perceptions on the current state of the construction industry to be identified. The perceptions of respondents towards the industry are relevant to the subject being studied, which is the occurrence of the Covid-19 pandemic outbreak.

Table 3 shows the result of the respondent's perceptions of the current state of the construction industry in the state of Sarawak. Four main perceptions were concluded in the table above based on the respondents' feedback from the questionnaire. The first perception that imparted the Likert-type answer scale was found to record a mean result of 4.77 with most respondents setting their agreeability towards the perception of Covid-19 pandemic has negatively impacted the construction industry. This was supported by the findings [22], whereby stated that the construction industry was

voted to be one of the most affected industries due to Covid-19. Meanwhile, the remaining 3 perceptions that were included in the questionnaire adopted the dichotomous scale of yes and no, hence, the results were slightly different. The second perception has resulted in the mean value of 1.02 with about 99% of the respondents responding to agreeing that the current changes in the construction industry occurred due to the implementation of restrictions such as MCO and WFH by the government. This is so as according to [5], the Covid-19 pandemic has significantly affected the operation and development of the construction industry due to the implementation of restrictions such as the Movement Control Order (MCO) and the measures of Working-From-Home (WFH) due to the government measures in curbing the spread of the virus. As for the perceptions of the respondents towards the construction industry imposing a high risk of Covid-19, a mean value of 1.03 making up to 96% of respondents have undertaken that the industry does impose such risk. This can be supported based on the findings of [11], stating that the construction industry is known to be exposed to numerous threats and uncertainty which contributes to one being exposed to risky and dangerous situations. Lastly, the fourth perception with a mean value of 1.84 and 84% of respondents rated upon scale no is the perception of the construction industry's preparedness in facing unexpected events such as the Covid-19 pandemic. According to [11], the dramatic spread of Covid-19 disease had caused most construction industry response plans to fail as the established plan lacked consequential measures and the risk predicted was quite underestimated.

Table 3
Results of respondents' perceptions on the current state of the construction industry

Perceptions of the Current State of Construction Industry	Mean	Standard Deviation	Ranking
The covid-19 pandemic has negatively impacted the state of the construction industry	4.77	0.427	1
Current changes in the construction industry occurred due to the implementation of restrictions such as MCO & WFH by the government	1.02	0.125	4
The construction industry imposes a high risk of Covid-19 infection	1.03	0.175	3
The construction industry is well prepared in facing unexpected events such as the Covid-19 pandemic	1.84	0.366	2

4.3 Analysis of the Impacts of Covid-19 Pandemic on the Construction Industry

The adoption of descriptive analysis was also employed in this part of the study. It acts in enabling the data on the impacts of the Covid-19 pandemic on the construction industry to be recognized. The impacts obtained are grouped into 5 main categories of such stated in the table below. Table 4 shown below exhibits the overall value of the mean as well as the ranking of the few impacts of the Covid-19 pandemic on the construction industry as perceived by the respondents of the questionnaire. In addition, the ranking is based upon the value of the mean, listing from the highest to the lowest. Shortage of workers is ranked as the element that was impacted the most with an overall mean value of 4.60. Meanwhile, the delay of construction works is ranked as number 2 with a mean value of 4.54. It is then followed by supply chain management in ranking 3 and financial problem in ranking 4 with the value mean of 4.40 and 4.38 respectively. Lastly, ranking number 5 of which involves the safety and health condition with a mean value of 4.05.

Table 4
Overall mean, standard deviation, and ranking of impacts of Covid-19 pandemic on construction

Impacts of Covid-19 on Construction Industry	Overall Mean	Standard Deviation	Ranking
Delay of Construction Works	4.54	0.522	2
Shortage of Workers	4.60	0.444	1
Financial Problems	4.38	0.514	4
Supply Chain Management	4.40	0.437	3
Safety & Health Conditions	4.05	0.491	5

Each impact that was discovered consists of a few relevant sub-items and each of the sub-items are the variables of the study that has been coded with different numbers as shown in Table 5 below.

Table 5
Results of the impacts of Covid-19 pandemic on the construction industry

Code	Delay of Construction Works	Mean	Standard Deviation
C1.1	The transition of the working method due to the requirements of SOP and MCO has obstructed workers from successfully conducting their tasks and responsibilities in a proper manner	4.56	0.687
C1.2	Lack of knowledge and technology-related support regarding the handling of unexpected virus outbreaks led to the disruption of construction industry operation	4.52	0.591
Code	Shortage of Workers	Mean	Standard Deviation
C2.1	The nature and working conditions of the construction industry increase the risk of Covid-19 transmission	4.56	0.560
C2.2	The pandemic outbreak has led to financial and health complications among construction players	4.64	0.515
C2.3	Deportation of foreign workers has contributed to the limited availability of competent workers	4.61	0.726
Code	Financial Problems	Mean	Standard Deviation
C3.1	The construction industry suffers financial burdens and profit loss due to the restriction imposed during the period of the Covid-19 outbreak	4.69	0.588
C3.2	Lack of government initiatives and support in aiding costs emerge due to pandemic outbreak	4.05	0.744
Code	Supply Chain Management	Mean	Standard Deviation
C4.1	Limited availability of construction materials supplier due to restrictions imposed by the government	4.19	0.664
C4.2	Difficulty in arranging and receiving material deliveries due to concern on risk of Covid-19 virus transmission and quarantine orders	4.81	0.432
C4.3	Lack of prospective measures regards to material and equipment supplies in the case of an unexpected event	4.20	0.596
Code	Safety & Health Condition	Mean	Standard Deviation
C5.1	Lack of effective safety and health measure implemented by construction industry regulators in the workplace	4.32	0.714
C5.2	Lack of accessibility to safety essentials and free Covid test center	3.61	0.681
C5.3	A precise study on risk exposure analysis affects the condition of safety and health in the construction industry	4.25	0.535

It is shown that the impacts of the Covid-19 pandemic on the construction industry are identified into 5 main categories which are the delay of construction works, shortage of workers, financial problems, supply chain management, and safety and health conditions. Under the impact of delay of construction works, it is discovered that such impact was donated by the transition of the working method due to the requirements of SOP and the lack of knowledge and technology-related support regarding the handling of unexpected virus outbreaks with each obtaining a mean value of 4.56 and 4.52 respectively. This is supported by the study of [6], which states the occurrence of a pandemic has obstructed workers to do their responsibilities which is to be on-site performing their respective task of general construction works, work inspections as well as work of monitoring by urging such workers to work remotely at home and are in line with the findings of [12], that stated the incident of work delays in construction projects was contributed by the unprecise and inefficient system imposed by the government in the event of transiting working method as well as due to the inadequate technology-related support established by the responsible authorities. Meanwhile, under the shortage of workers impact, it is discovered that it was caused by the nature and working conditions of the construction industry (mean = 4.56), the complications among construction players caused by complications that exist due to pandemic outbreak (mean = 4.64), and the deportation of foreign workers (mean = 4.61). Each of the matters is substantiated by findings of a study by [12] that implied construction workers are the most impacted by Covid-19 as it was accounted that they had recorded the highest number of positive and hospitalized due to the condition and nature of work in such industry, findings of [2] that states construction industry suffered about 40% of shortage of skilled workers due to issue of financial complications and research of [21] that states most construction professional members believe that such migrant workers are more proficient and competent in the work of construction thus deportation of foreign workers has led to the scarcity of experience and skillful workers.

Regarding the impact of financial problems, the identified cause was due to the construction industry suffering financial burdens and profit loss with a mean of 4.69 and the lack of government initiatives and supports with a mean of 4.05. Each of the causes was in line with findings of past researchers of such as [12], that state the restriction measures imposed by the authorities has resulted in few unexpected consequences for the financial state of the construction industry as such industry was required to bear the extra expenses of managing safety on pandemic related as well as additional expenditure on handling matters regarding contractual implications and findings of [16], stating that construction industry had suffered several serious financial burdens as it was discovered that over 70% of the companies, projects and personnel of the industry was unbenefited from the government initiatives of such as waivers and subsidies leading to problems of such parties having to endure most of the cost emerge due to the pandemic on its own without the support of any relief packages. As for the impact of supply chain management, it was due to occurrence of the limited availability of construction materials suppliers (mean = 4.19), the difficulty in arranging and receiving materials for deliveries (mean = 4.81), and the lack of prospective measures regards to material and equipment supplies (4.20). Each of the matters is substantiated by the findings of a study by [12] that implied the disruption of the supply chain occurs due to most raw materials of the construction industry are obtained and imported from other countries and that such suppliers and manufacturers of the raw materials are non-operative during the period of lockdown as a consequence of the parties deemed as non-essential, findings of [2] that states the undermining of supply chain management take place due to the hesitation of delivery in traveling or moving around during the term of lockdown and research of [11], that states the industry supply chain management suffers great complexity due to the lack of a prospective measure of an alternate plan of materials and equipment supplies been established and applied by the authoritative parties during the event of a pandemic crisis.

Lastly, the impact of safety and health conditions, which are donated by incidents such as the lack of effective safety and health measure implemented (mean = 4.32), the lack of accessibility to safety essentials, and the free Covid test center (mean = 3.65), and the preciseness of study on risk exposure analysis (mean = 4.25). This is supported by the study of [12], which states the safety measures that were peremptory implemented by construction players throughout the early period of the outbreak are incompetent and ineffective, the findings of [5], stating that the safety and health conditions of the industry are affected due to the lack of safety essentials such as the Personal Protective Equipment (PPE) suits and the accessibility upon free Covid test center and as well as in line with the study of [9], that states the disruption of safety and health conditions occur due to the unprecise study conducted on the matter of risk exposure analysis that of which are responsible in guiding upon issues related to workspace logistic.

4.4 Analysis of Technology Adaptation Measures that Aids in Overcoming the Impacts of Covid-19 Pandemic

The use of descriptive analysis was used in this part of the study as it acts to determine the data on the technology adaptation measures that aid in overcoming the impacts of the Covid-19 pandemic. Table 6 shown below exhibits the overall value of the mean as well as the ranking of the few technology adaptation measures that act in overcoming the impacts of the Covid-19 pandemic on the construction industry as perceived by the respondents of the questionnaire. In addition, the ranking is based upon the value of the mean, listing from the highest to the lowest. Implementation of Standard Operation Procedure (SOP) is ranked as the element that aids in mitigating the most with the overall mean value of 4.63. Meanwhile, site logistics and control are ranked number 2 with a mean value of 4.40. Lastly, ranking number 3 of which is the item of technology development and application with a mean value of 4.31. Table 6 below shows the summarized data obtained.

Table 6
Overall mean, standard deviation, and ranking of technology adaptation measures of Covid-19 pandemic in the construction industry

Technology Adaptation Measures that Overcome the Impacts of Covid-19 Pandemic	Overall Mean	Standard Deviation	Ranking
Implementation of SOP	4.63	0.439	1
Technology Development & Application	4.31	0.529	3
e-Monitoring for Site Logistic & Control	4.40	0.518	2

Each mitigating measure that was discovered consists of a few relevant sub-items and each of the sub-items are the variables of the study that has been coded with different numbers as shown in Table 7 below.

Table 7
Results of technology adaptation measure

Code	Implementation of SOP	Mean	Standard Deviation
D1.1	SOP in the construction industry is crucial to be implemented as it aids in preventing the spread of the Covid-19 virus	4.55	0.502
D1.2	SOP assists in ensuring a proper construction industry operation procedure and preserving the welfare of construction industry players	4.72	0.487
Code	Technology Development & Application	Mean	Standard Deviation
D2.1	Improve construction industry safety practices by e-monitoring to reduce close contact in the event of an unexpected crisis	4.36	0.545
D2.2	Advanced technology aids better in overseeing possible risks and issues to occur in an unexpected crisis	4.44	0.664
D2.3	An effective alternative instrument that sustains the structure of the construction industry	4.12	0.678
Code	e-Monitoring Site Logistic & Control	Mean	Standard Deviation
D3.1	An important measure in preventing the transmission of the Covid-19 virus	4.39	0.553
D3.2	Rigid limitation and procedure in the construction industry workplace aids by e-monitoring in reducing the likelihood of contracting the Covid-19 virus	4.50	0.563
D3.3	Enhancement of engineering control and site logistic system subsides the risk of Covid-19 virus transmission	4.22	0.745

The results of the technology adaptation measure are identified, and of which are categorized into 3 main categories which are implementation of SOP, technology development and application as well as site logistics and control. Under the measure of SOP implementation, it is identified that such implementation is donated by a factor such as that SOP is crucial to be implemented and that such measure act in assisting a proper construction industry operation with each obtaining a mean value of 4.55 and 4.72 respectively. This is supported by the study of [5] that states every construction industry is required to construct a Standard Operating Procedure (SOP) consecutively for running any physical activities on-site as it functions as a standard of prevention against the spread of the virus as well as a guideline for a successful operation and are in line with the findings of [12], that stated implementation of SOP in construction industry aids ensuring the operation of the industry involved are in smooth movement and that the welfare of any relevant parties involved is well taken care of.

Meanwhile, under the technology development and application measure, it is discovered to be included as one of the measures that aid in overcoming the impacts due to its ability in improving the industry safety practices in the event of an unexpected crisis (mean = 4.36), aids better in overseeing possible risk and issue to occur in an unexpected crisis (mean = 4.44) and acts as an effective alternative instrument that sustains the structure of construction industry (mean = 4.12). Each of the matters is substantiated by the findings of such a study by [34] that implied the implementation of advanced measures and developments aids in adopting long-term goals and aid in developing the best safety practices relevant to the current situation of a crisis based upon innovative technologies, findings of [31], modernization of technology allows the operations of safety measures to be set off flawlessly and effectively to of which acts better in overseeing possible risk and issue to occur in an unexpected crisis and research by [1], that states the existence of modernized technology has able to provide a reliable and effective alternative for the industry in the event of a crisis.

Regarding the measure of e-monitoring for site logistics and control, the measures were included because it was discovered how important it was for such measures to be implemented to prevent the transmission of Covid-19 (mean = 4.39), the indication of it as a rigid limitation and procedure

(mean = 4.50), and the act of measure in enhancing system of engineering control and site logistic (mean = 4.22). This is supported by the study of [1] that states a stern control on the issue of physical activity in the industry throughout a pandemic outbreak is crucial as it aids in maintaining a sustainable environment as well as preventing the transmission of Covid-19 virus by ensuring the safety and health, findings of [10], stating that administering a rigid limitation towards the access points of a workplace in the industry aids in curbing the transmission of Covid-19 and as well as in line with the study of [12], that states the enhancement of engineering control such as the ventilation and air purification of every setting in the construction industry is essential as it acts to avoid greater complications and suit the condition that subsists due to the event of Covid-19 crisis.

5. Conclusion

The construction industry is known as the key to the nation's economic drive as it plays a significant role in developing the nation's economic, societal, and political development. However, due to the outbreak of the Covid-19 pandemic, the industry has been known to suffer and be reeling to survive. Thus, recognizing any significant impacts and complications that arise in the industry is necessary as well as distinguishing all possible technology adaptation measures regarding overcoming the relevant issues. This is so as both factors mentioned are beneficial in rectifying the current state of the construction industry and are to be used as a reference in the future. Therefore, a conclusion was made based upon the objectives of this study which was also to answer the research questions that were constructed at the early stage of this study. Based upon objective 1 of this study, it is concluded that a significant amount of respondents are aware of the current changes that the construction industry suffers and that which it occurs due to the outbreak of the Covid-19 pandemic. This is due to their agreeability towards the matter of restrictions implementation such as MCO and WFH causing operation and development to be halted as well as due to the proneness of the industry to be affected by the event of Covid-19, especially with the industrial nature of high risk and hazardous. On top of that, the respondents also expressed their views of a point of which stating that the construction industry was unprepared for a faced unexpected event such as the Covid-19 outbreak. On top of that, it was also expressed by the respondents that such changes contributed due to the industry being unprepared for a faced unexpected event such as the Covid-19 outbreak.

Meanwhile, regarding objective 2 which is relevant to the impacts of Covid-19, the conclusion that is obtained includes the amiable agreeability of respondents towards the set of impacts that resulted from the event of the Covid-19 outbreak. Few of the impacts that the respondents significantly agreed to include the delay of construction work contributed by the act of working method transition as well as due to the lack of knowledge and technology support, shortage of workers that resulted from the deportation of foreign workers, complications in health and financial setting as well as the agitation towards the nature of the industry, financial problems that led by the issues of financial burdens, profit loss and lack of government initiatives, the supply chain management caused by the limited availability of construction materials, difficulty in arranging and receiving material deliveries and the lack of prospective measure and lastly, safety and health conditions due to as the lack of effective safety and health measure, the lack of accessibility on safety essential and free Covid test center as well as the lack of precise study on risk exposure analysis.

As for the findings of objective 3 which is on the technology adaptation measures against Covid-19, it was concluded as crucial to be constructed and well implemented to ensure that pandemic negative impact may be reduced. Thus, the most agreeability of measure that the respondents voted for was the implementation of SOP as such measure assists in ensuring a proper industry procedure. It is then followed by the measure of technology development and application which acts in

improving the safety practices of the construction industry, aids in overseeing the possible risk and issues that exist in a better and more efficient method as well as having to be claimed as an effective alternative instrument that would function in sustaining the structure of the construction industry. Lastly, the measure of site logistics and control that acts to in preventing the transmission of the Covid-19 virus by implying a rigid limitation and procedure to the industry work as well as enhancing the engineering system involved.

Acknowledgement
This research was funded by a grant from V2 Dana Pecutan Penerbitan (DPP) 2022, Fakulti Kejuruteraan dan Alam Bina, Universiti Kebangsaan Malaysia (UKM).

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