

Study on the Usage of 5G Technology in the ECRL Project

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Abstract

Using 5G technology in the construction industry can revolutionize and enhance various aspects of construction projects. With its high-speed, low-latency connectivity, and capacity to handle massive data transfers, 5G offers significant advantages for improved productivity, safety, collaboration, and operational efficiency in construction. These systems can be controlled and coordinated remotely, increasing efficiency, reducing labor requirements, and improving safety on construction sites. The successful implementation of 5G technology in the construction industry requires collaboration between construction companies, telecommunication providers, and technology vendors. Adequate infrastructure and coverage must be established to ensure reliable 5G connectivity on construction sites and robust security measures to protect sensitive data and privacy. However, 5G lack awareness and is low level in the necessity of 5G technology in the construction industry and this shows the problem where the use of 5G is not widely used in the construction industry. The research objective explains the level of awareness of 5G technology in construction, the level of necessity of 5G technology in construction, and the strategies that can be implemented in the usage of 5G technology in the construction industry. Therefore, this research uses a quantitative method involving a total of 32 respondents out of 436 respondents. In data analysis, this study uses Statistical Package for the Social Science (SPSS) version 27.0. The results of the research show that the first objective is the level of awareness of 5G technology in the construction industry was high. Furthermore, the level of necessity in construction are very necessary nowadays by the research findings were also high in the results. Next, the third objective was the strategies that can be implemented in the usage of 5G technology in the construction industry with the high results through research findings that has been made. The contribution is for the the students, industry, and for academic research in the future.

1. Introduction

There are service categories that can help 5G be more compatible which has the key aspects of 5G that make it possible to meet the requirements of the construction sector. Additionally, the implication of Satellite Communication as a 5G access network will serve as a transversal feature that, while not directly connected to any of the Construction 4.0 use cases, will cover both densely populated areas and rural or remote areas where terrestrial 5G networks are insufficient. According to the Cisco Corporate Social Responsibility (2019), the growth of 5G technology will raise the number of connected devices globally from an estimated 29 billion networked devices in 2022 to 300 billion by 2030. The next decade will focus on the utilization of network resources to support more and more user communication, with virtual cloud-based systems and artificial intelligence-based approaches. For construction, it will be easier for us to connect with the technology that can help us more through the limitation of the 5G such as building automation systems, IoT (Internet of Things), construction project management, and wastemanagement created in the future.

2. Literature Review

The potential of 5G, the latest generation of wireless network technology, and how it will improve mobile broadband service and provide a key platform for cutting-edge applications. It also looks at how 5G will be used in the future, and how it will be used in the future. 5G is a much more comprehensive wireless technology than past generations, allowing large numbers of devices to connect to and communicate with each other. It is necessary to realize future technologies like autonomous vehicles and smart buildings, but some strategies still need to be addressed (Carlson, 2020). In this literature review, the matters to be discussed are the definition, scenario, type of 5G, and three related objectives which are the awareness about the 5G technology in construction, the necessity of 5G technology in the construction industry and the strategies to enhance the usage of 5G technology in the construction industry.

2.1 Usage of 5G

The scenario will explain the 5G that has been existing in other countries and Malaysia. Generally, 5G technology offers faster internet speeds, lower latency, and increased device connectivity. 5G also supports the Internet of Things (IoT), powering in smart cities, autonomous vehicles, and various industrial applications with its efficient and reliable connectivity. In the construction industry, 5G is utilized for improved communication, real-time data transfer, and enhanced connectivity. It enables faster and more reliable sharing of larger construction plans and models, facilitating seamless collaboration among project stakeholders. The low latency of 5G supports remote-controlled machinery and augmented reality (AR) applications, optimizing tasks like equipment operation and building design. This technology also aids in the deployment of IoT sensors for monitoring construction sites, ensuring better safety, and efficient project management.

2.1.1 Existence of 5G in other countries

Many other countries are actively working on deploying 5G networks or have plans to do so soon. It is important to note that the availability and coverage of 5G may differ in each country, as it depends on the infrastructure development and the specific rollout plans of the telecommunication operators. Among them is the North American country because it was the first country to launch 5G and most of their states have installed 5G networks. China is the second leading country, and the country has launched 5G networks in several cities. Followed by North Korea, the United Kingdom, Germany, and Australia. Even though they have installed 5G in their country, they still have limitations in connecting the network because the capability was not 100%. Certain regions and states have gotten to the 5G network, most of which were in the city. While there are also some countries in Asia such as Japan, Malaysia, Bangladesh, Pakistan, Sri Lanka, and other countries that are in the process of installing 5G networks (Fisher, 2023).

2.1.2 Countries that implement 5G

Certain regions and states have gotten to the 5G network, most of which were in the city. While there are also some countries in Asia such as Japan, Malaysia, Bangladesh, Pakistan, Sri Lanka, and other countries that are in the process of installing 5G networks (Fisher, 2023). Many things cause the 5G network to be interrupted or may be slow. One of them is the factor of investment. Every carrier network needs a whole lot of money to be invested in their company. It may take millions of amounts of money to make every network a perfect and problem-free network. Other than that, the rural area where areas outside of the city do not meet the requirements of the 5G

network. This plan takes a longtime, but this will work if they take a step-by-step according to the plan. Soon, the country will be able to achieve a 5G network in the future.

2.1.3 5G in Malaysia

As for Malaysia, 5G is still a new technology in the country. According to DNB (Digital Nasional Berhad), Malaysia just implemented 5G in the year 2022. There are five important cities and districts in the state of Selangor, Kuala Lumpur, Johor, Penang, Sabah, and Sarawak. The 5G network will be expanded nationwide starting 2023 and this includes 17 cities as well as rural areas. Apart from that, DNB will always be working on and continue to roll out 5G network infrastructure in Malaysia until 80% coverage is achieved by the end of 2023. The rollout of the 5G will be conducted phase by phase. In 2019, telecommunications companies such as YES and Umobile made an event to call on the public about the 5G provided. Meanwhile, in Malaysia, the 5G network is still limited and only a quarter of areas such as Kuala Lumpur, Nilai (Negeri Sembilan) and Johor Bharu get 5G networks. Other telecommunication companies have not yet made provisions for providing 5G networks (Digital Nasional Berhad, 2022).

2.2 Awareness in the country

While awareness of 5G technology in the construction industry is increasing, the implementation, awareness, and adoption may vary depending on factors such as infrastructure availability, regulatory environment, and industry-specific requirements. The awareness of 5G technology in the construction industry has been increasing over time. As industry professionals and stakeholders become more familiar with the capabilities and benefits of 5G, interest and awareness are likely to grow. However, the potential benefits of 5G make it an attractive technology for improving productivity, efficiency, and safety in the construction industry. There are types of awareness that have been done such as workshops and training, demonstrations and site visits, and collaboration with telecommunication providers. It is very worth noting that the level of awareness and adoption of 5G technology in the construction industry can vary across countries and regions. To get up-to-date information on the current awareness in the country, it would be beneficial to consult industry reports, and news sources, or engage with local construction industry associations or professionals.

2.2.1 United States of America

The United States of America likely has been raising awareness of 5G in the construction industry. The interests, tasks, and duties of the United States are described in the National Strategy to Secure the 5G Implementation Plan. This can encourage the domestic rollout of 5G by identifying core security principles for 5G infrastructure in the construction industry and the need to evaluate the risks that can be threats to 5G infrastructure in the construction industry. Risks in addressing threats 5G Infrastructure Development to the consumers. The National 5G Security Strategy (2021), explains how the worldwide development, deployment, and management of secure and dependable 5G infrastructure in the construction industry that will be led by the United States and like-minded nations. The United States Government will need to make a variety of initiatives to improve the security of 5G networks, working closely with international and commercial partners in the construction industry. Based on the NTIA (2021), the Executive Branch is dedicated to supporting innovation and achieving 5G technology in the construction industry so that the potential while still preserving their economy and maintaining national security even in the construction industry.

2.2.2 China

The construction industry will be booming when the country invests in technology where they did the awareness by demonstrations and site visits. Especially when the 5G network has been installed in their country. China has so far been the most noteworthy construction project to utilize 5G technology on-site. Global Construction Review claims that this has made it possible for them to employ AI glasses that enable engineers in the office to see what workers see on the job site, monitor workers' vital signs, keep an eye on cranes, and even determine whether workers are donning masks in the construction industry in America. Other than that, the New York City Department of Buildings is trying a video inspection program at a few selected locations across the city to enable inspectors to travel about without physically being there. It is being used in one of the regions of the nation that currently has the strongest 5G coverage. According to Andrew Rudansky, press secretary for the DOB, the program depends on the contractor having an internet connection at the site so that they can use it for the video inspection. That could be cellular 5G or wifi (Yang *et al.*, 2021).

2.2.3 Japan

As for Japan, since March 2020, 5G has been commercialized in Japan, and numerous businesses are actively testing the 5G communication infrastructure. A construction machine's long-distance running and lifting tasks were replaced by a remote control, and a high-quality radio wave environment was created using 5G on a tunnel building site. It is anticipated that 5G will be employed in a variety of industrial applications in addition to conventional communications since it can achieve high speed and huge capacity, ultra-low delay, and many simultaneous connections. Unmanned construction is a technique using IoT and ICT that existed and was introduced by remotely operating construction equipment. From there, the 5G in Japan was introduced by doing demonstrations and site visits. Also, in Japan, there is a technique, where they use radio-controlled construction machines that communicate through radio and camera images to verify the construction situation, which is utilized for natural disaster repair and in harsh environments (Takai *et al.*, 2020).

2.2.4 South Korea

South Korea's 5G experts are coming to the World Bank Group for Korea Innovation Week February 18- 20. They will help turn the spotlight on Korea's policy framework and how developing countries can harness 5G technology. 5G is expected to generate US\$12.3 trillion in revenue and generate 22 million jobs worldwide. A paradigm shift is needed to recognize 5G as a core national infrastructure and prioritize spectrum allocation and effective spectrum management. The Korean government held the world's first 5G spectrum auction in 2018, releasing enough spectrum to power the nation. After Korea's success, 34 countries and 61 operators launched 5G services by the end of 2019. However, it takes a concerted effort from a range of stakeholders to gather investments, release spectrum, overhaul outdated policies, strike partnerships, develop digital skills, create demand, and nurture the innovation ecosystem. To help emerging markets, assistance from the international community is needed. The Korea Innovation Week is a chance to discuss best practices and build sustainable solutions together (Ryu *et al.*, 2020).

2.3 Necessity of 5G technology in the construction industry

With the rapid advancement of digitalization, the industry is now recognizing the urgent need to embrace the transformative power of 5G technology. The introduction of 5G holds immense potential to revolutionize construction practices, enhance productivity, improve safety, and enable seamless connectivity between stakeholders.

2.3.1 Construction machine

Unmanned construction equipment has been designed to satisfy the exact specifications of construction design and increase production. Bulldozers with autonomous design and automatic operation are crucial pieces of equipment for the earthwork process. In this study, an unmanned bulldozer for automatic construction is shown, and a 5G-based earthwork monitoring system is implemented. The deployment of the vision and communication systems is based on the concept of an unmanned bulldozer without a cab. The safety of the automated construction process can be ensured and safe while using unmanned construction equipment, such as unmanned bulldozers. The use of autonomous driving technology is indissociable from the use of unmanned bulldozers. With the advancement of urban autonomous driving technology, some common technologies continue to mature. The most common environmental perception sensors used in automated driving are lidar and stereo cameras. For the installation position of Lidar for autonomous cars, there is a suggested optimization approach that can decrease Lidar's blind region and increase the resolution of the point cloud (You *et al.*, 2020).

2.3.2 3D printing

This study provides a review of current state-of-the-art 3D printed antennas for 5G communication. It provides an overview of 3D printing technology, including polymer, metallic, ceramic, composite material, and multi-material integrated antennas. The main challenges and prospects are discussed to provide insight into how 3D printing can be further progressed in antenna manufacturing. With the advent of 5G and future trends for communication systems moving to millimeter wave (MMW) and higher frequencies, antennas will need to have high gain, wide bandwidth, and low losses. 3D printing realizes structures by sequential stacking layer-by-layer, enabling the manufacturing of antennas with arbitrary shapes in a cheaper, faster, and more flexible manner (Mendoza J *et al.*, 2021)

2.3.3 Internet of Things (IoT)

5G technology on IoT applications in construction project management. It identifies the potential usage of IoT technology for various construction project processes based on the PMBOK framework for construction and proposes a framework for the construction domain. It also discusses the barriers raised by connectivity issues within this framework and the influence of 5G. The authors are also working on related projects such as Collaboration in Construction Project Management, Construction Industry Institute India, and Collaboration in Construction Project Management. IoT is a disruptive technology that has brought significant improvement to commercial, consumer, industrial, and infrastructure applications. It can gather data to make the decision-making process faster and more efficient, but construction is different as it involves complexities like unstructured work. 5G technology has the potential to overcome this barrier. The adoption of IoT in construction requires significant effort to ensure appropriate changes in policy, technology, and project implementation. Woodhead suggests the industry needs to shift to digitized processes to make the project delivery process cost-effective. Digitalization has brought improvements in productivity, agility, innovation, consumer experience, quality, costs, and revenue. However, concerns have been expressed about the resistance to adopting such technology in the construction sector (Reja & Varghese, 2019).

2.3.4 Safety and risk management

A safe workplace might result from carefully tracking high-risk areas, and workers, and providing helpful alerts. The basic concept behind this use case is the real-time generation of a digital twin map of the building site. The location of personnel and equipment on the job site should be shown on the map, along with any high-risk regions. It is required to set up a network of sensors that can monitor environmental factors like noise, temperature, and air quality to keep an eye on high-risk regions. By lowering the incidence of falls and being struck by equipment or items, real-time alerting to workers in high-risk situations can avert innumerable accidents and fatalities. Additionally, this use case calls for the adoption of wearables that can monitor the vital signs of employees and provide them with alerts. The use of sensors in safety equipment (hard hats, boots, harnesses) that allow determining whether employees are utilizing it properly in the situation of fatigue. Access control jobs can also benefit from this technology. It will be necessary to link a significant number of devices (sensors and wearables) to the network to fulfill the requirements of this use case. Low data rates are a feature of these gadgets. Low latency communication between 5 and 10 MS is required to warn workers before their health is in danger (Mendoza J *et al*, 2021).

2.4 Strategies that can be implemented in the usage of 5G technology in the construction industry

The construction industry is constantly evolving, and the integration of advanced technologies is essential for its growth and efficiency. One such technology that holds immense potential for the construction industry is 5G (fifth generation) wireless technology. With its faster speeds, low latency, and high capacity, 5G can revolutionize various aspects of construction, including communication, collaboration, safety, and productivity. To fully leverage the benefits of 5G technology in the construction industry, it is crucial to implement strategies that enhance its usage.

2.4.1 Education and training

The part development also plays a role in establishing and managing an Industrial Information System. Secondly, CIDB plans, implements, evaluates, and coordinates the training of construction workers and contractors in the construction industry sector. Advancing technology, creating products, and carrying out research in education and training will make future generations in the construction industry good and have skills in construction. Strengthening quality control in education and training can make project management in construction strong and can create a good team in construction. CIDB is good at promoting and supporting the export of services. Construction companies should invest in training and educating their workforce on utilizing 5G technology effectively. This includes providing training on the use of IoT devices, AR/VR tools, and other technologies enabled by 5G. By equipping their workforce with the necessary skills, construction companies can maximize the benefits of 5G technology and drive innovation in their operations (CIDB, 2023).

2.4.2 Collaboration with telecommunication provider

Operators and the local governments that must approve each small cell site face several challenges because of the size of the 5G network. Carriers are implementing a piecemeal strategy in various towns, which overwhelms permit staff who are not knowledgeable about the details of the small new cell technology. To prevent liability and raise issues with the local permit engineers, telecom service providers need to approach this from an engineering perspective. Although the 5G rollout is the largest U.S. undertaking since the construction of the highway system, it is still using outmoded implementation techniques. To provide complete coverage and the capabilities of 5G, telecom companies need a specific density of antennae, thus they are competing with one another to secure places. Within the 5G antenna, there is a lack of scalability and consistency. Site selection, building plans, and inspection drawings were all created manually during the deployment process (Shahini, 2020).

2.4.3 IoT integration

To identify the Internet of Things (IoT) application cases in the construction industry, this study conducts a cross-sector comparative review of academic and industry literature. It describes an IoT layout for the suggested real-life scenarios and defines the architecture of those scenarios through an interpretivist epistemological lens. The study advances the sector by increasing knowledge of prospective IoT use cases for contractors as "proof of concepts." Future research studies on IoT, Industry 4.0, Industrial Internet, BIM, and RFID can use the findings as a model for their design. Customers now expect more from businesses and ask for hybrid renewable energy options that are connected to a building's daily carbon footprint. Mobile applications that are independent of devices are required to recognize essential information and address the requirements of clients, contractors, and consultants. When creating intelligent tools and platforms for data visualization, the accessibility of the data on websites is of utmost importance. The construction industry must provide BIM-capable technologies that will enable site workers to access design data and record information about the quality and status of their work in real-time. The Construction Industry has a chance to move from being a follower to being a leader in using the Internet of Things (IoT) to address its resource and time restrictions and frequent defaults. IoT uses connected devices and systems like sensors to track variables in real time and make choices (Ghosh *et al.*, 2023).

3. Research Methodology

This part examines the research methods used to collect data related to the research conducted. A methodological study is required to ensure that the information and data obtained to achieve the objective and objective study. In this methodology, there are two types of data, namely primary data and secondary data. These two data are used to help evaluate the research information obtained. There are three objectives in this study. The first objective is the awareness of 5G technology in the construction industry. Secondly, the necessity of 5G technology in the construction industry. Thirdly, the strategies to enhance the usage of 5G technology in the construction industry. Overall, this part describes the research method and analysis of the findings carried out to achieve the three objectives of the study.

3.1 Research design

The research paradigm directs the selection of alternative theoretical approaches, whereas the research methodology directs the procedures of data collection and analysis. There will be two ways on how to obtain the data. The first one is there will be a choice of ways to obtain the primary data. The respondent can choose either one. Secondary data was gathered from many sources, such as books, research reports, and websites. Face-to-face interviews or questionnaires which are the primary data were 38 of the chosen research method, and the creation and application of the research instruments were recovered (Mohajan, 2018).

The design of this research is descriptive where this research involves the use of e-questionnaires. The research design is made to help guide the researcher in conducting the research more orderly and systematically. This is important to understand the process of how a research objective can be achieved. The e-questionnaire is the best instrument for this research because it can be used by the respondents who are at a distance. E-questionnaires can be filled in at anytime and anywhere without using paper. E-questionnaire also can be used by only the URL link provided by the researcher. The e-questionnaire will undergo several evaluations such as effectiveness tests and a pilot study before the questions are distributed to respondents. The respondents that are involved will be contacted first for information purposes before the distribution

process is carried out.

3.2 Data collection

The collecting of data is an essential part of a thesis since it offers the knowledge and empirical support required to address research questions or hypotheses. This study will use data primer and data secondary to help the researcher gain knowledge to complete this study.

3.3 Data analysis

Furthermore, SPSS (Statistical Package for the Social Science) also known as IBM SPSS is a powerful window-based program that can perform various statistical functions, including descriptive statistics, analytic statistics, predictions, and group identification. It is commonly used in thesis, assignments, or works and its updates are often. SPSS can perform basic statistic functions, such as determining variances and frequency, as well as advanced functions like analytic statistics and predictions that are currently and likely to be used while doing data collection. It allows users to rearrange data and edit groups multiple times and can process data sequentially. The 48 interpretation of results depends on the respondent's knowledge level or opinion (Nagaiah & Ayyinar,2016).

Table 1 Data analysis of each objective

Research objective	Method	Methodology Data Analysis	Respondents		
To investigate the level awareness of 5G technology among project team of ECRL	Questionnaire	SPSS Software	Project	team	of
To identify level necessity of 5G technology in the construction	Questionnaire	SPSS Software	Project	team	of
To identify strategies that can be implemented of 5G technology in the construction industry	Questionnaire	SPSS Software	Project	team	of

4. Results and Discussion

A study on the usage of 5G technology in the construction industry. Among the related objectives is to investigate the level of awareness about 5G technology among the project team. Next, this study was conducted to identify the necessity of 5G technology in construction. In addition, this study was also conducted to identify strategies to enhance the usage of 5G technology in the construction industry.

a) Employment/Position

In this part of employment or position, there are so many positions that exist in the construction industry. In the e-questionnaire form, the researcher gave the option to choose, and the respondent also can choose the 'other' option where respondents can fill other positions that are related. The options that the researcher provided were architect, construction manager, mechanical engineer, civil engineer, electrical engineer, structure engineer, and quantity surveyor. Other than that, were respondents that filled in the 'other options' such as Customer Operator, Safety Officer, Project Engineer, Building Engineer, Planning Engineer, Head of System Design, Operation and Maintenance Engineer, Senior Manager Operation, System Manager, Junior Engineer, Planner, Engineer, System Engineer, and Assistant Engineer. The frequency and percentage are depicted in Fig. 1 and Table 2.

Fig. 1 Employment/Position

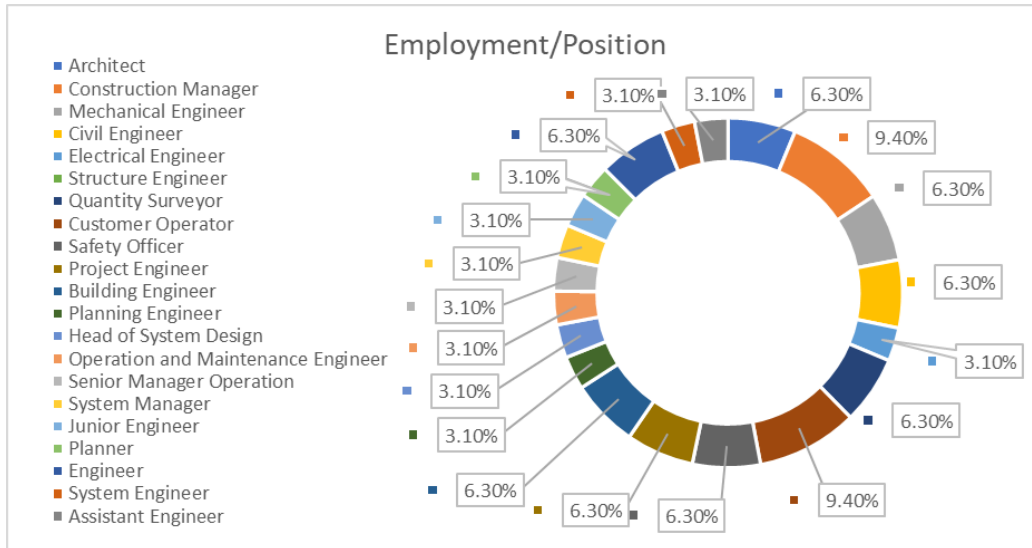


Table 2 Frequency and Percentage: Employment/Position

Employment /Position	Frequency	Percent
Architect	2	6.3
Assistant Engineer	1	3.1
Building Engineer	2	6.3
Civil Engineer	2	6.3
Construction Manager	3	9.4
Operator Customer	3	9.4
Electrical Engineer	1	3.1
Engineer	2	6.3
Engineer Operation and Maintenance	1	3.1
Head of Systems Design	1	3.1
Junior Engineer	1	3.1
Mechanical Engineers	2	6.3
Planner	1	3.1
Planning Engineer	1	3.1
Project Engineer	2	6.3
Quantity Surveyor	2	6.3
Safety Officer	2	6.3

Senior Manager Operation	1	3.1
System Engineer	1	3.1
System Manager	1	3.1
Total	32	100

4.1 The level of awareness about the 5G technology in the construction industry

The level of awareness is lower and not fully dominated in the construction industry. The goal of the fifth generation is to rapidly deliver many benefits to the customer. Many applications can be created way more productively and efficiently to make use of these tools are very customer friendly which means there are no limitations between communication of the program and the user. According to Dahiya (2017), 5G is about 40 times faster than 4G wireless networks, and it is anticipated to offer wireless download speeds of more than 1Gbps in local area networks (LAN) and 500 Mbps in wide area networks (WAN). So, this question was created to evaluate the level of awareness about 5G in the construction industry. The questions have been distributed to the respondents of a project team of ECRL. These questions also related to the objective of the awareness of 5G technology in the construction industry among the project team of ECRL. This is important how the awareness has 10 questions as shown below.

Table 3 Level awareness about the 5G technology in the construction industry

No	Question	Mean	Level
DS3	Demonstrations and site visits can expand the level of awareness of 5G technology in the construction industry.	4.13	High
LA3	The level of awareness of 5G technology brings about a big change in the construction industry.	4.13	High
AW2	With the availability of workshops and training, you can raise awareness of 5G technology in the construction.	4.09	High
RA2	Apply the use of technology in the company to raise awareness among the construction industry.	4.06	High
CT7	Producing collaborations with telecommunications providers can expand the level of awareness of 5G technology in the construction industry.	4.03	High
LA4	The level of awareness about 5G technology is still weak in construction industry.	3.97	High
GK	Gain knowledge on 5G technology from social media, websites, friends and blogs.	3.94	High
LA1	I am aware of 5G technology in construction.	3.63	Moderate
AE5	I am aware of the existence of 5G technology in the construction industry.	3.59	Moderate
LA2	The level of awareness of 5G technology brings harm to the construction industry.	3.06	Moderate
	Average mean	3.86	High

Based on the assumptions made, the mean average is 3.86, and the average mean is high. The total average was 4.13 where many of the respondents strongly agreed to the fact that the level of awareness about 5G technology is still weak and still can develop in expanding the usage of 5G technology in the construction industry and this level of awareness of 5G technology need to bring a big impact in the construction industry.

According to Digital Nasional Berhad (DNB, 2023), Malaysia just implementing 5G in the year 2022. There are five important cities and districts in the state of Selangor, Kuala Lumpur, Johor, Penang, Sabah, and Sarawak. The 5G network will be expanded nationwide starting 2023 and this includes 17 cities as well as rural areas. Apart from that, DNB will always be working on and continue to roll out 5G network infrastructure in Malaysia until 80% coverage is achieved by the end of 2023. The rollout of the 5G will be conducted phase by phase. This shows that 5G is still in the process of expanding its coverage throughout the country. In addition to that, it is also possible that 5G technology in Malaysia will develop in the future.

There are three questions related to the awareness of 5G technology, namely the awareness of 5G technology in construction, the level of awareness of 5G technology bringing harm in the construction industry, and being aware of the existence of 5G technology in the construction industry. These three questions got a medium mean average. This means that the awareness of people in the construction industry is still at a partial level where half of them are exposed to the knowledge of 5G technology. The highest mean in moderate interpretation is **3.63**. this means that the question about the awareness of 5G technology in the construction industry is at a moderate level.

This mean average shows that this awareness is still in process and could be influential in the construction industry. Next, the second highest average of the mean is the question about the awareness of the existence of 5G technology in the construction industry. The mean is **3.59**. there are still some employees who are aware of the existence of this 5g technology. This is possible with exposure to activities or events that can be announced in the construction industry while the third question which is in a simple interpretation, is a question about the level of awareness of 5g technology that brings harm in the construction industry. The mean is **3.06**. it is the lowest mean. This means that 5G technology in the construction industry does not bring harm to them 5G technology can save time and facilitate all complicated work that may take a long time.

4.2 The necessity of 5G technology in the construction

5G can deliver ten-fold increases in data speeds, 5G technology has the potential to have a huge influence on building projects in the construction. This is because it enables faster streaming of detailed 3D, BIM models and access to immersive virtual reality (VR) or augmented reality (AR). Digital technology has significantly changed the construction industry, with project management and BIM software increasing productivity. However, because of problems with on-site connectivity, the productivity gap in the business is still quite large. By transmitting data at up to 10 gigabits per second ten times faster than the fastest 4G connection, 5G technology has the claims to solve this problem. Project managers can obtain results overnight to this supercharged link, which speeds up the transmission of massive volumes of visual data like time-lapse photography and laser scans. The main feature of 5G is its extremely low latency, which enables real-time data access in the field and a live connection between site operations and the office (Cousins,2020).

Based on the research objective, researchers found that the importance of 5G technology is a necessity in the construction industry. This point has been proven through the answers of the respondents who have made the choice that the need for 5G technology is very necessary at this time. The table below shows the interpretations mentioned above received high interpretations Next, this research brings another view of where 5G technology can lead to problems in data security in the construction industry. The interpretation is high with an average mean of **4.06**. As stated, (Gavejian & Lazzarotti, 2022), since the construction sector is the third most likely to encounter ransomware attacks in 2021, cybersecurity dangers are not unique to it. The industry is susceptible to cyberattacks because of its unregulated nature, large volumes of private and sensitive corporate data, and growing usage of robotics and artificial intelligence. Organizations need to identify their vulnerabilities and create a plan to guard against these risks. From here it can be seen that cyberattacks will still happen and only the organization needs to take action to avoid this from happening.

Table 4 Necessity of 5G technology in the construction

No	Questions	Mean	Interpretation	Ranking
CM1	The need for 5G technology on construction machines is require present time.	3.84	High	7

IT5	The addition of 5G technology in the Internet of Things (IoT) is a necessity in the construction.	3.97	High	5
SR8	The production of 5G technology in safety and risk management necessity in the construction industry.	4.03	High	4
NE1	5G technology is a necessity in the construction industry.	3.75	High	8
PC5	3D printing in 5G technology needed among construction industry by the positions in your company.	3.53	High	9
TF4	The need for this technology to facilitate a project in the construction industry.	3.91	High	6
PC1	The problem of using 5G technology in the construction industry such as data security will occur in the construction industry.	4.06	High	3
BU2	The building can be completed within the stipulated time when the 5G technology is fully utilizable.	3.53	High	10
SR4	The use of 5G technologies such as drones, and risk management can help in enhancing the good impact in the construction industry from before.	4.22	High	2
UC3	Unlimited communication from far and near areas can help save a lot of time with the availability of 5G technology in the construction industry.	4.22	High	1
Average mean		3.91	High	

Behind the problems confirmed in this study, there is also 5G technology capable of helping the construction industry in communication even in rural areas. This matter has received a high interpretation with an average mean of **4.22**. It helps in saving time because of the speed of 5G technology that has been created to reduce lagging when communicating using non-face-to-face applications such as video calls, Google Meet, or Webex. Table 4 shows the ranking of each of the questions from the highest average mean to the lowest average mean. The purpose of doing the ranking is to show that the level of necessity of 5G technology is valid and agreeable to the respondents.

3.3 Strategies that can be implemented in the usage of 5G technology in the construction industry

According to (Bristow, 2021), even while 5G technology is developing at a rapid pace, the construction sector is still only beginning to realize the full potential of this technology. Like the advancements facilitated by the capabilities of 4G LTE, we are unsure of how 5G will materialize in fascinating new use cases down the road. Now, it is obvious that 5G will increase engineering and construction efficiency, safety, and compliance. Rather, 5G will serve as a spur for innovation and ongoing development, propelling businesses in the building sector and beyond into the use cases of the future. therefore, the researcher has prepared 10 positive questions about strategies to enhance the usage of 5G technology in the construction industry and will be evaluated through the mean value. the higher the mean value, the higher the level of interpretation. there, the researcher gets answersto related questions to help answer objective questions.

Table 5: Strategies that can be implemented in the usage of 5G technology in the construction industry

No	Questions	Mean	Interpretation	Ranking
SE1	I have a strategy to enhance the use of 5G technology in the construction industry	3.38	High	10
ET4	Strategies such as education and training may enhance the use of 5G technology in the construction industry.	4.19	High	5
CT3	Building collaboration with telecommunications provision a good strategy.	3.94	High	9
IT2	The Internet of Things (IoT) integration strategy expands the use of 5G technology in the construction industry.	4.19	High	4
IU5	With all the strategies above, this strategy will improve the usage of 5G technology in the construction industry.	4.19	High	3
PS2	Provide strategies by increasing the use of technology in my company.	4.19	High	2
GE1	Going to the event or booth to gain a piece of knowledge about the 5G technology that may change the construction industry.	4.16	High	6
TO3	Take the opportunity to make changes to use 5G technology in the construction industry.	4.25	High	1
PC2	Plans to make changes to use 5G technology in the construction industry.	3.94	High	8
ET3	Send a trainee to a training to let them explore about 5G technology.	4.16	High	7
	Average mean	4.06	High	

Taking the opportunity to make changes to use 5G technology in the construction industry also received high attention with an average mean of 4.25 and sending trainees to training received an average mean of 4.16. This explains that many agree on this strategy to make changes to 5G technology in the construction industry in our country. With the high total average mean being 4.06, through the implementation of these techniques, the construction sector may optimize the utilization of 5G technology, hence facilitating enhanced connection, efficiency, and innovation within the construction process. Consequently, this can aid in the general expansion and advancement of the building industry in the digital age. Table 4.9 also shows the ranking of the questions from the highest average mean to the lowest average mean. The purpose is to see strategies that can be implemented in the construction industry.

5. Conclusion

(a) Objective 1: To investigate the awareness of 5G technology in the construction industry.

The researcher has prepared a total of 10 questions with the concept of a five-point Likert scale to represent each question that has been discussed in the literature review section. Based on the findings of the research, the level of awareness about 5G technology in the construction industry is one of the statements included in the e-questionnaire form with the highest average value which is 3.86. The results of this study are also supported by (Digital Nasional Berhad, 2023) which states that only 60% of 5G coverage is in populated areas. also, according to (Malaysian Investment Development Authority (MIDA), 2022), starting with a 10% objective of 5G coverage in Kuala Lumpur, Putrajaya, and Cyberjaya by the end of this year, Malaysia is estimated to attain about 80% of 5G network coverage in populated areas by the end of 2024. By 2025, there should be over 2.1 million mobile 5G

subscriptions in Malaysia, or 6.6 mobile 5G subscriptions per 100 persons, according to estimates. This shows that 5G is still in the process of expanding its coverage throughout the country. In addition to that, it is also possible that 5G technology in Malaysia will develop in the future.

(b) Objective 2: To identify the necessity of 5G technology in the construction

Based on the findings of the research, the necessity of 5G technology in the construction industry. Based on the evaluation that has been carried out, the researchers found that the necessity of 5G technology in the construction industry is at the highest level, with an average value of 3.91. Based on the results of this conclusion, the necessity of 5G technology in the construction industry by adopting 5G technology is a necessity for the construction sector, not just a way to stay technologically modern. The construction industry will change because of the advantages of increased connectivity, faster data transfer, and the incorporation of cutting-edge technologies like IoT, AR, VR, and autonomous systems. Adopting 5G is about more than just efficiency and economy, it is about promoting innovation, sustainability, and competitiveness in a sector that plays a crucial role in the expansion and advancement of global communities. The approach of a new age in building, and the implementation of 5G technology is a necessary advancement rather than a choice.

(c) Objective 3: To identify strategies to enhance the usage of 5G technology in the construction industry.

Based on the findings of the research, the researchers found that the strategy to enhance the usage of 5G technology in the construction industry got a high average value of 4.06. The results of this study are supported by (CIDB, 2023), where CIDB does promote and support the export of services. Construction companies should invest in training and educating their workforce on utilizing 5G technology effectively. This includes providing training on the use of IoT devices, AR/VR tools, and other technologies enabled by 5G. By equipping their workforce with the necessary skills, construction companies can maximize the benefits of 5G technology and drive innovation in their operations. Other than that, the construction industry must provide BIM-capable technologies that will enable site workers to access design data and record information about the quality and status of their work in real time. The construction industry has a chance to move from being a follower to being a leader in using the Internet of Things (IoT) to address its resource and time restrictions and frequent defaults. IoT uses connected devices and systems like sensors to track variables in real time and make choices when the existence of 5G can be fully utilized (Ghosh *et al.*, 2023). Therefore, this strategy can enhance the usage of 5G technology in the construction industry.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Nurdalila Ayuni Ab Razak, Roshartini Omar; **data collection:** Nurdalila Ayuni Ab Razak; **analysis and interpretation of results:** Nurdalila Ayuni Ab Razak; **draft manuscript preparation:** Nurdalila Ayuni Ab Razak, Roshartini Omar, Goh Kai Chen, Sulzakimin Mohamed. All authors reviewed the results and approved the final version of the manuscript.*

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