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An Investigation of the current Trends in Integration of Internet of Things within the Construction Industry in Sri Lanka

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Abstract— In the era of Industry revolution 4.0, the construction industry is increasingly adopting IoT to improve operational efficiency. However, Sri Lanka's construction industry lags in competitiveness. To address this, the study examines IoT applications through a survey of 51 construction professionals, using a Likert scale questionnaire that was designed based on a literature review. From the literature review, the potential of IoT applications worldwide and recent trends in IoT were identified. The currents trends were evaluated based on three parameters: knowledge and awareness of IoT, patterns of usage and application in the construction industry, and cost allocation and investment in IoT implementation. The data was analyzed through SPSS software. This study highlights the growing awareness and use of IoT in the Sri Lankan construction industry, particularly in project planning, scheduling and quality control. While 82% of participants recognize the value of IoT, there is a significant gap in formal training and financial investment, 76% lack of training and 81% of companies do not allocate additional funds for IoT implementation. Key IoT technologies such as sensors, cloud computing, and GPS are widely used, but advanced technologies such as RFID and autonomous robotics are still underutilized. For the construction industry to fully exploit the potential of IoT, greater investment in training and resources is essential to drive efficiency, productivity and innovation across all project phases.

Index Terms— Internet of Things (IoT), Construction, Recent trends, Sri Lanka

1 INTRODUCTION

1.1 Background and Problem statement

In 1999, Kelvin Ashton first introduced the concept of Internet of Things (IoT) and it is an innovative concept of the internet [3]. It is defined as the possibility of connecting things using the internet to form a platform that is used to execute certain activities. With the rapid evolution of technological advancement, smart device can connect to the internet and use the internet connection and everything around them to communicate and connect with each other to perform specific tasks over the network.

The construction sector is frequently experiencing bottlenecks, and significant delays are constantly occurring in construction projects. As a result, many countries are expanding their IoT network in the construction sector and trying to apply modern technology to the maximum in the construction industry [6]. The IoT, according to the evidence, has a wide range of potential applications in the construction industry [15]. It also, allows volumes of data to be collected, recorded and synthesized into useful insight [10].

Consequently, IoT adoption in the construction sector can create additional economic opportunities and contribute to a larger data ecosystem, making future data-driven insights more accessible [14].

Nowadays, the construction industry is expanding rapidly and implementing IoT application in the construction sector is essential [2]. Otherwise, the construction sector will lag in the competition between industries [6]. In the modern era, which is the most advanced age of technology after the industrial revolution, IoT applications are used in various industries [8]. However, due to the backwardness of technological input in Sri Lanka, the implementation of IoT technology within the construction industry is currently limited to only a few specialized uses. This phenomenon might be attributed to address the deficiencies within the construction industry of Sri Lanka. Therefore, it is important to identify the present trends of using the IoT in construction projects.

1.2 Aims and Objectives

The aim of this research is to comprehensively examine and analyse the recent trends associated with the integration of Internet of Things (IoT) technologies within the construction industry in Sri Lanka. By doing so, this study seeks to provide a current and insightful understanding of the status of IoT adoption in the Sri Lankan construction sector, offering valuable insights for industry stakeholders, policymakers, and researchers. The objectives of the research are listed below.

i. Identify the technological advancements and innovations in IoT solutions relevant to the construction sector.
ii. Investigate recent trends in the use of Internet of Things (IoT) in the construction sector of Sri Lanka.

2 LITERATURE REVIEW

2.1 Internet of Things

The term Industry 4.0 stands for the fourth industrial revolution. Getting all the relevant information real is the basis here [9]. Industry 4.0 is characterized using electronics and information technology (IT) in production and services, as well as sophisticated automation and digitalization processes [4]. IoT, big data, cloud computing, and mobile computing are some of Industry 4.0's key technologies, ([16], [17]) specifically, industry 4.0 is made possible by mobile and cloud computing, which integrate industrial IoT networks. Lasi et al., [12] has elaborated that, the real-time decision support architecture outlined in Industry Standard 4.0 will encompass data collection, analysis, and interpretation from a range of sources, including customer management systems, industrial systems, and equipment. On the other hand, the integration of embedded sensors and actuator nodes has been made possible by the advancement of big data services, Bluetooth, and Wi-Fi technologies, which bodes well for IoT [5]. Moreover, most of the research have shown the key technologies for the effective creation of IoT as RFID, cloud computing, middleware, wireless sensor networks (WSN), and application software especially created for the IoT. According to its conceptual description, the Internet of Things can be separated into three layers: the network, application, and sensor layers [5]. The bottom layer of the internet of things architectures is made up of the sensor layer which is call the sensor layer. This layer primarily conducts extensive sensing activities by using sensing devices and components to collect data and monitor particular environments [13]. The primary goal of the network layer, also referred to as the transmission layer, in the architecture of the Internet of Things is to link networks faster and more broadly so that the information gathered by the sensing layer can be reliably

and securely transmitted to the designated target areas [1]. The platform layer and the application service layer are supported by the application layer, also known as the business layer, which is built on cloud computing and storage technologies. It analyses and processes data. Additionally, it offers pertinent intelligent services that facilitate information sharing, industry collaboration, and system interoperability the application layer, for instance, can offer analysis services to directly assess the received data to forecast the future condition of physical devices, or storage services where data is integrated into a database [5].

2.2 IoT and the construction industry

Research on the IoT's potential use in building construction is scarce. Especially research which have been done in developing countries like Sri Lanka. However recent studies show that IoT is gaining popularity in the construction industry, particularly in developed countries. Under Industry 4.0, Modelling and Simulation, Smart Construction Site, and Digitalization are three sub-categories related to the construction sector [17]. Based on that, technologies such as Cloud Computing, BIM, DPD, and RFID have been increasingly used in the past decade due to their rapid adoption in the construction industry [12]. In addition, the Industrial Internet of Things (IoT) combines several vital modern technologies to produce a system that is more sustainable and efficient [11]. According to Gamil et al., [8] cyber-physical construction is also seen to be accelerated by IoT. The scheduling, planning, and management of sustainable manufacturing processes and systems are made possible by IoT services and applications in the construction industry. This enhances a business's overall maintenance and availability as well as operational effectiveness. Using a network of linked devices, the IoT decentralizes analysis and decision making and enables real-time response and reaction [9].

3 METHODOLOGY

3.1 Research Design

The research design for this study is structured to investigate the applications of IoT technology in the construction industry, particularly in the Sri Lankan context. The design follows a systematic approach that includes identification of the research problem, formulation of research objectives, data collection, data analysis and interpretation of results (Fig. 1.).

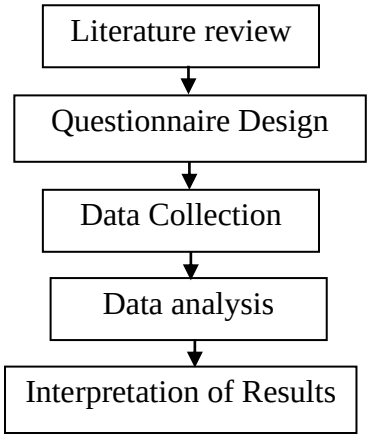


Fig. 1. Research Design

A comprehensive literature review was conducted to gather secondary data and gain an in-depth

understanding of the current state of IoT technology in the global construction industry. This review identified key factors influencing the adoption of IoT within the construction industry in various countries. The questionnaire was structured into 2 sections addressing basic demographic data and organizational information, and recent trends. The research was designed to analyse the data through quantitative approaches.

Table 1. Structure of Questionnaire

Section	Types of Questions
Section A	Basic demographic data and Organizational Information.
Section B	Recent trends

3.2 Questionnaire

As shown in Table 1, Section A of the questionnaire includes basic information such as the designation, years of experience, and the type of construction project they are currently working on. Section B focuses on the trends in the use of IoT within the industry. This section examines the respondents' knowledge and awareness of IoT, patterns of usage and application, and cost allocation and investment in IoT implementation.

3.3 Target population and sample selection

Before distributing the questionnaire among industry professionals, a pilot study was conducted using 5 construction professionals with more than 11 years of experience in construction projects in Sri Lanka. Feedback from the pilot study was thoroughly analyzed and necessary revisions and refinements were made to the questionnaire to ensure clarity, relevance, and reliability of the questions. Data were collected through a survey distributed to construction professionals in Sri Lanka. The target population included individuals in various roles within construction companies to ensure a diverse and representative sample. Sample size was determined using the statistical equation used by Enshassi et al. Swaity [7] and Gamil et al., [8] and the sample size was computed as 149.96 which is then rounded off to nearest decimal place, i.e. 150. An amount of 200 questionnaires were distributed to reach the sample size but only 51 were returned.

4 Results and Analysis

The data obtained through the questionnaire were analyzed using the Statistical Package for Social Sciences (SPSS, version 26).

4.1 Analyses of the respondents' demographic characteristics and Organizational Information

As shown in Fig. 2., the nomenclature of the participants shows that the majority are engineers, which is 41% of the total. The second largest group consists of other professionals including trainees, quantity surveyors, supervisors and security personnel who contribute 21%. There is a balanced distribution among other classifications, which facilitates the analysis of trends related to the application of IoT in the construction industry. The Fig. 3. shows gathered information about the respondents' years of experience in the construction industry. The majority, 33.0%, have 11 to 15 years of experience. Another 27% have 6 to 10 years, 26% have 1 to 5 years, 8% have 16 to 20 years, and 6% have over 20 years of experience. This

diverse range of experience levels ensures a comprehensive representation of the construction community. According to Fig. 4. 57% of the respondents are currently involved in the construction of commercial buildings, 23% are engaged in various types of infrastructure projects, and only 20% are working on residential projects.

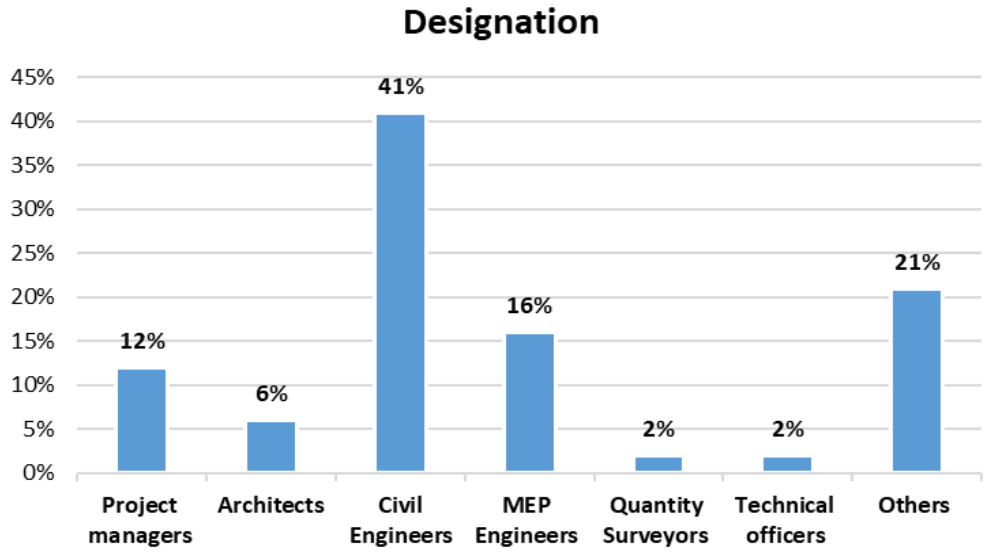


Fig. 2. Designation of Construction Professionals

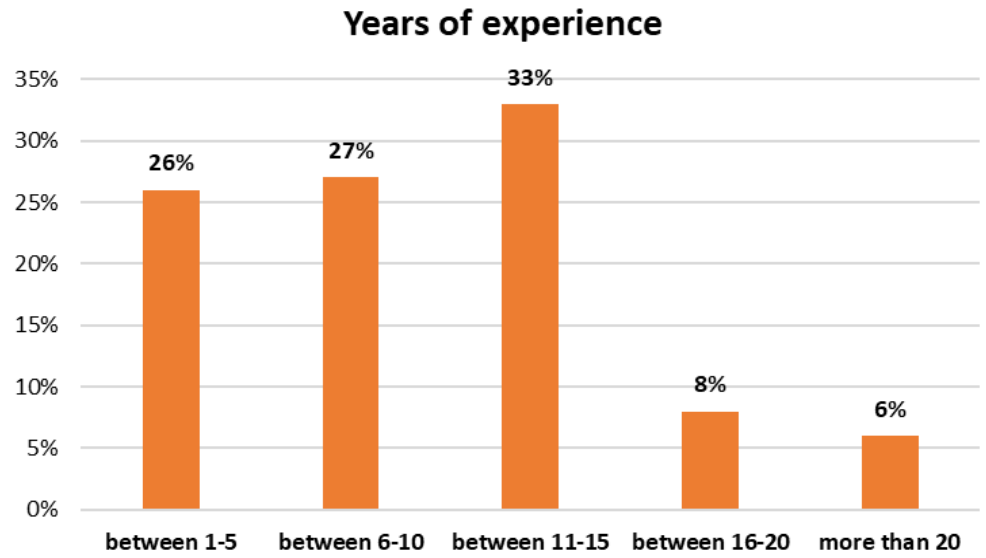


Fig. 3. Years of Experience

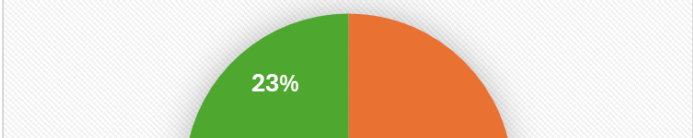


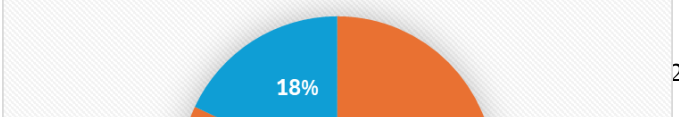
Fig. 4. Type of Construction Project

4.2 Current Trend of IoT integration in the construction industry

The currents trends were evaluated based on three parameters: knowledge and awareness of IoT, patterns of usage and application in the construction industry, and cost allocation and investment in IoT implementation.

4.2.1 Knowledge and awareness of IoT applications in the construction industry

Under the knowledge and awareness category the understanding regarding the IoT applications that are currently being used in the construction industry is checked as shown in the Fig. 5. 82% are aware of IoT applications and their importance while 18% said they are not aware of it. This shows how aware construction industry professionals are about using this new technology. Among the respondents, only those respondents who have awareness about IoT are referred to the survey. The remaining questions were analyzed based on responses from 41 participants. Fig. 6. shows the formal training conducted to increase awareness of IoT application in the construction industry and the involvement of professionals based on participant comments. According to the results, 76% of participants had not received such training, while 24 % appeared to have. It shows the obstacles to train professionals in the construction industry in Sri Lanka. It is clear that construction companies do not contribute much to the training of such professionals. The interest in gaining knowledge of new technologies and trends in the construction sector, including IoT is also a crucial factor when analysing the knowledge and awareness. Table 2 shows the sources from which construction sector professionals obtain information about new technologies and trends and the extent to which they use them. According to the response of the participants, industry conferences are the most popular source for improving new knowledge regarding technology and IoT and it is 24.2 % from the total participants. Online forms and communication and colleague use are at the same level, and it is 22.3 %. Furthermore, professional journals are used by only 22.9 %. Training programs seem to be used the least; it is 7.5 %.



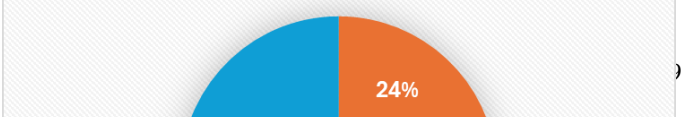


Fig. 5. Understanding of the Technology Applications

Fig. 6. Formal Training on IoT in the Construction Industry

Table 2. Sources of Information on new Technologies and Trends in the Construction Sector Including IoT

		Responses		Percent of
		N	Percent	Cases
Seek information is selected[a]	Industry conference	38	24.2%	90.5%
	Professional journals	35	22.3%	83.3%
	Online forms and communication	36	22.9%	85.7%
	Training programs	12	7.6%	28.6%
	Colleagues	36	22.9%	85.7%
Total		157	100.0%	373.8%

4.2.2 Patterns of usage and application of IoT in the construction industry

Investigating the use of new IoT technologies in the Sri Lankan construction industry is significant for understanding emerging trends. Table 3 highlights various IoT applications in Sri Lanka's construction sector. Participant responses indicate that sensors are the most widely used IoT application, representing 18.4% of usage. This is followed by cloud computing at 17.9%, GPS tracking at 17.3%, building information management at 16.8%, predictive maintenance at 14.3%, and smart building systems at 13.3%. In contrast, RFID, CPSS, and automation robotics technologies show minimal usage, each at only 1%. This study also shows the usage pattern of different IoT applications in different phases in construction projects. In the construction industry, there are 4 phases as project initiation, procurement, construction and monitoring and post-construction. Table 4 shows which construction phase IoT is most used in these different phases. Accordingly, the construction and monitoring phase and post construction phase can be indicated as the most commonly used IoT applications, which is 25.3%. The project initiation phase and procurement phase are in the 2nd place according to the alignment and it shows that the use of IoT in those phases is similar; which is 24.7%. In summary, the Table 4 confirms the nearly equal distribution of IoT usage across all construction phases, indicating its broad applicability and importance throughout project lifecycles. In addition, the findings reveal that IoT is mainly used for planning and scheduling activities of construction projects. Table 5 illustrates how the use of IoT varies with respect to different construction

activities based on the responses of all participants. According to their responses, 22.5% of IoT usage is dedicated to project planning and scheduling, making it the primary application field for IoT in construction. The study also reveals that 21.3% of IoT usage is for quality control, 20.1% for safety and security, 18.9% for monitoring and managing construction equipment, and 17.2% for building automation. The research examines how closely the construction collaborate with IoT solution providers to customize and optimize solutions for construction projects, as shown in Figure 7, based on participant comments. According to the results, 31% of sample work very closely with IoT solution providers, and 62 % are somewhat closely involved. In addition, 7 % don not communicate closely. Overall, this shows that Sri Lanka is working closely with IoT solution providers to customize and optimize solutions for construction projects.

Table 3. Specific Areas of IoT applications

		Responses		Percent
		N	Percent	of Cases
IoT application is selected[a]	RFID	2	1.0%	4.8%
	Sensors	36	18.4%	85.7%
	Cloud computing	35	17.9%	83.3%
	Building information management	33	16.8%	78.6%
	GPS Tracking	34	17.3%	81.0%
	Smart building systems	26	13.3%	61.9%
	Predictive maintained	28	14.3%	66.7%
	CPSs and Automation robotics technologies	2	1.0%	4.8%
Total		196	100.0%	466.7%

a. Dichotomy group tabulated at value 1

Table 4. IoT applications in various construction phases

		Responses		Percent of
		N	Percent	cases
Construction phase is selected[a]	Construction and Monitoring	40	25.3%	95.2%
	Project initiation	39	24.7%	92.9%
	Procurement	39	24.7%	92.9%
	Post-Construction	40	25.3%	95.2%
Total		158	100.0%	376.2%

a. Dichotomy group tabulated at value 1

Table 5. Specific Areas of IoT Applications

		Responses	Percent

		N	Percent	of cases
Specific area is selected[a]	Planning and scheduling	38	22.5%	90.5%
	Monitoring and management of construction equipment	32	18.9%	76.2%
	Building automation	29	17.2%	69.0%
	Safety and security	34	20.1%	81.0%
	Quality control	36	21.3%	85.7%
Total		169	100.0%	402.4%

a. Dichotomy group tabulated at value 1

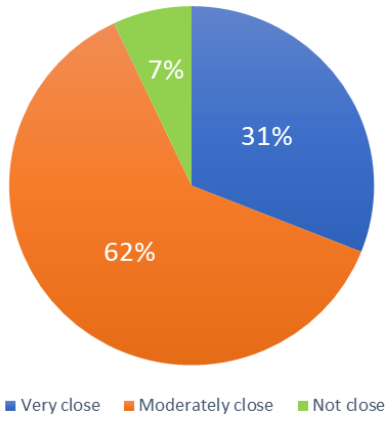


Fig. 7. Understanding of the Technology Applications

4.2.3 Cost allocation and investment in IoT implementation

The study evaluates cost allocation for IoT application involvement across various activities in construction projects. As shown in Figure 8, 81% of participants reported that companies do not allocate additional funds for IoT technology, indicating a low level of investment in its adoption and expansion. Only 19% stated that companies have reserved additional expenses for IoT use. These results suggest that most companies in Sri Lanka's construction industry have not allocated extra costs for from the total budget IoT implementation. Table 6 shows the factors that influence to invest on IoT for construction projects. The existing literatures depict that cost savings potential by utilization of IoT for construction works as the most significant factor with a notable mean score, followed by improved project outcomes, regulatory compliance requirements, and gaining a competitive advantage. Nevertheless, the results in this study indicate that most of the construction companies in Sri Lanka spend money on IoT application intending to improve the project outcomes; which is 26.1%. A percentage of 25.5 of respondents consider reducing costs from the estimated project budget of the construction project by utilizing IoT. The Table 6 further elaborates that, equal number of construction companies from the sample invest money on IoT to fulfill regulatory compliance requirements and to again competitive advantage in the industry; that the percentage is 24.4%. Table 6 highlights intention to improve projects outcome as the most significant factor, reflected by the highest mean score, followed by cost saving potential, regulatory compliance, and gaining a

competitive advantage.

Table 6. Factors that influenced the decision to invest in IoT

		Responses		Percent of
		N	Percent	Cases
Factor influenced is selected[a]	Cost savings potential	39	25.5%	92.9%
	Improved project outcomes	40	26.1%	95.2%
	Regulatory compliance requirements	37	24.2%	88.1%
	Competitive advantage	37	24.2%	88.1%
Total		153	100.0%	364.3%

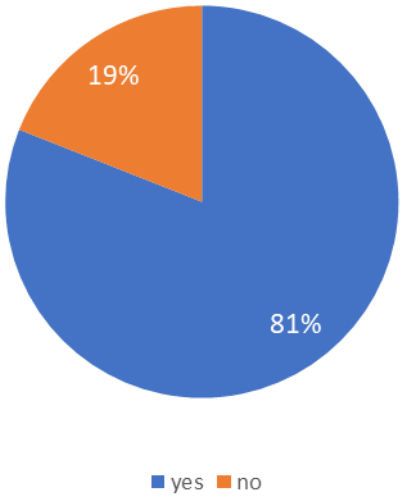


Fig. 8. Cost Allocation for Using IoT Technology Input in the Worksite

5 CONCLUSION

This study highlights the growing recognition of IoT technology in the construction industry of Sri Lanka, with a diverse group of professionals, ranging from engineers to supervisors, contributing to this research. The data shows that there is a high level of awareness among industry professionals in terms of IoT nevertheless, the adoption of this technology remains limited, particularly in terms of formal training and budget allocation for IoT applications. IoT is specifically used for project planning, scheduling and quality control where it has been observed to improve efficiency which indicates that the IoT can enable construction through all life cycle phases. However, the lack of substantial investment in IoT suggests that companies may not yet fully appreciate the cost-saving benefits and competitive advantages that IoT can bring. The research also indicates that the Sri Lankan construction industry is not well-acquainted with advanced technologies such as RFID, Cyber-Physical Systems (CPS), and automation robotics. Given that technologies like CPS and automation robotics involve substantial capital investment and maintenance costs, further analysis is necessary to assess the feasibility of implementing such technologies in the local context.

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